YUKON EXPLORATION & GEOLOGY

1996

- Mining & Exploration Overview
- Government Services
- Geological Fieldwork

Canada

YUKON GEOLOGY PROGRAM

Yukon Economic Development

Yukon Exploration and Geology 1996

PREFACE

Much of the information in this volume comes from prospectors, exploration geologists and mining companies who are willing to share information for the collective benefit of Yukon's minerals industry. This assistance is gratefully acknowledged and sincerely appreciated.

Published under the authority of
Honourable Ronald A. Irwin, P.C., MP
Minister of Indian Affairs and Northern Development, Whitehorse, 1997

QS-Y116-000-EE-AI
catalogue # R71-41/1996 E
ISBN 0-662-25311-6

Cover Photo:
Mark Baknes (Equity Engineering) mapping the Money Claims, a volcanogenic massive sulphide target 5 km east of the Wolverine deposit, southeastern Yukon.

Table of Contents

Preface

Yukon Mining and Exploration Overview 1996 *by Mike Burke* 5
- Lode Mining 9
- Advanced Development and Exploration 12
- Exploration-Base Metals 15
- Gold Exploration 25

Yukon Geology Program 33

Description of Selected Properties

Massive sulphide deposits in the Yukon-Tanana and adjacent terranes
Julie Hunt with contributions from M. Baknes, H.J. Keyser, and R. Stroshein 35

Fyre Lake Deposit: A new copper-cobalt-gold VMS discovery
Doug Blanchflower, J. Deighton, and I. Foreman 46

Wolverine massive sulphide project, Yukon
Terry Tucker 53

Mamu-Bravo-Kulan claims, a VHMS exploration target based on geochemical and geophysical anomalies in Mississippian volcanics within Cassiar Platform, NTS 105-F/7, 8, 9, & 10
Al Doherty 56

Geological Fieldwork

Preliminary geology of the northeast third of Grass Lakes map area (105G/7) Pelly Mountains, southeastern Yukon
Donald C. Murphy and Jay R.M. Timmerman 62

Biogeochemical Prospecting in the Yukon-Tanana Terrane, Yukon Territory
Julie Hunt, C.E. Dunn, J.R.M. Timmerman and W. Zantvoort 74

The Carmacks hydrothermal event: an alteration study in the southern Dawson Range, Yukon
Katherine A. Smuk, A.E. Williams-Jones and Donald Francis 92

Soil geochemistry above deeply oxidized porphyry deposits in unglaciated terrain, Dawson Range, central Yukon
Craig J.R. Hart and Shellie Jober 107

Paleomagnetism of the Mount McIntyre pluton, Whitehorse map area (105D), Yukon
Mike J. Harris, D.T.A. Symons, W.H. Blackburn and C.J.R. Hart 122

Geology and Geochemistry of the Teslin Crossing Pluton: A gold-rich alkalic porphyry target
Craig J.R. Hart 131

Upper Paleozoic strata with potential for massive sulphide mineralization, northwestern Lansing map area (105N) Yukon
Charlie Roots 138

Yukon Mining and Exploration Overview 1996

Mike Burke
Exploration and Geological Services Division
Indian and Northern Affairs Canada
#345-300 Main Street, Whitehorse, Yukon, Y1A 2B5

Burke, M.R., 1997. Yukon Mining and Exploration Overview 1996. In: Yukon Geology and Exploration 1996: Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada.

Introduction

Exploration and mine development expenditures surpassed $108 million in 1996 continuing the upward trend that began in 1992. As a direct result of the increased expenditures Yukon had three operating mines in 1996: Anvil Range Mining Corporations', Pb-Zn-Ag Faro mine, Viceroy Resource Corporation's Brewery Creek Mine, Yukon's first heap leach gold mine, and B.Y.G. Natural Resources' Mt. Nansen Au-Ag mine. The rise in exploration expenditures was also reflected in significant new discoveries in Canada's newest volcanic hosted massive sulphide (VHMS) camp, the Finlayson Lake area. A new massive sulphide lens, the Lynx lens was discovered late in the season on the Westmin/Atna Resources Wolverine property significantly adding to reserves. The Fyre Lake property of Columbia Gold Mines revealed a significant massive sulphide body as a result of the first substantial drill program conducted on the property since its discovery in 1960. On the Ice claims of Expatriate Resources massive sulphides were intersected in the final hole of the 1996 drill program in an area previously believed to host insignificant mineral potential.

Exploration expenditures in 1996 surpassed the 1995 total by 37% to $54.8 million (Fig. 1). Approximately 60% of expenditures were spent on the search for base metals, a significant portion of the total in the Finlayson Lake area, and the remaining 40% on the search for precious metals deposits. Mine development expenditures were $54.1 million in 1996, slightly lower than the $57 million spent in 1995. Development occurred mainly at the Brewery Creek Mine and the Mt. Nansen Mine which both produced their first gold in November, 1996. Development expenditures were also incurred at the Minto Project a

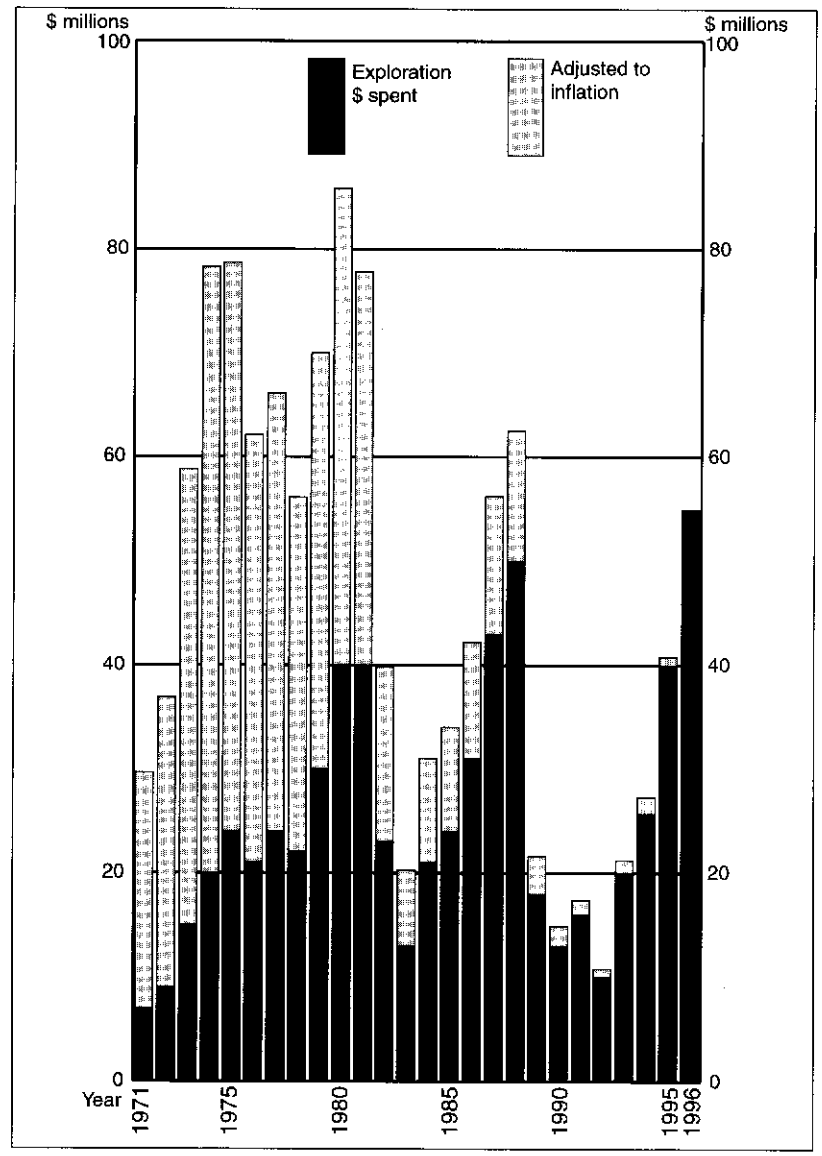


Figure 1: *Exploration Expenditures: 1971-1996*

Cu-Au-Ag porphyry deposit slated for construction in 1997, Carmacks Copper an oxidized Cu-Au porphyry deposit, Kudz Ze Kayah the first VHMS discovery in the Finlayson Lake area, the Laforma Gold Mine project in the Mt. Nansen area as well as at the Faro Mine.

New quartz claim staking reached a staggering level with 22,685 claims staked by the end of 1996 (Fig. 2). Never in the history of Yukon have this many claims been staked in a single year. The high level of new claims recorded over the last three years has resulted in quartz claims in good standing also reaching a historic high of 72,190 (Fig. 3). The high level of claims and continued exploration success in Yukon point toward a healthy exploration industry for the foreseeable future.

Over 100 exploration projects were conducted in 1996 (Appendix 1; Fig. 4). The Finlayson Lake area received close to 50% of all exploration expenditures in 1996 but the search for bulk tonnage gold deposits in Yukon accounted for a significant proportion of the expenditures. Thirteen different projects spent over a million dollars in Yukon. These included programs at Faro, Fyre Lake, Cominco (Finlayson Lake area), Expatriate (Finlayson Lake area), Dublin Gulch, Brewery Creek, Marg, Goddell, Skukum Creek, Laforma, Keno, Wolverine, and by Yukon Gold Corp. in the Emerald Lake area. Grassroots recconaisance exploration also resulted in significant activity in Yukon in 1996. One program, financed by a private consortium, identified several multi-element geochemical anomalies based on detailed stream sediment sampling and prospecting and resulted in the staking of roughly 2000 claims in the Brewery Creek area.

The discovery of new potential orebodies, successful exploration on advanced projects and the discovery of new areas of mineralization based on grassroots exploration all illustrate the as yet untapped mineral potential of Yukon. The development of new mines is diversifying our prime industry which will continue to be the Yukon's' economic engine.

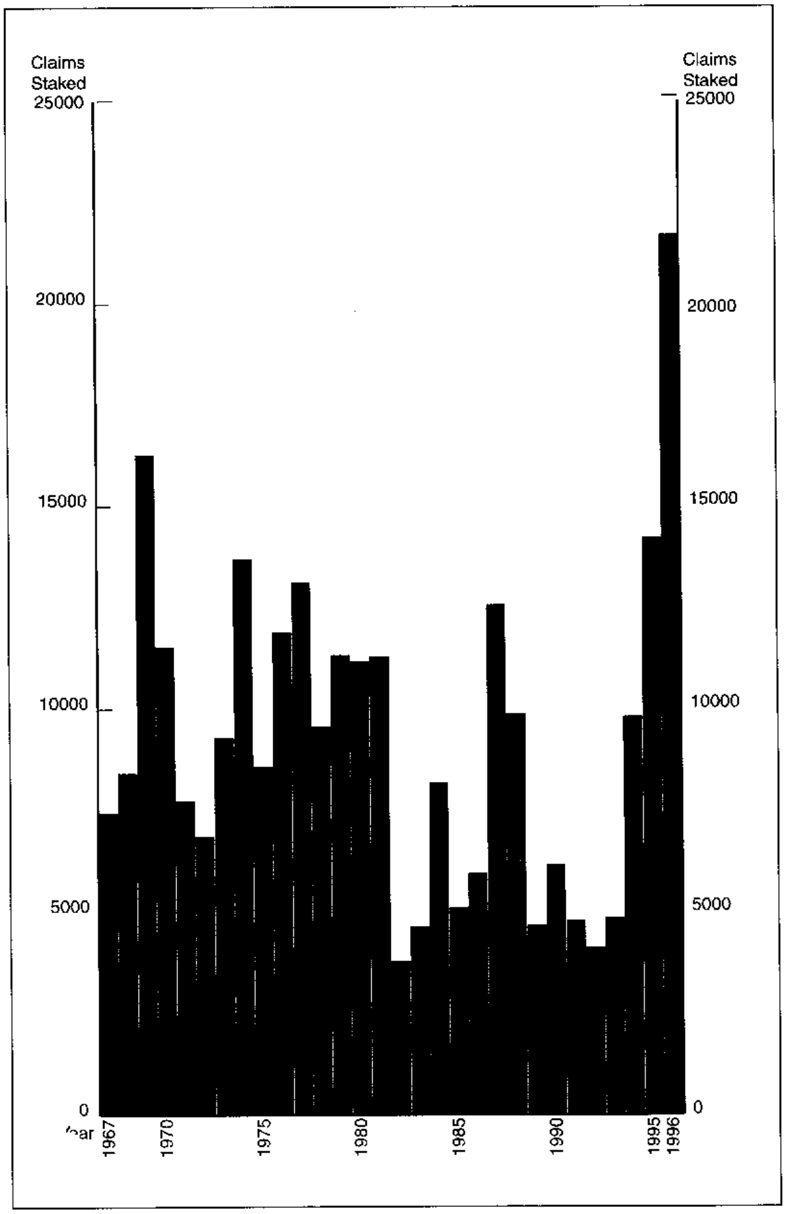


FIGURE 2: *Quartz claims staked: 1967-1996*

Résumé

Les dépenses d'exploration et de mise en valeur ont dépassé 108 millions de dollars en 1996, alimentant ainsi la tendance à la hausse qui a débuté en 1992. Conséquence directe de l'augmentation des dépenses, trois mines étaient en exploitation au Yukon en 1996 : la mine de Pb-Zn-Ag Faro, la mine d'or Brewery Creek, première exploitation de lixiviation en tas, et la mine d'Au-Ag Mount Nansen. La hausse des dépenses d'exploration a aussi mené à d'importantes découvertes dans le plus récent camp canadien de sulfure massif inclus dans des roches volcaniques (SMIV), la région du lac Finlayson. Une nouvelle lentille de sulfure massif, la lentille Lynx, a été découverte vers la fin de la campagne sur la propriété Wolverine, accroissant considérablement les réserves. Le premier grand programme de forage mené sur la propriété de Fyre Lake depuis sa découverte en 1961 a révélé la présence d'un important gisement de sulfure massif. Dans le claim Ice d'Expatriate Resources, des sulfures massifs ont été recoupés dans

le dernier trou du programme de forage de 1996, dans une zone autrefois réputée receler un potentiel minéral négligeable.

Les dépenses d'exploration de 1996 ont dépassé de 37 % le total de 1995, atteignant 54,8 millions de dollars (fig. 1). Quelque 60 % des dépenses ont été consacrées à la recherche de métaux communs, surtout dans la région du lac Finlayson, et le reste, à la recherche de gisements de métaux précieux. Les dépenses de mise en valeur de 54,1 millions de dollars en 1996 ont été légèrement inférieures à celles de 57 millions de dollars en 1995. Les travaux ont été concentrés aux mines Brewery Creek et Mount Nansen qui ont toutes les deux produit leurs premiers grammes d'or en 1996. Des dépenses ont aussi été faites pour la mise en valeur du projet Minto, gisement de porphyre à Cu-Au-Ag où des travaux de construction sont prévus pour 1997, de Carmacks Copper, gisement de porphyre à Cu-Au, de Kudz Ze Kayah, première découverte de SMIV dans la région du lac Finlayson, du projet de la mine d'or Laforma dans la région de Mount Nansen et de la mine Faro.

Le jalonnement de nouveaux claims quartzifères a atteint un record, xx 000 claims ayant été jalonnés à la fin de 1996 (fig. 2). Jamais dans l'histoire du Yukon autant de claims n'avaient été jalonnés en une même année. Le nombre élevé d'enregistrements de nouveaux claims au cours des trois dernières années s'est traduit par un record historique de xx 000 titres de claims quartzifères en règle (fig. 3). Le nombre élevé de claims et les succès répétés des efforts d'exploration au Yukon augurent pour l'industrie de l'exploration un proche avenir prometteur.

Plus de 100 projets d'exploration ont été réalisés en 1996 (annexe 1; fig. 4). Près de la moitié de toutes les dépenses d'exploration en 1996 ont été engagées dans la région du lac Finlayson, mais une part importante a été consacrée à la recherche de gisements d'or toutes teneurs ailleurs au Yukon. Treize projets ont fait l'objet de programmes de l'ordre du million de dollars : Faro, Fyre Lake, Cominco (région du lac Finlayson), Expatriate (région du lac Finlayson), Dublin Gulch, Brewery Creek, Marg, Goddell, Stukum Creek, Laforma, Keno, Wolverine et Yukon Gold Corp. (région du lac Emerald). Les efforts locaux d'exploration de reconnaissance ont aussi été importants au Yukon en 1996. Un programme financé par un consortium privé a permis de repérer plusieurs anomalies géochimiques mettant en cause plusieurs éléments, grâce à l'échantillonnage et à la prospection détaillées de sédiments fluviatiles, et a mené au jalonnement de quelque 2000 claims dans la région de Brewery Creek.

La découverte de nouveaux gisements potentiels, les succès de l'exploration dans le cadre de projets avancés et la découverte de nouvelles zones de minéralisation grâce à des efforts locaux d'exploration illustrent à quel point le potentiel minéral du Yukon reste à exploiter. L'exploitation de nouvelles mines démontre que la première industrie se diversifie et continuera d'être le moteur économique du Yukon.

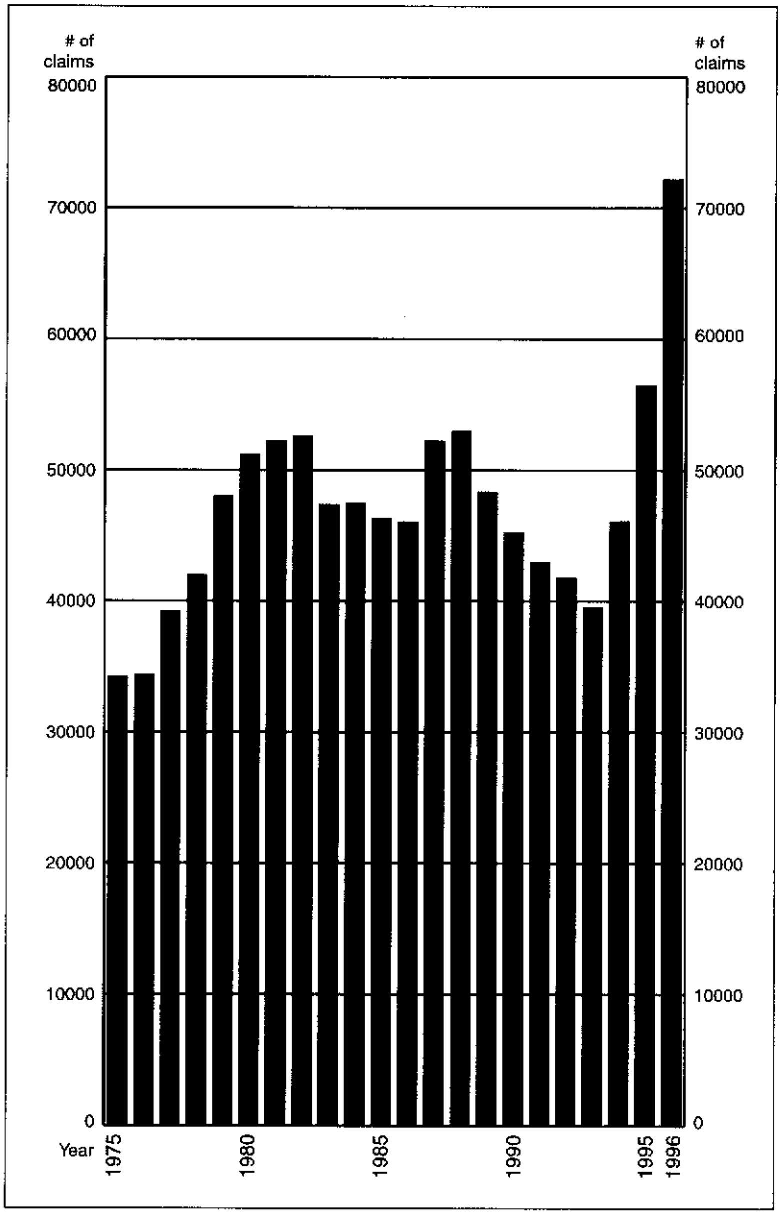


FIGURE 3: *Quartz claims in good standing: 1975-1996*

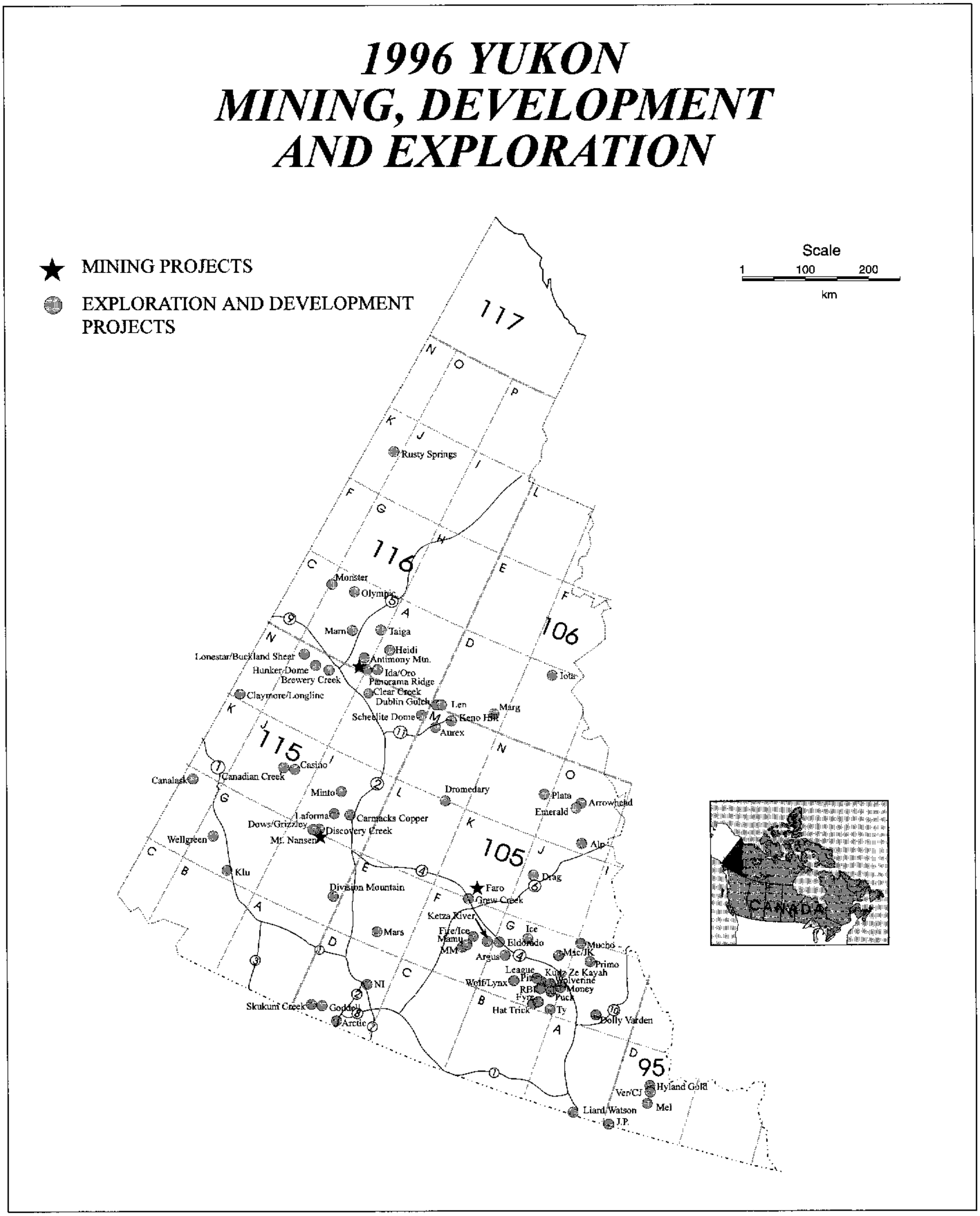


FIGURE 4: 1996 Mining and Exploration Activity. 1996 saw an increase in all types of exploration from the grassroots level to advanced projects. The total number of projects exceeds 100 and are not all shown on the location map .

Lode Mining

Anvil Range Mining Corporation completed its first full year of production at the **Faro Mine** (Minfile # 105K-55,56) since reopening in 1995. Orebodies at the Faro Mine are sedimentary-exhalative lead-zinc-silver deposits distributed in an arcuate belt along the south flank of the Anvil Batholith in central Yukon. They are distributed through a 150 metre thick stratigraphic interval straddling the boundary between non-calcareous phyllite of the Lower Cambrian Mt. Mye Formation and calcareous phyllite of the Cambro-Ordovician Vangorda Formation. The bulk of 1996 production came from the Grum orebody (Fig. 5) which contained open pit reserves estimated at 16.9 million tonnes grading 3.0% Pb, 4.9% Zn, 47 g/t Ag and about 1 g/t Au before mining. Minor production also came from the Vangorda orebody which has approximately 0.5 million tonnes of ore remaining. Anvil Range also conducted a substantial exploration program on the mine property. Three separate drill programs were conducted on the property, one along the northwest edge of the Grum pit, one to test geophysical anomalies and stratigraphy in the Swim basin to the east of the current workings and one program in the Grizzly deposit (Minfile #105K-101; formerly called the Dy) which contains a mineral inventory of 20.3 million tonnes grading 5.7% Pb, 7.0% Zn and 82 g/t Ag using a 9% Pb + Zn cutoff.

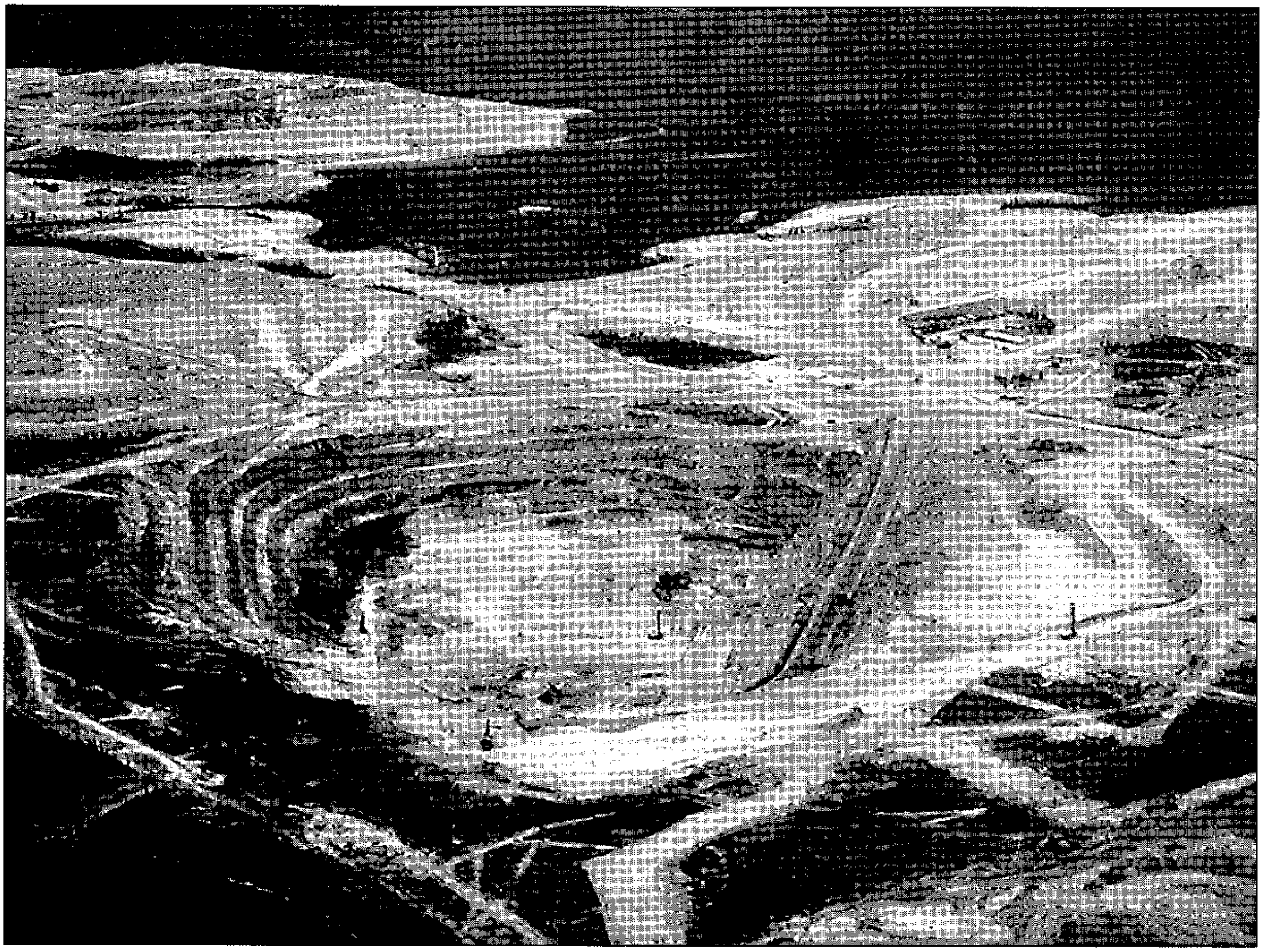


Figure 5: *The Faro Lead-Zinc-Silver Mine of Anvil Range Mining Corporation reached full production from the Grum Pit in 1996. The mine reopened in August, 1995 after a two year closure. To the end of the third quarter Faro produced 151.2 million kg Zn, 90.9 million kg Pb and 153,000 kg Ag for a value of production of approximately $320 million.*

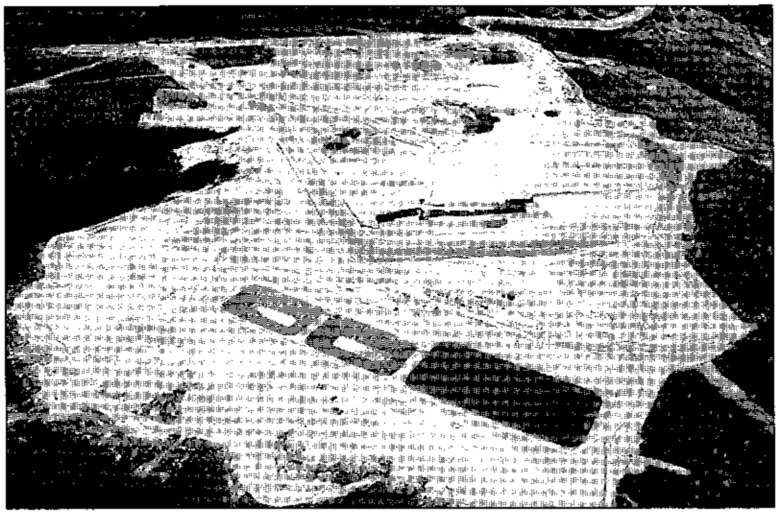


FIGURE 6: *Viceroy Resource Corporation completed construction of the Brewery Creek Mine 50 kilometres east of Dawson City in the fall of 1996. The nearly completed heap leach pad site and associated facilites pictured here is the northernmost heap leach gold mine in North America.*

Mining at Faro was temporarily suspended at the end of 1996 for a three month shutdown as a result of a stronger Canadian dollar, weaker than expected lead and zinc values and lower recoveries and grade in the mill. Milling operations at 50% of capacity will continue to process low grade stockpiled ore. At the end of the three months the operation will be reviewed and resumption of full production will be decided.

On August 15th, 1996 Viceroy Gold Corporation started loading ore on the completed heap-leach pad (Fig. 6) at the **Brewery Creek Mine** (Minfile #116B-160). The first gold at Brewery Creek was poured on November 15th, 1996 and production through the first winter is estimated at 10,000 to 15,000 ounces. Production costs are estimated at US$200 per ounce. This is a large, low grade oxide gold deposit hosted by Cretaceous Tombstone Suite quartz monzonite sills and underlying greywacke of the Devono-Mississippian Earn Group. The property is located in unglaciated terrain on the west edge of the Selwyn Basin, adjacent to the Tintina Fault. Open pit mineable reserves before the onset of production were 17,172,000 tonnes grading 1.45 g/T with a 1.3:1 strip ratio.

Mining at Brewery Creek will be 2.3 million tonnes of ore per year to produce approximately 83,000 ounces of gold. In 1996, 1.9 million tonnes of ore (Fig. 7) were placed on the pad with roughly 500,000 tonnes of ore under leach. The drip emitters on the pad are placed under a 4 metre layer of ore to protect them from freezing. Cyanide solutions are heated to 12^{O}C by waste heat from on-site diesel generators and from a waste oil burner. This mine burns all the Yukon's' waste oil, avoiding the cost of shipping and treating the oil in southern Canada.

Viceroy continued exploring the Brewery Creek mine property in 1996 with a substantial exploration program. Reverse circulation drilling was conducted on the East and West Big Rock zones discovered in 1994. The Big Rock zones consist of quartz monzonite intrusions into argillites similar to the zones currently hosting the reserves on the property. The Big Rock zones are the westernmost mineralized occurrences on the property and closest to the leach pad. A large program of geochemical sampling was conducted on the eastern portion of the property. Resampling of previous geochemical grids with care taken to collect quality samples has resulted in higher and better defined anomalies. Drilling was also conducted on mineralized zones in the easternmost part of the property.

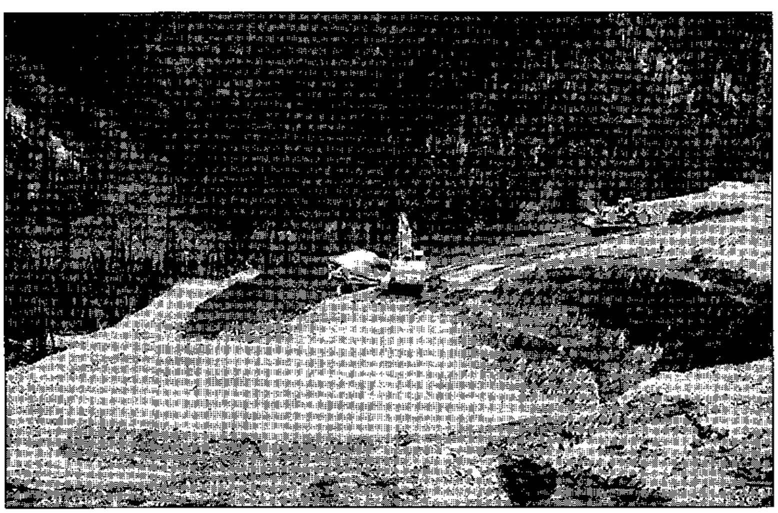


FIGURE 7: *Run of mine ore is loaded into 100 tonne trucks in the Canadian Pit and hauled to the heap leach pad at Brewery Creek.*

B.Y.G. Natural Resources Inc. received their Class A water license on April 1, 1996 for the **Mt. Nansen Au-Ag Mine** (Minfile # 115I-064,65). Production at Mt. Nansen is projected at 50,000 ounce gold equivalent at an operating cost of $US215 per oz. and a milling rate of 500 tonnes per day. The first gold-silver bar at Mt. Nansen was poured in November and production rates had reached 500 tonnes per day by year end. Mining at Mt. Nansen began in the Brown-McDade zone (Fig. 8) a strong vein fault up to 30 m wide

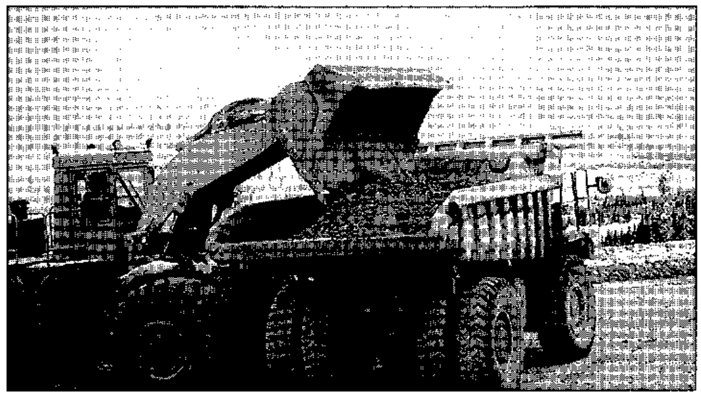


FIGURE 8: *Mining from the first of several ore zones began in October with the Brown-McDade Zone which contains 201,000 tonnes grading 7.1 g/T Au and 69 g/T Ag. The upgraded mill is visible in the background of this photo.*

trending northwest and dipping steeply west that cuts Lower Cretaceous granodiorite and feldspar porphyry of the Mount Nansen Group. The shear contains lenses of grey quartz with pyrite and arsenopyrite and minor chalcopyrite, galena, tetrahedrite, sphalerite and stibnite. The upper portion of the Brown-McDade and three other vein systems hosting reserves on the property are oxidized and mining will begin with the oxidized portions of these deposits. The Brown-McDade hosts proven and probable oxide reserves of 201,602 tonnes grading 7.1 g/T Au and 69 g/T Ag, plus a lower grade resource of 117,228 tonnes at 2.0 g/T Au and 24 g/T Ag. Prior to mining the existing on-site mill was upgraded to 700 tonnes per day and a carbon-in-pulp cyanide circuit added (Fig. 9). Previous operators at Mt. Nansen were unsuccessful mainly due to poor gold recoveries, the addition of a cyanide circuit will significantly improve recoveries.

B.Y.G. also acquired more land in the Mt. Nansen area and conducted exploration programs on the Mt. Nansen mine and adjacent properties. On the Mt. Nansen property drilling was conducted between the Webber and Heustis vein systems, located 700 metres apart. Drilling attempted to prove the vein systems are contiguous. During upgrading of the haul road to the Mt. Nansen mill a vein system parallel to the Brown-McDade zone was discovered. The vein is within a geochemical anomaly which strikes northwest, also parallel to the Brown-McDade vein. The vein assayed 17.6 and 9.5 g/T Au equivalent over 3.05 metres in two trenches located approximately 60 metres apart. The **Goulter** property (Minfile #115I-093) was optioned from Aurchem Exploration Ltd. The property, adjacent to the Mt. Nansen property to the north-west hosts numerous styles of mineralization including epither-

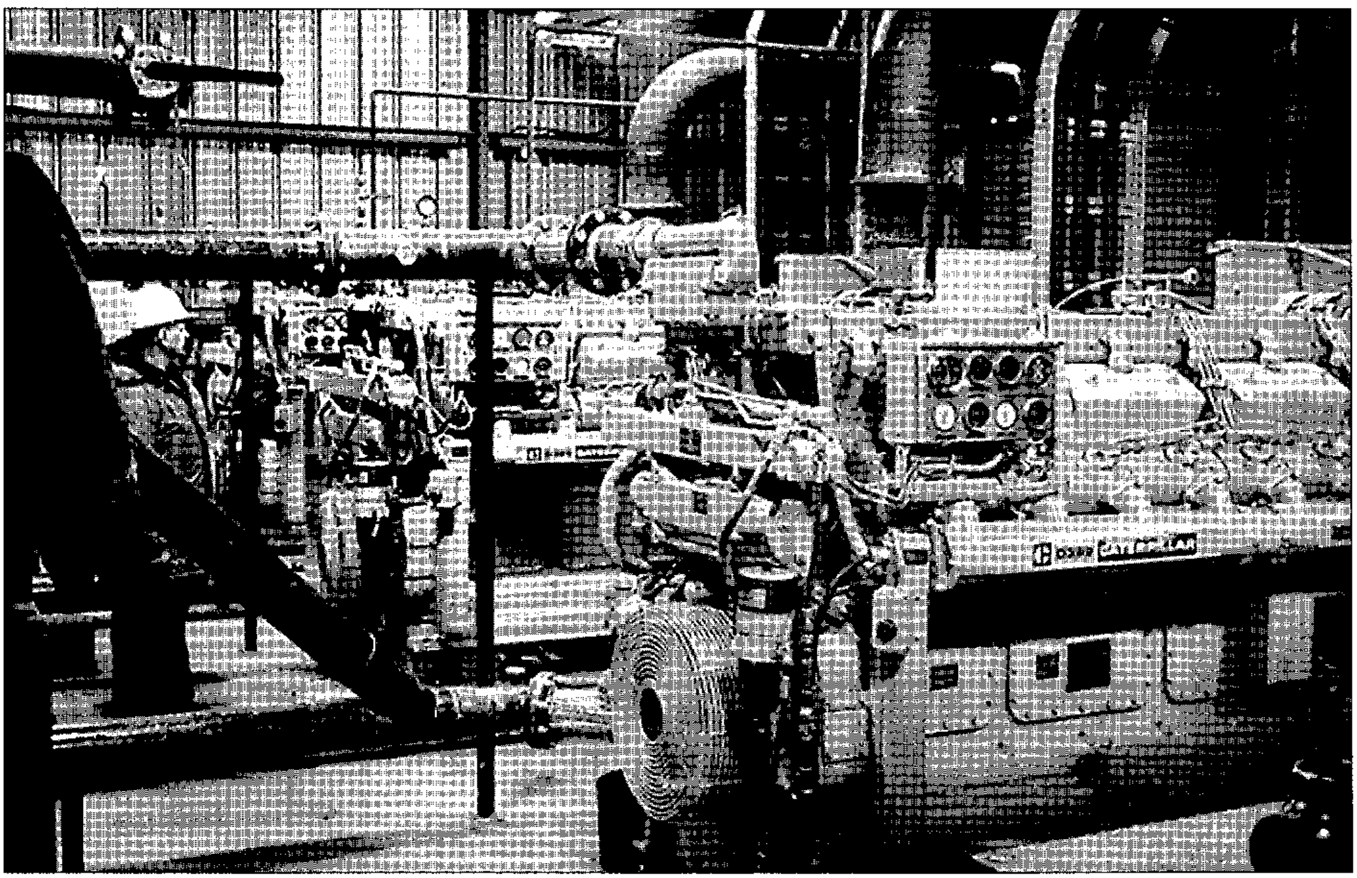


FIGURE 9: *Caterpillar diesel generators supply the power for the Mt. Nansen mill and camp facilities.*

mal and mesothermal veins as well as porphyry Cu-Mo-Au-Ag. Geochemistry, geophysics and trenching were conducted in 1996. B.Y.G. is also very active in other areas of mining in Yukon. They have the right to earn 50% of the Wheaton River area properties of Omni Resources through its exploration subsidiary Trumpeter Yukon Gold. They are also exploring the possibility of installing a custom milling facility in Whitehorse.

Sikanni Oilfield Construction mined 1800 tonnes of high grade polymetallic vein material from the **Moosehorn property** (Minfile #115N-024) to produce 1100 ounces of gold. Mining of the veins on the property was stopped due to high stripping ratios and the processing plant was subsequently dismantled. The Moosehorn and surrounding properties were explored for bulk tonnage gold potential as part of the **Longline** (Fig. 10) project by Barramundi Gold Ltd.. Barramundi completed a program of auger soil sampling, excavator trenching, airborne magnetics and geologic mapping within the Moosehorn Range granodiorite pluton, a part of the Lower Jurassic Klotassin Batholith which hosts all known high grade veins. Geochemical and geophysical anomalies located during the 1996 season will be followed up in 1997.

FIGURE 10: Barramundi Gold Ltd. conducted rock sampling, auger soil sampling, geological mapping, airborne magnetics and excavator trenching in an evaluation of the Longline property for its bulk tonnage gold potential.

ADVANCED DEVELOPMENT AND EXPLORATION

Base Metals

In Yukon several projects are undergoing environmental reviews and when permits are attained will add to the growing base of operating Yukon metal mines.

Cominco Ltd. continued to develop **Kudz Ze Kayah** (Minfile #105G-117), the first significant VHMS discovery in the Finlayson Lake area. Work in 1996 consisted of continued engineering, metallurgical and environmental studies on the ABM deposit which 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 and is in the final stages of environmental permitting. The access road constructed into the property in 1995 was upgraded in 1996. Cominco holds over 10,000 claims in the Finlayson Lake area and they explored several properties in the area in the search for additional VHMS deposits.

Minto Explorations Ltd. focused all their efforts on the development of the **Minto** (Minfile #115I-021,022) project in central Yukon. The project is a Cu-Ag-Au porphyry deposit that has mineable reserves within the current pit design of 6.51 million tonnes grading 2.13% Cu, 9.3 g/T Ag, and 0.62 g/T Au at a stripping ratio of 4.9:1. This gives the mine an initial life of approximately 13 years at a milling rate of 477,000 tonnes per year.

In 1996 the project was advanced on several fronts. The company completed a joint venture agreement with Asarco Inc. to bring the project into production. Asarco will acquire a 70% interest in the project by providing up to US$25 million for development of the mine. Minto Explorations Ltd. will retain 30% and be the operator of the project. In late August the company began road construction along the existing access to the property. Seventeen kilometres of the 27 km road was upgraded and a 40 m single span bridge was installed over Big Creek (Fig. 11). This will facilitate an early start to construction of the mine in the spring of 1997. Geotechnical programs were also completed on the property as well as a small diamond drilling program at the margins of the existing orebody. Drilling indicated a narrow high grade zone which may be exploited by underground methods early in the life of the mine.

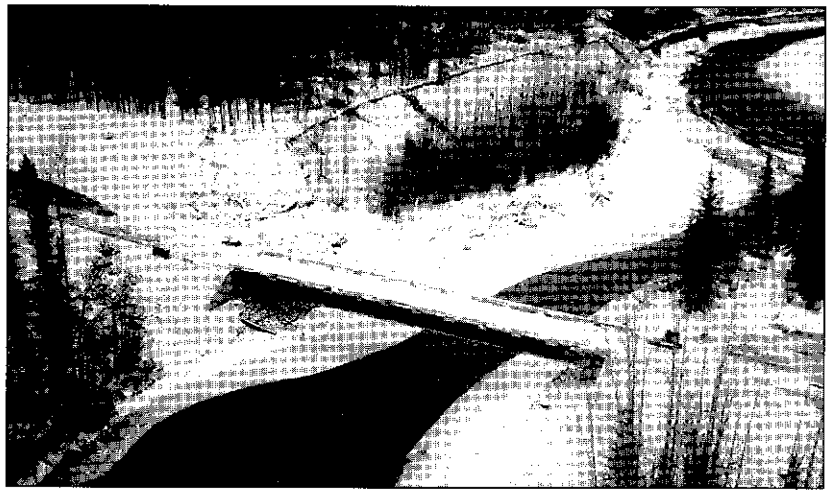


FIGURE 11: Minto Explorations Ltd. installed this 40 metre single span bridge over Big Creek.

Western Copper Holdings and Thermal Resources Ltd. amalgamated to form Carmacks Copper Ltd., a company solely committed to advancing the **Carmacks Copper Project** (Minfile #115I-008) to production. The property hosts a 14.1 million tonne oxidized Cu-Au porphyry deposit grading 1.01% Cu, 0.51 g/T Au which is amenable to solvent-extraction electrowinning technology. The company continued geotechnical work on the property in 1996 in an effort to complete permitting of the project and advance it toward production.

United Keno Hill Mines continued underground exploration on its high grade silver vein **Elsa properties** (Minfile 105M-001) in central Yukon. The main focus of exploration continued to be additional reserves and underground development in the former Bellekeno and Silver King Mines. At the Bellekeno mine the main ramp was extended 264 metres, a cross-cut through the Southwest Zone at the 750 level (Fig. 12) was driven and diamond drill stations were established. The drill stations will allow testing of the Southwest zone at Bellekeno at the 900 and 1000 levels. The 750 level crosscut encountered massive galena-sphalerite which graded 1370 g/T Ag, 0.45 g/T Au, 24% Pb and 16 % Zn over 5.5 metres. At the Silver King Mine two raises were driven on the #5 and #6 veins. The raise on the #6 vein returned an average grade of 1572 g/T Ag from face samples and 1576 g/T Ag from muck samples over 12.2 metres. The geological resource for the entire property was increased significantly to over 800,000 tonnes. 415,000 tonnes grading 1145 g/T Ag, 7.5% Pb and 5.6% Zn are classed as mineable reserves. A positive prefeasibility study was completed which recommended resumption of production from the Bellekeno and Silver King Mines. United Keno Hill has applied for permitting of these mines which could resume production as early as 1997.

FIGURE 12: Dennis Ouellette, Manager of the Yukon Chamber of Mines collects high grade Pb-Zn-Ag mineralization from the 750 level cross-cut in the Bellekeno Mine.

Gold

New Millennium Mining Ltd., a wholly owned subsidiary of First Dynasty Mines Ltd., continued to develop the **Dublin Gulch** (Minfile #106D-021-029) property, an intrusive-hosted gold target in central Yukon. In 1996 over 7000 meters of diamond and reverse circulation drilling (Fig. 13) was conducted to further define a high grade zone within the reserves, upgrade inferred reserves, and expand existing reserves to the north and west. The program resulted in a 70% increase in mineable reserve (proven and probable) to 50.4 mT grading 0.93 g/T Au in the Eagle Zone with a stripping ratio of 0.8:1. A further inferred resource of 7.7 mT

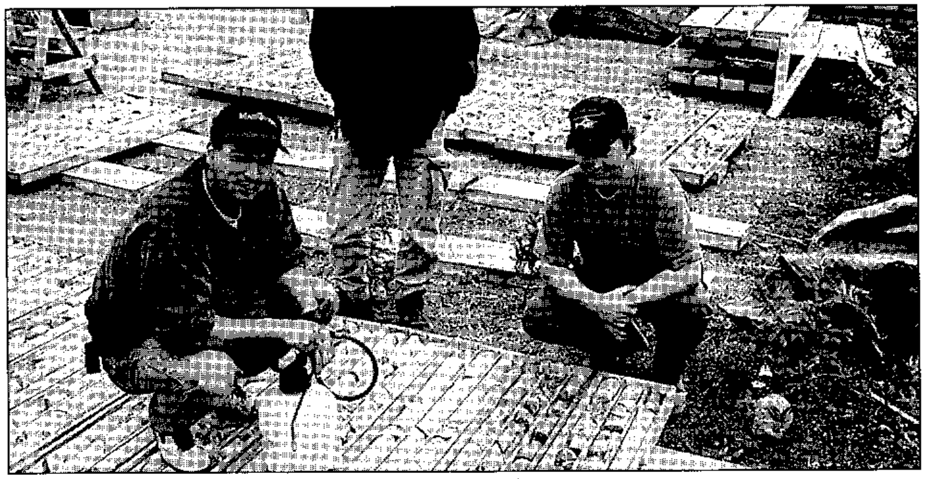


FIGURE 13: *Mike Sieb (left) of New Millennium Mining Ltd. shows the manager of the Yukon Chamber of Mines, Dennis Ouellette, diamond drill core from the Eagle Zone.*

grading 0.77 g/t Au exists within the designated pit. Three other zones, Steiner, Olive, and Platinum Gulch, were explored with trenching. Quartz-sulphide veins hosted in granodiorite, similar to the mineralization in the Eagle zone but with a higher sulphide content, were encountered in trenches at all three areas. Previous results from the Steiner zone include 0.96 g/T Au over 18.3 metres and 1.04 g/T Au over 16.8 metres in reverse circulation hole 93-070R from arsenopyrite-bearing veins within granodiorite. In the Olive zone previous trenching encountered 97.6 metres of 0.84 g/T Au. Geochemistry was also performed in other areas of the property.

The deposit is in the permitting phase and all data required to complete detailed engineering studies has been collected. Extensive geotechnical drilling and test pitting tested subsurface conditions under proposed infrastructure, mainly the heap leach pad area. Drilling was also conducted to explore for and test clay deposits to determine suitability for use in construction of the heap leach pad. Environmental data collection continued to gather baseline data for the area. With successful completion of permitting and a final feasibility study this project is expected to make a production decision in 1997.

FIGURE 14: *Mill building at the Laforma Gold Mine.*

Reddell Mining Corporation began to develop the **Laforma Gold Mine** (Minfile# 115I-054) a shear zone hosted gold vein in granodiorite north of Carmacks. Work in early 1996 consisted of construction of a winterized camp, construction of a mill utilizing Falcon concentrators to process a proposed bulk sample, and underground development and exploration in the G-3 and G-3 extension zones. Unfortunately all work on the property was halted in June when the Vancouver Stock Exchange suspended trading in Reddell for failure to provide independent verification of ore reserves at Laforma. The mill building was erected (Fig.14) but installation of the milling facility had not been completed before the shutdown. Upon resolution of a number of issues outlined by the VSE, development and exploration at Laforma can continue in 1997. B.Y.G. Natural Resources Inc. signed a letter of agreement with Reddell for custom milling of ore from Laforma in the Mt. Nansen mill 20 km to the northwest. As part of the agreement B.Y.G. can earn 50% of the Laforma Gold Mine by spending $5 million on exploration over four years.

EXPLORATION

Base Metals

Base metal exploration dominated in the Yukon accounting for 60% of exploration expenditures in 1996. The main focus of exploration was volcanic hosted massive sulphide deposits in Yukon-Tanana terrane, mainly in the Finlayson Lake area but also in other areas of Yukon. These deposits contain copper, lead and zinc as well as significant quantities of cobalt, silver and gold. There was also an increase in exploration for lead, zinc, and silver sedimentary-exhalative deposits with the largest program in the Faro Mine area.

The largest exploration program in Yukon was conducted on Westmin (60%) and Atna Resources (40%) **Wolverine Lake property** (Minfile #105G-032). The Wolverine deposit is high grade polymetallic massive sulphide hosted by Devonian-Mississippian carbonaceous metasediments and metamorphosed volcanic and pyroclastic felsic rocks of the Yukon-Tanana terrane of a similar age and composition to the rocks hosting the ABM deposit at the Kudz Ze Kayah project 20 kilometres to the west. The deposit was discovered late in 1995 and after two intensive seasons of exploration a significant deposit has been outlined.

The 1996 exploration program focused mainly on definition drilling of the Wolverine deposit and a regional stratigraphic drill program. An airborne geophysical survey, regional mapping, geochemical surveys, and construction of a 1000 metre airstrip were also completed. The result of the program was the discovery of a new massive sulphide lens, the Lynx Zone (Fig.15). The Lynx Zone adjoins the Wolverine Zone to the west at the same stratigraphic level. The Lynx Zone is on average thicker and higher grade than the Wolverine, contains an upper massive sulphide lens, and remains open to the south and west. The eastern margin of the Wolverine Zone is also open.

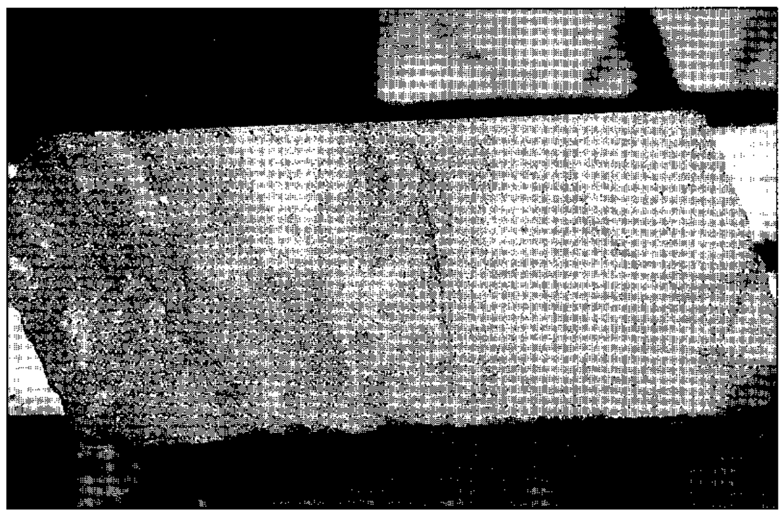


***FIGURE 15:** This piece of high grade massive sphalerite-pyrite is from Hole WV-96-65 on the Wolverine Property of Westmin and Atna Resources. The hole intersected 3.0 metres true thickness of 5.22 g/T Au, 657 g/T Ag, 0.49% Cu, 1.69% Pb and 32.88% Zn in the Lynx Lens which was discovered to the west of the Wolverine deposit late in the 1996 field season.*

The geological resource of the deposit based on a total of 49 drill intersections is estimated at 5,311,900 tonnes grading 1.41% Cu, 1.53% Pb, 12.96% Zn, 1.81 g/T Au and 359.1 g/T Ag. The upper lens in the Lynx Zone included in the above resource is estimated at 294,000 tonnes grading 0.79% Cu, 1.38% Pb, 8.73% Zn, 1.47 g/T Au and 303.1 g/T Ag. Preliminary metallurgical testwork indicate good base metal recoveries and excellent recoveries of precious metals. The resource will continue to expand with further definition drilling of the Wolverine and Lynx Zones. The program of stratigraphic drilling plus target definition using geological and geophysical techniques has a high probability of additional discoveries on this property. A large exploration program is planned for 1997.

Westmin also conducted programs on several other properties in the area. Drilling was conducted to the west of Wolverine on the **Toe** claims which are part of the Westmin/Atna joint venture to test favorable felsic volcanic stratigraphy combined with multielement geochemical anomalies. On the **TY** (Minfile #105G-072) property optioned from Pacific Bay Minerals Ltd. south of the Wolverine, Westmin conducted airborne geophysics, mapping, geochemistry and drilling. The claims which are underlain by pyritic felsic volcanic stratigraphy were tested by three diamond drill holes. The holes intersected anomalous base metal values but failed to explain the origin of the geochemical anomalies which were outlined on the property. Further drilling will be conducted in 1997. Westmin also conducted a similar program on their wholly owned **Wika** claims adjacent to the TY property and drilled two holes. Westmin optioned the **Puck** claims which adjoin the Wolverine property to the south from Expatriate Resources. Geophysics, geochemistry and six diamond drill holes were completed on the property which indicated that the iron formation forming a marker horizon in

FIGURE 16: The lower gossan zone immediately above the geologists on the Money property is possibly a feeder zone for a massive sulphide.

the hanging-wall of the Wolverine and favorable volcanic stratigraphy extend onto the claims.

Atna Resources was active exploring properties in the Finlayson area. Drilling was conducted on three properties, the **Money, Argus** and **Wolf** (Minfile #105H-078, 105G-013, 105G-008) all optioned from YGC Resources. The **Money** is located approximately 5 kilometres east of the Wolverine deposit. Massive sulphide mineralization at Money consists of massive pyrite with a siliceous matrix hosted by pillowed mafic volcanics similar to those overlying the felsic metavolcanic ore sequence at Wolverine. Drilling was directed at the down-dip and strike extensions of massive sulphide mineralization exposed in surface showings. Hole MON96-4 intersected pyritic and chalcopyrite bearing massive sulphides and an associated quartz-sericite-pyrite stockwork zone (Fig. 16). The massive sulphides in the hole assayed 407 ppb Au, 21.0 ppm Ag, 1.75% Cu and 0.4% Zn over a true thickness of 0.82 metres. Hole MON96-5 also intersected pyritic massive sulphides which assayed 526 ppb Au, 32 ppm Ag, 1.0% Cu, 0.63% Zn over a true thickness of 1.0 metres.

The **Argus** property was explored with a magnetics and VLF ground survey prior to drilling with eight holes by Atna. Pb-Zn-Ag sedimentary-exhalative style mineralization is hosted in carbonaceous phyllites and occurs above or within a carbonaceous limestone-marble unit (Fig. 17). The mineralization consists of sphalerite, galena and pyrite as intergrowths, semi-conformable replacement masses, stringers with quartz and marble and as conformable massive to disseminated bands. The geophysics were successful in defining stratigraphy and several holes intersected significant mineralization. Drilling concentrated on the A-zone and intersections of 2.75% Zn, 0.12% Pb and 7.06 g/T Ag over 7.3 metres and 2.67% Zn, 0.75% Pb and 11.0 g/T Ag over 15 metres were obtained in holes ARG96-01 and 02 respectively. Step-out holes to the east of the intersections in the first two holes intersected mineralization with the best result in Hole ARG96-07 with 10.1 metres grading 18.7 g/T Ag, 0.86 % Pb, and 3.26% Zn. The A-zone remains open in several directions and other zones and areas of potential exist on the property which remain to be tested by drilling.

FIGURE 17: This photo shows samples of lead-zinc-silver mineralization in limestone from trenches on the Argus property in the Finlayson Lake area.

Columbia Gold Mines Ltd., completed a major exploration program on the **Fyre Lake** (Minfile #105G-034) Cu-Co-Au volcanic hosted massive sulphide property. The property is located approximately 30 kilometres southwest of the Wolverine deposit. The program consisted of geological mapping, geochemical and geophysical surveys and 9,531 metres of diamond drilling (Fig. 18) in 71 holes.

The mineralization in the Kona zone is hosted by chlorite-actinolite-quartz schists interpreted to be basic to intermediate flows with intercalated volcaniclastics and volcanically derived fine grained sedimentary rocks which belong to Mortensen's "Middle Unit" of Yukon Tanana terrane. This is the same unit that hosts the ABM and Wolverine deposits however Fyre

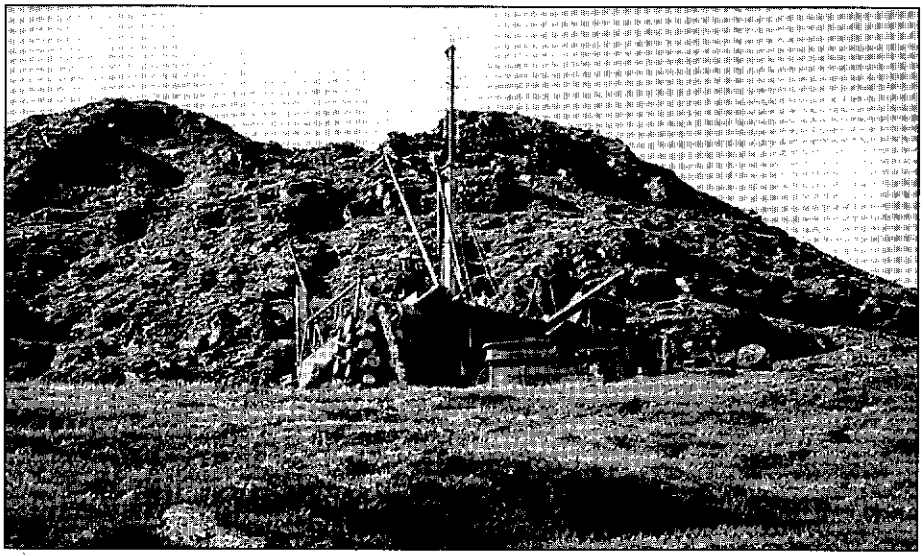


Figure 18: *An uphill veiw of a log drill platform at the Fyre Lake property of Columbia Gold Mines. A large helicopter supported drill program was conducted on this volcanic hosted massive sulphide occurance west of the Finlayson Lake area.*

Lake occurs in mafic rocks as opposed to felsic rocks at ABM and Wolverine. Drilling in the Kona zone tested a central area approximately 1000 metres long by 250 metres wide within a coincident geochemical and geophysical anomaly which is 3.5 km long. Three mineralized horizons were intersected consisting in general of massive pyrite (Fig. 19) and magnetite with minor chalcopyrite and sphalerite. The Upper Horizon contains a weighted average of 0.12% Co, 1.9% Cu, and 0.53 g/T Au over an average thickness of 13 metres. The two southernmost holes that intersected the horizon indicate a rapid thickening of the massive sulphide which indicates a sub-basin or trough in this direction. Drill hole 96-68 intersected 10.1 metres grading 2.66% Cu, 0.11% Co, and 1.44 g/T Au while hole 96-65 drilled a further 100 metres south intersected 31.3 metres grading 2.29% Cu, 0.07% Co, and 0.53 g/T Au. The Lower Horizon has a weighted average of 0.12% Co, 1.2% Cu, 0.77 g/T Au over an average thickness of 7 metres and remains open to the north and west. Preliminary metallurgical testwork and tonnage and grade calculations should be completed in early 1997. A large drill program is planned to continue defining the deposit in 1997 as well as test other favorable targets on the property defined by geology, geophysics and geochemistry which remain untested by drilling.

Figure 19: *Massive pyrite-quartz boulder in Kona Creek on the Fyre Lake Property.*

Expatriate Resources Ltd. holds over 5300 claims in the Finlayson Lake area and were very active in 1996 conducting exploration for massive sulphides on 24 separate properties. The 1996 program consisted of airborne magnetics/electromagnetics on many of the larger claim groups, followed by ground geophysics, geochemistry, mapping and prospecting. Expatriate followed the initial work with helicopter supported diamond drilling on six properties; **Redline, League, Slapshot, Hat Trick, Puck** and **Ice** and trenching on the **Breakaway** property. No significant intersections of massive sulphide mineralization were encountered except for on the Ice property. The drilling on the Puck claims indicated the stratigraphy hosting the Wolverine deposit continued onto the claims. Westmin as part of a previous agreement optioned the Puck claims.

Expatriate expanded the **Ice** property to over 1000 claims upon discovery of high grade secondary oxide copper mineralization. The oxide mineralization consists of fracture filling cuprite, tenorite, malachite, azurite, native copper and chalcocite overprinting pyrite. This style of mineralization extends to a depth of approximately 50 metres below surface and is hosted by basalts of the Campbell Range Belt, an area previously thought to have low mineral potential. This style of mineralization was intersected in 23 of the first 33 holes drilled on the property and produced intersections up to 43.13 metres grading 1.56% Cu in Hole IC96-02, 2.22% Cu over 10.31 metres in Hole IC96-13 and 2.03% Cu over 7.32 metres in Hole IC96-15. The zone of oxide mineralization covers an area of approximately 450 by 250 metres (Fig. 20). The final hole of the 1996 drill program intersected massive sulphide mineralization consisting of pyrite, chalcopyrite, bornite with minor digenite and a quartz +/- calcite gangue which graded 5.2% Cu, 0.6 g/T Au, 25 g/T Ag and 0.06% Co over 20.56 metres. Airborne geophysics were flown over the expanded property and indicate other targets which will be investigated in an extensive program in 1997. The discovery of massive sulphides on the Ice property in mafic volcanic rocks of the Campbell Range Belt indicates a new style of volcanic hosted massive sulphide mineralization.

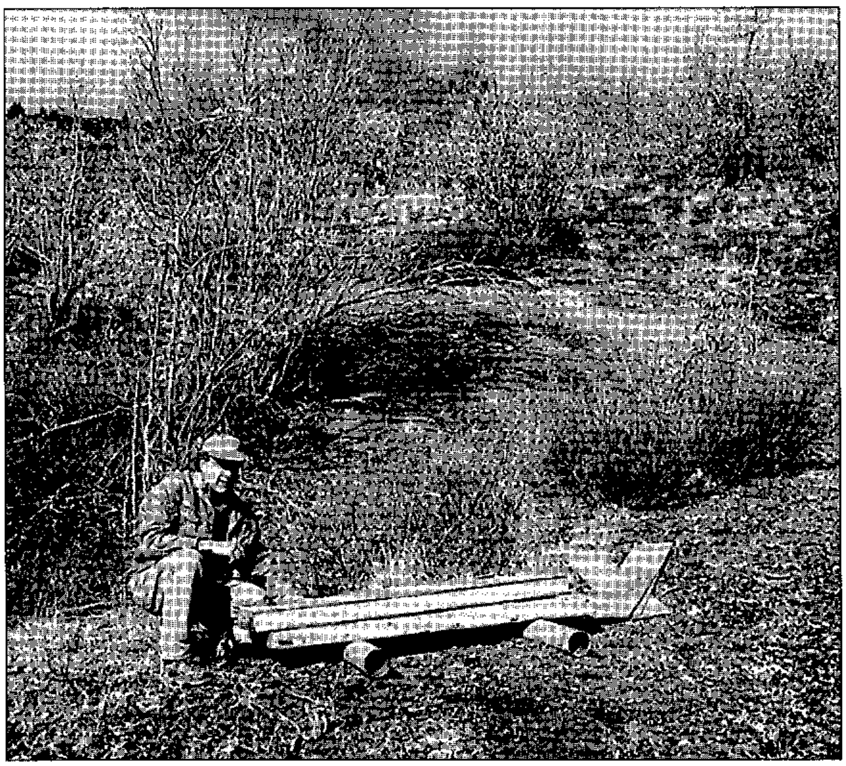


FIGURE 20: *Tom Becker of Archer, Cathro and Associates at a vegetative kill zone on the Ice property in the Finlayson Lake area.*

Mar-West Resources Ltd. conducted a five hole, 450 metre diamond drilling program on the **Eldorado** Property (Minfile #105G-048). The property is located approximately 60 kilometres northwest of Cominco's ABM deposit in Yukon-Tanana terrane. Work by Noranda in 1989 obtained encouraging gold values from rusty weathering schist containing arsenopyrite with minor galena and chalcopyrite. Grab samples assayed up to 10 g/t Au. The 1996 drilling intersected a narrow band of massive arsenopyrite hosted in schist in one hole. Mar-West did not renew their option on the property which was returned to the owner, prospector Al Carlos of Whitehorse.

Pacific Bay Minerals Ltd. explored for massive sulphide mineralization on several of its claim groups in the Finlayson area. The **TY** (Minfile #105G-073) claims optioned by Westmin Resources received the most work including airborne and ground geophysics, mapping and geochemistry and three diamond drill holes totalling 721 metres. Westmin will continue to explore the property in 1997. Pacific Bay flew an airborne geophysical survey early in the season followed by prospecting, mapping and geochemistry over the **MAC** and **JK** (Minfile #105G-060) claims north of Finlayson Lake.

Demand Gold Ltd., performed geochemical, geophysical (Max-Min II HLEM) and geological surveys on their **RBI** claim group located approximately three kilometres south of Cominco's ABM deposit. Coincident geophysical and geochemical anomalies have been outlined on the property and Demand Gold intends to conduct drilling on the property in 1997. Demand also conducted an exploration program on the **Man** and **Bay** claims located immediately south of Simpson Lake on NTS mapsheet 105A/11 (Fig. 21).

Condor International Resources Inc., explored two properties in the Finlayson Lake area, the War and Lip. The **Lip** claims are located approximately 25 kilometres west of Finlayson Lake (Minfile #105G-070). Airborne and ground EM surveys were conducted on the property followed by mapping and prospecting. Mapping identified lithologies correlative with the "Middle unit" of Mortensen which hosts the Wolverine, ABM and Fyre Lake deposits. On the northern part of the claims mafic lithologies belonging to the Campbell Range Belt were mapped. These mafic rocks are host to the Ice discovery immediately north of the Lip claims. Mineralization on the Lip claims includes conformable to discordant stringers and lenses of sphalerite +/- galena, chalcopyrite hosted in pale green siliceous phyllite. Drilling in 1981 intersected 1.3 metres of 3.12% Zn, 3.1% Pb and 26.7 g/T Ag from this horizon. Quartz-siderite-ankerite veins associated with listweanite alteration hosts minor copper mineralization in the central portion of the claims. Close to these veins quartz-sericite schist float with conformable bands of chalcopyrite assayed up to 12% Cu. In rocks of the Campbell Range Belt disseminated chalcopyrite in a zone of intense listweanite alteration was discovered and in the same area siliceous baritic exhalative rocks anomalous in copper and with greater than 5% barium were found. Outcrop is less extensive on the **War** claim block approximately 10 kilometres north of Finlayson Lake but mapping indicates lithologies correlative with Mortensens "Middle unit".

Klondike Gold Corp. performed geological mapping, ground geophysics and drilling on the **Primo** property (Minfile #105H-096) located approximately 60 kilometres north-east of Finlayson Lake in rocks of the Selwyn Basin. Previous work on the property identified sulphide mineralization that was interpreted to be a skarn. Mapping by Klondike Gold identified a package of volcanic tuffs, rhyolites, argillite and carbonates with the volcanics closely associated with the known mineralization. Mineralization on the property is located in two showings located 2.1 kilometres apart and consists mainly of pyrite-pyrrhotite with minor galena and sphalerite. Diamond drilling intersected sulphide mineralization with anomalous copper, gold, zinc and silver. Further work in 1997 will help define the style and extent of mineralization on the property.

Nordac Resources Ltd., a private exploration company, worked nine properties to the south and southwest of the Finlayson Lake in the Rancheria-Wolf Lake-Sambo Lake areas. Airborne geophysics, geochemisty, prospecting and mapping were performed on the properties to evaluate their potential for volcanic hosted massive sulphide mineralization.

FIGURE 21: From horses to helicopters a good geologist is undaunted by any terrain as illustrated by Gary Wesa of Pacific Bay Minerals and his herd of faithful assistants.

KRL Resources Corp., flew an airborne magnetics/VLF survey over the **Watson/Liard** property located 5 kilometres south of the town of Watson Lake and the **JP/Border** claims 45 kilometres to the east of Watson Lake. Follow-up ground geophysics, geochemistry, and mapping were also conducted on the properties. On the Watson/Liard claims a coincident airborne magnetics/VLF and gold in soil anomaly over an area 1000m by 200 metres returned values up to 1421 ppb Au. Trenching of the anomaly revealed a zone of quartz stockwork in metasediments that returned elevated Au, Cu, and Pb but failed to explain the anomaly. Further work including diamond drilling may be performed in 1997.

The largest VHMS program outside of the Finlayson Lake area was conducted on the **Marg**

FIGURE 22: *Drill core from the Marg deposit being examined by company geologists and visiting professor Brian Marshall from Australia.*

deposit (Minfile #106D-004) of NDU Resources Ltd.(Fig. 22). The deposit east of Keno Hill in central Yukon consists of four stacked massive sulphide lenses hosted by felsic metavolcanic rocks of the Devono-Mississippian Earn Group. The deposit contained drill indicated reserves of 2.9 million tonnes averaging 1.62% Cu, 2.25% Pb, 4.17% Zn, 55.9 g/T Ag and 0.89 g/T Au prior to the start of the 1996 program. NDU completed 29 holes to test the down-dip and down-rake extensions of the known zones as well as fill-in drilling to upgrade possible reserves to the drill indicated category. The updated drill indicated mineral reserve is 5,527,002 tonnes at an average grade of 1.76% Cu, 2.46% Pb, 4.6%Zn, 62.7 g/T Ag, and 1.0 g/T Au, using a minimum 3 m width.

Several VHMS properties including the **MM**, **Fire** and **Ice,** and **Mamu** (Minfile #'s 105F-12,71,73 and 13) located approximately 75 kilometres west of Cominco's ABM deposit were explored in 1996. Massive sulphide occurrences in this area occur in Devono-Mississippian brecciated, pyritic, acid volcanic rocks with barite horizons in Yukon-Tanana Terrane on the western side of the Tintina Trench in the Pelly-Cassiar Platform. These rocks are possibly correlative with the Devono-Mississippian stratigraphy hosting the Finlayson Lake area deposits.

Anvil Range Mining Corporation conducted a four hole diamond drilling program on the **MM** property (Fig. 23). The program was designed to test the continuity of known mineralized horizons which consist of sphalerite, galena, pyrite and pyrrhotite with barite and minor chalcopyrite in three massive sulphide layers. Mineralization was intersected in all four holes however no grades and thicknesses have been released from this program. The mineralized horizon remains open to the north and northwest. A total of nineteen drill holes have been completed on the property since 1973.

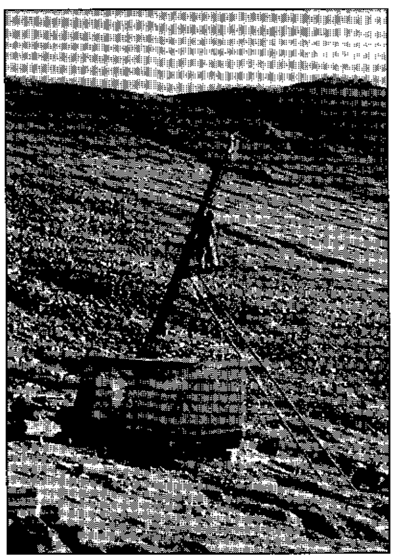


FIGURE 23: *Drilling on the MM claims of Anvil Range Mining Corporation.*

Eagle Plains Resources conducted a program of mapping, prospecting, rock sampling and hand trenching on the **Fire** and **Ice** properties formerly known as the Chzerpnough and Bnob. On the **Ice** claims a 30 metre by 5 metre outcrop of barite with disseminated pyrite and galena (Fig. 24) discovered by previous operators returned assays up to 30.3 g/T Ag, 1.55% Pb, 0.038% Zn. A new barite horizon approximately 10 metres thick containing banded galena and sphalerite found in 1996 returned assays up to 55.6 g/T Ag, 0.57% Pb, 0.17% Zn and 4.5 g/T Ag, 9.53% Pb, 4.74% Zn. This horizon may represent a separate barite exhalative horizon or may be the strike extent of the existing showing which would give an overall strike length of 1000 metres. The barite-sulphide horizon(s) occur within the felsic volcanic package on the property. The new horizon occurs immediately above the basal contact between the volcanics and the underlying basinal argillites.

On the **Fire** claims a stratigraphic horizon mineralized with barite-sphalerite-galena and minor chalcopyrite could not be relocated in the 1996 program due to extensive snow cover. Anomalous base metal values in talus fines coincided with the on-strike extent of the horizon returning values up to 2086 ppm Zn, 318 ppm Pb and 555 ppm Cu. Mineralization that was discovered on the claims included disseminated pyrite, pyrite in amygdules in rhyolite flows, pyrite blebs and stringers in a quartz-stockwork zone and a fault zone containing a quartz stockwork containing chalcopyrite, pyrite, galena and sphalerite in a silicified rhyolite. Values up to 1.06% Pb and 3.07% Zn, 0.61% Pb and 2.88% Zn were obtained from mineralized rhyolite tuffs, and 0.54% Cu 7.12% Zn, 0.28 g/T Au from a quartz-sericite stockwork with chalcopyrite. Alteration on the claims consisted of quartz-sericite-pyrite with local strong chlorite as well as fluorite. Eagle Plains is seeking a joint venture partner to explore these properties in 1997.

The **Mamu** property of Oro Bravo Resources Ltd. occurs in a package of Mississippian vol-

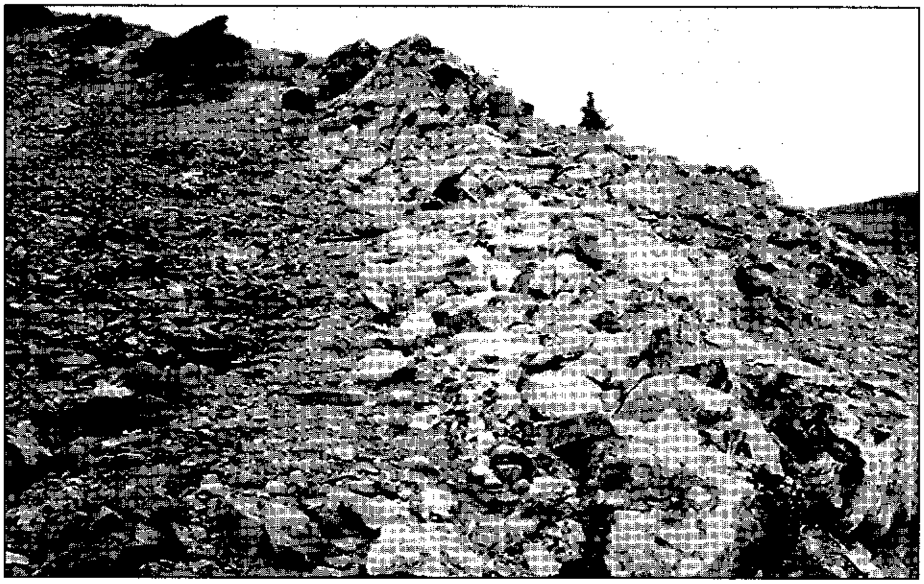


FIGURE 24: *Outcrop of barite with disseminated pyrite and galena on the Ice property of Eagle Plains Resources.*

canic and sedimentary rocks intruded by syenite, monzonite, quartz monzonite, diorite and gabbro. Pyritic chert or pyritic cherty rhyolites are thought to represent exhalative horizons on the property. Massive bedded pyrite (up to 1.8 metres thick), quartz veins and quartz breccias with pyrite, +/- sphalerite, tetrahedrite, galena and chalcopyrite also occur on the property. Alteration consists of an assemblage of quartz-sericite-carbonate-pyrite with local secondary biotite and chlorite. Work on the property in 1995 and 1996 have included mapping, prospecting, geochemical surveys, and magnetometer/VLF surveys.

Other base metal targets in Yukon included Cu-Ni-PGE mineralization in the Kluane area in western Yukon, sedimentary-exhalative Pb-Zn-Ag in central and south-eastern Yukon, exhalative Ni-Mo-Zn-Au-Pt in north-central Yukon, Cu-Pb-Zn-Ag in northern Yukon and Cu-Au porphyries in south-central Yukon.

Blackstone Resources Inc., was active in Yukon on several different projects. The largest program they conducted was on the **Dromedary** property (Minfile #105L-031,051) a sedimentary-exhalative Pb-Zn-Ag target 100 km northwest of Faro in central Yukon. Five diamond drill holes totaling 939 metres were drilled in the overburden covered Francois grid area. Drilling was aimed at gravity, electromagnetic and magnetic geophysical anomalies outlined by extensive surveys conducted in the 1980's. Two laminated massive sulphide horizons were intersected at the top and bottom of a chert-siliceous/graphitic argillite unit within the Devonian-Mississippian Earn Group. The two most significant intersections were in hole FRN96-02 (Fig. 25) which intersected 0.8 metres of 5.48% Zn, 6.13% Pb and 136.7 g/T Ag and hole FRN96-04 which returned 8.42% Zn, 2.43% Pb and 29.8 g/T Ag over 2.0 metres. The mineralization in these intersections, both from the Upper zone, consisted of stringer and massive pyrite, pyrrhotite, sphalerite and galena. A 4.4 metre interval of massive and laminated pyrrhotite from the Lower zone in hole FRN96-02 assayed 2.21 g/T Au, 5.7 g/T Ag, 0.04% Zn, and 0.14% Pb. The mineralized zones encountered in

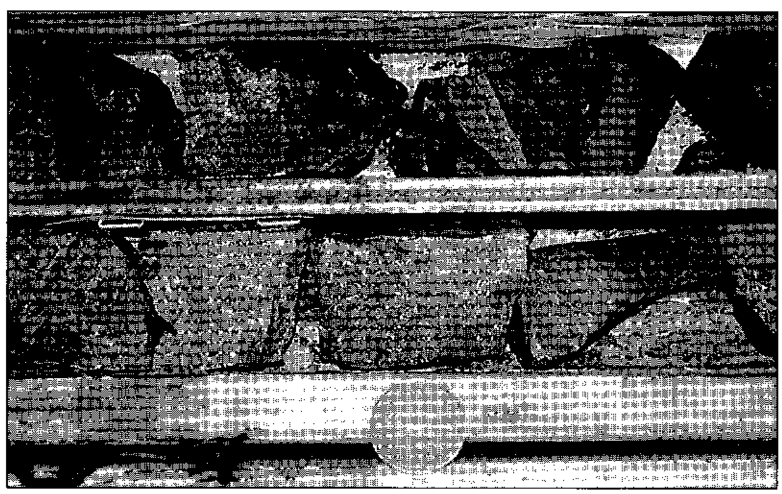


FIGURE 25: *Photograph of laminated sulphide intersection from hole FRN96-02 on the Dromedary property.*

FIGURE 26: High grade stratiform nickel horizon on the Taiga property of Blackstone Resources.

drilling will be further defined in 1997 as well as numerous geophysical targets on the property that remain untested by drilling.

Blackstone also completed a program of geological mapping, prospecting and soil sampling on the **Taiga** project (Minfile #116A-024, 116B-128) a stratiform Ni-Mo-Zn-Au-Pt target in north-central Yukon (Fig. 26). The program was following up on a high grade nickel sample (2.06% Ni) discovered in 1994. The nickeliferrous horizon is located in silty argillites and shale of the Devonian-Mississippian Earn group and has many similarities to the Nick (Minfile #106D-092) deposit located 100 km to the east. The 1996 program traced the horizon to another location that yielded an assay of 3.58% Ni over 0.4 metres from a chip sample. In another location a 1.7 km long Ni soil anomaly is intimately associated with a bedded barite horizon. In total some 9 kilometres of favorable stratigraphy has been outlined by soil and rock geochemistry and will be the focus of the 1997 program.

Blackstone conducted an airborne magnetics and radiometrics survey over the **Monster** (Minfile #116B 084, 102, 103) property, an Olympic Dam Cu-U-Au-Ag target north of Dawson. The area is situated in the southern Ogilvie Mountains and is cored by the Coal Creek Inlier, an oval shaped and east-trending window of Middle and Late Proterozoic clastic rocks that have been penetrated by mineralized breccias and cut by mafic sills and dykes. The Middle Proterozoic stratigraphy (Fig. 27) of the Coal Creek Inlier has been correlated to that of the Wernecke Supergroup located some 250 km to the east where a joint venture between Westmin and Newmont has been exploring for Olympic Dam style deposits. The geological setting of the southern Ogilvie Mountains is considered highly favorable for hosting Olympic Dam type Cu-U-Au-Ag deposits. Previous work on the properties by Blackstone has identified several areas containing copper, cobalt and gold mineralization in hematite-rich heterolithic breccias. Assays in excess of 1% copper and cobalt and gold values ranging from 0.2 to 1.0 g/T have been obtained. The airborne data was interpreted in the context of Olymic Dam and Ernest Henry type models to identify and prioritize targets for future exploration.

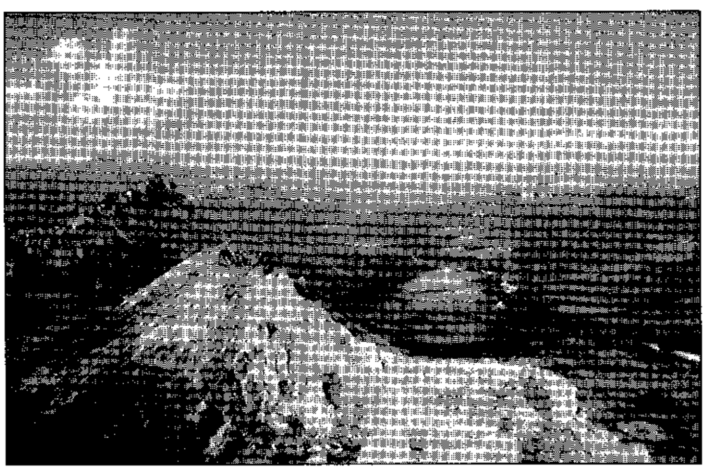


FIGURE 27: Middle and Late Proterozoic sedimentary rocks exposed in the Ogilvie Mountains north of Dawson.

Cominco Ltd. also conducted a program in the Ogilvie Mountains on the **Olympic** (Minfile #116B-099) property optioned from Major General Resouces. The property is also an Olympic Dam style target covering a large hematite breccia complex which hosts numerous copper showings. Major General reports that previous trench sampling has returned values up to 7% Cu over four metres.

Eagle Plains Resources conducted a fourteen hole, 3000 metre diamond drilling program on the **Rusty Springs** property (Minfile #116K-003) in northern Yukon. Geological mapping, geochemistry and geophysics were also conducted in the 1996 program. Drilling at the Marilyn (Fig. 28) and Big Onion showings encountered anomalous Cu-Pb-Zn-Ag values in a highly oxidized, clay rich, siliceous horizon. This drilling, some 1.5 km west of all previous drilling on the property, remapping of trenches, and re-examination of previous drill holes led

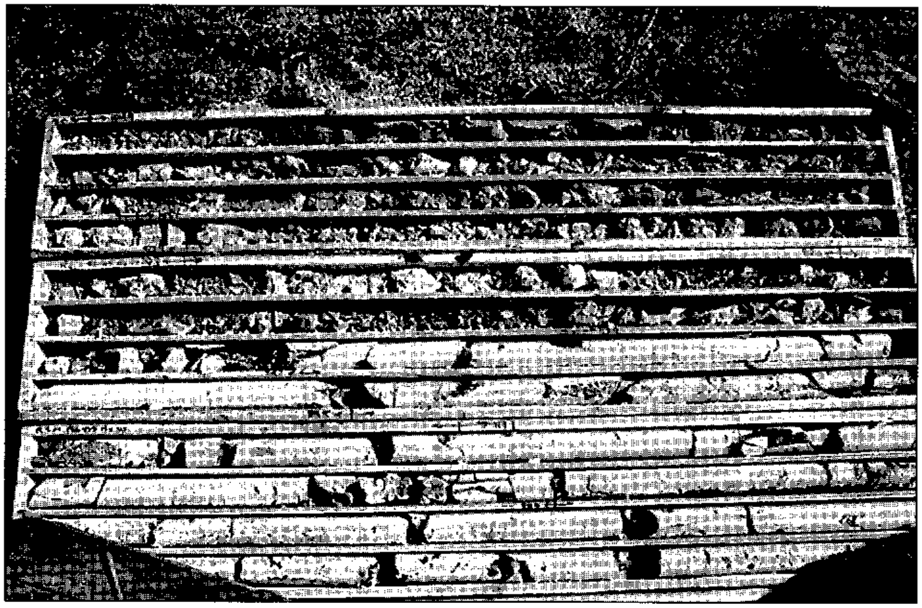


Figure 28: *Drill core from the Marilyn showing area. The highly oxidized and clay rich siliceous horizon overlying dolomites is over 40 metres thick in this hole. Drilling 5 km to the east near the airstrip encountered similar stratigraphy.*

to a reinterpretation of the property geology and host to mineralization. The siliceous horizon occurs at the unconformable contact of Middle Devonian Ogilvie Formation dolomite with overlying siliceous shales and chert of the Devonian-Mississippian Earn Group and is interpreted to be a highly altered tuffaceous unit. The unit hosts all known showings on the property which includes both oxide and sulphide mineralization. Sulphide mineralization from drilling at the Orma Hill has intersected up to 4.54 m of 3873.8 g/t Ag, 13.0% Pb and 2.0% Cu, while the highest intersection from oxide mineralization occurred on the Mike Hill and returned 15.3 m of 517.7 g/T Ag, 3% Cu and 1.3% Zn. The final hole of the 1996 drill program was conducted to the east of all known mineralization to test the reinterpreted geologic model for the property. The hole, 96-14, intersected 33.0 metres of the altered tuffaceous unit. Within the 33.0 metre interval 11.7 metres returned an assay of 1.25% Pb with anomalous Zn, Cu and Ag. A number of gravity and Induced Polarization anomalies outlined by previous operators remain to be tested.

In southwestern Yukon several properties in the Kluane area were explored for ultramafic hosted Cu-Ni-PGE. Northern Platinum Ltd. performed percussion drilling of the **Wellgreen** deposit (Minfile #115G-024) to upgrade reserves of 50 million tonnes grading, 0.35% Cu, 0.36% Ni, 0.51 g/T Pt, and 0.34 g/T Pd. The Wellgreen deposit was in production from 1972 to 1973 and consists of nickel, copper and platinum group elements near the base of a Triassic layered mafic-ultramafic sill 600 m thick, which intrudes Pennsylvanian and Permian pyroclastic and sedimentary rocks. Northern Platinum drilled 3900 metres in 57 holes using a 4.5 inch rotary percussion drill (Fig. 29) in the 1996 program.

Figure 29: *Rotary percussion drilling was used by Northern Platinum to infill drill on the Wellgreen Cu-Ni-PGE deposit.*

Inco Limited flew an airborne geophysical survey over its **KLU** claims in the Nines Creek area near Burwash Landing. Ultramafic hosted Cu-Ni-PGE mineralization is also the target on these claims. Inco has conducted exploration on these claims for the last couple of years and may conduct a program of diamond drilling in 1997.

Expatriate Resources Ltd., followed up on a drill program conducted in 1995 with an airborne magnetics-electromagnetics survey over the entire **Canalask** Ni-Cu-Co-PGE (Minfile #115F-045) property. Pyrrhotite and lesser amounts of pentlandite, sphalerite, pyrite, marcasite and chalcopyrite occur as fine-grained patchy disseminations and less commonly as small massive lenses in Permo-Pennsylvanian volcanic rocks of the Station Creek Formation. These rocks are dense and siliceous and probably of tuffaceous origin. Reserves are estimated at 450,000 tonnes at 1.5% Ni. The survey outlined known zones on the property and several very strong and coincident conductivity high-resistivity low-magnetic high anomalies in overburden covered areas which have not received any previous exploration.

Cominco Ltd. optioned the **Mel** property (Minfile #95D-005,032) a Pb-Zn-Ba sedimentary-exhalative deposit 80 kilometres northeast of Watson Lake in southeastern Yukon from International Barytex. Cominco conducted a drilling program on the property initially aimed at the Jeri North zone where two holes in 1995 intersected coarse grained sphalerite in a black chert unit that assayed 9.9% Zn and 15.6% Zn over 5.0 and 5.1 metres respectively. The Jeri North intersections are at the same stratigraphic horizon as the main Mel zone which has reserves of 6.8 million tonnes grading 7.1% Zn, 2.0% Pb and 54.7% barite located eight kilometres to the southeast. Barytex also reported that four samples provided to Cominco for trace elements assayed 23, 63, 105 and 125 g/T germanium.

Camdan Explorations a private exploration company based in Whitehorse staked the **Mars** (Minfile #105E-002) property 60 kilometres northeast of Whitehorse. The claims cover the Teslin Crossing Pluton an alkalic monzonite stock which preliminary results from recent age dating indicates a Middle Jurassic age of approximately 170-180 Ma. Camdan performed a program of geological mapping, prospecting, geochemistry and geophysics on the Cu-Au porphyry target. Intensive potasic alteration and magnetite occurs within the stock. Mineralization consists of quartz stockworks +/- chalcopyrite (Fig. 30). The property was previously explored for Cu-Mo mineralization in the early 1970's but the gold content was not recognized until the 1996 program.

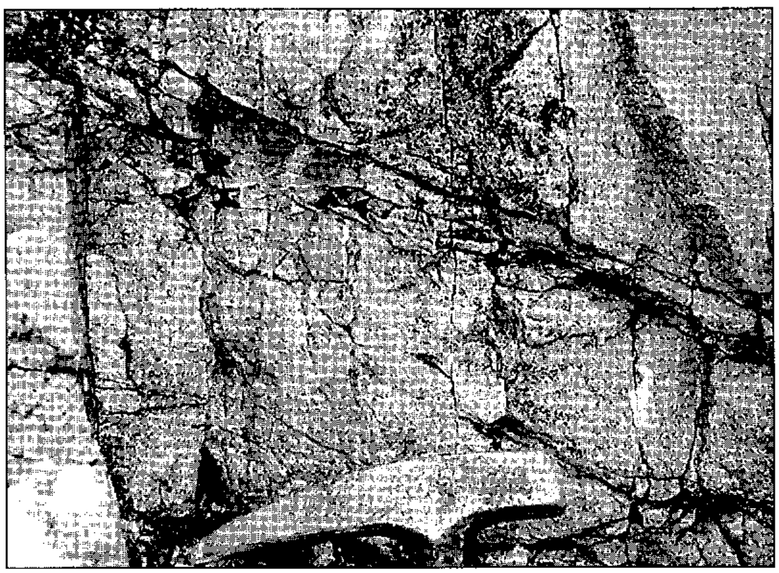


FIGURE 30: *Quartz stockwork in pervasivly pottasium altered intrusive rocks of the Teslin Crossing Pluton a Cu-Au porphyry target northeast of Whitehorse near the Livingstone Creek road.*

Alexis Resources Ltd., optioned the **Canadian Creek** (Minfile #115J-036) property from Eastfield Resouces and performed a program of geophysical and geochemical surveys and an extensive amount of excavator trenching on the Cu-Au porphyry target. The property is located immediately to the west of the Casino (Minfile #115J-028) deposit and covers similar rocks of the Casino intrusive complex. The trenching defined new areas of intrusive rocks with potential to host porphyry style mineralization. Trenching returned values up to 0.9 g/T Au over 13 metres. Diamond drilling is planned for several areas of the property in 1997.

Reward Mining Corp., conducted a two hole diamond drilling program late in the season on the **Dolly Varden** property (Minfile# 105H-005). Mineralization exposed by previous operators consists of galena, sphalerite, chalcopyrite and scheelite disseminated in skarn which is developed in hornfels and argillite of the Devono-Mississippian Earn Group, near the southwest contact of the Cretaceous Billings Batholith. The drilling conducted by Reward intersected sulphides in a quartzite-marble horizon within a thick sequence of phyllites. Hole 96-1 returned values up to 9.6% Zn, 11.58% Pb, 43.8 g/T Ag and 0.017% WO3 over 0.91 metres and 11.3% Zn, 0.83% Pb, 78.3 g/T Ag and 0.137% WO3 over 1.83 metres. Hole 96-2 intersected 0.3 metres of 5.18% Zn, 4.48% Pb, 45.8 g/T Ag and 0.014% WO3. Reward also conducted a program of mapping, prospecting and geophysics on the **KM** claims (Minfile

#105H-011). Skarn mineralization previously identified on the property was located and resampled returning values up to 8.52% Zn, 10.89% Pb, 3.78% Cu and 0.67 g/T Ag. The property will be the focus of continuing exploration in 1997.

Nicholson and Associates, on behalf of a private mining company, performed a program of geological mapping, geochemistry, prospecting and geophysics on the **NI** claims immediately west of Whitehorse on Mt. Lorne. The property hosts vein and disseminated arsenopyrite-gold (Fig. 31) associated with multi-phase felsic dykes and Cu-Au skarn mineralization. Anomalous areas identified in the program will be followed up in 1997.

Figure 31: *R. Dan Cosgrove a prospector with Nicholson and Associates examines arsenopyrite-gold mineralization on the NI claims of local prospector Brian Carter.*

Gold Exploration

Gold exploration in Yukon was dominated by the search for bulk tonnage, low grade gold deposits. The largest program was at Dublin Gulch previously outlined in this report but several other large programs were also conducted. The amount of gold exploration, especially for the Fort Knox style deposit, although not disappointing did not reach the levels anticipated for 1996. Successful production from Fort Knox in Alaska and Brewery Creek in Yukon will hopefully put to rest any doubts over the economic viability of these deposits in the north and lead to increased exploration for these deposits in Yukon.

Yukon Gold Corp. conducted several drilling programs on properties in the **Emerald Lake** (Minfile #105O-009) area of eastern Yukon. Drilling was aimed at sheeted quartz veins and quartz vein stockwork zones in Tombstone suite granodioite intrusions. Drilling was conducted on the **Ann Mark, Tom, Plata North** and **Arrowhead** Lake zones. Drilling at the **Ann Mark** zone intersected quartz-arsenopyrite-bismuthinite veins at the intrusive contact and the best intersection returned 1.01 g/T Au over 21 metres. Further drilling will test the contact zone. Drilling at the **Plata North** failed to intersect the contact between the intrusive host rocks and the surrounding sediments however the best result from drilling was 1.02 g/T Au over 13.6 metres. The **Tom** zone failed to return any significant intersections. The **Arrowhead** zone (Fig. 32) is a small granitic pluton which hosts numerous styles of mineralization including subparallel quartz-arsenopyrite veins, stockwork and sheeted quartz-pyrite-arsenopyrite, and quartz-bismuthinite veins. Three holes were drilled into the pluton with the best result being obtained from drill hole AS-3 which returned 0.74 g/T Au, 1.4 g/T Ag, 0.034% Cu over 272 metres including 1.83 metres of 70.0 g/T Au. Drilling will continue in 1997 to follow-up these results.

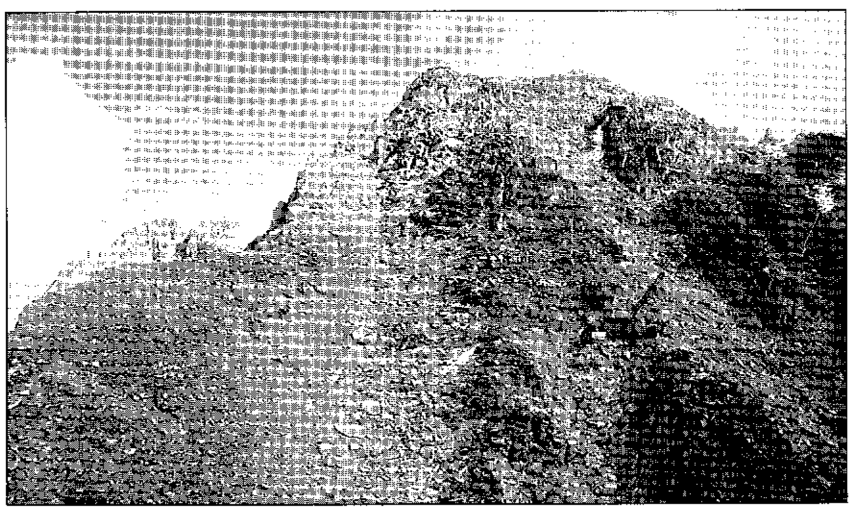


Figure 32: *The Arrowhead Zone north of Emerald Lake in eastern Yukon is an intrusive hosted gold target similar to Dublin Gulch and Fort Knox. Three drill holes all intersected subparallel quartz-arsenopyrite-gold veins in a small granitic stock.*

Yukon Gold also drilled the **Plata** Mine (Minfile #105N-003) property in 1996. The Plata Silver Mine was a high grade silver mine which last produced in 1987. Yukon Gold conducted a drill program on the "P4 vein" now called the Plata Thrust zone. The Plata Thrust is a major gently southwest-dipping thrust fault that is associated with a 1 to 3 m wide quartz feldspar porphyry dyke of probable mid Cretaceous age. Mineralization consists of disseminated pyrite, arsenopyrite, tetrahedrite and other sulphosalts in a massive white quartz gangue. Lenses of massive pyrite-pyrrhotite-galena-sulphosalt are also present. Specimens of the latter material range up to 20.9 g/t Au and about 6800 g/t Ag. Reserves at the Plata Thrust in 1987 were reported as 450 000 possible tonnes grading 8 g/t Au and 340 g/t Ag over an average width of 1.5 m to a depth of 60 m. Drill hole Plata - 2 collared approximately 400 metres down-dip from the previously defined reserves (Fig. 33), intersected quartz-sulphide mineralization on the Plata thrust which assayed 17.14 g/T Au, 4.5 g/T Ag over 2.1 metres.

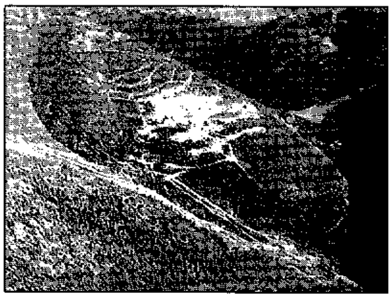


FIGURE 33: Drill hole Plata - 2 collared down-dip from the area of 1987 drilling intersected quartz-sulphide mineralization on the Plata thrust which assayed 17.14 g/T Au, 4.5 g/T Ag over 2.1 metres.

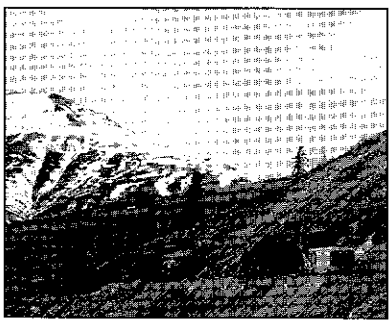


FIGURE 34: Al Doherty and Harman Keyser examine a zone of oxidized, altered and intensely fractured granodiorite containing multiple quartz-arsenopyrite veins and veinlets. The zone in the photo assayed 4.4 g/T Au over 8 metres.

Balaclava Industries Ltd. explored the **Len** Property (Minfile #106D-020) with soil geochemistry, geological mapping, excavator trenching and geophysics. The property is located approximately 10 kilometres to the east of Dublin Gulch. Trenching of gold soil anomalies exposed a granodiorite stock similar to host rocks at Dublin Gulch. Within the granodiorite structurally-controlled clay-quartz-sulphide-carbonate veins (Fig. 34) were sampled and assays up to 22.2 g/T Au over 3 metres and 4.4 g/T Au over 8 metres were obtained.

Orinoco Gold Inc. completed a mapping, trenching and drilling program in September and October on the **Panorama Ridge** (Minfile #116A-031) property located 5 kilometres east of Brewery Creek. Drilling was conducted with a helicopter supported air hammer drill (Fig. 35). The property is underlain by a highly altered quartz monzonite intrusive with mineralization consisting of quartz-arsenopyrite veins. Trenching results include 1.8 g/T Au over 13 metres and drill results should be released in early 1997.

Eagle Plains Resources and Miner River Resources performed a preliminary program of geological mapping and prospecting on a number of intrusive-hosted gold targets in east central Yukon. The properties explored include the **Alp** (Minfile #105O-004), **Nug** (Minfile #105O-048), **Rog, Fan, Ran** (Minfile #105O-055), **Old** and **Cabin** (Minfile #105O-39) and the **Drag** (Minfile #105J-007). The program was successful in locating gold mineralization on all the claim groups with the best results being obtained from the Alp and Drag claims.

On the **Alp** claims mineralization consists of arsenopyrite in tension fractures within felsic porphyry dykes associated with a Cretaceous granitic stock. Five dykes have been discovered to date with the largest dyke traced over a strike length of 1000 metres and an average width of 10 metres. Forty-one chip and grab samples from this dyke averaged 4.64 g/T Au. Another dyke returned an assay of 0.92 g/T Au over 10 metres from a continuous chip sample. Anomalous gold values were obtained from all the dykes on the property and within adjacent sedimentary rocks.

The **Drag** claims host gold skarn mineralization in argillaceous limestone and quartzites associated with a Cretaceous granitic stock. The pyroxene skarn lenses returned values up to 12.7 g/T Au over 1.0 metres and 3.54 g/T Au over 5.0 metres. Alteration envelopes of calc-silicate hornfels and sericitized quartzite surround the skarn lenses and returned values up to 0.6 g/T Au over 19.0 metres. Numerous copper-gold geochemical anomalies outlined by previous operators remains to be investigated but indicate the possibility of multiple zones.

Yukon Revenue Mines Ltd. reported several intersections from a program of air rotary per-

FIGURE 35: Air hammer drill on the Panorama Ridge property of Orinoco Gold.

cussion drilling on the **Aurex** (Minfile #105M-060) property near Mayo in central Yukon. The property is 20 kilometres south of Dublin Gulch. Calc-silicate skarns in several old trenches, suggest the presence of one or more buried plutons in the area. Coincident airborne resistivity and magnetic anomalies provide further evidence for possible buried intrusions beneath the property. Twelve intersections ranging from 0.68 to 5.04 g/T Au each over 3.05 metres were obtained from the 92 hole, 2700 metre drill program.

YGC Resources Ltd. explored the **Ketza River Mine** (Minfile #105F-019) property with detailed geological mapping, prospecting, core-relogging and a diamond drilling program. The Ketza River Mine produced over three million grams of gold from high grade oxide manto deposits between 1988 and 1990. A total of 5570 metres were drilled in 35 holes in the vicinity of the former mine workings and at the bulk tonnage, low grade gold target, the Shamrock zone (Fig. 36).

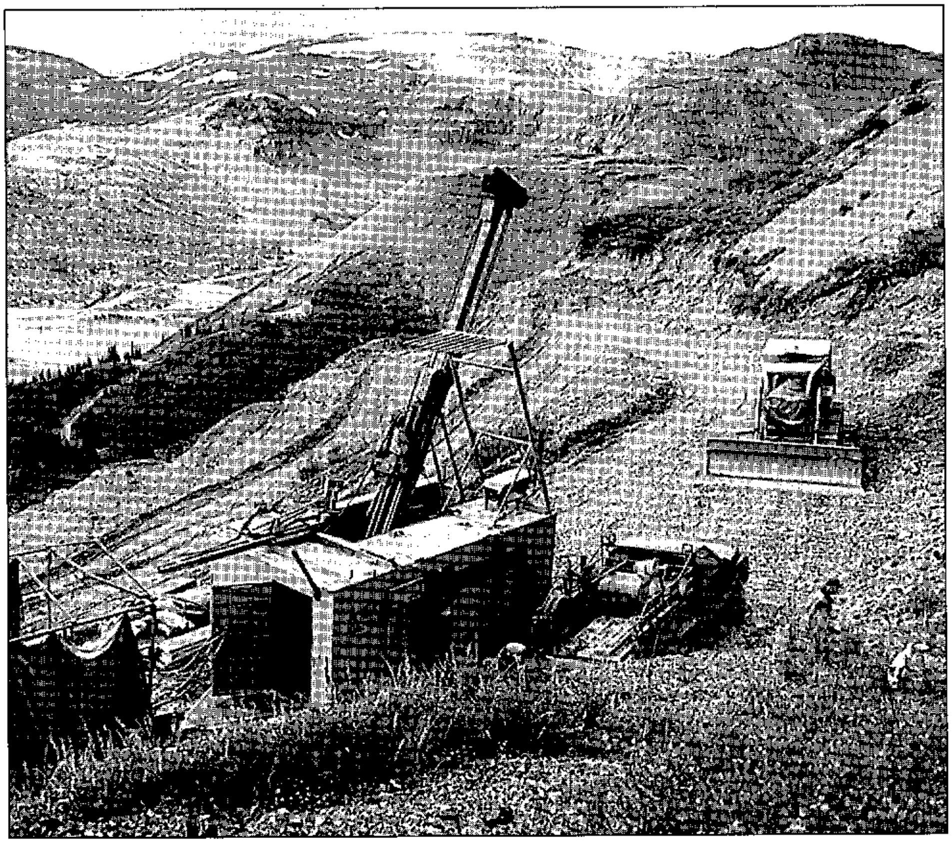


Figure 36: *Diamond drilling on the bulk tonnage low grade gold target, the Shamrock Zone at Ketza River was the main focus of exploration for YGC Resources on the property. Former mine workings are visible in the background.*

In the area of the mine workings a new oxide zone in the vicinity of the Hoodoo zone was intersected with one drill hole that intersected 8.4 g/T Au over 5.3 metres. This intersection was not followed up and remains open in all directions. Drilling was also conducted in the Peel West sulphide zone. Two holes in this area intersected 7.9 g/T Au over 15.0 metres and 7.8 g/T Au over 15.3 metres enhancing the possibility of adding to probable sulphide reserves on the property which are estimated at 175 000 tonnes grading 11.3 g/t Au. Follow-up drilling on the Hoodoo, Fork, B-mag, and McGiver oxide manto zones and the Peel West sulphide zone was deferred so that drilling could focus on the Shamrock zone. Twenty-one holes were drilled in the Shamrock within a 1300 by 700 metre area of a larger >300 ppb Au soil, magnetic and visual anomaly. Mineralization at the Shamrock occurs in rusty weathering, variably altered quartzites and argillites. Alteration consists of silicification, sericitization, pyritization and argillaceous minerals. The drilling encountered mineralization consisting of massive quartz-arsenopyrite veins, skarnified and hornfelsed units and anastomosing quartz-stockwork zones. Results from this style of mineralization include 0.86 g/T Au over 156 metres, 1.9 g/T Au over 20.5 metres, and 2.2 g/T Au over 15 metres. Two intersections were also obtained from altered calcareous siltstone beds and returned 2.4 g/T Au over 12.0 metres and 5.2 g/T Au over 4.5 metres. Fourteen of the twenty-one holes intersected significant mineralization. This is the first drill program on the Shamrock zone which was directed towards a bulk tonnage, low grade target. Drilling was conducted by previous operators but it was directed at the upper oxidized portion of sulphide veins that occur within the zone.

The mapping and prospecting program traced the mineralized trend at the Shamrock zone a further four kilometres to the northwest. Three zones within this trend host outcropping mineralization in sedimentary rocks. The Pass zone is a quartz breccia vein that returned grades of 3.5 g/T Au over 6 metres. The Cliff zone consists of quartz-sulphide veins in

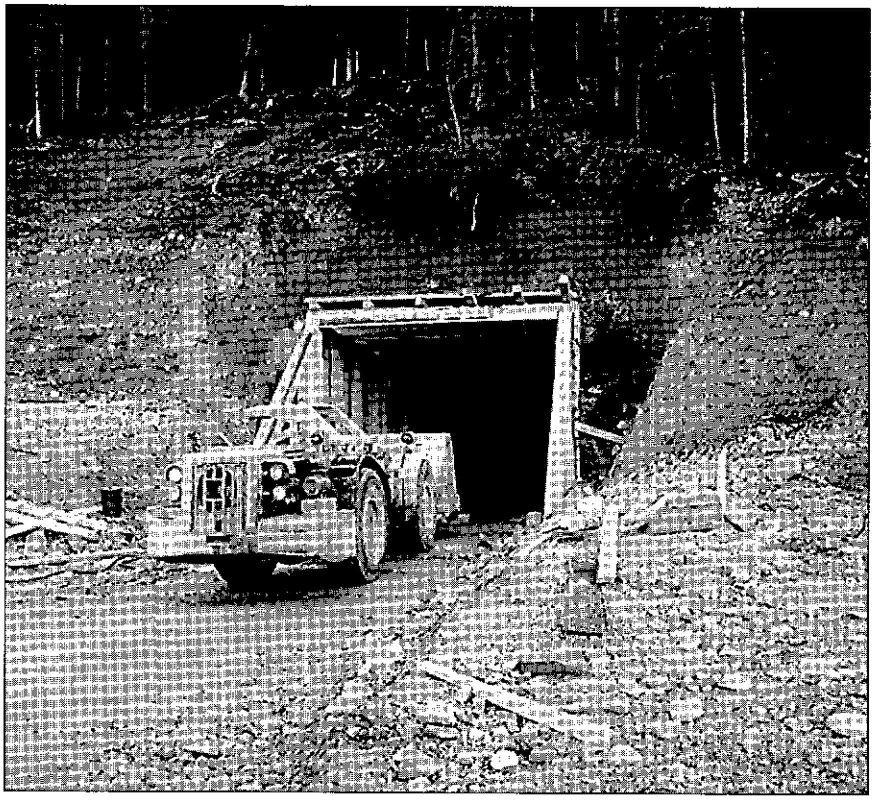


***FIGURE 37:** In early August, Omni Resources began driving a 620 metre decline parallel to the Goddell Shear Zone to establish underground drilling stations.*

dolomitized limestone and assayed up to 5.7 g/T Au. The Lake zone is a 200 by 300 metre area of a quartz-stockwork breccia in carbonates and four grab samples returned values between 2.0 to 4.8 g/T Au.

YGC also conducted a 17 hole 1560 metre drill program at the Grew Creek (Minfile #105K-009) gold deposit. The epithermal gold deposit hosted by Eocene volcanics within the Tintina Trench contains 270,000 tonnes of drill-indicated reserves grading 11.11 g/T Au. Drill intersections up to 10.6 g/T Au over 7.6 metres were reported from six of the first eight holes of the program. YGC elected not to complete the final year of the option agreement and returned the property to Al Carlos of Whitehorse.

In the Dawson area Klondike Gold Corp. continued to explore the **Lonestar, Boulder Lode** and **Buckland Shear** (Minfile #115O-072,077) properties. Geological mapping, bulk sampling and an extensive trenching program was performed on the properties.

Omni Resources Inc. collared a portal (Fig. 37) on the **Goddell** (Minfile #105D-025) project 60 kilometres south of Whitehorse. Gold and silver occur with stibnite, galena, sphalerite and arsenopyrite in the Goddell Shear Zone, a 35 m wide, east-trending shear zone of black augen cataclasite and brecciated granite bounded by two quartz-feldspar porphyry dykes. The shear zone cuts the mid-Cretaceous Carbon Hill granite. Deep drilling conducted in late 1995 encountered disseminated acicular arsenopyrite and pyrite on hairline fractures in thin andesite dykes, three holes from the program intersected 12.7 g/T Au, 13.7 g/T Au and 8.2 g/T Au over 3.8, 6.9 and 4.4 metres respectively. An indicated reserve of 565,000 tonnes grading 5.5 g/T Au was calculated. The 620 metre decline was driven parallel to the Goddell Shear Zone to establish underground diamond drilling stations and to provide future haulage access. The decline was completed in late December, 1996 and two holes completed before year end. The first hole intersected the mineralized andesite dyke swarm and intersected 40.3 metres grading 3.84 g/T Au. The true thickness of the intersection is estimated at 28.5 metres. The second hole was drilled deeper and did not intersect the dyke swarm but returned two intersections of 4.1 metres grading 3.94 g/T Au and 3.1 metres grading 3.28 g/T Au.

Omni also completed a 15 hole underground drill program (Fig. 38) on the **Skukum Creek** (Minfile #105D-022) polymetallic vein deposit which hosts previously defined drill indicated and inferred reserves of 800,150 tonnes at 7.6 g/T Au 275 Ag. The mineralized veins consist of quartz or quartz-rhyolite breccia containing 20-40% sulphides, which include pyrite, arsenopyrite, sphalerite, galena, minor chalcopyrite, pyrargyrite, pyrrhotite and bornite, and traces of argentite, tetrahedrite, gold and electrum. The veins cut aphanitic rhyolite dykes which intrude propylitically altered Cretaceous granodiorite. The drilling was successful in expanding the deposit which remains open in several directions. The deepest hole drilled on the deposit intersected 25.3 m of 23.1 g/T Au, 262 g/T Ag, the true thickness of this intersection is approximately 6 metres. New reserves based on the program are being calculated.

ACKNOWLEDGEMENTS

This report is based on public information gathered from a variety of sources. It also includes information provided by companies through press releases, property summaries provided to the department, and from property visits conducted in the field season. Without the cooperation of the many companies exploring in the Yukon this would be a very short report. The hospitality and excellent property tours during the field season are greatly appreciated. Special thanks to Mark Baknes of Equity Engineering for providing a couch when the Welcome Inn in the metropolis of Ross River was full.

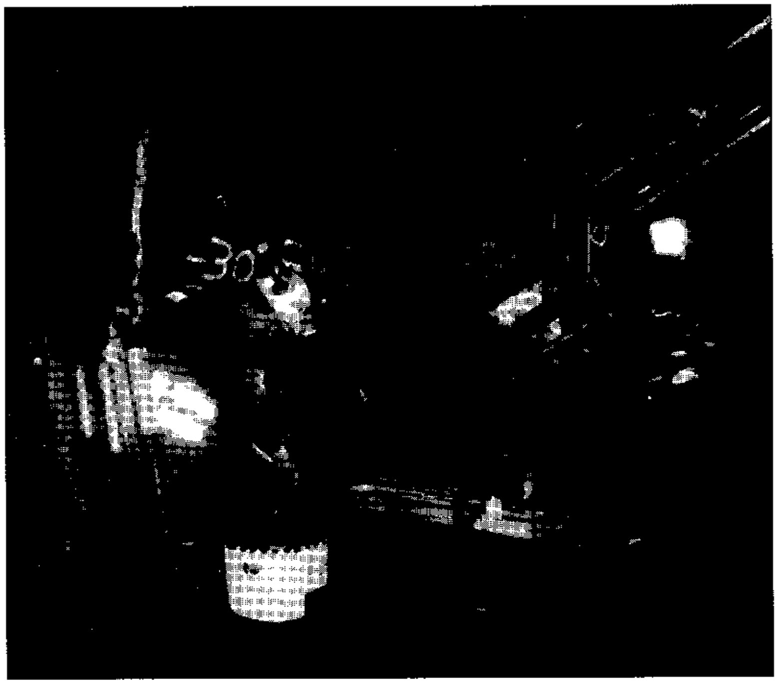


FIGURE 38: *Geologist Bill Mann examines core underground at the Skukum Creek deposit.*

APPENDIX 1: 1996 EXPLORATION PROJECTS

PROPERTY	COMPANY	MINING DISTRICT	MINFILE # (1:50,000 NTS)	WORK TYPE	COMMODITY
Alp/Nug/Rog/Old Drag	Eagle Plains Resources Miner River Resources	Mayo	105O-4,48,55 39, 105J-007	G, GC, P	Au
Antimony Mountain	Kennecott Canada	Dawson	116B-001	GC, G	Au
Aurex	Yukon Revenue	Mayo	105M-060	G, GP, G	Au
Banana	Pacific Galleon	Whitehorse	105D-076	G, GC	Au
Brewery Ck	Viceroy Resource Corporation	Dawson	116B-160	PD,T, G GC	Au
Canadian Creek	Alexis/Eastfield Resources	Whitehorse	115J-036	G, GC, GP, T	Cu, Au
Canalask	Expatriate Resources	Whitehorse	115F-045	DD, G	Ni, Cu
Canol, Oop etc.	Minfocus International	Watson Lake	105A-38,44,45,5	DD, G, GC, GP	Cu, Zn, Pb, Au, Ag
Caribou Creek	Midnight Mines	Whitehorse	115I-049	G, BS	Au
Carmacks Copper	Carmacks Copper Limited	Whitehorse	115I-008	T, G, ES	Cu, Au
Casino	Pacific Sentinel Resources	Whitehorse	115I-028	PF, ES	Cu, Mo, Au
Claymore	Sikanni Oilfield Const.	Whitehorse	115N-024	G,GP, M	Au
Clear Creek	New Millennium Mining	Dawson	115P-011	G, GC, DD	Au
Discovery Ck	B.Y.G. Natural Res.	Whitehorse	115I-093	G, GC	Au, Ag, Cu, Mo, Pb, Zn
Division	Cash Resources Ltd.	Whitehorse	115H-013	DD, T, G, ES	Coal
Dromedary	Blackstone Resources	Whitehorse	105L-031,051	G, DD	Pb, Zn, Ag
Dolly Varden	Reward Mining Corp.	Watson Lake	105H-005	G, GC, DD	Zn, Pb, Ag
Dublin Gulch	New Millennium Mining	Mayo	106D-21-29	PD, DD, PF, ES	Au
Eldorado	Mar-West	Watson Lake	105G-048	G, DD	Au, Ag, Cu
Emerald	Yukon Gold Corp.	Watson Lake	105O-009	G, GC, R	Au
Faro (Grum)	Anvil Range Mining Corporation	Whitehorse	105K-46,55, 56,61	D, M	Pb, Zn, Ag, Au
Finlyson Project	Expatriate	Watson Lake		G, GC, GP, DD	Cu, Zn, Pb, Au, Ag
Fire/Ice	Eagle Plains Resources	Whitehorse	105F-071,073	G, GC, P	Cu, Zn, Pb, Au, Ag
Fyre Lake	Columbia Gold Mines	Watson Lake	105G-034	G, GC, GP, DD	Cu, Co, Au
Grew Ck	YGC Resources	Whitehorse	105K-009	DD, G	Au
Goddell	Omni/Arkona	Whitehorse	105D-025	DD, U/GD	Au
Hat	Rob Hamel	Whitehorse	105D-053	G, T	Cu, Au
Hyland Gold	Hemlo Gold	Watson Lake	095D-011	G, DD	Au
Hunker Dome	Barramundi Gold	Dawson	115O-067	G, GC, GP, T	Au
Iota	Westlake Ltd/Montoro	Mayo	106C-014	DD	Cu, Au, Ag, Co
JP/Border	KRL Resources	Watson Lake	(95D-4)	G, GP	Pb, Zn, Ag
Keno Hill	United Keno Hill Mines	Mayo	105M-001	U/GD, DD, PD, G	Pb, Zn, Ag
Ketza	YGC Resources	Watson Lake	105F-019	DD, G	Au
Klu	Inco Exploration	Whitehorse	(115G/2)	G, GP	Cu, Ni, PGE
Kudz Ze Kayah	Cominco Ltd.	Watson Lake	105G-117	ES, F	Cu, Zn, Pb, Ag, Au
Laforma	Redell Mining Corp.	Whitehorse	115I-054	DD, T, U/GD	Au
Len	Balaclava Industries	Mayo	106D-020	G, GC, GP, T	Au
Liard/Watson	KRL Resouces	Watson Lake	(105A/2)	G, GP	Au
Longline	Barramundi Gold	Whitehorse	115N-024	G, GC, GP, T	Au
Lonestar/Buckland	Klondike Gold	Dawson	115O-72,77	G, GC, BS	Au
Mack/JK	Pacific Bay Minerals	Watson Lake	105G-060	G, GC	Cu, Pb, Zn, Au

PROPERTY	COMPANY	MINING DISTRICT	MINFILE # (1:50,000 NTS)	WORK TYPE	COMMODITY
Man/Bay	Demand Gold	Watson Lake	(105A/11)	G, GC	
Marg	NDU Resources	Mayo	106D-004	G, GC, DD	Cu, Pb, Zn, Ag, Au
Marn	Battle Mountain	Dawson	116B-147	G, GC, GP	Au
Mamu	Oro Bravo	Whitehorse	105F-13	G, GC, GP	
Mars	Camdan Explorations	Whitehorse	105E-002	G, GC, GP	Cu, Au
Mel	International Barytex Resources/Cominco	Watson Lake	95D-005	DD, G	Zn, Pb, Ba
Minto/DEF	Minto Explorations	Whitehorse	115I-21, 22	DD, G, F, ES	Cu, Au, Ag
MM	Anvil Range Mining	Whitehorse	105F-012	G, DD	Cu, Pb, Zn, Ag, Au
Monster	Blackstone Resources	Dawson	116B-084,102	G, GC, GP	Cu, U, Au, Ag, Co
Money/Argus/Wolf	Atna/YGC	Watson Lake	105H-78/G-13,8	G, GC, GP, DD	Cu, Zn, Pb, Au, Ag
Mt Nansen	BYG Natural Resources	Whitehorse	115I-64, 65	DD, G, D, M, ES	Au, Ag
Mucho	Cash Resources	Watson Lake	105I-004	G, GC, GP, DD	Ag, Pb
Olympic	Cominco/Major General	Dawson	116B-099	G, GP	Cu, U, Co, Au, Ag
Panorama Ridge	Orinoco Gold	Dawson	116A-031	G, GC, T, PD	Au
Primo	Klondike Gold	Watson Lake	105H-96	G, GC, DD	Cu, Zn, Au, Ag
RBI	Demand Gold	Watson Lake	105G-117	G, GC, GP	Cu, Zn, Pb
Rusty Springs	Eagle Plains Resourses	Dawson	116K-003	G, GC, T, DD	Ag, Cu, Zn, Pb
Scheelite Dome	Kennecott Canada	Mayo	115P-033	G, GC, P	Au
Taiga/Rein	Blackstone Resources	Dawson	116B-128	G, GC, P	Ni, Mo, Zn, Au, Pt
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, DD	Cu, Zn, Pb, Au, Ag
Ver/CJ	Westmin	Watson Lake	95D-011	GC	Au
War/Lip	Condor International	Watson Lake	105G-070	G, GC, GP	Cu, Pb, Zn, Ag, Au
Wellgreen	Northern Platinum	Whitehorse	115G-024	G, PD	Cu, Ni, PGE
Wolverine	Westmin/Atna	Watson Lake	105G-032	G, GC, GP, DD	Ag, Cu, Zn, Pb

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

APPENDIX 2
1996 DRILLING STATISTICS

PROPERTY	COMPANY	DIAMOND DRILL METRES	DIAMOND DRILL # HOLES	RC/PERCUSSION DRILL METRES	RC/PERCUSSION DRILL # HOLES
Argus	Atna Resources	910	9		
Aurex	Yukon Revenue			2700	92
Brewery Ck	Viceroy Resource Corp.			3000	28
Dolly Varden	Reward Mining	250	2		
Dromedary	Blackstone Resources	939	5		
Dublin Gulch	New Millenium Mining	5400	54	6068	70
Eldorado	Mar-West	450	5		
Emerald Lake etc.	Yukon Gold Corp.	7500	25		
Faro Mine	Anvil Range Mining	1465	16		
Finlayson Project	Expatriate Resources	3398	20		
Fyre Lake	Columbia Gold	9600	71		
Grew Ck	YGC Resources	1560	17		
GMS	Minfocus	398	3		
Goddell Gold	Omni Resources/Arkona	388	2		
Hyland Gold	Hemlo Gold Mines Inc.	127	1		
Ice	Expatriate Resources	2704	34		
Iota	Montoro	1100	11		
Keno Hill	United Keno	1600		2000	
Ketza	YGC Resources	5570	35		
Marg	NDU Resources	8518	29		
MM	Anvil Range Mining	1889	4		
Minto	Minto Explorations	548	4		
Money	Atna Resources	960	7		
Mt Nansen	BYG Resources	745			
Mucho	Cash Resources	550	5		
Panorama Ridge	Orinoco Gold			500	8
Plata Mine	Yukon Gold Corp.	750	6		
Primo	Klondike Gold Corp.	600	3		
Rusty Springs	Eagle Plains Resources Ltd.	2350	14		
Skukum Creek	Omni Resources/Arkona	1640			
Various	Cominco	4025	25		
Wellgreen	Northern Platinum			3900	57
Wolverine	Westmin Resources/Atna	18810	64		
TOTALS		**82,606**		**18,168**	

YUKON GEOLOGY PROGRAM

Government geoscience in Yukon took a big step this year; the federal and territorial geoscience people and programs became operationally integrated. Until now each operated independently and from separate offices. Thus DIAND, which inherited the geoscientific role in Yukon from the GSC in 1969, monitored and reported on mineral exploration in Yukon and studied mineral deposits and districts in support of industry. The Yukon Geoscience Office started in 1990 with detailed geological mapping in areas of exploration interest as a spur to exploration, under the aegis of the second Canada-Yukon Economic Development Agreement (EDA). This led, during the last five or six years, to two separate units with distinct functions.

This year the leaders of the two groups, Trevor Bremner and Rod Hill, realized that this represented an opportunity and took the initiative to begin integration. They instituted joint budgeting and cooperative and complementary operational planning of the year's work. The goal was a relevant program balanced between mineral deposit studies, detailed mapping, environmental geoscience and placer deposit studies and tightly connected with the work needed to meet requirements under DIAND legislation. Such a balanced tightly knit program was constructed.

The integrated group operates under the banner- "Yukon Geology Program". For now separate offices and distinct operational systems continue to constrain us; these hurdles between us and complete integration are for the future.

Weekly joint meetings of the combined staffs have followed on the program building start. This has given a clear sense of direction, engendered understanding of the connectedness of the functions and fostered cooperation and trust at the working level; it has begun to forge a cohesive unit. Operational lines are blurring and functions, seen as distinct till now, are integrating. Economies of scale are being realized through joint use of expertise, facilities and services.

The "Yukon Geology Program" lost its spark plug, Trevor Bremner, late in the year . At least for some months he will act as Director of Mineral Resources for DIAND. Dirk Tempelman-Kluit has agreed to fill in for him in the short term.

As part of the jointly developed plan a Minerals Geologist, Julie Hunt, was hired to study Yukon volcanogenic mineral deposits. Several important new occurrences of this deposit type (Kudz Ze Kayah, Wolverine, Ice and Fyre Lake) made it imperative to begin this work on these occurrences about which little was known. Julie's initial findings are reported elsewhere in this volume. In response to the huge exploration interest in the Finlayson Lake area Don Murphy began mapping the bedrock geology near the Kudz Ze Kayah deposit; his preliminary report is in this volume.

YUKON GEOLOGY PROGRAM

Mineral deposit studies in the Dawson Range, one of the economically promising parts of Yukon, are the focus for Craig Hart. His three reports in this volume reflect his changing focus and wide expertise.

Placer deposits and placer exploration are important elements of the Yukon economy. Much remains to be understood about the nature origin and distribution of Yukon placers and the placer industry needs support with scientific ideas and data. The departure of the Placer Geologist from the EDA in 1996 left a vacuum. Bill Laberge took the lead here and in cooperation with Frances Hein and Jeff Bond of the University of Calgary focussed work in the Mayo placer district; reports of this work are in this volume and in a companion volume- Yukon Quaternary Geology, vol. 2 (1997). Two contractors, S. Morison and C. Mougeot were hired to continue the Stewart River placer mapping project.

Sound environmental geoscience information for Yukon is critical for balanced land use decisions including the land claims process, environmental reviews of development projects and new Parks. Karen Pelletier was hired as Environmental Geologist. Hers is a new position focussed on the development of Mining land use regulations. She joins Hugh Copland and Diane Emond, two other Environmental Geologists who represent the minerals side of negotiations in the native land claims process and in mining environmental reviews. Daniele Heon, the Yukon Geology Program's link to planning for and decisions about Yukon Parks, worked on proposals along the Dempster Highway.

The departure of Steve Johnston and Derek Thorkelson from the Yukon Geoscience Office has reduced bedrock mapping strength. It also leaves the final report of Johnston's work in the Aishihik Lake area incomplete. Although Thorkelsen retains a connection with the program it will delay his final report on the Wernecke Mountains, which he mapped in detail.

Much effort this year has focussed on preparing final reports. Grant Abbott, Craig Hart, Don Murphy and Charlie Roots are close to completing final reports on their work in the Hart River, Whitehorse, McQuesten and Mayo areas respectively. Publication in 1997 is the goal.

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

BOTTOM ROW, FROM LEFT
Hugh Copland, Craig Hart, Dirk Tempelman-Kluit, Trevor Bremner

MIDDLE ROW: *Mike Burke, Tony Smerychynski, Bill LeBarge, Rod Hill, Ali Wagner, Dianne Carruthers, Will vanRanden*

BACK ROW: *Rob Deklerk, Don Murphy, Julie Hunt, Daniéle Hèon, Charlie Roots, Logan Roots, Jay Timmerman. Absent: Karen Pelletier, Diane Emond, Bob Holmes, Grant Abbott*

Part of the push to integration was to raise awareness of the "Yukon Geology Program" outside and inside government. Posters explaining the aims, results and impact of the bedrock, placer and environmental geoscience work were prepared and aired for public view in the spacious foyers of the two government buildings in Whitehorse.

One early product of the new "Yukon Geology Program" is the Minfile CD-ROM. This is a digitally searchable text file of known Yukon mineral occurrences, with thorough descriptions of the geology, mineralization and work history. Rob de Klerk plans to add the digital database and map data to this product.

The "Yukon Geology Program" also supports work by several GSC scientists. Steve Gordey was supported to prepare a synthesis and compilation of Yukon geology. It is planned for release in 1998 as a digital graphics file from which the latest geological mapping down to 1:50,000 scale can be viewed and manipulated. It will provide the starting point for future Yukon bedrock mapping. A coloured paper map at 1:1,000,000 scale is planned as part of this effort. Rob Shives carried out an airborne radiometric and geophysical survey in the southern Ogilvie Mountains to test the effectiveness of the technique for bulk tonnage gold exploration. R. Friske reanalyzed geochemical samples from the same region, for pathfinder elements to Fort Knox, bulk tonnage gold mineralization. A. Duk-Rodkin was supported to study the placer potential, high level terraces and glacial limits near Dawson.

Although EDA funding ended in 1996 the geology program was deemed so valuable and successful that DIAND and the government of Yukon decided to continue it at 50-50 cost share until 1998. The Yukon Geology Program's future depends on devolution of DIAND's Mineral Resources Directorate to the government of Yukon. Linkage of the people and integration of the work at the grass roots level is a key step of goodwill for success in that direction.

Massive Sulphide deposits in the Yukon-Tanana and adjacent Terranes

by Julie A. Hunt, Yukon Geology Program, Indian and Northern Affairs Canada,
with contributions from **M. Baknes,** Equity Engineering Ltd.,
R. Stoshein, YGC Resources Ltd., and **H.J. Keyser,** for Mar-West Resources Ltd.

HUNT, J.A., 1997. Massive Sulphide deposits in the Yukon-Tanana and adjacent Terranes. In: Yukon Exploration and Geology 1996, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 35-45

ABSTRACT

Recent discoveries of at least two types of volcanogenic massive sulphide (VMS) deposits hosted in varying terranes have greatly expanded the mineral potential of the Yukon Territory. Kuroko style deposits at ***Kudz Ze Kayah*** *and* ***Wolverine*** *are hosted by an Early Mississippian felsic metavolcanic and carbonaceous sedimentary package within the Yukon-Tanana Terrane in the Finlayson Lake area. The massive sulphide lenses at* ***Wolverine*** *have spectacular grades and constitute a geological resource, as of November 1996, of 5,311,000 tonnes with 1.81 gpt Au, 359.1 gpt Ag, 1.41% Cu, 1.53% Pb and 12.96% Zn. New discoveries at the* ***Fyre Lake*** *and* ***Ice*** *properties continue to expand the volcanic hosted massive sulphide potential of the Finlayson Lake area.* ***Fyre Lake*** *is a copper-cobalt-gold Besshi-type deposit hosted by chlorite schist. Towards the end of the season DDH 65 at Fyre Lake intersected 31.3 m of 2.29% Cu, 0.53 gpt Au and 0.07% Co. The enigmatic, "Cyprus-type",* ***Ice*** *occurrence has copper-cobalt mineralization in mafic volcanic rocks that are interpreted to belong to the Slide Mountain Terrane. The last hole of the season, DDH IC96-34, intersected 20.56 m of massive pyrite, chalcopyrite and bornite with grades of 5.2% Cu, 0.6 gpt Au, 25 gpt Ag and 0.6% Co. Prior to the discovery of* ***Ice****, volcanic hosted massive sulphide mineralization was unknown in the Slide Mountain Terrane in the Yukon.*

The Yukon-Tanana and Slide Mountain Terranes are not restricted to the Finlayson Lake area but cover a considerable portion of the Yukon Territory. West of Dawson the Yukon-Tanana Terrane contains several exhalite occurrences in the Devono-Mississippian Nasina Assemblage and the Permian Klondike Schist. Devono-Mississippian strata in the Yukon-Tanana Terrane may correlate with similar aged units in the Pelly-Cassiar Platform and Selwyn Basin where there are several massive sulphide occurrences. The Marg Deposit occurs at the northern edge of the Selwyn Basin; the MM, Bnob and Chzerpnough properties are hosted by extension related, pyritic, brecciated, felsic metavolcanic rocks within the Pelly-Cassiar Platform. The Yukon-Tanana Terrane extends westward into the Delta District of Alaska where there are at least 26 stratiform and replacement massive sulphide deposits and occurrences. Strata potentially correlative with the Yukon-Tanana Terrane hosts several volcanogenic massive sulphide deposits and occurrences in northern British Columbia.

RÉSUMÉ

Les récentes découvertes d'au moins deux types de gisements de sulfure massif d'origine volcanique dans divers terranes ont grandement élargi le potentiel minéral du Yukon. Les gisements de style Kuroko de ***Kudz Ze Kayah*** *et de* ***Wolverine*** *reposent dans un ensemble de roches sédimentaires carbonées et métavolcaniques felsiques du Mississippien précoce du terrane de Yukon-Tanana, dans la région du lac Finlayson. Les lentilles de sufure massif de* ***Wolverine*** *présentent des teneurs remarquables et constituent depuis novembre 1996 une ressource géologique de 5 310 000 tonnes titrant 1,81 g/t Au, 359,1 g/t Ag, 1,41 % Cu, 1,53 % Pb et 12,96 % Zn. Les nouvelles découvertes sur les propriétés de* ***Fyre Lake*** *et de* ***Ice*** *viennent grossir le potentiel des sulfures massifs d'origine volcanique de la région du lac Finlayson.* ***Fyre Lake*** *est un gisement de cuivre-cobalt-or de type Besshi logé dans un schiste chloritique. Vers la fin de la campagne, le forage au diamant 65 dans Fyre Lake a recoupé 31,3 m de roche titrant 2,29 % Cu, 0,53 g/t Au et 0,07 % Co. L'énigmatique occurrence* ***Ice****, de type «Cyprus», présente une minéralisation de cuivre et cobalt dans des roches volcaniques mafiques qui appartiendraient au terrane de Slide Mountain. Le dernier trou de forage de la campagne, IC96-34, a recoupé 20,56 m de pyrite, chalcopyrite et bornite massives titrant 5,2 % Cu, 0,6 g/t Au, 25 g/t Ag et 0,6 % Co. Avant la découverte de* ***Ice****, la minéralisation de sulfure massif d'origine volcanique était inconnue dans le terrane de Slide Mountain au Yukon.*

Les terranes de Yukon-Tanana et de Slide Mountain ne sont pas limités à la région du lac Finlayson, mais couvrent une grande partie du Yukon. À l'ouest de Dawson, le terrane de Yukon-Tanana contient plusieurs occurrences d'exhalite dans l'assemblage dévono-mississippien de Nasina et le schiste permien de Klondyke. Les couches dévono-mississippiennes du terrane de Yukon-Tanana pourraient être corrélées avec des unités contemporaines de la plate-forme Pelly-Cassiar et du bassin Selwyn qui renferment plusieurs occurrences de sulfure massif. Le gisement Marg se trouve à la limite septentrionale du bassin Selwyn; les propriétés MM, Bnob et Chzerpnough se trouvent dans des roches métavolcaniques felsiques bréchoïdes pyritiques d'extension de la plate-forme Pelly-Cassiar. Le terrane de Yukon-Tanana s'étend vers l'ouest dans la région du delta, en Alaska, où se trouvent au moins 26 gisements et occurrences de sulfure massif stratiformes et de substitution.

INTRODUCTION

Several high grade copper-zinc-lead massive sulphide deposits have been discovered recently in the Finlayson Lake area. These include Cominco Ltd.'s ABM deposit at Kudz Ze Kayah and the Wolverine project owned by Atna Resources Ltd. and Westmin Resources Limited. These deposits, most notably those at Wolverine Lake, have exceptional gold and silver grades associated with the base metals. New discoveries at Columbia Gold's Fyre Lake and Expatriate's Ice properties continue to expand the volcanic hosted massive sulphide potential of the Finlayson Lake area. Fyre Lake is a copper-cobalt-gold Besshi style deposit hosted by chlorite schists. The enigmatic, "Cyprus-type", Ice occurrence has copper-cobalt mineralization hosted in mafic volcanic rocks interpreted to be Slide Mountain Terrane. Prior to the discovery of Ice, massive sulphide mineralization was unknown in the Slide Mountain Terrane in this area.

The recently discovered massive sulphide deposits in the Finlayson Lake area occur in rocks of the Yukon-Tanana Terrane. This terrane covers a large portion of the Yukon, Alaska and British Columbia and contains favourable stratigraphy in several locations, creating a huge expanse of rocks with the potential to host volcanogenic massive sulphide deposits. Similar, coeval, possibly correlative, rocks are found in the Selwyn Basin and Pelly-Cassiar Platform (Fig. 1).

This paper describes briefly the stratigraphy of the Yukon-Tanana Terrane and some of the volcanic hosted massive sulphide deposits and occurrences. Mineralization in the Finlayson Lake area is addressed first, followed by other areas of the Yukon-Tanana Terrane and finally areas of coeval and potentially correlative strata in the Pelly-Cassiar Platform and Selwyn Basin.

The Yukon-Tanana Terrane and the massive sulphide mineralization hosted within are poorly understood. Until 1994 significant mineral potential was unrecognised in those rocks, consequently few detailed studies were available and the structural and metamorphic overprint of the stratigraphy remains unresolved. In January of 1996 the Yukon Geology Program initiated a project to study volcanic hosted massive sulphide deposits and occurrences within the Yukon-Tanana Terrane and coeval strata. The principal focus of the project is on genesis, metallogeny and host rocks. Research in these areas should enable the characteristics of the mineralization to be defined so that they may be used as pointers in future exploration.

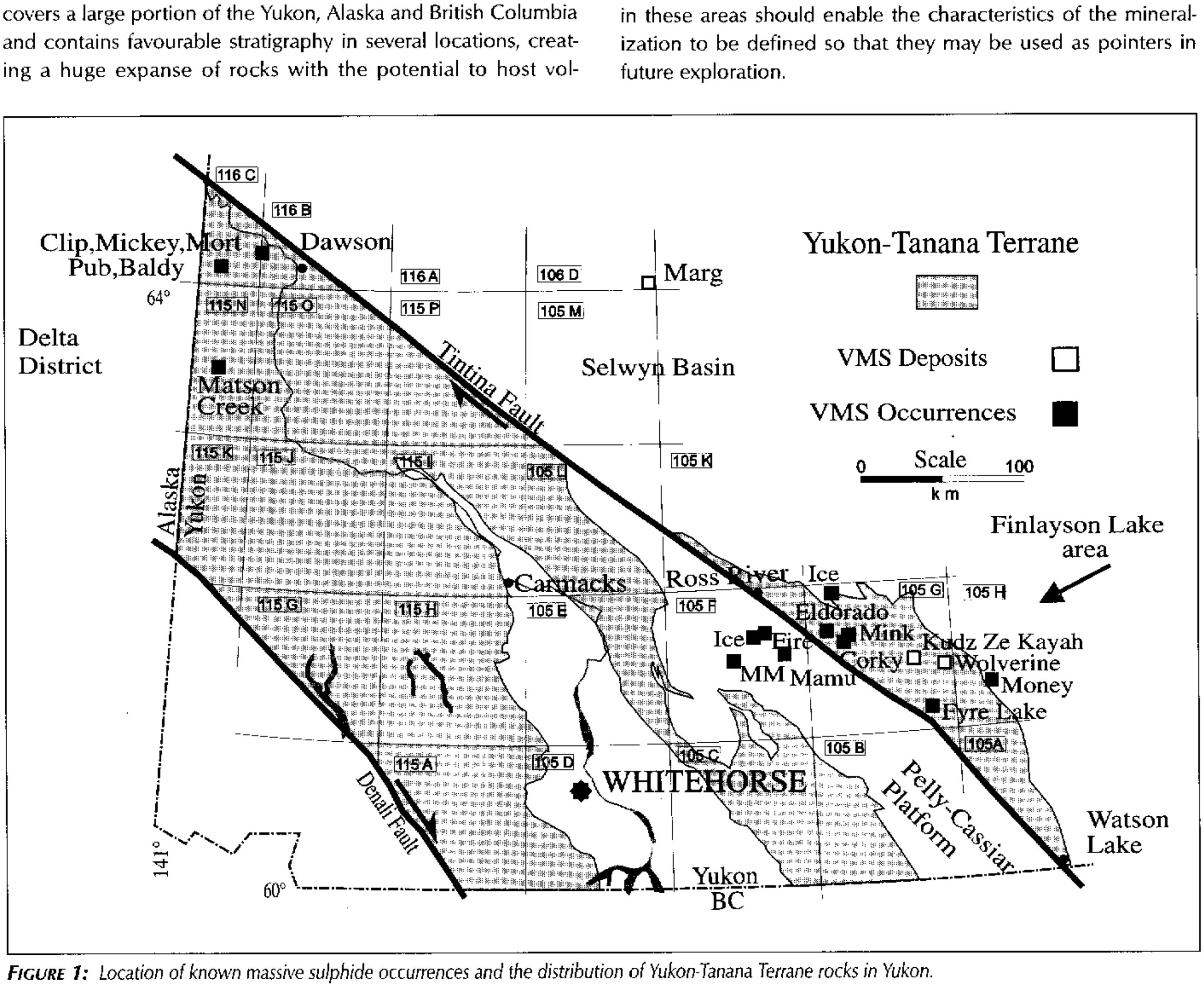


FIGURE 1: Location of known massive sulphide occurrences and the distribution of Yukon-Tanana Terrane rocks in Yukon.

Stratigraphic correlations in the Yukon-Tanana Terrane

In the Dawson area the Yukon-Tanana Terrane is described as being made up of three packages of rocks as follows (Johnston and Mortensen, 1994): 1) a lower package of Proterozoic to Paleozoic age quartzofeldspathic siliclastic rocks and marble known as the NISLING ASSEMBLAGE, inferred to be a continental margin sequence; 2) a middle package of Late Devonian to middle Mississippian age carbonaceous quartzite, quartz mica schist, marble, mafic and felsic meta-volcanic rocks, and lesser amounts of meta-plutonic rocks known as the NASINA ASSEMBLAGE or NISUTLIN SUB-TERRANE which are interpreted as a continental arc sequence; and 3) an upper package of felsic meta-volcanic and meta-plutonic rocks of primarily middle-Permian age that include the KLONDIKE SCHIST and are interpreted as a continental arc sequence or an anorogenic magmatic suite.

The massive sulphide occurrences there are hosted by the Nasina Assemblage and the Klondike Schist.

In the Finlayson Lake area, in southeastern Yukon, Mortensen and Jilson (1985) divided the Yukon-Tanana Terrane into the Layered Metamorphic Sequence with Lower, Middle and Upper Units. The Lower Unit consists of pre Late Devonian micaceous quartzite and minor marble (equivalent, at least in part to the Nisling Assemblage; Mortensen, 1992). The Middle Unit comprises Late Devonian to mid Mississippian interlayered mafic and minor felsic metavolcanic rocks, carbonaceous metasediments and "quartzeye" grits (equivalent, at least in part to the Nasina Assemblage), this unit hosts the massive sulphide mineralization at Kudz Ze Kayah and Wolverine. The Upper Unit contains Early Pennsylvannian to Early Permian massive carbonate and quartzite.

Figure 2 shows correlations for the Finlayson Lake area as defined by Tempelman-Kluit (1996).

The Grass Lakes map area (105G/7), near Kudz Ze Kayah, was studied by Murphy and Timmerman (1997, this volume) who identified stratigraphy equivalent to Mortensen and Jilson's (1985) Middle and Lower Units as shown below. The upper unit hosts the ABM deposit at Kudz Ze Kayah.

Murphy and Timmerman (1997, this vol.)	Mortensen and Jilson (1985)
upper unit	Middle Unit
middle unit	Middle Unit
lower unit	Lower Unit - upper part

Massive sulphide Occurrences - within Yukon-Tanana Terrane

1) Finlayson Lake Area

Known massive sulphide mineralization in the Finlayson Lake area occurs in Devono-Mississippian age meta-volcanic and meta-sedimentary rocks of the Middle Unit of the Layered Metamorphic Sequence (Mortensen and Jilson, 1985), which is believed to correlate with the Nasina Assemblage of the Yukon-Tanana Terrane.

Kudz Ze Kayah

The ABM deposit at Kudz Ze Kayah (Yukon Minfile 105G 117; 61°28'N, 130°36'W) is located within the Pelly Mountains about 200 km northwest of Watson Lake (Fig. 1). The deposit lies in an area with high soil geochemistry, polymetallic sulphide float, felsic volcanic rocks and an EM anomaly. To date there is a geological resource of 13 mt of 5.5% Zn, 1% Cu, 1.3% Pb, 125 gpt Ag and 1.2 gpt Au which includes an open pit mineable ore reserve of 11 mt with 5.9% Zn, 0.9% Cu, 1.5 % Pb, 130 gpt Ag and 1.3 gpt Au (Schultze, 1996).

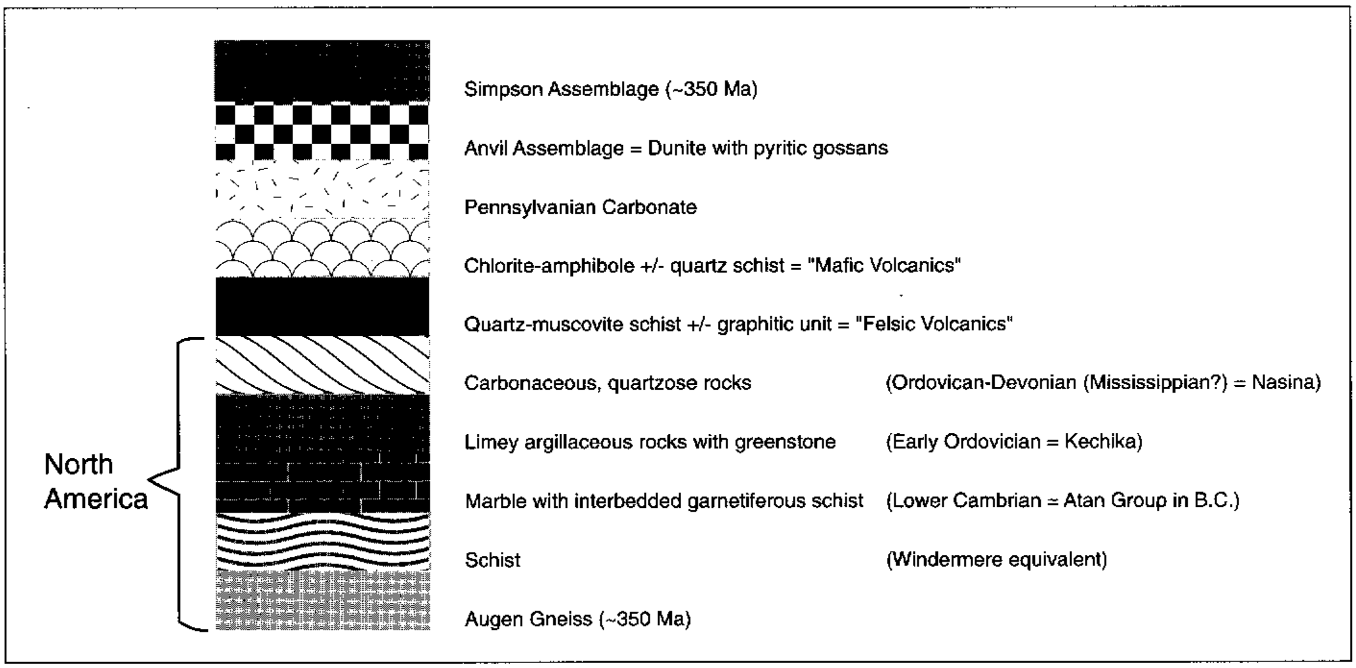


Figure 2: *Finlayson Lake area stratigraphy. Correlations defined by Tempelman-Kluit (1996)*

The ABM deposit is hosted by a thick complex of felsic tuffs and sills or flows interlayered with minor mafic sills or flows and sedimentary rocks (Schultz, 1996a). The strata exhibit isoclinal recumbent folding with bedding generally sub-parallel to schistosity (Schultze, 1996b; Murphy and Timmerman, 1997, this volume). The deposit parallels the F1 fold limbs, has been thickened by F2 and imbricated by F3 (Schultze, 1996b). Metal and barium zonation within the deposit and the position of chloritic alteration above the deposit suggest that it has, at least in part, been overturned by folding (Schultze, 1996a). The sulphide layer ranges in thickness from less than 2 m to 39m. Ore types at the ABM deposit include: magnetite laminated, wispy laminated and chalcopyrite net texture (Schultze, 1996b).

In general the stratigraphy at Kudz Ze Kayah is similar to that at the Wolverine deposit except that Kudz Ze Kayah has no iron formation marker horizon (Fig. 3). Although it is tempting to correlate the two areas, at present there is insufficient data to justify this correlation. For more information on the stratigraphy and structure in this area see Murphy and Timmerman (1997, this volume).

Wolverine

The Wolverine project area (Yukon Minfile 105G 72; 61°25′37″N, 130°07′56″W) is located in the Pelly Mountains on the east side of Wolverine Lake about 20 km east of Kudz Ze Kayah (Fig. 1). The Wolverine deposit is hosted by Devono-Mississippian carbonaceous metasediments and metavolcanic rocks similar to those at the Kudz Ze Kayah deposit (Tucker et al., 1997, this volume). Mineralization at Wolverine lies between graphitic phyllite in the footwall and andesite in the hanging wall, beneath magnetite iron formation which acts as a marker horizon. A more detailed description of deposit geology and mineralization is in Tucker et al. (1997, this volume).

Money (M. Baknes, Equity Engineering Ltd.)

The 46 Money claims (Yukon Minfile 105H 78; 61°24′57″N, 129°58′44″W) are located 140 km southeast of Ross River, about 5 km east of the Wolverine deposit within a package of pillowed basaltic volcanic rocks of uncertain affinity belonging either to the Devono-Mississippian Yukon-Tanana Terrane or the upper Paleozoic Slide Mountain Terrane. Pillowed mafic volcanic rocks

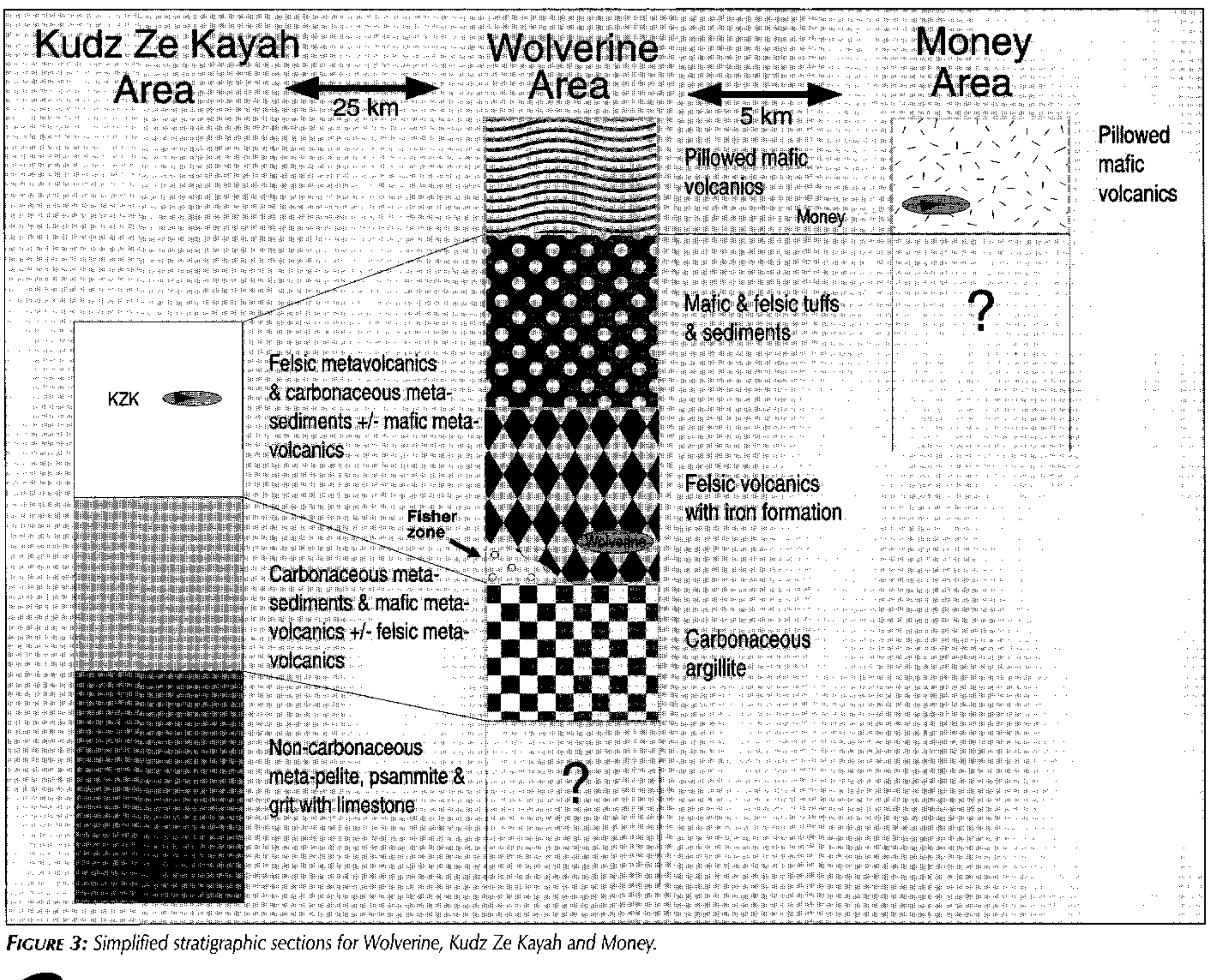


***FIGURE 3:** Simplified stratigraphic sections for Wolverine, Kudz Ze Kayah and Money.*

are characteristic of the Slide Mountain Terrane at the Ice prospect 90 km to the northwest of the Money occurrence. The Money mineralization, primarily copper and zinc with lesser gold and silver, represents a Besshi- or Cyprus-type volcanogenic massive sulphide occurrence.

The Money mineralization lies within a thick sequence of pillowed basalts intercalated with discrete fine to medium grained sedimentary sequences. Massive sulphide mineralization is exposed in two drainages, Welcome North and Boulder Creek (Fig. 4). In Welcome North Creek massive pyrite with a siliceous matrix is exposed in boulder float and in a trench where true thickness approaches 2 m; chip sampling returned results of 0.17% Cu and 35 gpt Ag, a grab sample returned 0.5 gpt Au. In Boulder Creek massive pyritic sulphides comprise large float boulders in the creek bottom. Surface results returned assays of 1.1% Cu, 31.9 gpt Ag and 0.22 gpt Au. The best drill result down dip of the surface

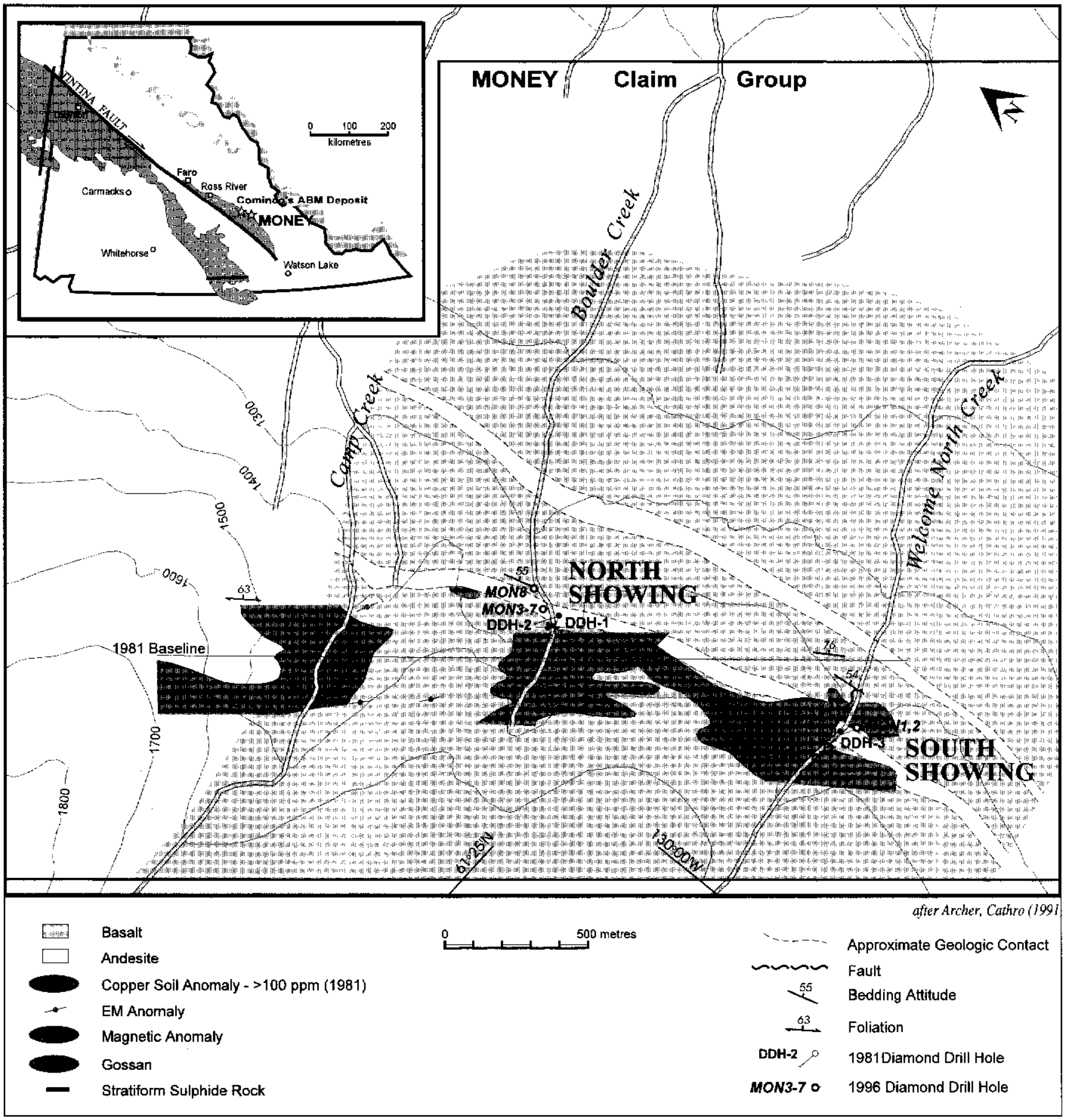


Figure 4: *The Money Property*

showing returned 1.2 m of 0.62% Cu, 0.15% Zn, 32 gpt Ag and 0.7 gpt Au.

Drill holes on Boulder and Welcome North Creeks have similar stratigraphic successions that from top to bottom include: 1) dark green massive pillow basalt; 2) pillow breccia with maroon mudstone matrix; 3) maroon cherts and mudstones; 4) pale greyish green and pink tuffaceous and fragmental (exhalitive?) chert; 5) maroon shale; 6) massive banded and siliceous pyritic sulphides; 7) quartz-sericite-pyrite altered pillow basalt and basalt tuff (not always present); and 8) monotonous dark green to locally maroon pillow basalt and basalt tuff-breccia. The similar successions and mapping over the poorly exposed intervening area between the Boulder and Welcome North Creek showings indicate that the massive sulphides on the two separate drainages lie within the same stratigraphic interval marked by maroon and oxidized fine-grained sediments. There are two other sedimentary intervals about 200 m up and down section from the mineralized horizon, but neither appears to be mineralized. Several weakly copper mineralized quartz-sericite+/-chlorite gossanous zones occur on the property. These are thought to represent footwall stockwork zones (interval 7 above) like those often associated and proximal to massive sulphides in Cyprus-type VMS deposits.

The meta-sedimentary units have a general attitude of 155° dipping 50° to 65° east. Deformation occurs as moderately developed, heterogeneous schistosity formed along pillow selvages and strong schistosity within the altered stockwork zones. Folding is not evident, but local strike slip faults, trending parallel to stratigraphy, are noted on surface and expressed as EM conductors.

Information from drill holes defines a tabular massive sulphide layer with a down-dip length of at least 130 m, a strike length greater than 53 m and an average thickness of 1.0 m. Drilling indicates a continuity of the surface sulphide mineralization in Boulder Creek down dip and along strike. Drilling on Welcome North Creek was inconclusive.

Fyre Lake

The Fyre Lake deposit (Yukon Minfile 105G 34; 61°14'N, 130°30'W) is located on the east side of Fire Lake about 30 km southwest of the Wolverine deposit (Fig. 1). The Fyre Lake occurrence is similar to Money, but the strata have undergone greater deformation and metamorphism and the host rock is mainly chlorite schist. Mineralization consists of several zones of massive pyrite-pyrrhotite with lesser chalcopyrite and sphalerite. Ferricrete is formed in nearby creeks and massive quartz-pyrite boulders are found as float. Latest results from the Fyre Lake property indicate the discovery of a new zone with high grade copper (Blanchflower et al., 1997, this volume).

Copper-cobalt-gold mineralization at the Kona zone is hosted by deformed and metamorphosed chlorite and quartz-chlorite schist, interpreted to be basic to intermediate flows, with interlayered tuffs and fine grained sediments of the lower unit of the layered metamorphic sequence. Mineralization at the Kona zone consists of at least three distinct horizons of massive to semi-massive sulphide and magnetite with a combined thickness of 70 to 80 m. A more detailed description of property geology and mineralization can be found in Blanchflower et al. (1997, this volume).

Ice

The Ice property (61°53'N, 131°25W) is located north of the Campbell Highway about 60 km east of Ross River in an area of subdued topography with limited outcrop (Fig.1). Mineralization at the Ice property is hosted by pillowed, massive and brecciated mafic volcanic rocks interlayered with chert (Eaton, 1996). These rocks were initially mapped as part of the Anvil Allochthon (Tempelman-Kluit, 1977) but are now interpreted to belong to the Slide Mountain Terrane (Monger et al., 1991, p. 284). Prior to the discovery of Ice, volcanic hosted massive sulphide mineralization was unknown in the Slide Mountain Terrane in the Yukon.

The Ice property was first identified by a single 2000 ppm Cu soil geochemical anomaly (Eaton, 1996). Gossans occur locally with limonitic boxwork (Eaton, 1996; Pigage 1996). Ground geophysics was able to separate basalt and chert horizons (Pigage, 1996). Diamond drilling has revealed three types of mineralization: 1) fracture controlled supergene copper minerals such as malachite, cuprite and native copper; 2) disseminated pyrite in specular hematite with minor chalcocite and 3) pyrite - chalcopyrite - bornite massive sulphide (Pigage, 1996). The pyrite-hematite mineralization is locally bedded and up to 5 m thick (Pigage, 1996). The last hole of the season, DDH IC96-34, intersected 20.56m of massive pyrite, chalcopyrite and bornite with grades of 5.2% Cu, 0.6 gpt Au, 25 gpt Ag and 0.06% Co (Eaton, 1996; Pigage, 1996). The host rock and copper-cobalt mineralization suggest this is a Cyprus-type VMS deposit (GCNL, 1996 No. 231).

Eldorado (H. J. Keyser for Mar-West Resources Ltd.)

The Eldorado property (Yukon Minfile 105G 48; 61°43'N, 131°46'W) is located on the west side of the Hoole River about 70 km northwest of Kudz Ze Kayah (Fig. 1). Bedrock, which is exposed only along the banks of the Hoole River and Hoolio Creek, consists of variably deformed, altered and metamorphosed black shale, argillite and phyllite of the Yukon-Tanana Terrane. Mineralization consists of thin quartz-arsenopyrite lenses hosted by calcareous phyllite, stringers of pyrrhotite and pyrite in graphitic phyllite along the Hoole River and a narrow massive sulphide zone (GCNL,1996 No 132; Mar-West Resources Ltd., 1996). This zone was intersected in DDH 96-04 and consists of 0.30 m of arsenopyrite-pyrite-sphalerite. Hanging wall rocks, in sharp contact with the massive sulphide zone, consist of graphitic shale interbedded with minor dacitic tuff. Green sericitic volcaniclastic sedimentary footwall rocks are in gradational contact with the sulphide mineralization, which is reported to be similar in style to that at Kudz Ze Kayah and Wolverine (GCNL, 1996 No. 132).

Corky and Mink (R. Stroshein, YGC Resources Ltd.)

The Corky and Mink claims (Yukon Minfile 105G 15 and 77; 61°33'34"N, 131°28'15"W and 61°39'15"N, 131°16'42"W respectively) are located in an area of subdued topography with limited outcrop south of the Campbell Highway about 40 km northwest of Kudz Ze Kayah (Fig. 1). The claims, which were staked over EM conductors located in a 1974 airborne geophysical survey (Morin et al., 1977), are underlain by shallow dipping interbedded meta-volcanic and meta-sedimentary rocks of the Devono-Mississippian Nasina Assemblage, likely correlatable to those at Kudz Ze Kayah and Wolverine. The Nasina Assemblage rocks consist of well foliated phyllite and schist. On the properties, calcareous phyllite and chlorite phyllite overlie carbonaceous to graphitic siliceous argillite/phyllite, dolomite, and lower most quartz-sericite schist. In the southwest corner of the Corky Claim block Early Pennsylvanian to Early Permian white carbonate constitutes the uppermost unit of the stratigraphic section.

The Nasina Assemblage stratigraphy is well exposed on the north slope of the Corky Claim block. Stratigraphic horizons have been traced along strike for up to five kilometers. Disseminated sulphide mineralization overlying a strongly chloritized schist, coincides with a HLEM conductor, and soil samples with anomalous gold-copper values.

Geochemical sampling on the claims produced contrasting values in base and precious metals (maximum values of 157 ppb Au, 1.9 ppm Ag, 338 ppm Cu, 1060 ppm Zn, and 74 ppm Pb) as well as diagnostic bedrock mineral indicators (ie. Mg for chloritic rich phyllite or chlorite schist). The results indicate that soil sampling is a useful tool for mapping and locating potential sulphide mineralization in this area.

On the Mink West Claims, a drill hole from 1976 intersected 1.5 m of sphalerite-galena stringer mineralization which yielded 2.04% Zn and 0.60% Pb in a schistose carbonate horizon interbedded with carbonaceous metasedimentary rocks. The carbonaceous horizons on the Mink West claims are anomalous in zinc with values of up to 1700 ppm. A thin band of semi-massive pyrite on the Mink East claim block assayed 600 ppm Cu and 332 ppm Pb within calcareous quartz-sericite schist.

2) Yukon-Tanana Terrane West Of Dawson

Restoration of the postulated 450 km of right lateral post mid Cretaceous movement on the Tintina Fault brings the massive sulphide-rich Finlayson area of the Yukon-Tanana Terrane opposite to the Yukon-Tanana Terrane west of Dawson (Fig. 5). Yukon-Tanana strata in west central Yukon host several "exhalite showings" suggesting the presence of VHMS deposits similar to those in the Finlayson Lake area (Fig. 5).

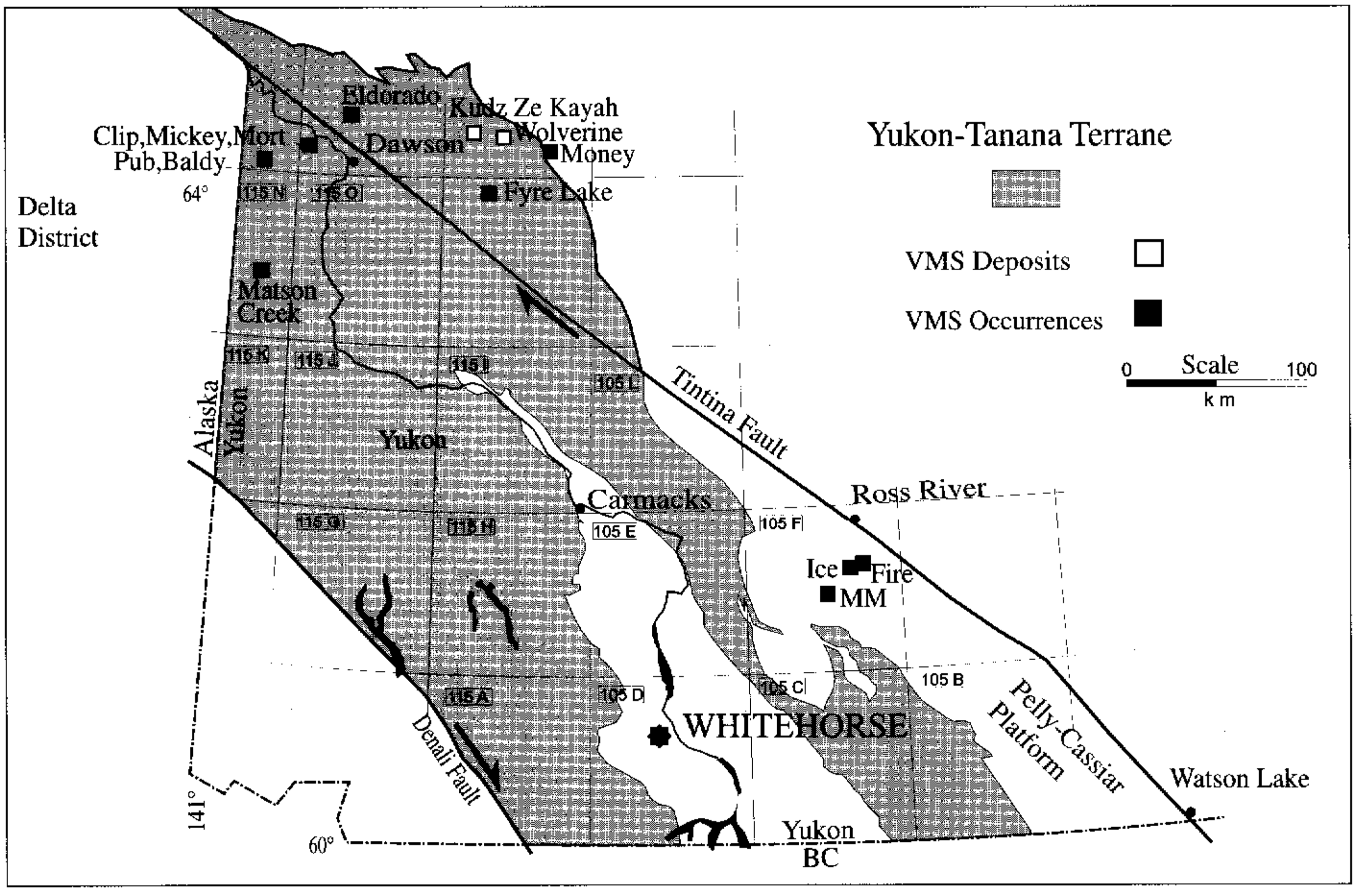


FIGURE 5: Restoration of 450 km of right-lateral movement on the Tintina Trench brings the Finlayson Lake area to a location northeast of Dawson.

Matson Creek, Baldy and Pub

Mineralization at the Matson Creek (Yukon Minfile 115N 100; 63°31'22" N, 140°26'23" W), Baldy (Yukon Minfile 116C 133; 64°06'10" N, 140°59'01" W) and Pub (Yukon Minfile 116C 112; 64°07'10" N, 140°52'28" W) properties occurs in a belt of Permian, recessive weathering, pyritic intercalated meta-volcanic and meta-sedimentary rocks comprising the Klondike Schist which forms the uppermost unit of the Yukon-Tanana Terrane (Johnston and Mortensen, 1994). Surface mineralization at Matson Creek occurs as boxwork textured strongly oxidized gossanous fragments. Coincident lead, zinc and copper geochemical anomalies suggest sulphide mineralization occurs at depth (Ocean Home Exploration Co. Ltd., 1978). Disseminated sphalerite, chalcopyrite, galena and minor pyrite occur in the slumped bank of a creek on the Baldy property. The sulphides occur along the foliation planes; a sample collected in 1991 returned 3.43% Pb, 8.09% Zn, 0.20% Cu, 41.0 gpt Ag and 195 ppb Au (A-C, 1993). On the Pub Claims leached pyrite-sphalerite-chalcopyrite laminations occur in schistose metavolcanic rocks and disseminated sphalerite, galena, chalcopyrite and pyrite were found in siliceous schist at the contact between chloritic and sericitic layers (Ocean Home Exploration Co. Ltd., 1978).

Clip, Mickey and Mort

The Clip (Yukon Minfile 116C 115; 64°13'52" N, 140°23'45" W), Mickey (Yukon Minfile 116C 116; 64°19'43" N; 140°29'03" W) and Mort (Yukon Minfile 116C 168; 64°17'00" N, 140° 25'00" W) occurrences are hosted by rocks of the Devono-Mississippian Nasina Assemblage, which make up the middle unit of the Yukon-Tanana Terrane. At the Mort prospect several thin concordant bands of galena and oxidized sphalerite occur in a 1-2 m thick layer of quartz-muscovite phyllite exposed in a roadcut. Vuggy gossanous rocks with oxidized sphalerite, bands of galena, and disseminated pyrite occur on the Mickey Claims. Bands and stringers of galena in quartzite plus thin, stratiform bands of sphalerite, barite and pyrite hosted by micaceous quartzite occur at the Clip prospect.

3) Delta District

There are at least 35 massive sulphide occurrences in the Delta District of Alaska. These consist of layers and zones with varying amounts of massive to disseminated pyrite and pyrrhotite, and lesser amounts of chalcopyrite, galena, sphalerite and arsenopyrite hosted by Late Devonian rocks of the Yukon-Tanana Terrane which may be equivalent to those in the Finlayson Lake area (Lange et al., 1993).

Most VMS occurrences in the Delta District are hosted by felsic metavolcaniclastic units located within the Delta schist belt (Newberry et al., 1996). This includes the largest deposit in the Delta District, the DW-LP, which comprises a single massive sulphide sheet 1.8 x 2.5 km in area and 0.12 to 12 m thick. The DW-LP is hosted by pervasively sericite-chlorite-ankerite-pyrite altered metavolcaniclastic schist near the contact between overlying metadacite and underlying calc-schist (Newberry et al., 1996). Zones of intense silicification up to 3 m thick border a sericite-quartz-pyrite schist that envelopes the massive sulphide layer. Hanging wall rocks to the sulphide horizon are quartz-sericite mylonitic schists. Footwall rocks are strongly sulphidized chloritic schists, forming a 15 to 30 m thick contact zone above a footwall metagabbro sill (Newberry et al., 1996).

Vertical metal zonation is well developed at the DW-LP and there is a progressive increase in Cu/(Cu+Pb) and Cu/(Cu+Zn) ratios towards the base (Newberry et al., 1996). Silver is commonly higher in the upper parts of the deposit, concomitant with increased Pb and Zn. Higher gold values occur within intensely chlorite-altered footwall schists. The massive sulphide exhibits a wide range of textures with mineral banding being the most common. The principal gangue minerals are chlorite, quartz and carbonate. The dominant sulphides are pyrite, pyrrhotite, chalcopyrite, sphalerite and galena. Gold is associated with chalcopyrite and pyrite (Newberry et al., 1996).

4) British Columbia

Strata potentially correlative to the Yukon-Tanana Terrane occur in northern British Columbia where several volcanogenic massive sulphide deposit and occurrences are known.

Massive sulphide Occurrences - in coeval strata, potentially correlative to the Yukon-Tanana Terrane

Strata coeval, and possibly correlative, to the Yukon-Tanana Terrane occur in the Pelly-Cassiar Platform and the Selwyn Basin (Fig. 1).

1) Pelly-Cassiar Platform

Intercalated with Devono-Mississippian shales on the Pelly-Cassiar Platform are locally voluminous volcanic rocks of intermediate and felsic composition. The volcanic rocks which are up to 600 m thick, but generally less than 100 m, occur in a belt 80 km long and up to 25 km wide (Morin, 1977). These rocks are predominantly submarine lapilli tuffs and breccias capped throughout much of the Pelly Mountains by a laterally persistent tuffaceous and argillaceous chert unit about 100 m thick (Mortensen and Godwin, 1982). This in turn is overlain by carbonaceous shale. The lower portions of the volcanic section are intruded by high-level syenite domes and stocks considered to be the subvolcanic equivalents of some of the felsic tuffs and flows (Mortensen and Godwin, 1982). Rb-Sr geochronology indicates a mid-Mississippian age for the igneous suite (Mortensen and Godwin, 1982). Trace element data indicate that the rocks are metaluminous trachytes, most closely resembling peralkaline volcanics generated in extensional environments (Mortensen and Godwin, 1982).

The strata-bound, stratiform Zn-Pb-Ba showings associated with the Mississippian volcanic rocks share the following features with the Kuroko deposits of Japan (Mortensen and Godwin, 1982): 1) they form on or near small felsic domes or plugs; 2) they occur within sequences of felsic and intermediate volcanic rocks, generally in the latter part of an explosive felsic eruptive event; 3) the metal values are typically Zn>Pb>Cu>Ag; and 4) barite forms massive to bedded sucrosic deposits distal to the main base metal deposit.

In the mid 1970's exploration of the MM prospect sparked interest in this sequence of Mississippian felsic volcanic rocks as a potential host for stratabound VHMS mineralization. The MM showing occurs in a pyritic quartzite bed between intermediate and felsic metavolcanic rocks. The Bnob (Ice) and Chzerpnough (Fire) claims, owned by Eagle Plains Resources, cover two other stratabound showings, each consisting of barite units within which layered galena, sphalerite and pyrite occur. The barite horizons at these two showings may be correlative with those at MM.

MM

The MM (Yukon Minfile 105F 012; 61°25′ N, 132°40′ W; Fig.1) prospect occurs within a package of predominantly volcanic rocks about 200 m thick that is over- and underlain by carbonaceous pelitic sediments (Morin, 1977; Mortensen and Godwin, 1982). The following description is summarized from Mortensen and Godwin (1982). The volcanic sequence has been traced laterally into a massive trachyte dome flanked by coarse volcanic breccia. Sulphides occur as narrow lenses in the middle and upper parts of the volcanic sequence. The largest of these, measuring 2 m in thickness, was intersected by drill hole 77-03. The lens lies immediately above the trachyte dome and consists primarily of pyrite and pyrrhotite with lesser galena, sphalerite, chalcopyrite and quartz. The massive trachyte that underlies the lens is strongly fractured and veined by quartz, chlorite, pyrite, and chalcopyrite stringers. About 12 m of this stringer style mineralization was intersected beneath the main massive sulphide lens and is believed to represent part of the vent zone.

Small sulphide lenses are present throughout more than 75 m of the section above the main lens and are persistent laterally as discontinuous bodies up to 3 m thick for over 3 km east of the dome at approximately the same stratigraphic level. These bodies become increasingly baritic and pyritic in this direction, generally consisting of massive, poorly banded sucrosic barite and pyrite with minor disseminated sphalerite and galena.

Chzerpnough (Fire)

The Chzerpnough (Fire) (Yukon Minfile 105F 071; 61°36′ N; 132°26′ W) claims are underlain by acid volcanic breccias of Mississippian age (Mortensen, 1982). The breccias vary from tuffs to coarse agglomerates. Good ouctcrops are rare and in general the volcanics weather into piles of blocky felsenmeer. The most common rock unit, hosting all the known showings, is lapilli tuff with abundant carbonate in the matrix. Float of disseminated sphalerite, galena and fluorite and sugary sedimentary barite have been discovered on the claims. Large and complex geochemical anomalies are partly coincident with the known showings, but are more extensive (Cyprus Anvil Mining Corporation Limited, 1976,1977).

Bnob (Ice)

The Bnob (Ice) (Yukon Minfile 105F 073; 61°35′ N; 61°35′ N) claims are underlain by strongly pyritic acid volcanic breccias with barite and Pb and Zn geochemical anomalies. A 30 m long by 5 m wide outcrop of bedded (laminated ?) sucrosic, white to pale grey barite with minor disseminated pyrite and lesser galena occurs on top of the ridge. The barite dips moderately to the west and is overlain by schistose, feldspar-bearing, felsic tuff which is in turn overlain by grey, fine grained, siliceous tuff with up to 10% pyrite. Overlying the tuff is a weakly foliated, feldspar-phyric volcanic flow (intrusive ?). The contact between the underlying tuff and the flow is strongly silicified and oxidized, weathering to a bright rusty orange. A second barite horizon is suggested by barite float boulders in a small hand-dug pit about 15 m east of the barite outcrop. Barite with bands of galena-sphalerite is reported to occur lower down in the valley, near the McConnell River.

Mamu

The Mamu (Yukon Minfile 105F 13; 61°30′ N; 132°30′ W) property covers a package of Mississippian volcanic and sedimentary rocks intruded by a Mississippian intrusive complex of syenite, monzonite, quartz monzonite, diorite and gabbro. The following description is summarized from AGCI (1996). The volcanic-sedimentary package is comprised of intermediate volcanics, felsic volcanics, argillite and phyllite . Pyritic chert or pyritic cherty rhyolite is thought to represent exhalite horizons . Mineralization consists of disseminated pyrite in exhalite horizons, massive bedded pyrite and quartz veins and quartz breccias containing pyrite +/- sphalerite, tetrahedrite, galena and chalcopyrite . The main showing consists of a stratigraphic horizon of 1.0-1.8 m thick massive pyrite.

The volcanic and sedimentary rocks are variably altered. Most alteration consists of a phyllic assemblage of quartz-sericite-carbonate-pyrite . Locally secondary biotite or chlorite are present in significant amounts. Ankerite, fluorite and tremolite-actinolite are reported from mapping and petrographic reports. Most sulphides have been oxidized to limonite and other iron oxides . More detailed information on this prospect can be found in Dougherty (1997, this volume).

2) Selwyn Basin

Marg

The Marg (Yukon Minfile 106D 009; 64o01′ N; 134o28′ W) deposit lies within interbedded Early Mississippian carbonaceous metachert and schist in a 4 km long fault repetition or recumbent infold within a thrust panel (Turner and Abbott, 1990; Figure 1). This sequence is overlain by massive quartzite and is in fault contact with a similar underlying quartzite (Turner and Abbott, 1990). Locally the sulphide body overlies a sequence of schists at least 30 m thick and is overlain by at least 200 m of dominantly black phyllite and carbonaceous pyritic metachert. This stratigraphy suggests that sulphide deposition coincided with waning of volcanic activity within an anoxic deep marine basin dominated by hemipelagic and pelagic deposition of muds, biogenic silica and organic matter (Turner and Abbott, 1990).

Mineralization consists of relatively continuous, tabular, massive sulphide horizons at four stratigraphic intervals plus a number of smaller sulphide lenses located between them. The horizons are subparallel, strike approximately east-west and dip 50o south (Carne and Gish, 1996). They are up to 23 m thick, averaging about 5 m. Mineralization has been traced along strike for 1500 m by drilling.

The sulphide body is composed of fine-grained pyrite, quartz and ferroan carbonates, lesser sphalerite, chalcopyrite and galena, and minor tetrahedrite and arsenopyrite. Pyrite is the dominant sulphide and comprises up to 90% of the sulphide body. In the eastern portion of the deposit the sulphide body can be divided into three facies based on the proportions of the dominant minerals pyrite, quartz and ferroan carbonate (Turner and Abbott, 1990). A central core of carbonate-rich semi-massive pyrite (pyrite-carbonate facies) is surrounded by a transitional envelope of semi-massive quartz-rich pyrite (pyrite-quartz facies) and distal massive pyrite (pyrite facies). Non-sulphide gangue is primarily quartz with lesser iron-carbonate, sericite and barite.

Drill indicated reserves at the Marg are 5,527,002 tonnes averaging 1.76% Cu, 2.46% Pb, 4.60% Zn, 62.7 gpt Ag and 1.0 gpt Au (NDU News release, 13/01/97).

Conclusions

The Finlayson Lake area in southeastern Yukon hosts VMS mineralization in Devono-Mississippian strata correlated with the Nasina Assemblage of the Yukon-Tanana Terrane. This area contains Kuroko (Kudz Ze Kayah and Wolverine), Besshi (Fyre Lake and Money ?) and Cyprus (Ice ?) type mineralization. The discovery of the Ice heightens the potential of the Slide Mountain Terrane to host similar VMS deposits.

Within the Finlayson Lake area the ABM deposit at Kudz Ze Kayah and the mineralization at Wolverine are hosted by similar, possibly correlative strata. Massive sulphide mineralization at Money is hosted by mafic pillowed volcanic rocks that overlie the Wolverine sequence.

Restoration of 450 km of right-lateral movement on the Tintina Fault brings the Finlayson Lake area to a location southeast of Dawson suggesting that strata in west central Yukon have similarities to those in the Finlayson area and are therefore prospective for massive sulphide mineralization.

Within the Yukon-Tanana Terrane are two time horizons with the potential to host massive sulphide mineralization: the Devono-Mississippian Nasina Assemblage, which is host to mineralization in the Finlayson and Dawson areas; and the Permian Klondike Schist which contains several exhalative mineral occurrences in west central Yukon.

Strata potentially correlative to those of the Yukon-Tanana Terrane occur in the Pelly-Cassiar Platform and Selwyn Basin where several VMS occurrences are known.

ACKNOWLEDGMENTS

Thanks and appreciation are extended to the following companies and individuals for their cooperation and support during the 1996 field season: Archer, Cathro and Associates (1981) Limited, NDU Resources Ltd., Expatriate Resources Ltd., Mar West Resources Ltd., Atna Resources Ltd., Westmin Resources Limited, Columbia Gold Mines Ltd., YGC Resources Ltd., Eagle Plains Resources, Equity Engineering Ltd., Aurum Geological Consultants Inc., Anvil Range Mining Corporation, American Copper and Nickel Company Inc.; Mark Baknes, Frank Gish, Lee Pigage, Dirk Tempelman-Kluit, Robert Stroshein, Tom Becker, Gill McDougall, John Deighton, Doug Blanchflower, Brian Thurston, Ian Foreman, Harman Keyser, Don Murphy, Kate Bull, Jim Mortensen, Chris Schultze, Dick Arndt, Doug Brownlee, John Flemming, Paul Lhotka, Terry Tucker; and John Witham for awesome flying, Mat the engineer for sharing the hanger and Will Zantvoort for helpful and enthusiastic field assistance.

REFERENCES

Archer, Cathro and Associates (1981) Limited, 1993. Summary report on 1992 exploration, BAL and PUB Claims, Dawson Mining District. Assessment Report 093098 written by R.C. Carne for YGC Resources Ltd.

Aurum Geological Consultants Inc., 1996. The Mamu property. Assessment Report 093411 written by R.A. Dougherty for Oro Bravo.

Blanchflower, D., Deighton, J. and Foreman, I., 1997. The Fyre Lake deposit: a new VMS discovery. In: Yukon Exploration and Geology, 1996; Yukon Geology Program, this volume.

Carne, R.C. and Gish, F., 1996. The Marg Property. Talk given at the Geoscience Forum, Whitehorse, Yukon Territory, November 26, 1996.

Columbia Gold Mines Ltd., 1996. High grade mineralization hit in southerly step-outs. News Release # 96-14, October 24, 1996.

**Cyprus Anvil Mining Corporation Limited, 1976. Geochemical report, CHZERPNOUGH Claim Group. Assessment Report 090173 written by P. Dean.

**Cyprus Anvil Mining Corporation Limited, 1977. Geological and geophysical report, CHZERPNOUGH Claim Group. Assessment Report 061628 written by P. Dean.

Eaton, D., 1996. The Ice Property. Talk given at the Geological Association of Canada volcanogenic massive sulphide deposits workshop held at Simon Fraser University downtown campus, Vancouver, British Columbia , November 14, 1996.

George Cross News Letter, 1996. Expatriate Resources Ltd. Ice project drill results reviewed. No. 231, November 29, p. 1, published by George Cross News Letter Ltd.

Johnston, S.T. and Mortensen, J.K., 1994. Regional setting of porphyry Cu-Mo deposits and volcanogenic massive sulphide deposit, and mesothermal gold deposits in the Yukon-Tanana Terrane, Yukon. In: J.L. Jambor (editor), Abstracts and Proceedings of the district 6 Canadian Institute of Mining 1994 Annual General Meeting, p. 30-34.

Lange, I.M., Nokelberg, W.J., Newkirk, S.R., Aleinikoff, J.N, Church, S.E. and Krouse, H.R., 1993. Devonian volcanogenic massive sulfide deposits and occurrences, southern Yukon-Tanana Terrane, eastern Alaska Range, Alaska. Economic Geology, vol. 88, p. 344-376.

Marwest Resources Ltd., 1996. Report on the 1996 diamond drilling program on the Eldorado Property. Assessment Report written by H.J. Keyser.

Monger, J.W.H., Wheeler, J.O., Tipper, H.W., Gabrielse, H., Harms, T, Struik, L.C., Campbell, R.B., Dodds, C.J., Gehrels, G.E. and O'Brien, J., 1991. Part B. Cordilleran terranes. In: Upper Devonian to Middle Jurassic assemblages, Chapter 8 of Geology of the Cordilleran Orogen in Canada, (eds.) H. Gabrielse and C.J. Yorath. Geological Survey of Canada, Geology of Canada, no. 4, p. 281-327.

Morin, J.A., 1977. Ag-Pb-Zn mineralization in the MM deposit and associated Mississippian felsic volcanic rocks in the St. Cyr Range, Pelly Mountains. In: Mineral Industry Report, 1976, Yukon Territory. EGS 1977-1, p. 83-97.

Morin, J.A., Sinclair, W.D., Craig, D.B. and Marchand, M., 1977. Mineral Industry Report, 1976, Yukon Territory. EGS 1977-1, p. 205.

Mortensen, J.K., 1982. Geological setting and tectonic significance of Mississippian felsic metavolcanic rocks in the Pelly Mountains, southeastern Yukon Territory. Canadian Journal of Earth Sciences, vol. 19, p. 8-22.

Mortensen, J.K., 1992. Pre-mid Mesozoic tectonic evolution of the Yukon-Tanana Terrane, Yukon and Alaska. Tectonics, vol. 11, p. 836-853.

Mortensen, J.K. and Godwin, C.I., 1982. Volcanogenic massive sulphide deposits associated with highly alkaline rift volcanics in the southeastern Yukon Territory. Economic Geology, vol. 77, #5, p. 1225-1230.

Mortensen, J.K. and Jilson, G.A., 1985. Evolution of the Yukon-Tanana terrane: Evidence from southeastern Yukon Territory. Geology, v. 13, no 11, p. 806-810.

Murphy, D.C. and Timmerman, J.R.M., 1997. Preliminary geology of part of Grass Lakes map area (105G/7, northeast third). In: Yukon Exploration and Geology, 1996; Yukon Geology Program, this volume.

George Cross News Letter, 1996. NDU Resources Ltd. Yukon Mineral Interest being acquired. No.5, p. 1, published by George Cross News Letter Ltd.

Newberry, R.J., Crafford, T.C., Newkirk, S.R., Young, L.E., Nelson, S.W. and Duke, N.A., 1996. Volcanogenic massive sulphide deposit of Alaska. In: Mineral Deposits of Alaska; Economic Geology, Monograph 9, In press.

**Ocean Home Exploration Co. Ltd., 1978. Borden Creek prospect, Bord Claims. Assessment Report 090437 written by R.E. Haverslew.

Pigage, L, 1996. The Ice Property. Talk given at the Geoscience Forum, Whitehorse, Yukon Territory, November 26, 1996.

Schultze, H.C., 1996. Summary of the Kudz Ze Kayah project, volcanic hosted massive sulphide deposit, Yukon Territory. In: Yukon Exploration and Geology 1995; Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 29-31.

Schultze, H.C., 1996b. Talk given at the Geological Association of Canada volcanogenic massive sulphide workshop, November 14th, 1996 at Simon Fraser University Downtown Campus, Vancouver, British Columbia.

Tempelman-Kluit, D.J., 1996. The Finlayson Lake Area revisited. Talk given at the Geoscience Forum, Whitehorse, Yukon Territory, November 26, 1996.

Tempelman-Kluit, D.J., 1977. Quiet Lake (105F) and Finlayson Lake (105G) map areas. GSC Open File 486, scale 1:250,000.

Tucker, T.L., Turner, A.J., Terry, D.A. and Bradshaw, G.D., 1997. Wolverine massive sulphide project, Yukon Territory, Canada. In: Yukon Exploration and Geology, 1996; Yukon Geology Program, this volume.

Turner, R.J.W. and Abbott, G., 1990. Regional setting, structure, and zonation of the Marg volcanogenic massive sulphide deposit, Yukon. Geological Survey of Canada Paper 90-1E, p. 31-41.

Yukon Yukon Minfile, 1996. Exploration and Geological Services, Yukon, Indian and Northern Affairs Canada.

** Non-confidential Assessment Reports

The Fyre Lake Deposit: A New Copper-Cobalt-Gold VMS Discovery

by D. Blanchflower, J.Deighton, I. Foreman
Columbia Gold Mines Ltd.[1]

BLANCHFLOWER, D, DEIGHTON, J., FOREMAN, I., 1997. The Fyre Lake Deposit : A New Copper-Cobalt-Gold VMS Discovery. In: Yukon Exploration and Geology, 1996, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 46-52

ABSTRACT

The Fyre Lake volcanogenic massive sulphide (VMS) copper-cobalt-gold property is situated 160 kilometres northwest of Watson Lake in the Finlayson Lake area of the Yukon-Tanana Terrane. Columbia Gold Mines Ltd. conducted an integrated exploration program there between late June and early October, 1996.

The Fyre Lake property is underlain by a sequence of metamorphosed sedimentary and volcanic rocks known as the Layered Metamorphic Sequence (LMS). Copper-cobalt-gold VMS mineralization within the Kona Creek cirque area is hosted by deformed and metamorphosed chlorite-actinolite-quartz schist of the middle unit of the LMS which is interpreted to be a succession of basic to possibly intermediate flows with intercalated volcaniclastics and volcanically-derived fine-grained sedimentary rocks. These rocks are structurally overlain by a thick sequence of phyllitic metasedimentary rocks with a basal unit of micaceous quartz-chlorite-mica schist. The copper-cobalt-gold (± zinc, silver) VMS mineralization within the central portion of the Kona deposit occurs in three distinct horizons of massive to semi-massive sulphide and magnetite mineralization over a combined thickness of 70 to 80 metres, a continuous strike length of more than 1,000 metres and widths in excess of 100 metres.

The geological setting and mineralogy of the copper-cobalt-gold VMS mineralization within the Kona zone is that of a mafic, volcanic-hosted Besshi-type VMS deposit. The Fyre Lake contains copper-cobalt-gold mineralization with significant thickness, grade and continuity.

RÉSUMÉ

La propriété de Fyre Lake dont les sulfures massifs d'origine volcanique (SMV) renferment du cuivre, du cobalt et de l'or, est située immédiatement à l'est du lac Fyre, longeant le bassin de la rivière North, à quelque 160 kilomètres au nord-ouest du lac Watson, dans le sud-ouest du Yukon. Columbia Gold Mines Ltd. a acquis la propriété en 1995 et a réalisé un programme d'exploration intégré entre la fin de juin et le début d'octobre 1996.

La région du lac Finlayson repose sur un assemblage volcano-sédimentaire métamorphisé du Paléozoïque précoce appartenant au terrane de Yukon-Tanana. La propriété de Fyre Lake repose sur une séquence de roches sédimentaires et volcaniques métamorphisées appartenant à la séquence métamorphisée stratifiée (SMS). La minéralisation de cuivre-cobalt-or des SMV de la région du cirque Kona est incluse dans une séquence de schiste à chlorite-actinolite-quartz déformé et métamorphisé qui serait une succession de coulées basiques et peut-être intermédiaires, interpénétrées de roches sédimentaires à grain fin d'origine volcanique appartenant à l'unité médiane de la SMS, et qui est recouverte par une épaisse séquence de roches métasédimentaires phylliteuses avec une unité basale de schiste micacé à quartz-chlorite-mica. La minéralisation de cuivre-cobalt-or (Å zinc, argent) des SMV du centre du gisement Kona se présente en trois horizons distincts d'une minéralisation de magnétite et de sulfure massif à semi-massif sur une épaisseur totale de 70 à 80 mètres, sur une distance continue en direction de plus de 1000 mètres et sur des largeurs de plus de 100 mètres.

Le contexte géologique et la minéralogie du corps minéralisé de la Zone de Kona semble indiquer un gisement de SMV de type «Besshi» inclus dans de la roche volcanique mafique. De tels gisements sont souvent inclus dans des roches volcaniques basiques et sédimentaires clastiques interstratifiées et métamorphisées. La propriété de Fyre Lake pourrait contenir une minéralisation de SMV à cuivre-cobalt-or d'épaisseur, de teneur et de continuité latérale importantes.

[1] 1500-675 West Hastings St., Vancouver, B.C., V6B 1N2

Introduction

The Fyre Lake volcanogenic massive sulphide copper-cobalt-gold property (Fig. 1) is situated immediately east of Fire Lake along the North River drainage, approximately 160 kilometres northwest of Watson Lake in southwestern Yukon Territory. Fire Lake was originally spelled Fyre Lake and has since been changed on recent government maps. The claim holdings cover approximately 70 square kilometres and are centred at latitude 61°14′ North by longitude 130°30′ West (N.T.S. 105 G/1,2,7,8) in the Finlayson Lake area of the Watson Lake Mining District. The Finlayson Lake area has received intensive exploration by many companies over the past year as a result of the discovery of the Kudz Ze Kayah (formerly 'ABM') deposit by Cominco Ltd. and the Wolverine deposit by Westmin Resources and Atna Resources.

History

The Fyre Lake massive sulphide showings have been explored since 1960 by Cassiar Asbestos (1960-61), Atlas Explorations Ltd. (1966-67), Amax Potash Limited (1976), Welcome North Mines Ltd. (1980-81) and Placer Dome Exploration Limited (1990-91). In September, 1960 prospectors of Cassiar Asbestos Corp. discovered a 2- by 2.5 metre boulder of massive sulphide mineralization on a glacial esker near the south end of Fire Lake. This was quickly followed by the discovery outcrops containing massive pyrite, chalcopyrite and sphalerite mineralization in Kona Creek (the 'E' zone). After staking their 'TOP' mining claims, Cassiar Asbestos Corp. explored their claim holdings in 1960 and 1961 with prospecting, geological and geophysical surveying, trenching, and twenty-three packsack and twelve AX-core diamond drill holes. In 1966 Atlas Explorations Ltd. staked the 'DUB' mineral claims and over a two-year period explored their claim holdings with airborne and ground geophysical surveying, soil geochemical sampling and AX-core diamond drilling. Amax Potash staked the 'FYRE' mineral claims in 1976 and conducted prospecting and limited geological mapping with rock geochemical sampling over the 'E' zone and adjacent areas. Welcome North Mines staked the 'KONA' mineral claims in 1980, and extended the soil sampling coverage with limited detailed geological mapping. Placer Dome Exploration Limited optioned the KONA mining claims in 1990 from Welcome North Mines and conducted an airborne geophysical survey of the area. During the 1991 field season Placer Dome staked the 'FIRE' mineral claims and conducted geological, geochemical and geophysical surveys over the known mineral showings and along the eastern slopes of Fire Lake.

The historical exploration work resulted in the discovery of twelve mineral showings and massive sulphide float boulders as well as coincident soil geochemical and geophysical anomalies, all spatially-associated with several horizons of stratiform iron formation. Within the Kona Creek cirque the mineralized iron formations are hosted by metamorphosed Late Devonian mafic volcanic and volcaniclastic rocks and have inferred surface traces over 3.2 km. Mineral occurrences and float showings were mapped over a 1.7 km strike length but only a 500 m long by 100 m wide area was locally tested with forty shallow drill holes in 1961 and 1966.

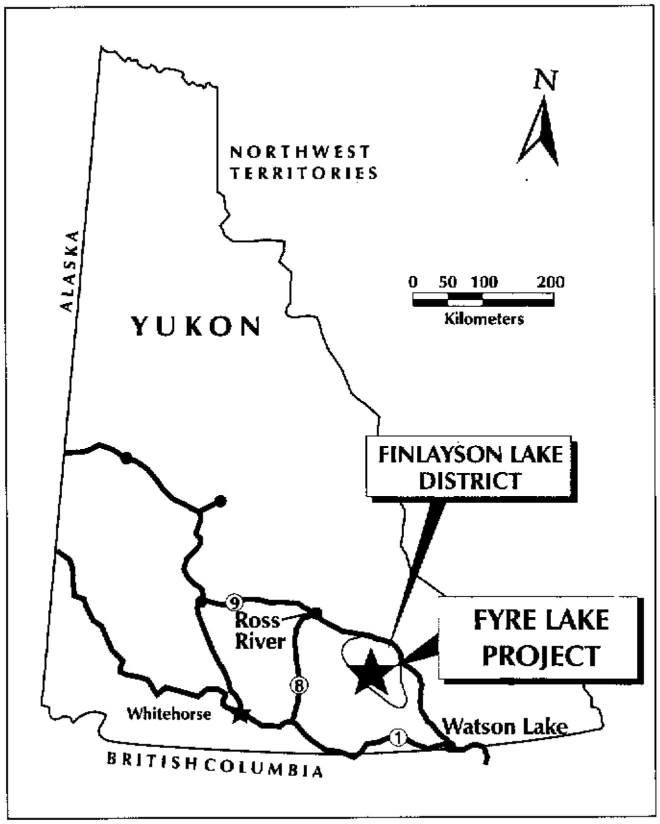


FIGURE 1: Location of Columbia Gold Mines' Fyre Lake Project, Yukon.

1996 Exploration Program

Columbia Gold Mines Ltd. acquired the Fyre Lake property in 1995 and between late June and early October, 1996, conducted an integrated exploration program. A total of 142.8 line-km of combined geological, geochemical, and geophysical surveying was undertaken property-wide and 71 NQ- and/or BQTK-core diamond drill holes, totalling 9,531.51 metres, were completed within the Kona grid area; partially testing copper-cobalt-gold volcanogenic massive sulphide ("VMS") mineralization of the Kona deposit.

Exploration work was concentrated within three survey control grid areas (Fig. 2), which from north to south are: the 'Kona' grid area which covers the upper Kona Creek drainage and contains the Kona deposit as well as the original massive sulphide discoveries; the 'Lake' grid area, situated immediately east of the south end of Fire Lake, that covers geochemical and geophysical anomalies reported by Atlas Explorations and Placer Dome; and the 'Dub' grid area, located on the east side of the North River approximately 3 to 7 kilometres southeast of Fire Lake.

Geology

The Finlayson Lake district is underlain by an Early Paleozoic metamorphosed volcano-sedimentary assemblage of the Yukon-Tanana Terrane (YTT) which is regionally bounded to the southwest by the Tintina Fault and to the northeast by the Finlayson Lake Fault

Zone. This terrane hosts several known volcanogenic massive sulphide deposits and occurrences, including the Kudz Ze Kayah and Wolverine deposits.

The Fyre Lake property is underlain by a sequence of metamorphosed sedimentary and volcanic rocks belonging to the Layered Metamorphic Sequence ("LMS") (Mortensen, 1985) of the Yukon-Tanana Terrane. Mortensen and Jilson (1985) divided the LMS into three units; lower and upper metasedimentary units separated by an interlayered volcanic-sedimentary middle unit. The lower metasedimentary rocks crop out predominantly along the western side of the property and a belt of metamorphosed mafic volcanic and carbonaceous clastic sedimentary rocks of the middle member underlie the centre of the property while the eastern

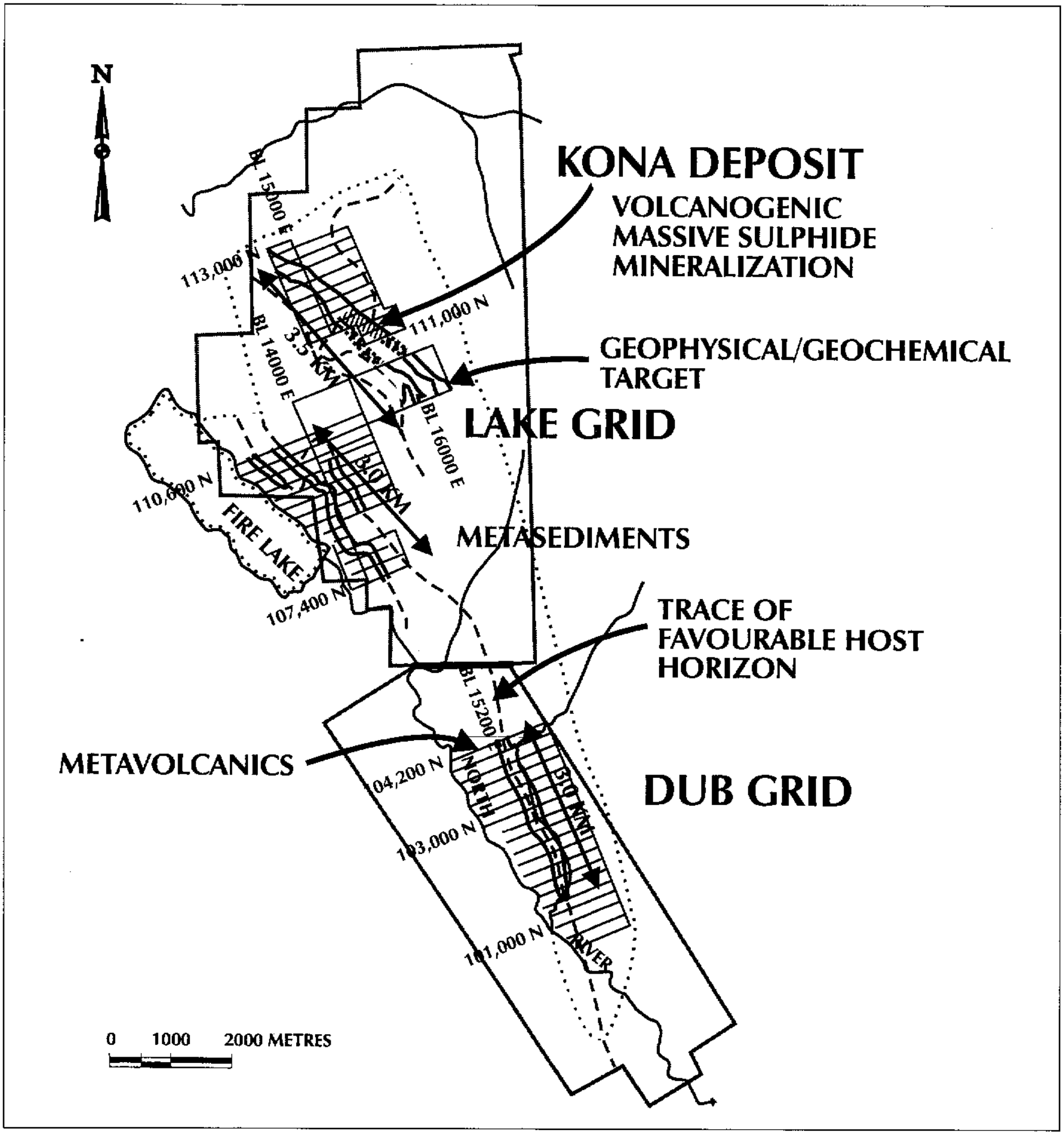


FIGURE 2: The three principal grid areas on the Fyre Lake property. Stippled belts are potential mineralized horizons outlined by geophysical and geochemical surveys and geological mapping.

portion of the property contains a thin wedge of upper unit metasedimentary rocks that is overthrust by the Late Devonian to Late Pennsylvanian-Early Permian Slide Mountain Terrane (Anvil-Campbell Allochthonous Assemblage) (Stroshein, 1991).

Copper-cobalt-gold VMS mineralization within the Kona cirque area is hosted by a well deformed and metamorphosed chlorite-actinolite-quartz schist sequence that is interpreted to be a succession of basic to possibly intermediate flows with intercalated volcaniclastics and volcanically-derived fine-grained sedimentary rocks belonging to the middle unit of the LMS. The chlorite-actinolite-quartz schist is medium to dark green in colour, aphanitic to fine-grained, and has a pervasive distinct foliation. Chlorite and actinolite contents range from less than 10 to over 40 percent of the rock volume, and there is 3 to 5 percent, locally up to 20 percent, clear to milky white quartz as 2 to 15 mm thick laminae and 2 to 20 cm boudins. The quartz content is very irregular possibly indicating a variety of protoliths. Biotite is present in varying amounts as < 1.5 mm phenocrysts in the groundmass, or as < 4 mm black to dark brown masses that commonly form 0.5 to 2 cm thick laminae. Variations of the chlorite-actinolite-quartz schist include those hosting local, 1 to 6 cm irregular masses of black amphibole, (probably actinolite or tremolite), and rare subhedral to anhedral, 2 to 4 mm porphyroblasts of an orange-red garnet.

The chlorite-actinolite-quartz schist is overlain by thick sequence of phyllitic metasedimentary rocks with a basal unit of micaceous quartz-chlorite mica schist. The phyllitic metasedimentary rocks are very fine-grained to fine-grained and finely laminated. This rock unit may locally contain 3 to 10 percent fine-grained biotite and/or phlogopite as laminae within 10 to 50 cm wide biotite-rich layers. The unit is locally calcareous with mottled white carbonate-rich layers up to 50 cm thick. A variety of protoliths is reflected by feldspar-biotite and/or carbonate-rich bands with local orange-red garnetiferous sections.

The basal micaceous quartz-chlorite schist unit occurs consistently between the upper phyllitic metasedimentary rocks and the lower chlorite-actinolite-quartz schists. It averages approximately 4 m in thickness but thickens to 20 m further south. This unit contains laminated brown and locally massive green sections separated by 50 to 80 percent quartz as 2 to 20 cm white bands.

Structure

Large scale thrust faulting is prominent within the region and evident on the property. Internal thrust faults have been mapped within the YTT rocks (LMS) as well as at the base of the Slide Mountain Terrane (Stroshein, 1991). The 1991 Placer Dome exploration documented a thrust fault contact between the upper metasedimentary (i.e. phyllites)and lower metavolcanic rocks. The 1996 exploration indicates that these two rock units are not separated by any obvious large scale faulting but represent a continuous stratigraphic succession, at least within the Kona cirque area.

The structural geology of the property is very complex resulting from intense deformation and metamorphism of the LMS. S_1 foliation parallel to compositional layering is defined by conformable bands of new growth micas, actinolite and chlorite in the mafic

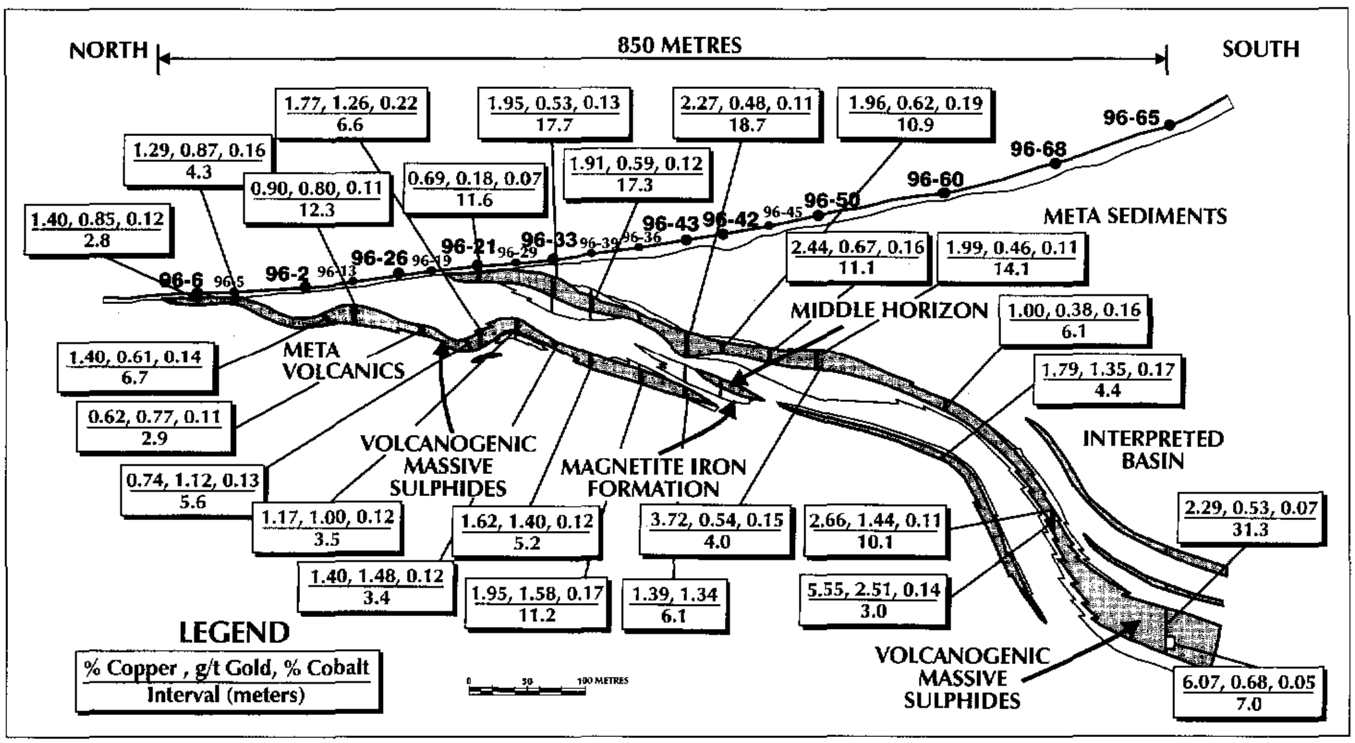


FIGURE 3: *Longitudinal vertical section through the Kona Zone (location on figure 4).*

rocks and as ribbons of stretched quartz bands in the quartz-rich sedimentary rocks, and a L_1 lineation is defined by mineral streaking along the foliation surface (Stroshein, 1991). When the S_1 foliation is used as a substitute for bedding plane measurements and the L_1 measurements are used to define direction and plunge of deformation Stroshein (1991) found that the schistosity measurements within the property are consistent with a shallow easterly dipping regional trend. L_1 lineations in the Kona Creek cirque area parallel the approximate orientation of the mineralization at 120° to 140° and plunge 20° to the south.

Mineralization

Drilling of copper-cobalt-gold (± zinc, silver) VMS mineralization within the central portion of the Kona deposit defined three distinct horizons (Fig. 3) of massive to semi-massive sulphide and magnetite with a combined thickness of 70 to 80 metres, a continuous strike length of more than 1,000 metres and widths in excess of 100 metres. The mineralization is dominantly hosted within the upper section of the chlorite-actinolite-quartz schist unit and immediately beneath the chlorite-actinolite-quartz schist and phyllite stratigraphic contact.

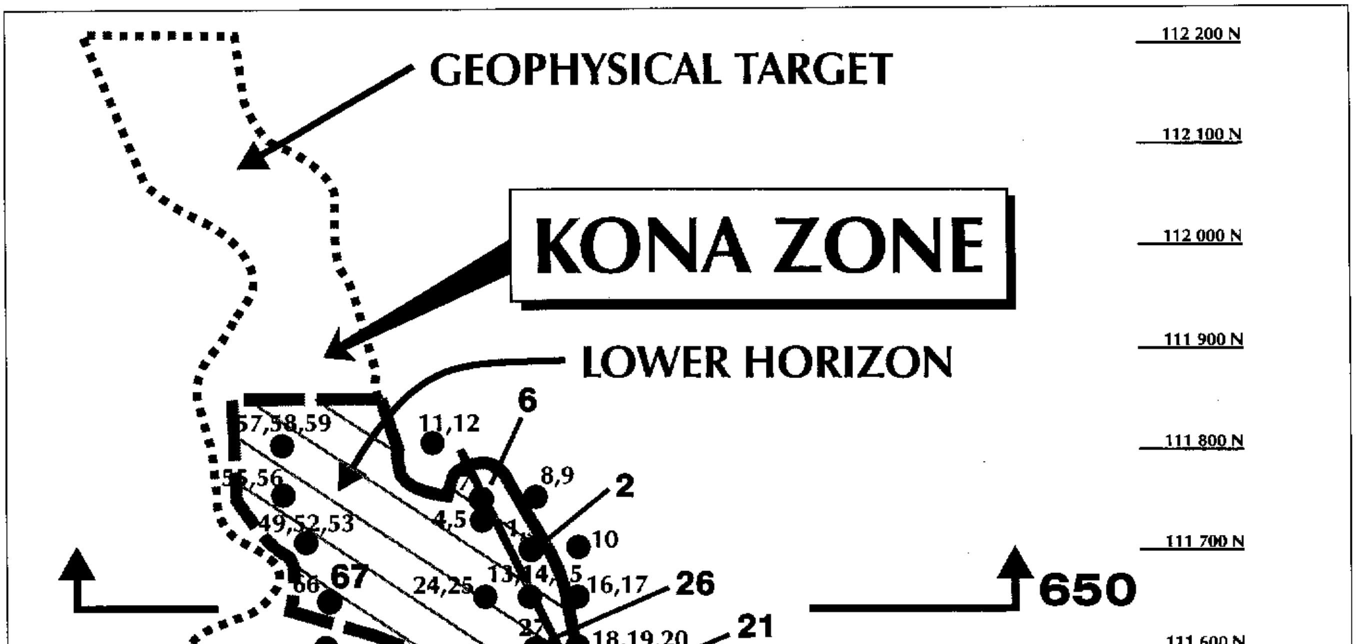


FIGURE 4: Plan map showing locations of the 1996 drill holes and approximate oulines of drill tested mineralization (striped pattern) and coincident geophysical anomaly. Longitudinal vertical section is at 160°.

The 'Lower Horizon' is 4 to 16 m thick and has been drill tested over a length of 450 metres. It is comprised of alternating layers of massive sulphide and massive magnetite mineralization with the uppermost massive sulphide layer being the thickest of the layers, averaging 7 m thick. The sulphides are typically fine- to medium-grained and dominantly pyritic. Chalcopyrite content averages from 3 to 5 percent by volume. Magnetite is typically fine-grained and may comprise more than 90 percent of the underlying massive magnetite band with lesser pyrite, chalcopyrite and white carbonate and/or quartz as 2 to 5 mm laminae and irregular clusters.

The 'Middle Horizon' is situated within the southern portion of the deposit, and averages 5 m thick and thickens locally to more than 10 m. The styles of mineralization within this horizon are similar to those of the Lower Horizon but semi-massive magnetite overlyies alternating 0.3 to 2.0 metre thick layers of massive sulphide and massive magnetite. The upper portion of the massive sulphides locally contains 2 to 6 % sphalerite as interstitial grains between coarser-grained pyrite. The Middle Horizon is generally thinner than the Lower Horizon but has only been tested by 6 holes over a length of 250 metres.

The "Upper Horizon' is the most laterally continuous of the three horizons and ranges from 6 to 40 m thick. The upper 0.5 to 1.5 m of the horizon is massive sulphides with more than 75 percent pyrite by volume which locally contains subrounded pyritic quartz clasts, possibly precipitated silica nodules. The central copper-rich section comprises banded massive sulphides composed of 2 to 10 cm bands, locally to 30 cm, separated by 1 to 10 cm bands of foliated chlorite schist and/or quartz. The massive sulphides are dominantly pyrite, chalcopyrite and lesser pyrrhotite within a greyish white cherty matrix. Magnetite occurs within the chlorite-actinolite-quartz schist unit as 0.5 to 2 mm subhedral grains. The sulphide content and thicknesses of the mineralized bands gradually decrease downward with a corresponding increase in volume of magnetite and the chlorite-actinolite-quartz schist host. Near the base of the known mineralization the sulphides constitute less than 1 percent of the rock volume and most of the mineralization is banded semi-massive magnetite. The basal portion of the horizon usually hosts 10 to 25 percent banded magnetite within greyish white metachert and chlorite-actinolite-quartz schist layers and varies in thickness from 1 to 17 m.

The thickest portion of the Upper Horizon was intersected by the most southern 1996 drill hole (Fig. 4) (i.e. DDH 96-065 intersected 49.75 m of mineralization at a depth of 427.50 m). The pyrite, pyrrhotite and chalcopyrite mineralization is hosted by a siliceous section with chalcopyrite locally representing as high as 40 percent of the volume within a 7 m section. Magnetite is pervasive throughout the mineralized horizon, ranging from 5 to 80 percent of the volume as disseminations, bands and masses. Within the overlying metasedimentary rocks there are 0.5 to 3.0-metre thick lenses of massive sulphides with significant copper and cobalt mineralization. The geometry and thickness of the Upper Horizon at the southern limit of the 1996 drilling indicates that there may be a southeastwardly trending mineralized trough opening and thickening to the south.

The massive sulphide mineralization within the northwestern drill-tested area (Fig. 4) is similar in geometry and mineralogy to the three southern horizons of the central Kona VMS deposit. Locally, the massive sulphide mineralization varies laterally to fine- to medium-grained pyrite with pyrrhotite and chalcopyrite in a cherty matrix and vertically with depth to massive magnetite.

Exploration Potential

The Kona Zone VMS mineralization has been drill-tested over a combined length of 1,000 metres within a coincident geochemical and geophysical (ground magnetics and MaxMin EM) anomaly extending over a 3.5 km strike length. The southern drill-tested portion of this zone has a 31.3 metre thick section of stratiform pyrite, chalcopyrite and magnetite mineralization averaging 2.29 percent copper, 0.07 percent cobalt and 0.53 grams per tonne gold. The mineralization of the Kona Zone is open (Fig. 5) to the north, south and west. Furthermore, there are two other 3-kilo-

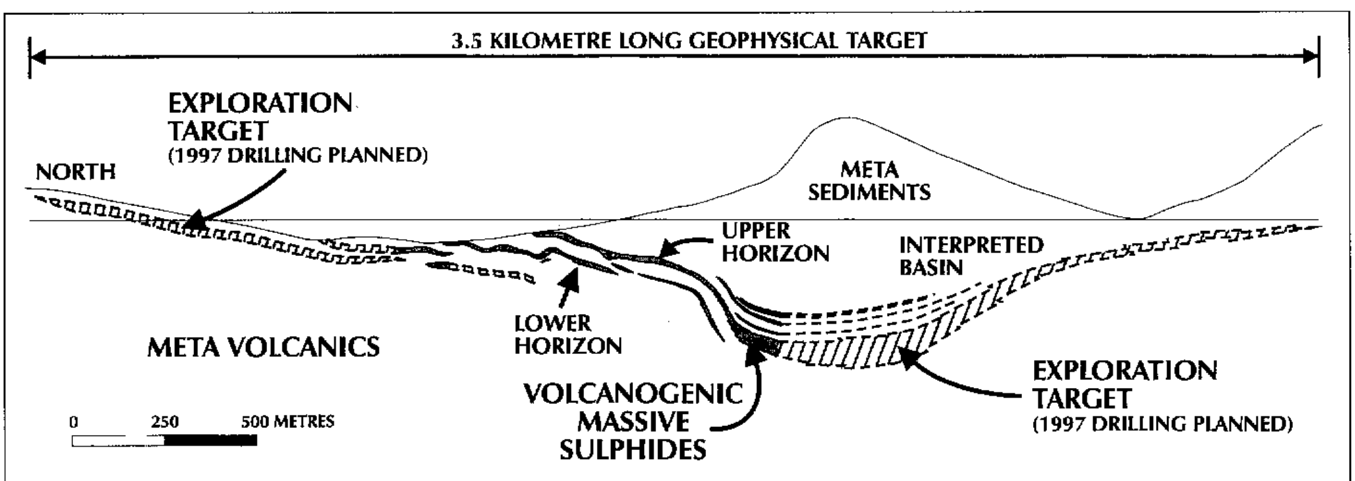


FIGURE 5: Longitudinal section of the Kona grid area showing exploration targets for the 1997 drill program.

metre long coincident geological, geochemical and geophysical anomalies within the Lake and Dub survey grid areas (Fig. 2) that remain to be tested by drilling.

The geological setting and mineralogy of the copper-cobalt-gold VMS mineralization within the Kona Zone resembles a mafic volcanic-hosted 'Besshi-type' VMS deposit. Such deposits are often hosted by metamorphosed interbedded clastic sedimentary and basic volcanic rocks. The metasedimentary rocks are typically pelitic schists, or metamorphosed greywackes and fine-grained sedimentary rocks, and the volcanic assemblages are typically metabasalts. Sulphide mineralogy is usually pyrite, pyrrhotite, chalcopyrite and sphalerite with variable copper and zinc grades but very low lead values. Besshi-type VMS deposits commonly have high concentrations of cobalt; for example 24 Besshi deposits in Japan average 0.06 percent (Slack, 1993).

The Fyre Lake property has considerable copper-cobalt-gold VMS potential as indicated by the significant thickness, grade and lateral continuity of mineralization discovered in 1996. A major diamond drilling campaign is planned for 1997.

REFERENCES

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

Slack, J.F., 1993, Descriptive and Grade-Tonnage Models for Besshi-Type Massive Sulphide Deposits. In: Mineral Deposit Modeling, GAC Special Paper 40, Edited by R.V. Kirkham, W.D. Sinclair, R.I. Thorpe, and J.M. Duke. p. 343-371.

Stroshein, R.W., 1991, Geology, Geochemical, and Geophysical Report on the Kona Property, Watson Lake Mining District, Yukon Territory; Unpublished report for Placer Dome Exploration Limited.

Wolverine Massive Sulfide Project, Yukon

Terry L. Tucker[1], A.J. Turner[1], D.A. Terry[1], G.D. Bradshaw[1]
Westmin Resources Limited and Atna Resources Ltd., Vancouver, BC

TUCKER, T.L.; TURNER, A.J.; TERRY, D.A.; BRADSHAW, G.D., 1997. Wolverine Massive Sulfide project, Yukon Territory, Canada-Westmin Resources Limited and Atna Resources Ltd, Vancouver, B.C. In: Yukon Exploration and Geology, 1996, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 53-55

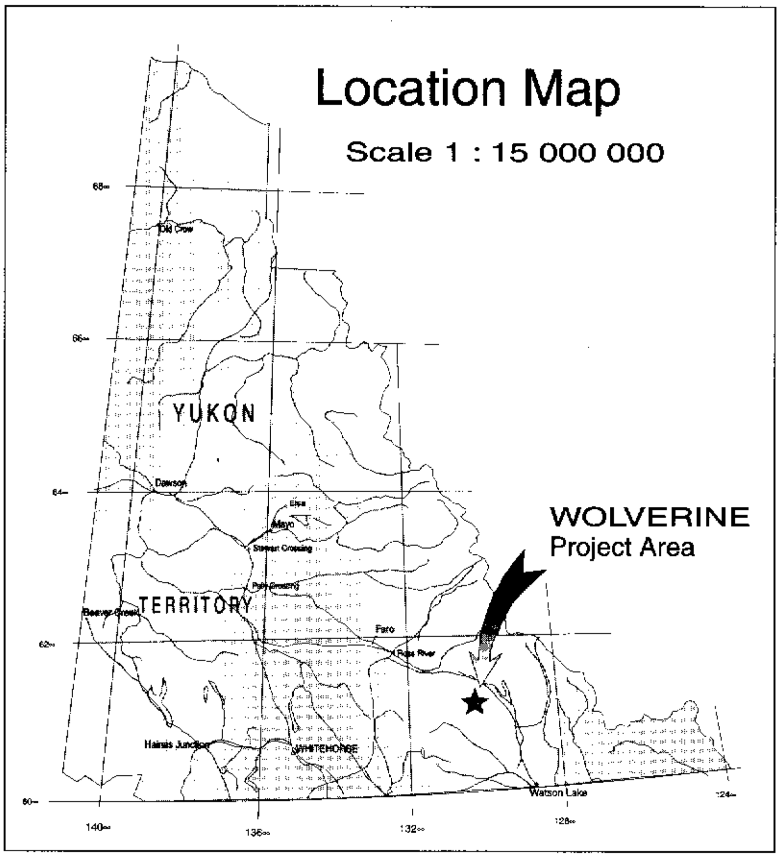


FIGURE 1: *Property location*

LOCATION

The Wolverine massive sulfide project is located in the southeastern Yukon Territory within the Pelly Mountains, midway between the communities of Ross River and Watson Lake (Fig. 1).

REGIONAL GEOLOGY

The project area lies within the Finlayson Lake belt, an elongate composite body bound on the southwest by the Tintina Fault zone and on the northeast by the Finlayson Lake fault zone, and comprised mainly of rocks belonging to the pericratonic Yukon-Tanana Terrane. The Wolverine Deposit is hosted by Devonian-Mississippian aged carbonaceous metasediments and metamorphosed volcanic and pyroclastic felsic rocks of the Yukon-Tanana Terrane. Rocks of similar age and composition host the Kudz Ze Kayah deposit located 20 kilometres to the west of Wolverine.

EXPLORATION

The Wolverine Deposit was discovered in 1995 after a surface exploration program generated multi-element soil anomalies and the recognition of a geologically permissive environment for volcanogenic sulfide mineralization. Drill testing of the higher soil anomalies in the late summer intersected massive sulfide mineralization in the first hole.

[1] Westmin Resources Limited, #904-1055 Dunsmuir St., Vancouver, B.C., V7X 1C4

DEPOSIT GEOLOGY

The Wolverine Deposit is hosted by a mixed volcano-sedimentary package of lower greenschist metamorphic rank. Carbonaceous argillite and a porphyritic felsic volcanic unit form the immediate footwall to the mineralization. The massive sulfides are hosted in either argillite or aphryic rhyolite. Interlayered carbonaceous argillites, felsic volcanic, fragmental and tuffaceous units and magnetite iron formation occur in the hangingwall of the deposit. The massive sulfide body is zoned, polymetallic, and displays banded, clastic and massive-replacement textures. Drilling to date suggests that it has a tabular morphology. Commonly sulfide intersections have Mg-chlorite footwall alteration zones enveloping pyrite/chalcopyrite/pyrrhotite stringer mineralization. The main sulfide minerals in order of decreasing abundance are pyrite, sphalerite, chalcopyrite, and galena. Argentian tetrahedrite contains more than 90% of the silver in the deposit, the remainder occurring in solid solution with galena and in Au-Ag solid solution series. Au is present as Ag-rich native gold and Au-rich native silver. Gangue minerals associated with the massive sulfide are comprised of quartz, muscovite, calcite, and dolomite-ankerite. Texturally the sulfide minerals are generally fine- to medium-grained. Ore minerals occur either interstitial to pyrite or as a matrix for disseminated pyrite.

1996 EXPLORATION

The exploration program included continued definition drilling of the Wolverine Deposit and a regional stratigraphic drill program consisting of 18,810 metres in 64 holes. A regional exploration program was designed to evaluate the 2,963 claims in the Wolverine Lake area in which Westmin has an interest. Drilling on the Wolverine Deposit resulted in the discovery in the fall of 1996 of the Lynx Zone. The Lynx Zone adjoins the western part of the main Wolverine Zone (figure 2). Average thickness and grade of the Lynx Zone based on current drill information is 6.7 metres of 1.71 g/t Au, 363 g/t Ag, 1.44% Cu, 1.59% Pb, and 11.84% Zn. Figure 3 and 4 illustrate typical sections through the Wolverine and Lynx Zones respectively. The geological inventory of the Wolverine Deposit has been calculated at 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. The Lynx Zone remains open to the south and west and more drilling is needed to define the eastern margin of the Wolverine Zone.

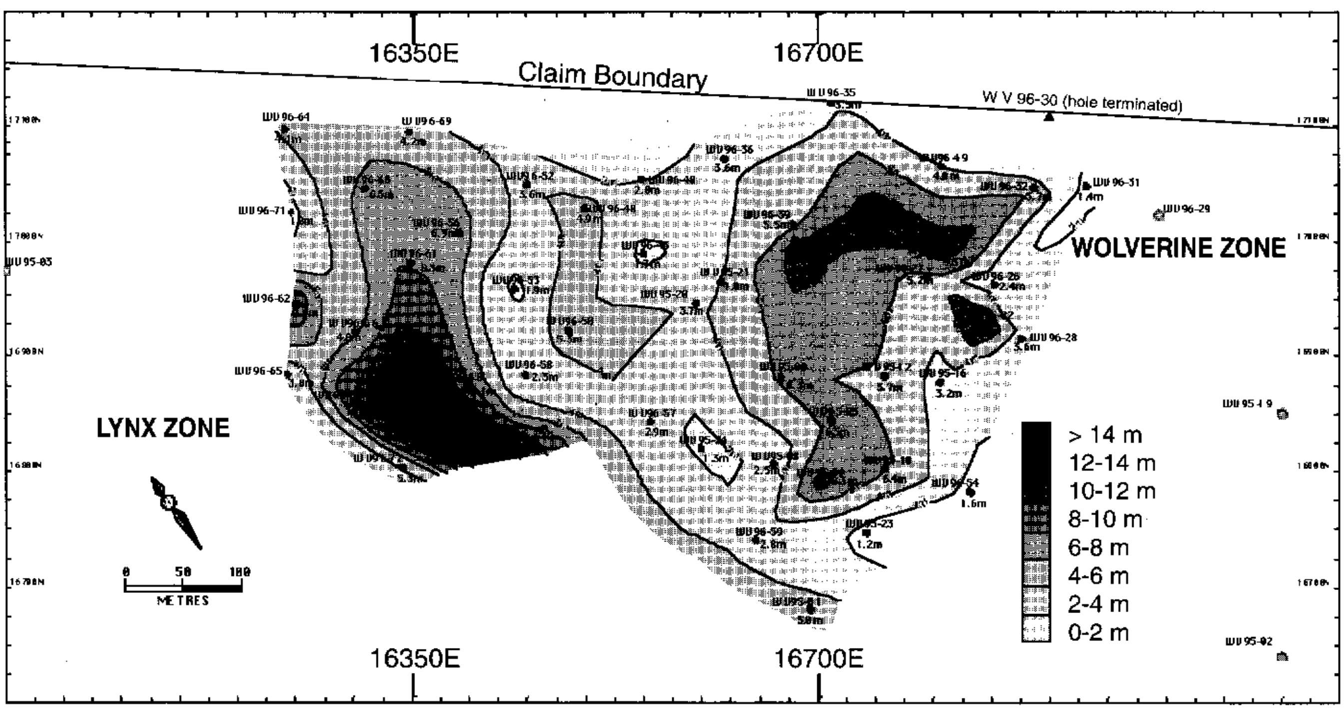
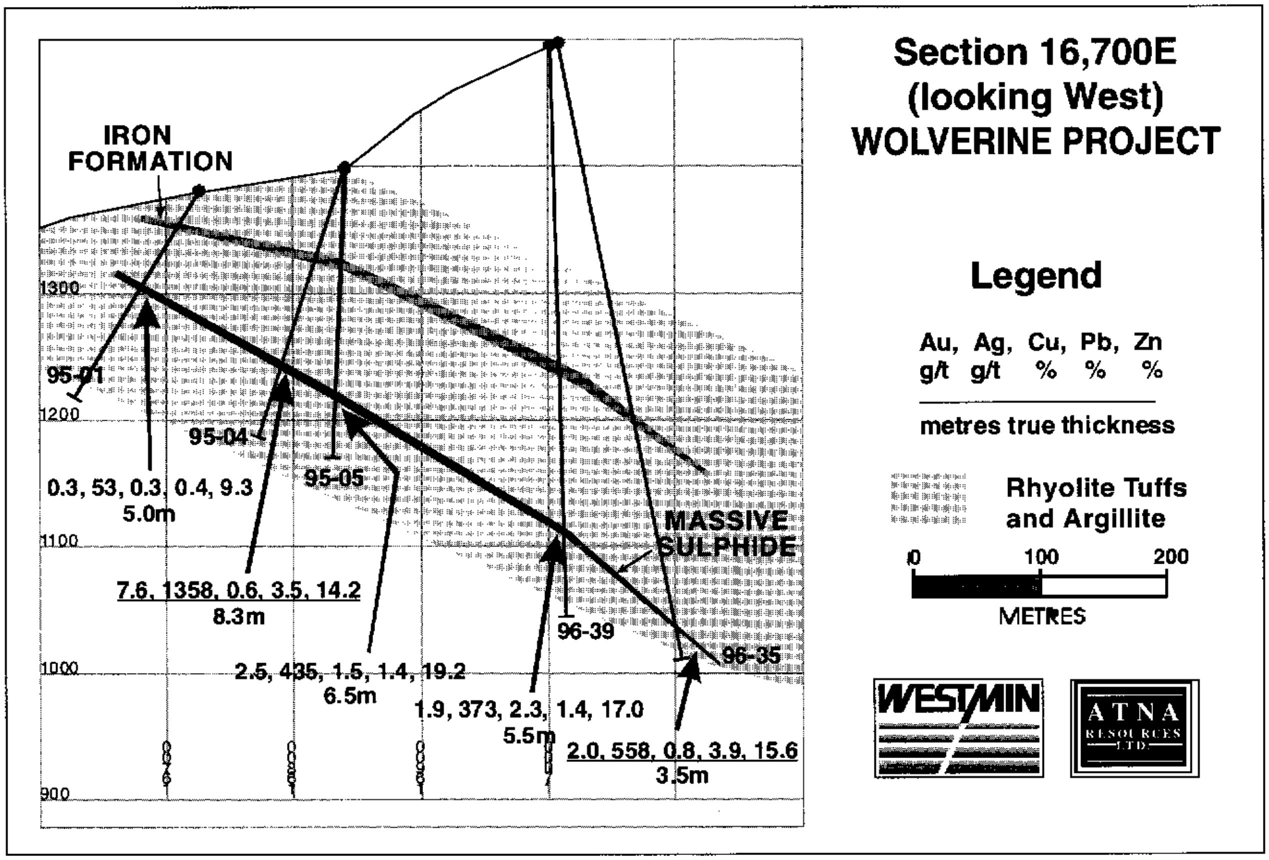
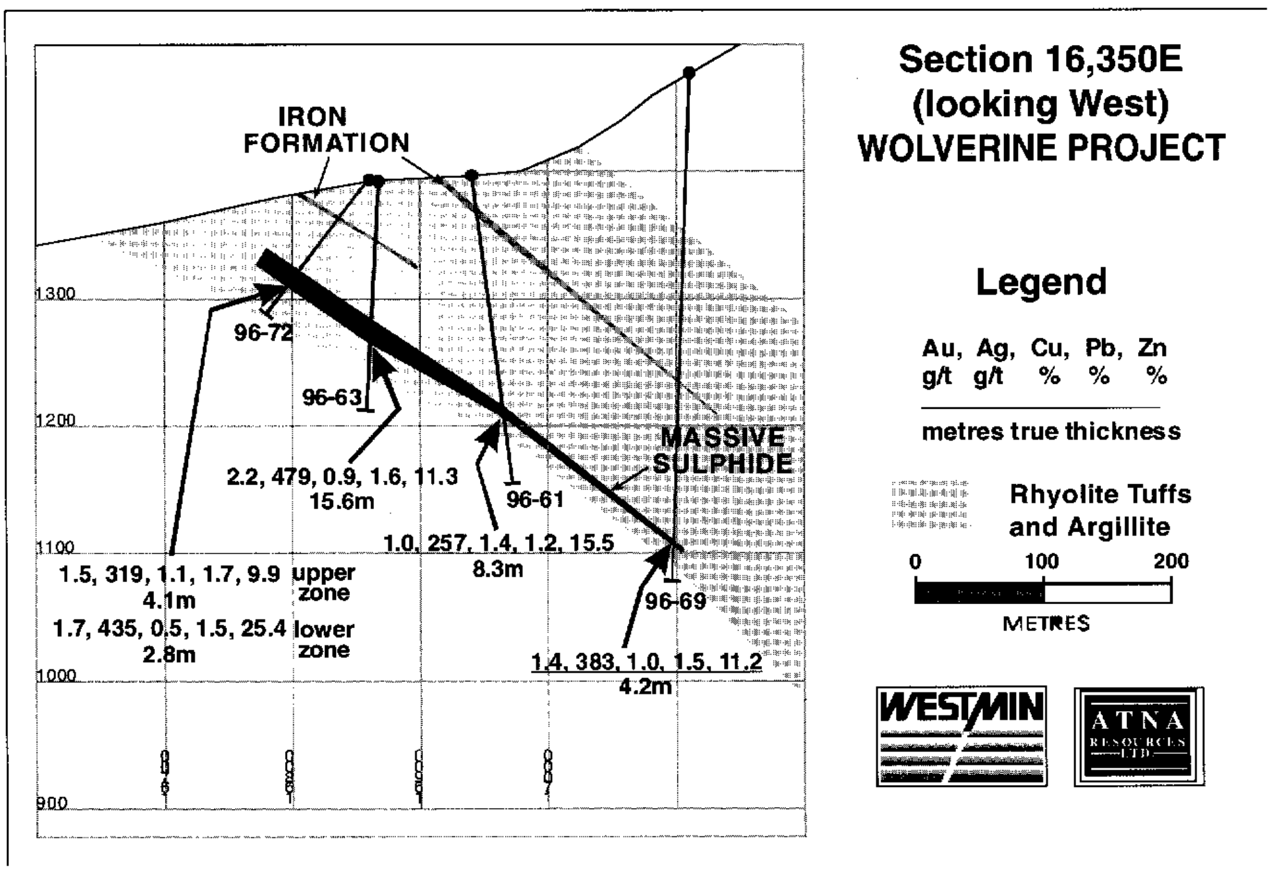


FIGURE 2: Wolverine deposit plan with Isopachs



ABOVE, Figure 3: *Section 16700 E-Wolverinx Zone* ***BELOW, Figure 4:*** *Section 16350 E-Lynx Zone*



Mamu-Bravo-Kulan claims: A VHMS exploration target based on geochemical and geophysical anomalies in Mississippian volcanics within Cassiar Platform, NTS 105-F/7, 8, 9, & 10

by Allan Doherty, P.Geo.
Aurum Geological Consultants Inc. [1]

DOHERTY, A, 1997. Mamu-Bravo-Kulan claims: A VHMS exploration target based on geochemical and geophysical anomalies in Mississippian volcanics within Cassiar Platform, NTS 105-F/7, 8, 9, & 10. In: Yukon Exploration and Geology 1996, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 56-61

INTRODUCTION

Oro Bravo Resources Ltd., completed preliminary exploration work in 1995 and 1996 on the central part of the Mamu-Bravo-Kulan property. Coincident multi-element (Pb, Zn, Cu, Ag, Ba, Fe, and Cd) soil geochemical anomalies associated with total field magnetic anomalies indicated that the property may host VMS style mineralization associated with Mississippian felsic and intermediate volcanic rocks.

The 1995-96 work program consisting of griding and line cutting, soil sampling, magnetometer and VLF-EM geophysical surveys, and very limited geological mapping was carried out from a helicopter supported fly camp. Field work consisted of 250 crew days of field work by a five to six person crew. The geophysical surveys were completed by Amerok Geosciences Ltd.

The Mamu 1-24, Bravo 25-44 and Kulan 1-109 claims straddle the boundary of NTS map areas 105F/7,8,9 and 10. The property is approximately 12 km southwest of the Ketza River mine. A point at the centre of the claim block is at 61°30'N and 132°30'W.

Year round access to the Mamu claims is via helicopter from Ross River, 55 km North of the property. There is a seasonal access road to the Ketza River mine site and an exploration tote road from the mine that terminates approximately 2 km northeast of the property. Another exploration tote trail leads up Groundhog Creek from the South Canol road and terminates within two kilometres of the property.

HISTORY

In 1969 the CPA 1-12 claims staked by Charta Mines Ltd., were explored for possible porphyry-type deposit with peripheral Pb-Ag veins (Minfile 105F-013). The property was optioned to United Keno Hill Mines Ltd. in 1977 who explored with mapping, geochemistry and trenching.

In 1990, Granges Inc., optioned the property from Cascade Pacific Resources Ltd., and completed an airborne magnetic, electromagnetic and VLF survey (Kilin, 1990). A follow-up exploration program in 1991 consisting of ground investigation of airborne geophysical anomalies, prospecting, line-cutting with soil sampling and mapping, contour soil sampling, blast trenching, EM geophysics, and thin section petrography (Solkoski,1991).

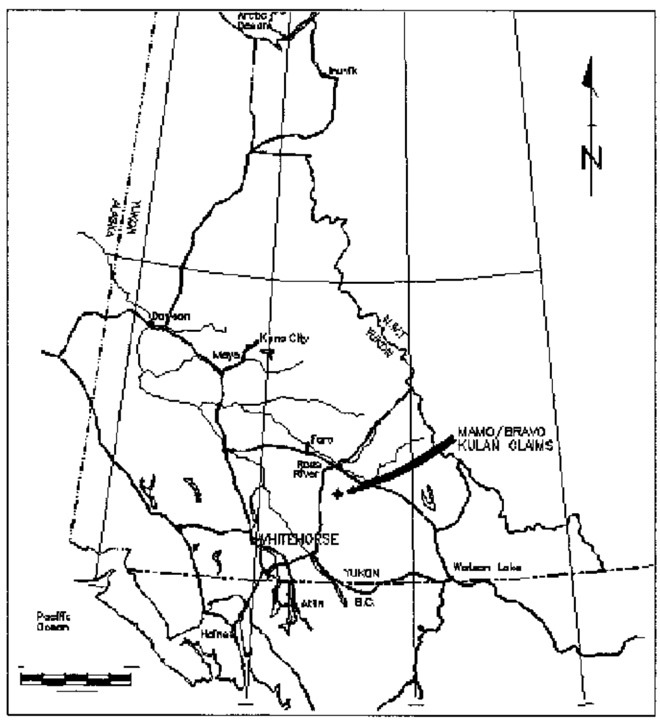


FIGURE 1

[1] P.O. Box 4367, Whitehorse, Yukon, Y1A 3T5

The conclusions from this work program was that the property had potential for VMS-style mineralization and that further work should be conducted. A small two-stage program of mapping and sampling was completed by Granges Inc., in 1992, and was reported on by Downing, 1993.

The Mamu-Bravo claims were staked in 1994 by Brian Hall and optioned to Oro Bravo Resources Ltd., in early 1995 and a program of griding, mapping sampling and Magnetometer and VLF-EM surveys were completed in 1995 and 1996, (Doherty, 1996a, 1996b). The Kulan 1-109 claims were added in February 1996 and the property currently comprises 153 claims covering 3200 hectares.

Geology

Regional Geology

The property is situated within the Cassiar Platform (Figure 2), which is comprised mostly of moderately faulted and folded Paleozoic miogeoclinal clastic and carbonate sedimentary rocks that were deformed during Mesozoic arc-continent collision, and intruded by mid Cretaceous plutons of intermediate composition (Tempelman-Kluit, 1977 & 1981). The Ketza-Seagull District is bounded on the northeast by the Tintina fault which has postulated right lateral strike slip displacement in excess of 450 km. This area of the Cassiar platform is characterized by northeast directed thrust panels that are parallel to the Tintina Fault' (Abbott, 1986). The McConnell Thrust fault is located on the southwest side of the property. A package of Mississippian volcanic rocks overlies the Paleozoic platform carbonates and is intruded by the syenite, (Morin,1981) The Mamu-Bravo-Kulan property is located just north of the McConnell Thrust fault, and on the south side of a large Mississippian syenite intrusion. Structures within the window are characterized by steeply dipping normal faults.

Regional Metallogeny

Regional metallogeny of this portion of the northern Cordillera is characterized by Kuroko style VMS occurrences associated with Mississippian felsic to intermediate volcanics overlying the Cassiar Platform; and gold and base metal occurrences and deposits spatially related to two domal uplifts or arches named the Ketza and Seagull arches (Abbott, 1986).

Kuroko style VMS occurrences have been recognized from the Mississippian volcanics since the 1970's (Morin, 1977; Mortensen, 1982; Mortensen and Godwin,1982). The Mamu-Bravo-Kulan property (Minfile 105F-013), the MM property Minfile 105F-012), Chzerpnough (Minfile 105F-071), Bnob (Minfile 105F-073), and Mat occurrence (Minfile 105F-021) have characteristics that typify VMS deposits. The locations of all these occurrences are shown on Figure 2.

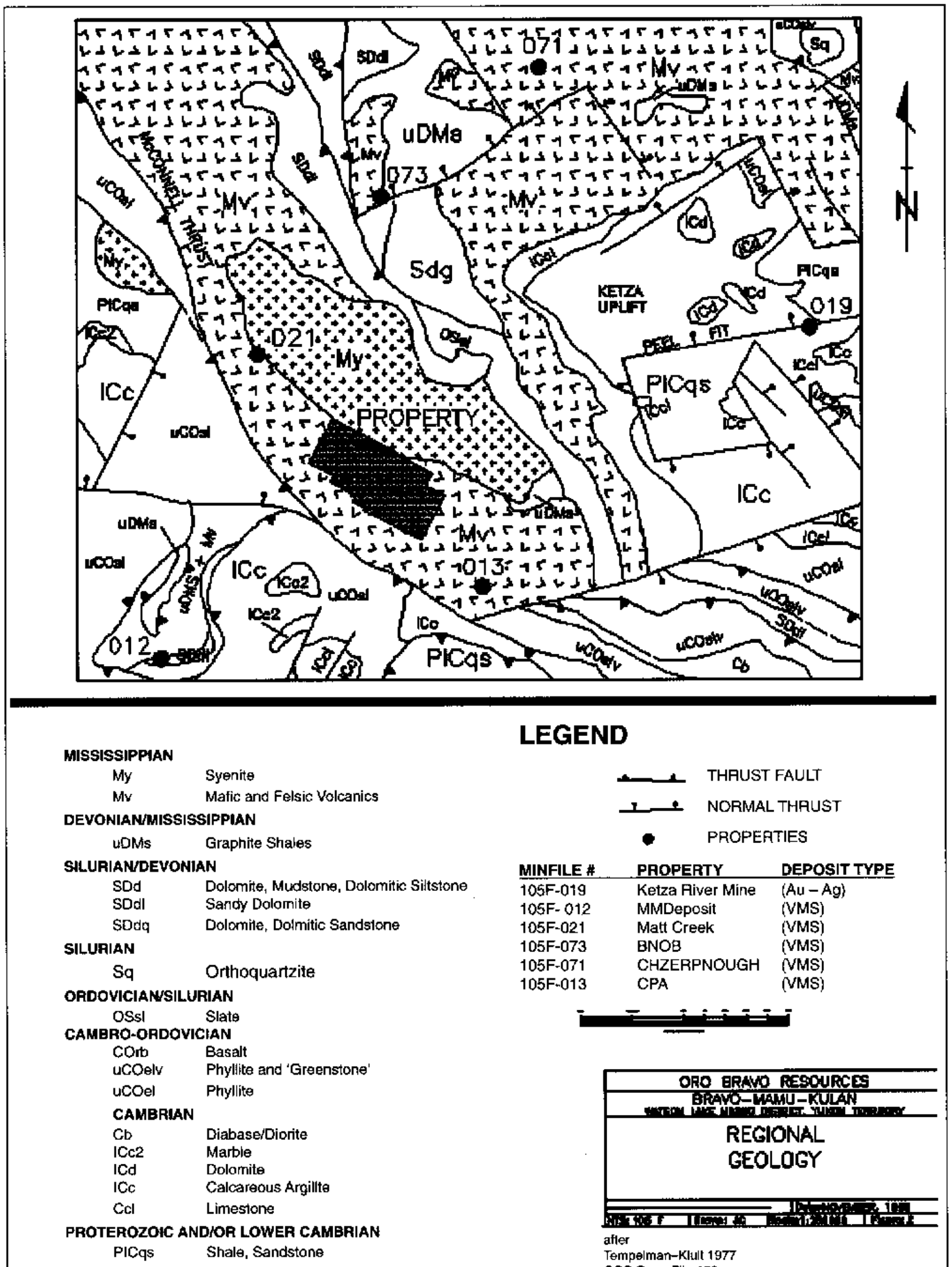


Figure 2

Property Geology

The Mamu property covers a package of Mississippian volcanics and Devonian sedimentary rocks intruded by or in faulted contact with a Mississippian intrusive complex consisting of syenite, diorite, monzonite, quartz monzonite, and gabbro (Burson 1989; Solkoski, 1991; Downing, 1993; and Reynolds, 1994). The main intrusive body is an elongate 12 km long by 3 km wide northwest trending pluton outcropping on the north side of the Mamu-Kulan claims. Intrusive complex lithologies that outcrop on the property consist of dikes or sills or a small stock of intermediate composition.

The Mississippian volcanic-sedimentary rocks consist of: 1)intermediate volcanics comprising tuff, breccia, flows, and minor felsic volcanics; 2) felsic volcanics including rhyolite, limonite pitted rhyolite, and ash tuff; 3) argillite and phyllite. The volcanics are strongly foliated so that primary textures are often masked. The felsic metavolcanics are fragmental, have pyrite rich horizons and weather to prominent gossans that are generally coincident with the soil geochemical anomalies. Pyritic chert or pyritic tuffs found on the property are thought to represent exhalative horizons within the volcanic stratigraphy. The exhalites appear to be associated with both intermediate and felsic volcanic units.

The volcanics and sedimentary rocks are variably altered. Most alteration consists of a phyllic assemblage of quartz-sericite-carbonate-pyrite. Secondary biotite or chlorite are present in significant amounts in some areas. Ankerite, fluorite, and tremolite-actinolite are reported both from mapping and petrographic reports (Solkoski, 1991; Downing, 1993). Most sulfides have been oxidized to limonite and other Fe-oxides.

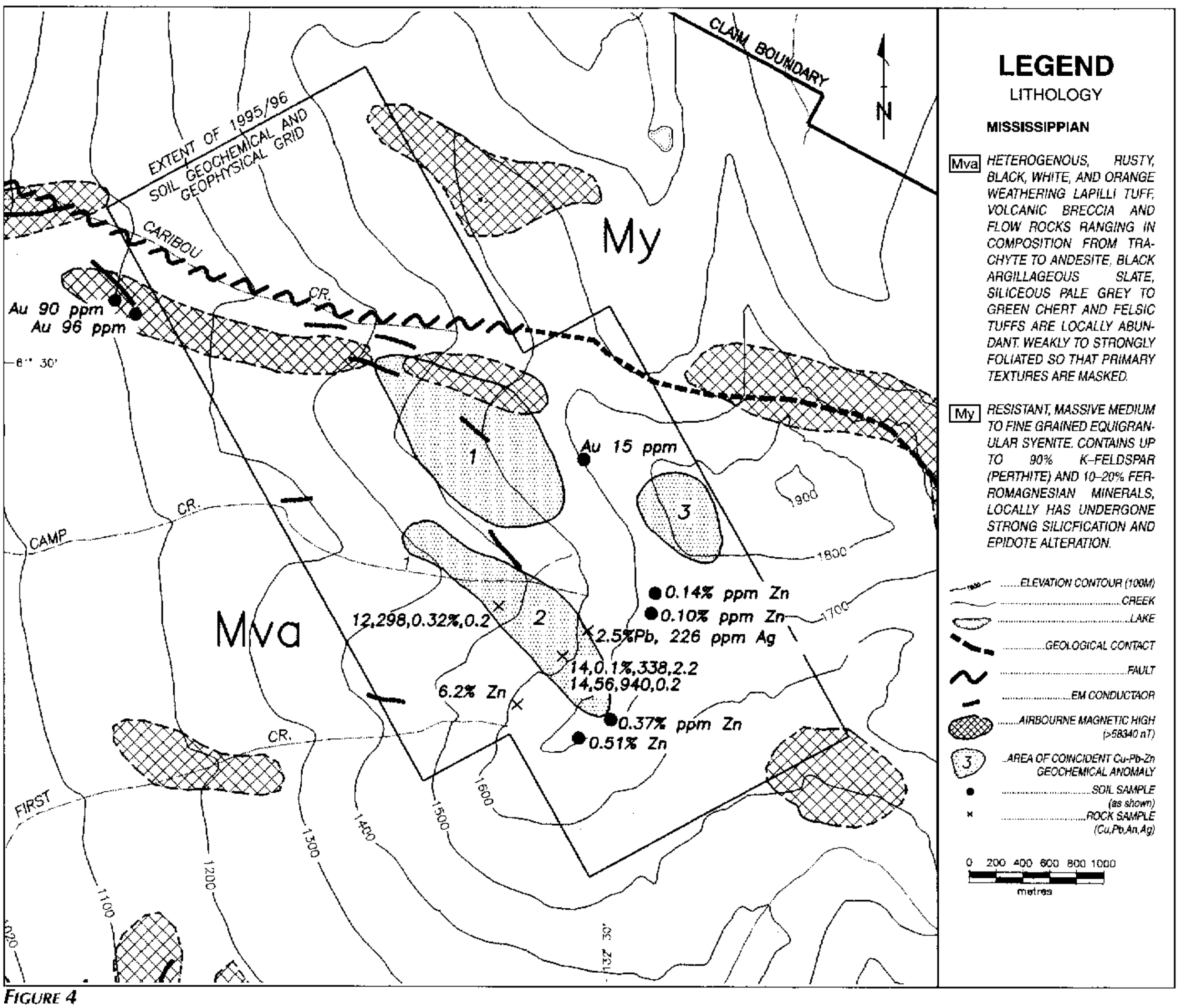


FIGURE 4

Mineralization

Mineralization located to date on the property consists of: 1) disseminated pyrite in exhalite horizons, 2) massive bedded pyrite, and 3) quartz veins and quartz breccias containing pyrite, +/- sphalerite, tetrahedrite, galena, and chalcopyrite. Surface showings are generally pyrite rich and geochemically do not contain significant copper lead or zinc. Selected rock samples over surface mineralization have returned up to 6.2% Zn and 2.5% Pb (Figure 4).

Geochemistry

A total of 1807 grid soil samples were collected in 1995 and 1996 . All analytical work was completed by Acme Analytical Laboratories Ltd., using a 31 element ICP package. The results were statistically analyzed and the threshold and anomalous values derived from those calculations was used to plot the results (Doherty, 1996a). A correlation matrix for selected samples is shown in Table I.

The contoured soil geochemical plots for Cu, Pb, and Zn are shown in Figure 3. There are three strong multi-element soil geochemical anomalies that have a trend of 131° across the centre of the grid (Figure 4). Anomaly #1 is a 700 m by 300 m multi-element anomaly that is flanked on the southeast side by a magnetic high and a VLF-EM conductor. Anomaly #2 is located approximately 200 m southeast of anomaly #1 and measures 800 m by 200 m. Anomaly #3 measures 300 m by 200 m and is open ended to the southeast.

The anomalous areas are best defined by Cu, Pb, Zn contoured geochemical soil results. Copper because of its greater mobility shows a wider dispersion than lead or zinc. There is a broad barite anomaly as well as iron and cadmium anomalies associated with the coincident Cu-Pb-Zn anomalies.

Geophysics

A total field magnetic survey and a very low frequency electromagnetic (VLF-EM) survey was completed over 45.5 line kilometres of grid. The surveys were completed by Amerok Geosciences Ltd., of Whitehorse. Readings were taken at 12.5 m spaced stations on 50 m spaced lines.

The significant total field magnetic anomalies are shown with the geochemical anomalies (Figure 4). A prominent magnetic high with 50 nT relief is located between geochemical Anomalies 1 and 2. A second large magnetic high runs across the west side of the grid and is interpreted as a faulted contact between the Mississippian volcanics and the Mississippian syenite. There is no geochemical anomalies related to this magnetic high.

Discussion and Conclusions

At present the best VMS target at the Mamu-Bravo-Kulan Claims is located on the 1995-96 grid just north of the baseline. This area has coincident total field magnetic and multi-element (Pb, Zn, Cu, Fe, and Cd) soil geochemical anomaly that extends over a strike length of greater than 700 m. The magnetic anomaly is slightly offset to the southwest with respect to the multi-element soil geochemical anomaly.

The magnitude of the anomalies is what would be expected from a deposit model with dimensions of 600 m by 400 m. The soil and rock geochemical data indicate that the system is zinc rich (i.e. Zn > Pb > Cu) and as such the geophysical responses may be less obvious than over copper rich systems (M. Power, Pers Com.).

The soil geochemical data shows coincident Pb, Cu, Zn, Cd, Ba, and Fe anomalies. Mo is also weakly anomalous and correlates with Cu, Pb, Zn; this geochemical association is apparently common in the Finlayson Lake area which hosts the Kudz Ze Kayah and Wolverine deposits. In the Finlayson area when Mo is present it commonly considered to be a positive indication for the presence of VMS mineralization hosted in felsic volcanics.

Acknowledgements

The author would like to thank Oro Bravo Resources Ltd., for permission to publish these preliminary exploration results. The figures were drafted by Joseph Clarke.

TABLE I Correlation Coefficients for 1995 Soil Samples, Selected Elements

	Mo	Cu	Pb	Zn	Ag	Fe	Au	Cd	Ba
Mo	1.000								
Cu	0.434	1.000							
Pb	0.314	0.548	1.000						
Zn	0.384	0.616	0.612	1.000					
Ag	0.439	0.401	0.425	0.295	1.000				
Fe	0.540	0.529	0.346	0.475	0.428	1.000			
Au	0.123	0170	0.116	0.241	0.009	0.169	1.000		
Cd	0.224	0.432	0.390	0.770	0.170	0.238	0.232	1.000	
Ba	0.124	0.352	0.157	0.278	0.025	0.338	0.015	0.266	1.000

FIGURE 3:
Zn, Pb and anomalies in soil, Mamu-Bravo-Kulan claims, central Yukon.

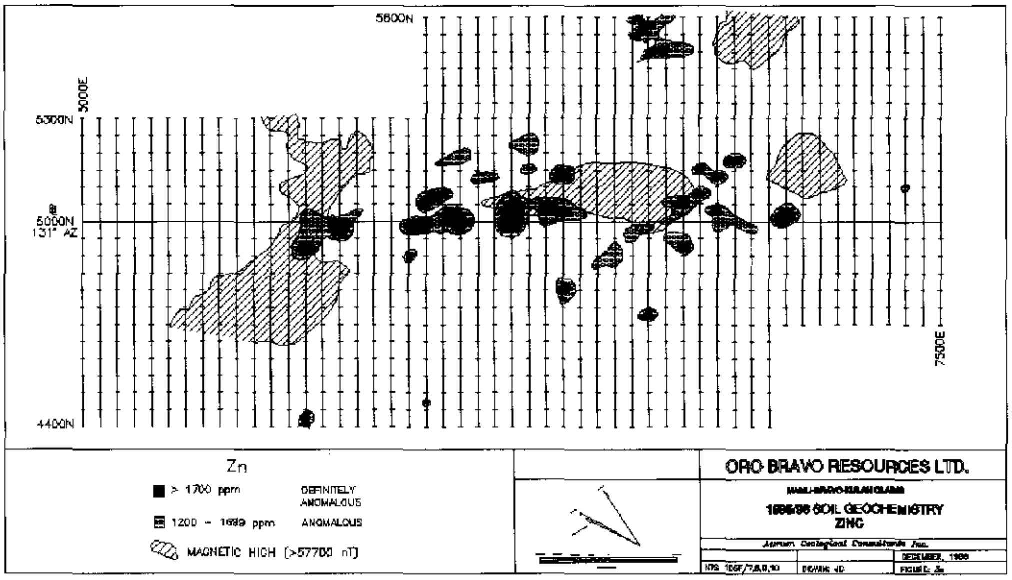


FIGURE 3A

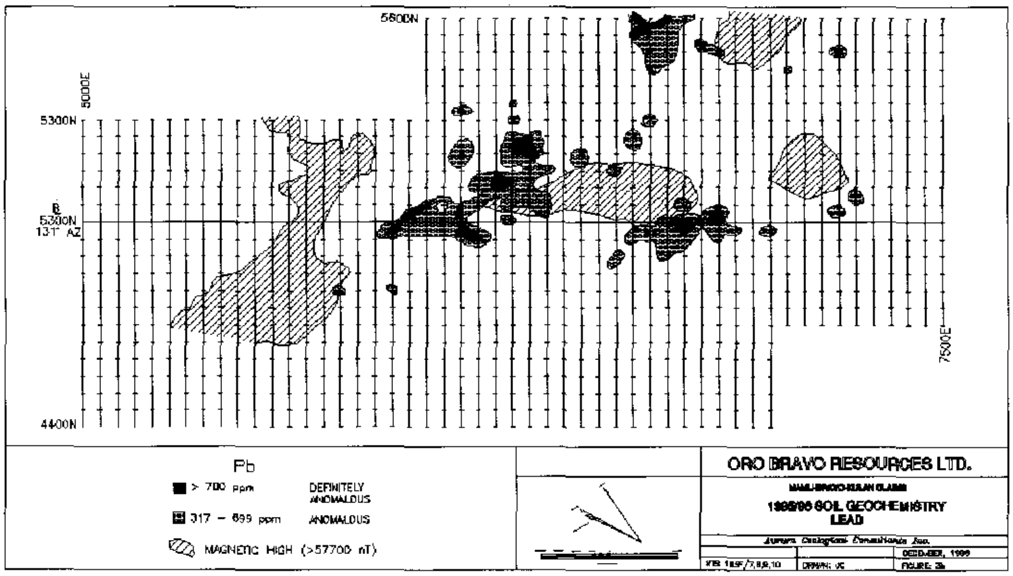


FIGURE 3B

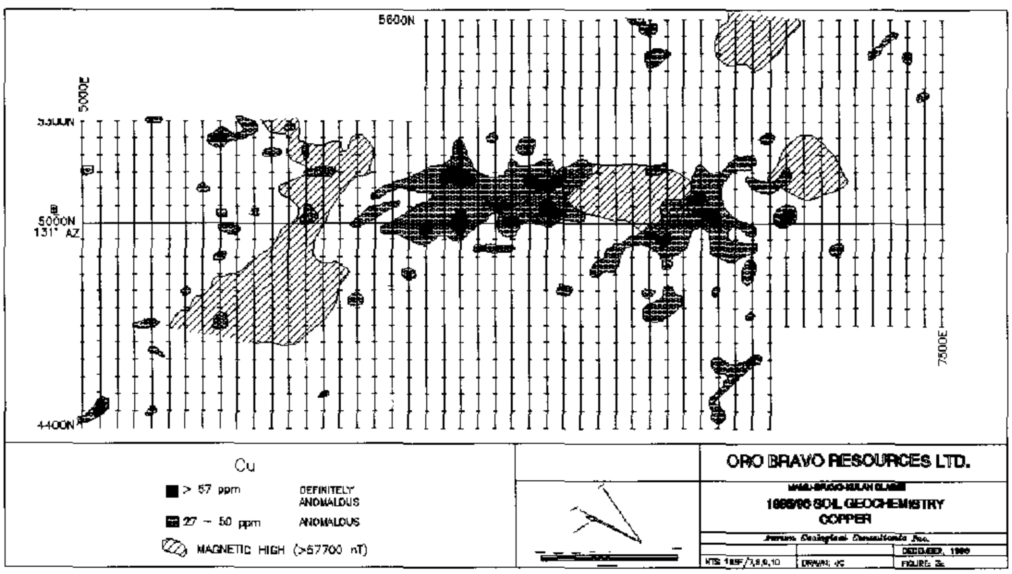


FIGURE 3C

REFERENCES

Abbott, J.G., 1986: Epigenetic mineral deposits of the Ketza-Seagull district, Yukon; in Yukon Geology, Vol 1, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p 55-56.

Burson, M.J., 1989: 1988 Program of Geological Mapping, Geochemistry and Prospecting on the Matthew Claim Group, private report for Cascade Pacific Resources Ltd.

Doherty, R.A., 1996a: 1995 Report on the Soil Geochemistry and Magnetometer and VLF-EM Geophysical Surveys on the Mamu 1-23 and Bravo 24-44 Claims, Watson Lake Mining District. Private Company report for Oro Bravo Resources Ltd.

Doherty, R.A., 1996b: 1996 Report on the Mapping, Soil Geochemistry and Magnetometer and VLF-EM Geophysical Surveys on the Mamu 1-23 and Bravo 24-44 and Kulan 1-109 Claims, Watson Lake Mining District. Private Company report for Oro Bravo Resources Ltd.

Downing, B.W., 1993: 1992 Program on the Matthew Claims, McConnell River Area, Yukon Territory, NTS 105F/7,8,9 and 10, private report for Granges Inc.

Killin, K, 1990: Report on a Combined Helicopter Borne Magnetic, Electromagnetic and VLF Survey McConnell River Area, Yukon Territory, private report for Granges Inc. by Aerodat Limited.

Morin, J.A., 1981: Model of Mineralization related to Cauldron Facies Syenite in the Pelly Mountains, in Yukon Geology and Exploration 1979-80, Indian and Northern Affairs Canada, p 88-90

Mortensen, J.K., 1982: Geological setting and tectonic significance of Mississippian felsic metavolcanic rocks in the Pelly Mountains, southeastern Yukon Territory, Can. J. Earth Sci. Vol 19, pp 8-22.

Mortensen, .K., and Godwin, C.I., 1982: Volcanogenic Massive Sulphide Deposits Associated with highly Alkaline Rift Volcanics in the Southeastern Yukon Territory, Economic Geology, Vol 77, pp 1225-1230.

Reynolds, P., 1994: Summary Report on the Mamu 1-24 Claims, Watson Lake Mining District, Yukon Territory, Private report for B.V. Hall .

Solkoski, L.R., 1990: Geological & Geochemical Assessment Report of the Matthew Claims, Watson Lake Mining District, for Granges Inc.

Solkoski, L.R., 1991: Geological & Geochemical Assessment Report of the Matthew Claims, Watson Lake Mining District, for Granges Inc.

Tempelman-Kluit, D., 1977: Quiet Lake (105F) and Finlayson Lake (105G) Map-Areas. Geol. Surv. Can., Open File 486.

Tempelman-Kluit, D., 1981: Geology and Mineral deposits of Southern Yukon: in Yukon Geology and Exploration 1979-80; Geology Section, Department of Indian and Northern Affairs, Whitehorse, Yukon.

Preliminary Geology of the Northeast Third of Grass Lakes Map Area (105G/7), Pelly Mountains, Southeastern Yukon

Donald C. Murphy and J.R.M. Timmerman
Yukon Geology Program

MURPHY, D.C. and TIMMERMAN, J.R.M., 1997. Preliminary geology of the northeast third of Grass Lakes map area (105G/7), Pelly Mountains, southeastern Yukon. In: Yukon Exploration and Geology 1996, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 62-73.

ABSTRACT

The northeast corner of Grass Lakes map area is underlain by polydeformed metasedimentary, metavolcanic and metaplutonic rocks of Yukon-Tanana Terrane, and ultramafic rocks of unknown affinity. Layered metasedimentary and metavolcanic rocks, about half the area mapped, include a basal unit of quartz-rich schist, psammite, metapelitic schist, and grit with a laterally continuous sandy marble marker high in the unit; a unit made up of a variety of mafic metavolcanic (?) rock types interlayered with carbonaceous phyllite, grey quartzite, quartzofeldspathic psammite and grit; Devono-Mississippian felsic metavolcanic (?) rocks interlayered with carbonaceous phyllite and grey quartzite, and an upper mafic metavolcanic (?) unit with quartzofeldspathic psammite and grit, and carbonaceous phyllite and quartzite. Metarhyolite of the third unit hosts the Kudz Ze Kayah massive sulphide deposit and underlies numerous gossans. The succession is thought to be upright based on an interpretation of the structure of metarhyolitic rocks at Kudz Ze Kayah.

The remainder of the area is underlain by metaplutonic rocks. Quartz-feldspar metaporphyry near Kudz Ze Kayah is thought to be a hypabyssal intrusion coeval with the adjacent metavolcanic pile. Coarse-grained granitic to monzonitic Grass Lakes Orthogneiss of probable Early Mississippian age underlies much of the area; it and its apophyses intrude the layered units. The undated North Lakes Metadiorite is thought to intrude the Grass Lakes Orthogneiss. Three large undated bodies and numerous discordant dykes of weakly foliated biotite-muscovite granite intrude the layered succession.

Ultramafic rocks occur in two settings in the eastern part of the area. Discontinuous 10 to 100 metre-scale bodies of ultramafic rock occur along the contact between actinolite-chlorite schist and calcareous quartzose psammite (above) near the Pack occurrence. A km-scale body of ultramafic rock also overlies the same calcareous quartzose psammite in the prominent peak along the east side of the map area. An axial surface trace of a recumbent north-closing fold lies between the two localities suggesting that the ultramafic rocks are folded.

All rocks except biotite-muscovite granite and ultramafic rocks are strongly foliated and lineated. The prominent foliation transposes an older foliation and bedding and is axial-planar to south-vergent folds mappable at 1:50 000 scale. This deformation occurred after the intrusion of the Grass Lakes Orthogneiss (therefore post-Mississippian) and waned during the emplacement of biotite-muscovite granite. Two weak later phases of deformation comprise sporadically developed north-trending, east-vergent folds of the second-phase foliation and regional arching of the second phase foliation over a southwest-trending hinge in the central part of the map area.

RÉSUMÉ

Le coin nord-est de la région de la carte de Grass Lakes repose sur des roches métasédimentaires, métavolcaniques et métaplutoniques polydéformées et hétérogènes du terrane de Yukon-Tanana, et des roches ultramafiques moins abondantes d'affinité inconnue. Les roches métasédimentaires et métavolcaniques stratifiées, comptant pour la moitié environ de la région de la carte, forment une succession comprenant : une unité basale de schiste riche en quartz, de psammite, de schiste métapélitique et de grès grossier avec un repère de marbre sableux latéralement continu vers le sommet de l'unité; une unité intermédiaire composée de divers types de roches métavolcaniques mafiques (?) avec interstratification de phyllite carbonée, de grès quartzitique gris, de psammite quartzofeldspathique et de grès grossier; et une unité sommitale composée de roches métavolcaniques felsiques (?) du Dévono-Mississippien avec interstratification de phyllite carbonée et de grès quartzitique gris. La métarhyolite de l'unité sommitale contient le gisement de sulfure massif de Kudz Ze Kayah et repose sous de nombreux chapeaux de fer. La stratigraphie de la succession aurait évolué à la verticale d'après une interprétation de la structure des roches métarhyolitiques de Kudz Ze Kayah.

Le reste de la région repose sur des roches métaplutoniques. Le métaporphyre quartzofeldspathique près de Kudz Ze Kayah serait une intrusion hypabyssale contemporaine de la pile métavolcanique adjacente. L'orthogneiss oeillé granitique à monzonitique à grain grossier de Grass Lakes, qui remonterait au Mississippien précoce, s'étend sous la plus grande partie de la région; cette roche et ses apophyses pénètrent toutes les unités stratifiées. La métadiorite non datée de North Lakes pénétrerait l'orthogneiss de Grass Lakes. Trois grands corps non datés et de nombreux dykes discordants de granite à biotite-muscovite faiblement folié pénètrent la succession stratifiée.

On trouve des roches ultramafiques à deux endroits dans l'est de la région. Des corps discontinus de quelque 10 à 100 mètres de roche ultramafique sont répartis le long du contact entre le schiste à actinolite-chlorite et la psammite quartzeuse calcaire (sus-jacente) près de l'occurrence Pack. La roche ultramafique repose sur la même psammite quartzeuse calcaire dans le pic proéminent à la limite est de la région de la carte. Les deux endroits sont séparés par la trace de la surface axiale d'un pli renversé se fermant au nord, indiquant que les roches ultramafiques sont plissées.

Toutes les roches autres qu'ultramafiques ont une structure foliée à linéations marquée. La foliation marquée est une transposition d'une foliation et d'un litage plus anciens, et est orientée suivant le plan axial des plis à vergence sud cartographiables à l'échelle de 1/50. Cette déformation s'est produite après l'intrusion de l'orthogneiss de Grass Lakes (donc après le Mississippien) et s'est résorbée durant la mise en place du granite à biotite-muscovite. Deux faibles phases de déformation ultérieures comprennent des plis de direction nord et de vergence est qui se sont formés sporadiquement au cours de la foliation de la deuxième phase, et un mouvement régional en voûte de la foliation de la deuxième phase au-dessus d'une charnière de direction ouest dans le centre de la région de la carte.

Introduction

Being generally poorly exposed, structurally and lithologically complex and only locally studied in detail, Yukon-Tanana Terrane (YTT) remains the least well understood geological element in the Yukon. The paucity of basic information about the stratigraphic makeup of the terrane, its structure, its geological evolution, and its relationships to neighbouring terranes precludes understanding of its role in the evolution of the Cordillera and has hindered mineral exploration. Recent discoveries of high-grade massive sulphide deposits in the terrane (Cominco's Kudz Ze Kayah and Westmin/Atna's Wolverine Lake deposits) has renewed interest in it as an exploration target, underscoring the need for a better understanding.

A multi-year 1:50 000-scale mapping program in the reasonably well exposed part of the terrane northeast of the Tintina Fault was started in 1996 to address the outstanding fundamental questions about the nature and evolution of the YTT. The northeastern third of Grass Lakes map area (105G/7) was completed in six weeks of mapping in 1996.

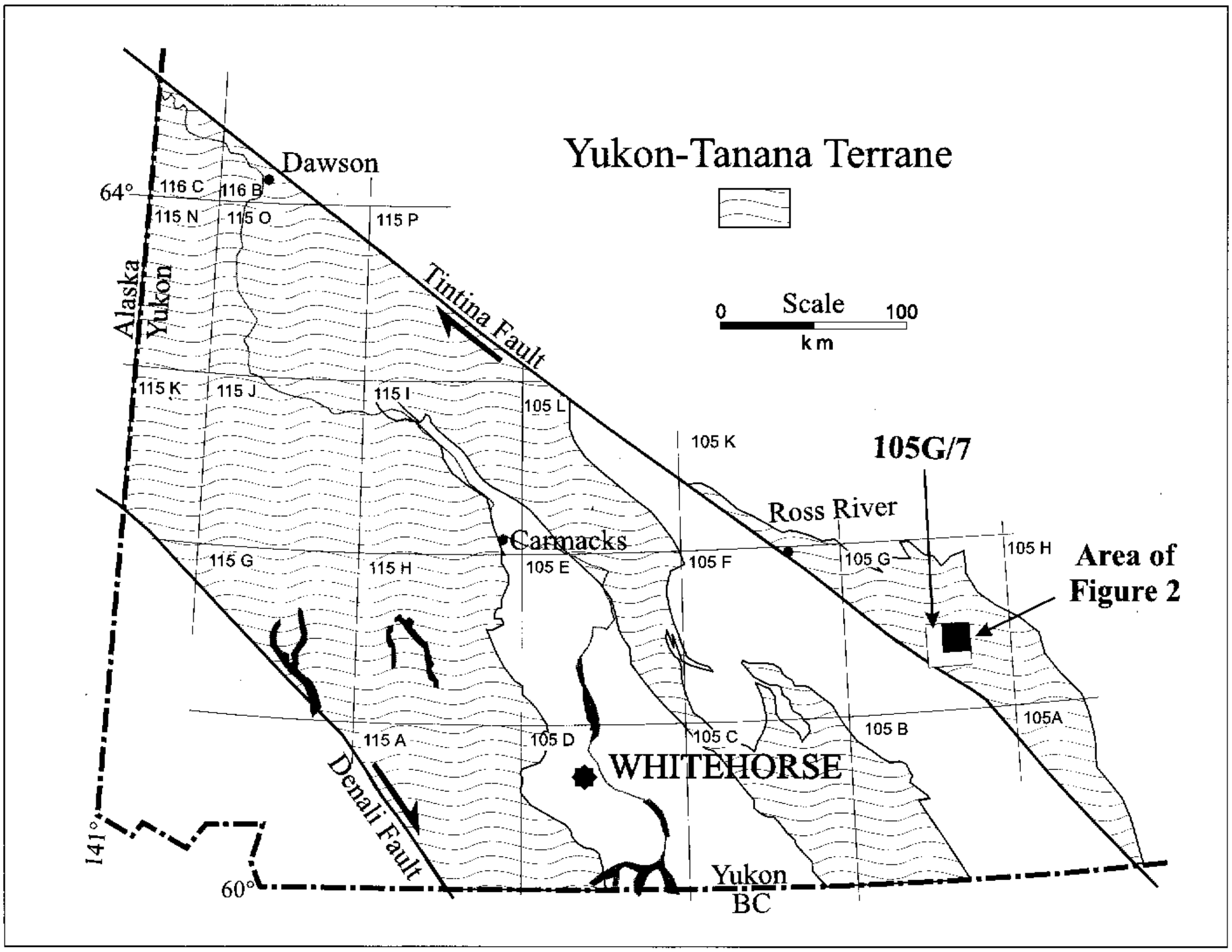


FIGURE 1: Grass Lakes map area (105G/7) with respect to the distribution of Yukon-Tanana Terrane in Yukon.

Location, access and exposure

Grass Lakes map area is about 110 km southeast of Ross River and about 20 km south of the Robert Campbell Highway at Finlayson Lake (Fig. 1). Fieldwork was done primarily by foot traverses from fly camps supported by a helicopter based at Kudz Ze Kayah. Cominco generously allowed truck access to Kudz Ze Kayah along their private road from the Robert Campbell Highway, access to their contract helicopter, and offered the use of their camp while examining the geology around Kudz Ze Kayah.

The terrain is mountain uplands (with peaks up to 2100m) dissected by second-order tributary drainages and surrounded by broad, deep, flat-floored first-order valleys filled with unconsolidated sediment. Boulder fields of transported resistant rock types locally mantle the upland areas, obscuring the underlying rocks. Good continuous exposures are found along ridge tops, below steep cliffs and locally along creeks in the bottoms of second-order valleys. Isolated exposures occur in gentler colluvium-covered slopes.

Previous work

Grass Lakes map area was previously visited during three regional mapping programs. Wheeler and others (1960) examined Grass Lakes map area during the first systematic 1:250 000-scale mapping of Finlayson Lake map area. Their map outlined the extent of undifferentiated metamorphic rocks, granitic intrusive rocks and ultramafic rocks in the region. In the first generation of 1:250 000-scale revision mapping of the area, Tempelman-Kluit (1977, 1979) further subdivided the rocks, presented an interpretation of the relationships between the various metamorphic rock units and, emphasizing the mylonitic character of many of the rocks in the region, interpreted these features in terms of a model of Jurassic arc-continent collision. Mortensen and Jilson (1985) presented a map and interpretation of YTT northeast of the Tintina Fault, including the Grass Lakes map area. In this paper and Mortensen (1992), the authors interpreted the protoliths of the metamorphic rocks, proposed a stratigraphic interpretation, presented new radiometric ages of various metavolcanic and metaplutonic rock units, and contrasted the evolution of YTT with that of the neighbouring North American continental margin.

GEOLOGY OF NORTHEASTERN GRASS LAKES MAP AREA

The northeastern third of Grass Lakes map area is underlain by strongly foliated heterogeneous metasedimentary, metavolcanic and metaplutonic rocks (Figure 2). Metaplutonic rocks of three different suites underlie nearly half the area; metasedimentary and metavolcanic rocks occur around the margins of the intrusive bodies and as enclaves within them. The amount of metaplutonic rock makes tracing rock units difficult, a task that is complicated by structural complexity. The rocks are polydeformed and the general parallelism of the strong foliation to compositional layering suggests that the rock sequence is transposed. However, the continuity of some key metasedimentary rock units, the consistent lithologic succession throughout the area, the consistent structural vergence of the main phase of deformation throughout most of the area and the continuous nature of metaplutonic contacts that have been affected by the deformation argue against wholesale disruption of the rocks. Stratigraphic variability is also likely given the coarse-grained nature of some of the metaclastic rocks and the volcanic protolith of others.

Stratigraphic succession

A stratigraphic succession of four generalized rock units has been recognized in the area (Figure 2 and 3). The subdivisions defined for this area are based on the similarity of rock sequences in different places above a marble marker in the lowest unit. The applicability of this sequence beyond the map area is unknown but will be evaluated in upcoming field seasons. About 1.5 km of structural section is represented.

Unit 1

The deepest exposed rocks are quartzose and pelitic metaclastic rocks with a laterally continuous 150 m-thick marble unit about 150 metres from the top (Figure 4). Metaclastic rocks include tan to dark brown-weathering, grey muscovite-biotite-quartz psammite (Figure 5), biotite-muscovite(-garnet) pelitic schist, and quartz-pebble grit. The marble unit is made up of light brown weathering sandy grey marble, calc-schist and green-brown calc-silicate rock. Coarsely porphyroblastic garnet schist commonly occurs at the top of the marble. The marble has been traced throughout much of the range west of the largest Grass Lakes and is the datum from which the stratigraphic succession has been defined.

Unit 2

Overlying the basal metaclastic unit is a lithologically varied succession of mafic schists interbedded with carbonaceous phyllite, grey quartzite and brown quartzofeldspathic psammite, grit and conglomerate (Figures 6 and 7). Mafic schists include mottled dark brown to black biotite-plagioclase schist (Figure 8), dark green massive chlorite-actinolite schist and locally banded light and dark green actinolite-chlorite-plagioclase greenstone (Figure 9); all are variably calcareous. Biotite-plagioclase schist is commonly cut by calcite veins and pods of marble occur locally with greenstone.

Mafic rocks of unit 2 are inferred to be volcanic in origin. This inference is based primarily on their composition and generally massive texture; deformation obscures primary features.

Unit 3

The mafic metavolcanic unit passes upward into quartz-muscovite (sericite?) +/-biotite schist with lesser laterally variable amounts of carbonaceous phyllite and quartzite and rarely mafic biotite-plagioclase schist. Quartz-muscovite(-biotite) schist is waxy greenish-white to tan in colour and locally is interbedded with m- to 10 m-scale bands of cream-coloured, fine-grained siliceous rock with mm- to cm-scale sugary (polycrystalline?), light grey, rounded quartz blebs that could be recrystallized amygdules or phenocrysts (Figure 10). Mm-scale quartz and potassium feldspar augen occur in both rock types. Quartz-muscovite schist locally exhibits a texture suggestive of flattened fragments (Figures 11 and 12).

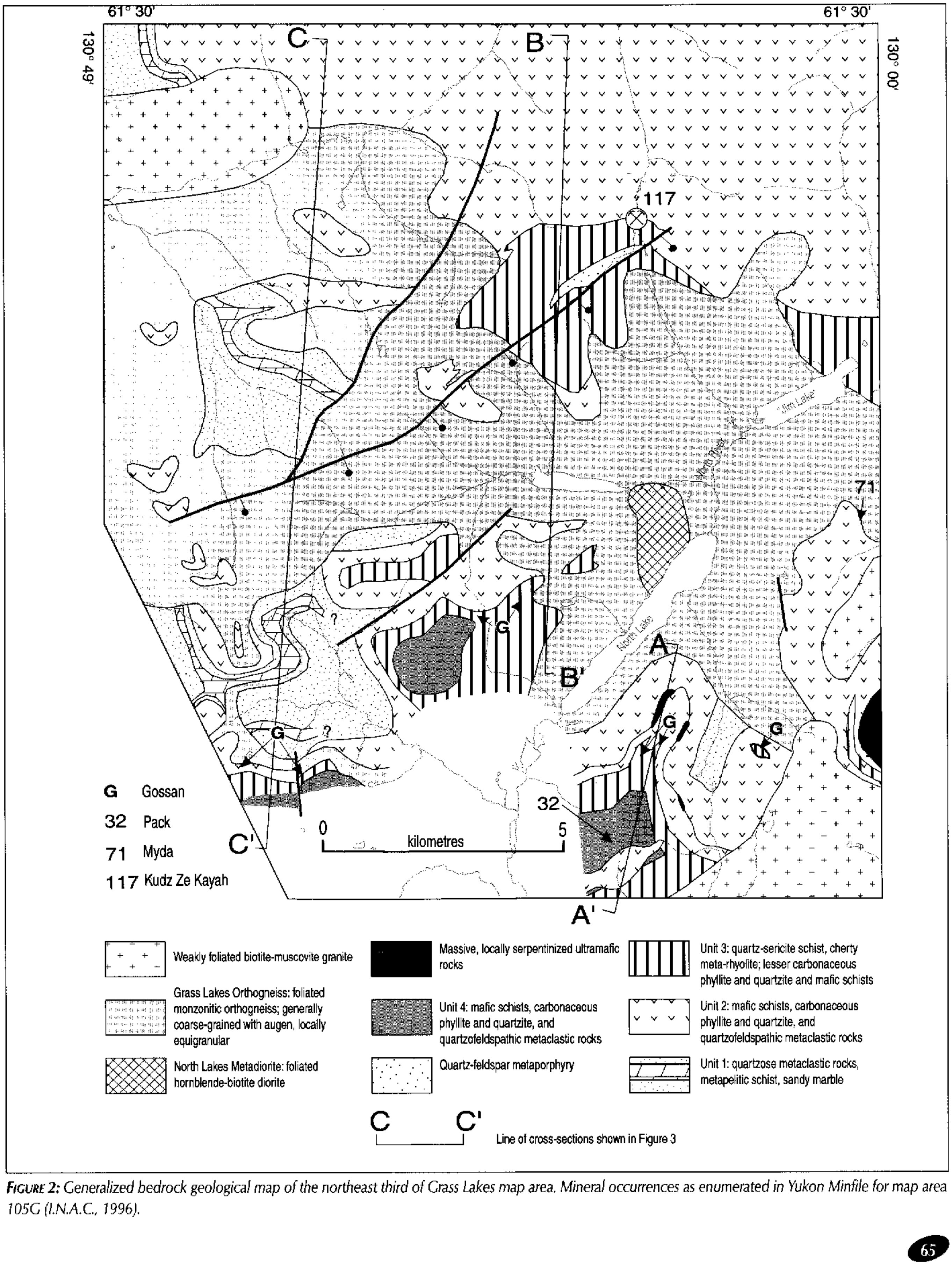


FIGURE 2: Generalized bedrock geological map of the northeast third of Grass Lakes map area. Mineral occurrences as enumerated in Yukon Minfile for map area 105G (I.N.A.C., 1996).

Felsic schists of unit 3 are interpreted as felsic metavolcanic rocks. The siliceous rock with rounded quartz blebs and locally with quartz and feldspar augen is thought to be a metarhyolite. Metarhyolite is variably altered, underlies numerous gossans throughout the region, and hosts the massive sulphide deposit at Kudz Ze Kayah. A sample of felsic rock from near Kudz Ze Kayah yielded a Devono-Mississippian U-Pb zircon age (J. Mortensen, pers. comm., 1996; Mortensen, 1992).

Unit 4

Rocks overlying the felsic metavolcanic unit resemble those of unit 2, consisting of dark weathering biotite-plagioclase schist, brown locally calcareous quartz-feldspar-biotite psammite, and carbonaceous phyllite and quartzite. Although rocks of unit 4 are similar to unit 2, there is no evidence to suggest that unit 4 is a structural repetition of unit 2. Unit 4 occurs in only three localities in the area.

Although stratigraphic facing indicators were not observed during mapping, the succession is inferred to be upright, with unit 1 at the base and unit 4 at the top. This inference is based on Schultze's (1996) conclusion that the Kudz Ze Kayah massive sulphide deposit is overturned and the structural interpretation in Figure 3. Kudz Ze Kayah is inferred to be on the short limb of a south-vergent antiform-synform pair (see Figure 3) and rocks throughout most of the rest of the area are on the long lower limb of the synform. If Kudz Ze Kayah is overturned then the rocks in much of the rest of the area would be upright.

Metaplutonic rocks

Several bodies of granitic metaplutonic rock, one body of metadiorite, and several bodies of ultramafic rock occur in the area. Texture and relationship to deformational fabrics in the host rock discriminate three different episodes of granitic rocks. U-Pb dating has been started to establish the ages of crystallization of all the suites and episodes and will limit the age(s) of deformation.

Quartz-feldspar metaporphyry at Kudz Ze Kayah

A mappable body of quartz-feldspar-sericite augen schist (Figure 13) occurs southwest of the Kudz Ze Kayah massive sulphide deposit. Hundreds of metres from the deposit, quartz and feldspar phenocrysts are cm-sized and the rock is recognizable as an originally porphyritic rock. Closer to the deposit, quartz and feldspar phenocrysts are less obvious and the rock is softer and rustier with bands of pyrite and quartz. Its coarse grainsize suggests that it is metaplutonic rock, possibly a subvolcanic porphyry.

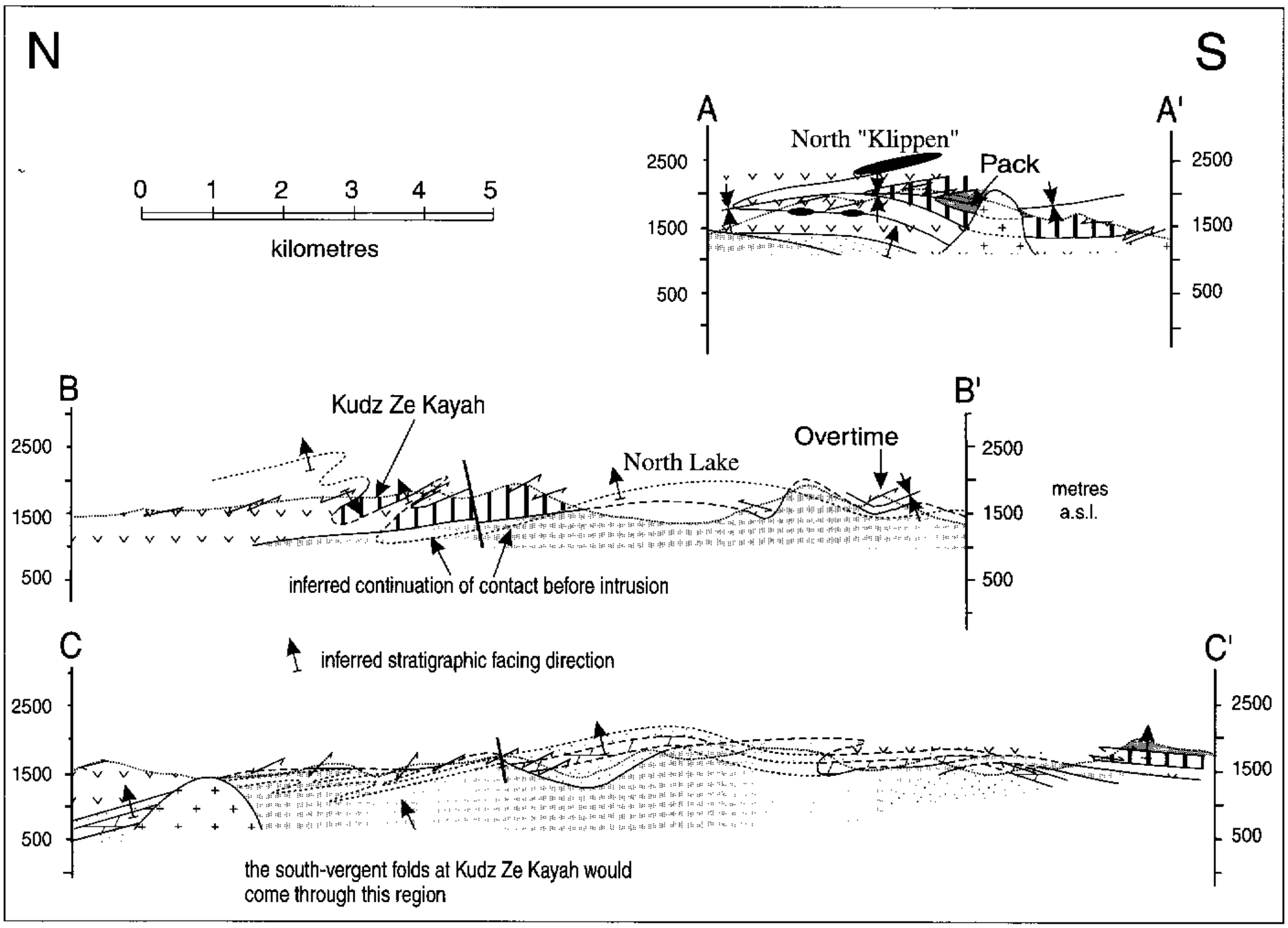


FIGURE 3: Generalized cross sections along lines of section indicated in Figure 2.

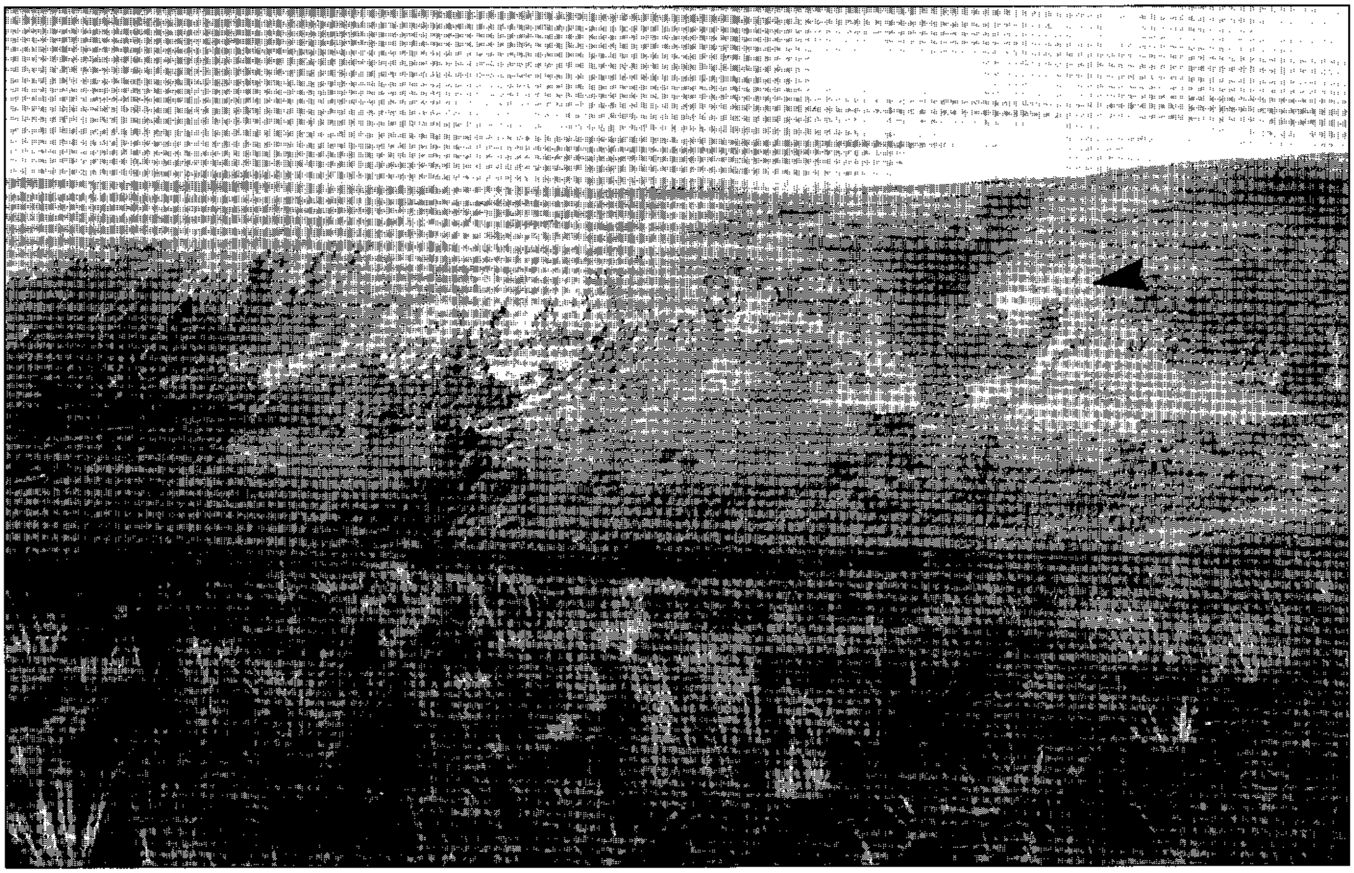


FIGURE 4: View of valley wall showing continuous band of marble near top of Unit 1. Above and below marble are gritty quartzose psammite and grit and lesser metapelitic schist.

Grass Lakes Orthogneiss

The largest metaplutonic body is the Grass Lakes Orthogneiss, underlying more than a third of the map area. The Grass Lakes Orthogneiss has angular to broadly elliptical cm-scale potassium feldspar porphyroclastic phenocrysts in a strongly foliated finer grained matrix of quartz, plagioclase, biotite and muscovite. The relative proportion of porphyroclasts and matrix varies. The rock is generally coarse-grained and equigranular with flattened cm-scale potassium feldspar megacrysts making up most of the rock (Figure 14). Locally, augen orthogneiss made up of cm-scale augen in a finer grained quartz-feldspar-biotite matrix predominates (Figure 15). Also locally, as at the Overtime occurrence (Figure 2), augen are inconspicuous to absent and the orthogneiss is a foliated potassium feldspar-rich rock. The orthogneiss crosscuts the stratigraphic succession, intruding as high as the felsic metavolcanic rock unit. The age of the Grass Lakes Orthogneiss is thought to be Early Mississippian based on its resemblance to dated bodies elsewhere in YTT.

North Lakes Metadiorite

The North Lakes Metadiorite(?) is weakly foliated medium- to coarse-grained (up to 4 mm) hornblende(?)-biotite-plagioclase rock at the end of the ridge between the larger of the two North Lakes (Figure 16). Equigranular medium green mafic clots thought to be chloritized hornblende and biotite are intergrown in a mosaic with less abundant plagioclase. Flecks of mm-scale, chalky white, subangular crystals of plagioclase(?) appear on sawn surface. Although contacts are not exposed, the North Lakes Metadiorite(?) is surrounded by Grass Lakes Orthogneiss and is thought to intrude it.

Late kinematic granites

Four mappable stocks and numerous dykes of weakly foliated biotite-muscovite granite occur in the area (Figure 2). The stocks are leucocratic and composed of whitish grey to light grey, medium-grained, weakly foliated, equigranular mixtures of quartz, plagioclase and potassium feldspar in roughly equal amounts. Biotite and muscovite make up about 5% of the rock, are common on foliation surfaces, and with muscovite after biotite. Fine-grained, weakly foliated, equigranular felsite dykes are common in country rock especially near the margins of stocks. They are locally discordant with respect to the prominent country rock foliation (Figure 17), commonly folded (Figure 18), and locally asymmetrically boudinaged (Figure 19). The structures affecting these granite rocks are kinematically compatible with the prominent second-phase of deformation implying that they intruded late in the development of second-phase structures.

***FIGURE 5:** Drab brown weathering metapelitic schist and psammite above carbonate marker unit. Garnet in schist is locally coarse-grained (diameter to 2 cm). Note top-to-south shear bands at top of outcrop.*

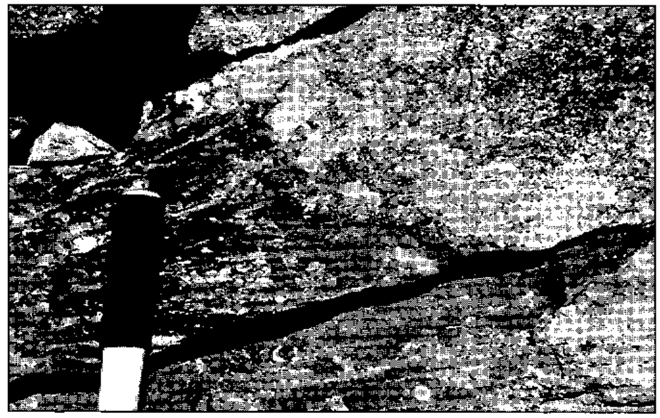


***FIGURE 6:** Interbedded gritty quartzofeldspathic metasandstone and grey phyllite of Unit 2. Beds are in hinge of synform (cline?) in train of south-vergent folds.*

***FIGURE 7:** Interbedded coarse-grained to gritty quartzofeldspathic metasandstone and grey quartzite.*

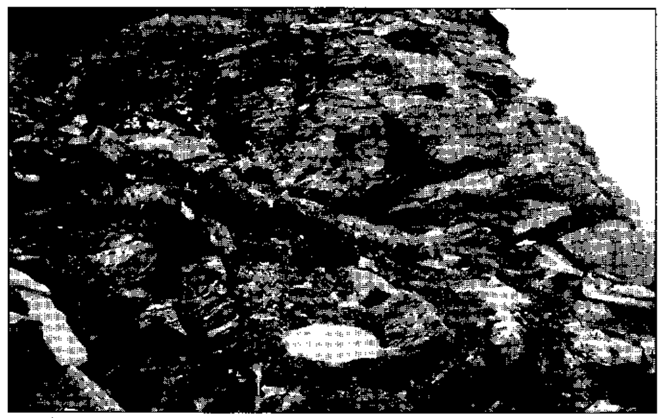


***FIGURE 8:** Dark brown to black biotite-plagioclase schist with calcite veins cut by massive felsite dykes.*

Ultramafic rocks

Utramafic and mafic rocks occur in the eastern part of the map area, in two settings. Three 10 to 50 m-scale bodies of massive, resistant, brown-weathering, coarse-grained pyroxenite (?, bronzite(?) up to 5 cm?, Figure 20) and gabbro occur discontinuously along a contact between actinolite-chlorite schist and calcareous quartzose psammite and quartzite within Unit 2 near the **Pack** massive sulphide occurrence (Figure 2). Second, a portion of the prominent peak along the eastern edge of the map area due east of the **Pack** occurrence is underlain by dunite and other ultramafic and mafic rock which lies above the same calcareous quartzose psammite (North Klippen of Tempelman-Kluit, 1979). Lying between the two occurrences is the axial surface trace of a recumbent north-closing structure (Figure 3) and the two occurrences may represent a folded semi-continuous sheet at about the same stratigraphic level.

The nature of these mafic and ultramafic rocks is not clear. Although locally serpentinized and altered to talc, chlorite, carbonate and quartz along fractures, these rocks are not strongly foliated. The contacts at the former setting are not exposed. At the latter setting, the top few metres of metaclastic rocks beneath the mafic/ultramafic rocks are very fine-grained, strongly foliated and may be mylonitic.

Structure

The rocks of Grass Lakes map area show four phases of deformation. The earliest recognizable phase of deformation is manifested solely by a foliation that is isoclinally folded and transposed into the prominent second-phase foliation. This foliation is everywhere sub-parallel to bedding. The second-phase of deformation is manifest by a prominent foliation and lineation, a less prominent set of spaced shear band-like deflections of the foliation (Figures 5 and 19), and tight to isoclinal hand-specimen- to mountain-scale folds (Figures 21 and 22) which, like the shear bands, show regional south-vergence. The folds fold the first-phase foliation and have the second-phase foliation in their axial surface. The second-phase structures are locally folded by north-trending east-vergent outcrop-scale folds and arched over a diffuse east-north-east-trending fold in the centre of the map area.

The ages of the various phases of deformation are not tightly constrained. Metasedimentary and metavolcanic rocks show all four phases of deformation, constraining them to be all post-

FIGURE 9: Subtly banded to massive chlorite-actinolite-plagioclase phyllite of Unit 3.

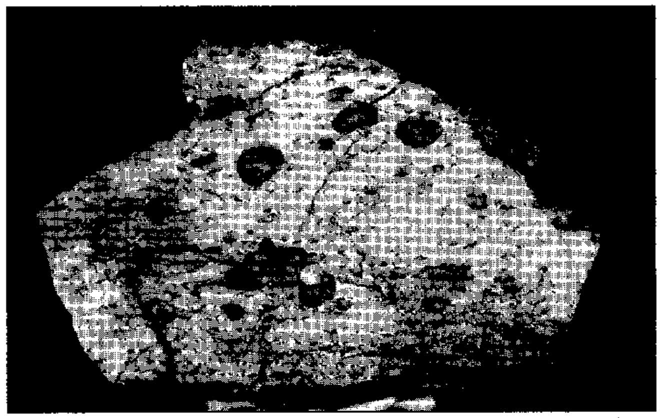


FIGURE 10: Metarhyolite composed of rounded, slightly elliptical quartz blebs in aphanitic matrix. Such domains have been variously interpreted as amygdules or resorbed phenocrysts.

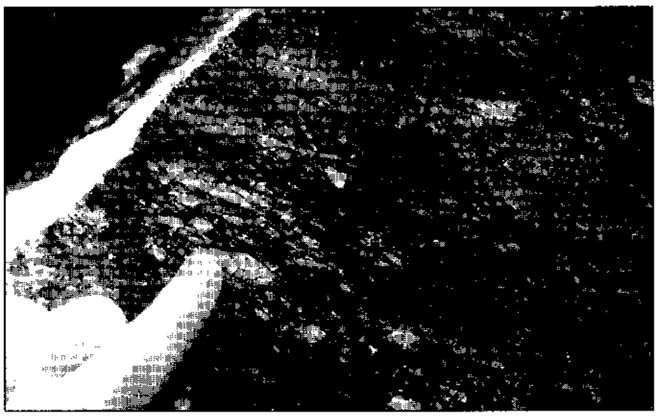


FIGURE 11: Felsic rock composed of unsorted parallel elliptical fragments of fine-grained siliceous rock in a darker matrix. This texture could be interpreted as a fragmental metavolcanic texture. Alternatively, the texture could be entirely deformational. The former interpretation is preferred at this point.

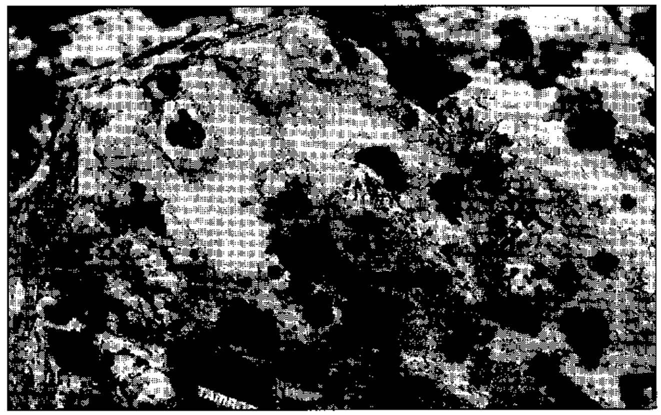


FIGURE 12: View of foliation surface in siliceous quartz-sericite schist showing oblate elliptical lumps reminiscent of fragmental texture.

FIGURE 13: Foliated quartz-feldspar metaporphyry near Kudz Ze Kayah.

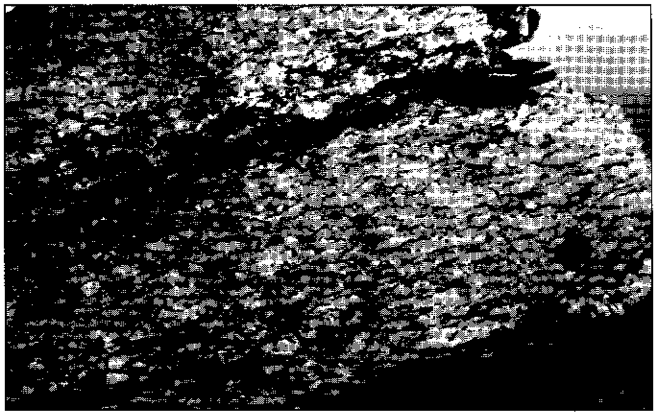


FIGURE 14: *Grass Lakes Orthogneiss: coarse-grained homogenous potassium feldspar-rich orthogneiss.*

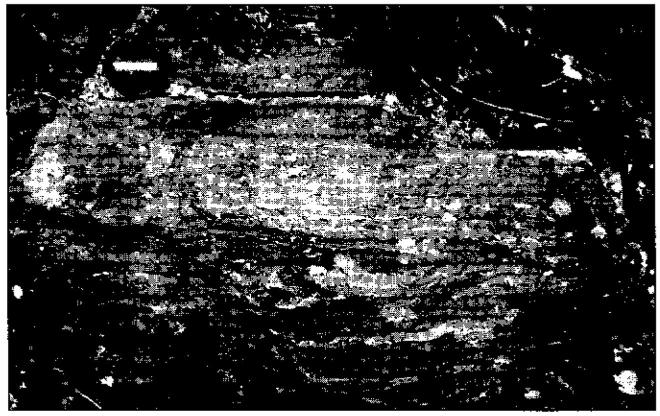


FIGURE 15: *A 15 cm-thick sheet of potassium feldspar augen schist interfoliated with biotite schist.*

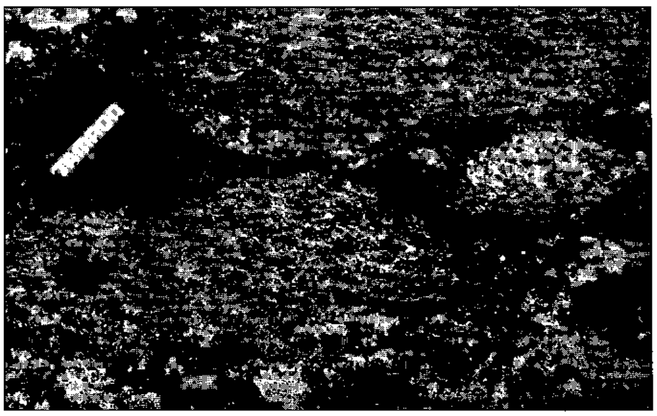


FIGURE 16: *North Lakes Metadiorite.*

Devono-Mississippian. The Early Mississippian(?) Grass Lakes Orthogneiss bears the prominent second-phase foliation and lineation further constraining the second-phase to be post-Early Mississippian. The relationship between the Grass Lakes Orthogneiss and the first-phase foliation is not known. Biotite-muscovite granites are late kinematic with respect to the second phase of deformation.

Mineral occurrences

In addition to the known deposit at **Kudz Ze Kayah** (open pit mineable ore reserve of 11 million tonnes of 5.9% Zn, 0.9% Cu, 1.5% Pb, 130 g/T Ag, and 1.3 g/T Au, Schultze, 1996), the area includes two other known mineral occurrences (I.N.A.C., 1996). The **Pack** (105G 32) is a massive pyrrhotite-pyrite (-chalcopyrite-sphalerite-galena) lens east of the larger of the North Lakes. The lens is hosted in chlorite-actinolite phyllite and is thought by Morin (1981) to be a Besshi-type volcanic-hosted massive sulphide occurrence. The **Myda** occurrence (105G 71) is reported as float of scapolite skarn in a limestone horizon at its contact with a quartz monzonite stock. Both the Grass Lakes Orthogneiss and a body of biotite-muscovite granite occur near the **Myda** so it is not clear which intrusion is responsible for the skarn.

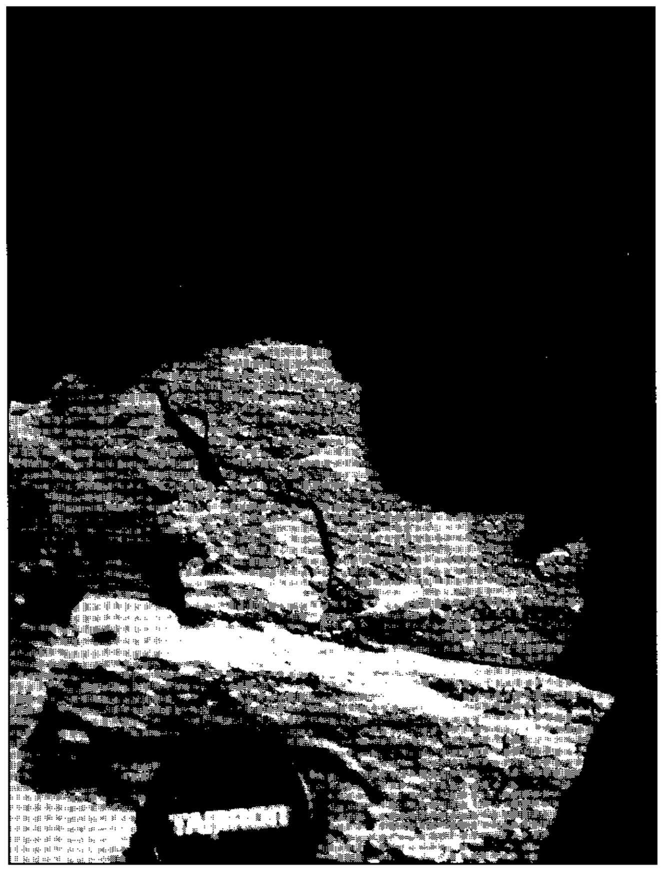


FIGURE 17: *Intrusive contact between fine-grained felsite dyke and siliceous quartz-muscovite schist.*

Numerous gossans were noted during mapping (Figure 2). Several gossanous areas were noted near the **Pack**. A prominent gossan occurs about 700 m north of the **Pack** showing along the headwall of the valley hosting the **Pack**. This gossan is associated with fractured, rusty, locally pyritic unit 3 felsic metavolcanic rocks in the core of a recumbent, isoclinal north-closing fold. The same fractured rusty felsic metavolcanic rocks pass eastward through the ridge, outcrop in the steep headwall of an east-facing cirque

FIGURE 18: *Symmetrically foliated felsite dykes cutting mafic metavolcanic rock in hinge of recumbent north-closing fold near Pack occurrence.*

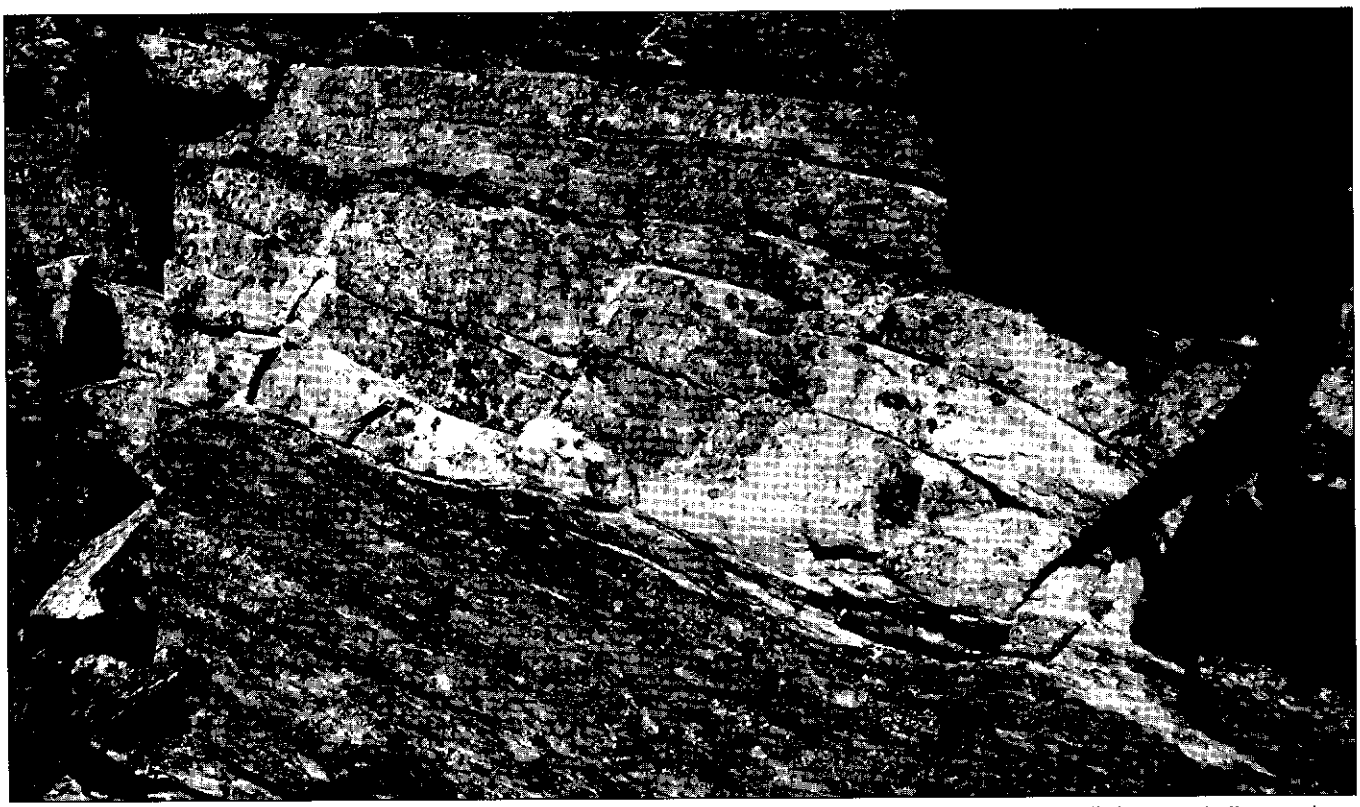


FIGURE 19: *Asymmetrically pulled-apart felsite dyke within siliceous quartz-sericite (muscovite) schists. Dyke is systematically pulled apart and offset in a down-to-the-south sense. Zone of displacement dies upward and downward into host rock in manner reminiscent of shear bands. Top-to-south vergence indicated by this structure is compatible with top-to-south vergence of folds.*

FIGURE 20: *Brown weathering massive pyroxenite(?) found in 10 m-scale pods along contact between actinolite-chlorite schist and calcareous quartzose metaclastic rocks in unit 3 about a kilometre north of the Pack occurrence.*

FIGURE 21: *Outcrop showing felsite dykes duplicated by south-vergent isoclinal folding and thrusting*

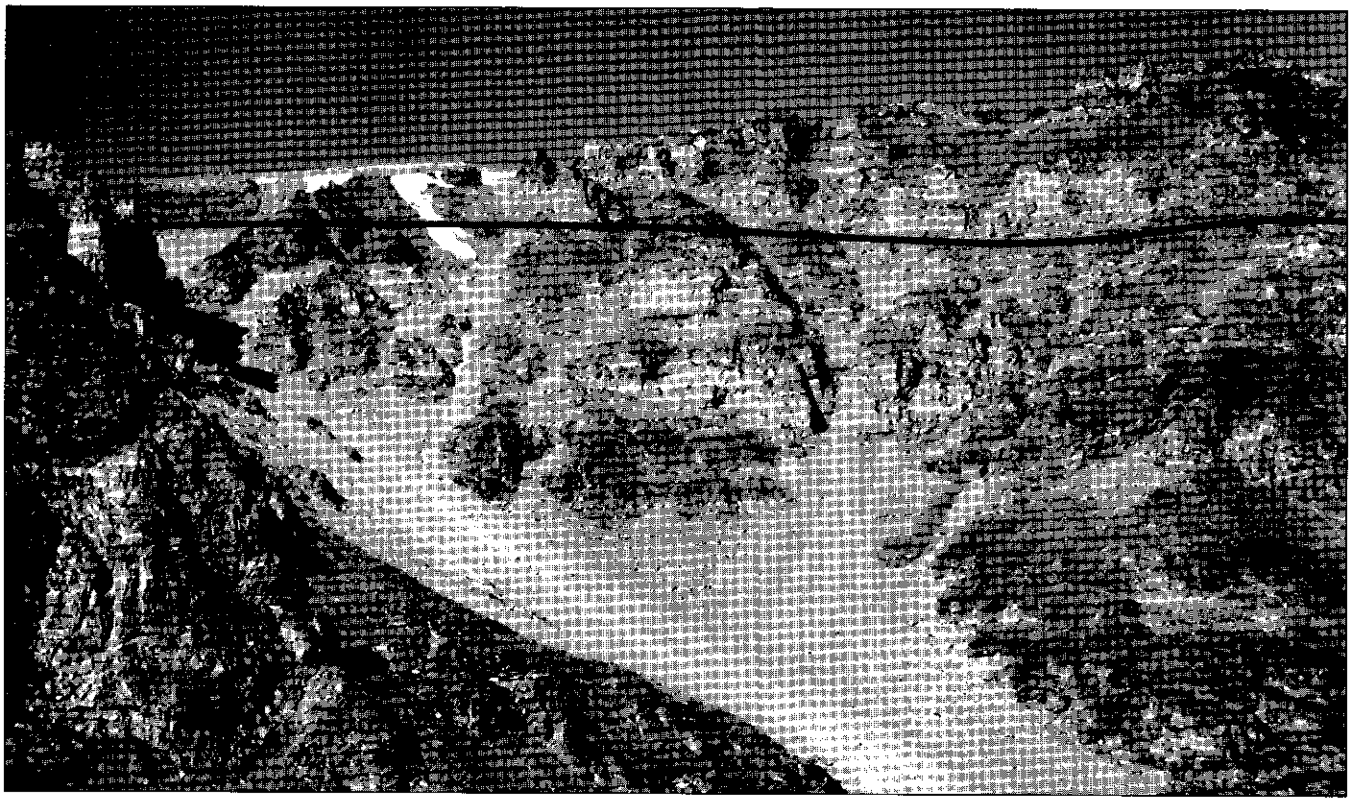


FIGURE 22: *View to west of recumbent axial surface trace of north-closing fold mappable at 1:50 000- scale. Axial surface trace is at top of cliff; massive gossanous felsic metavolcanic rocks close at left side of cliff, calcareous quartzofeldspathic metasandstones close throughout the rest of the top of cliff.*

(Figure 22), intersect the top of the next ridge to the east and project into the face of the prominent mountain capped by ultramafic rocks. Locally rusty felsic metavolcanic rocks about 2 km south of the **Pack** are thought to be the same unit. Gossans associated with felsic metavolcanic rocks also occur: 1) on Expatriate Resources' Overtime claims west of a tarn located about 1.5 km west of the midpoint of the largest of the three North Lakes, 2) on Cominco's Cobb claims west of the Overtime occurrence, and 3) on Arcturus Resources' claims between Grass and North lakes.

Other mineralization includes: 1) skarn-like mineralization noted in calcareous quartz-feldspar psammite east-southeast of the Pack occurrence in the creek draining southward and eastward from the Pack drill shack, 2) calc-silicate hornfels developed at the contact of the unit 1 marble and weakly foliated granite east of Big Campbell Creek, and 3) garnet-diopside calc-silicate hornfels developed in a band of marble just above the contact with Grass Lakes Orthogneiss east-southeast of the north end of the largest of the North Lakes.

Conclusions

About half of the northeastern part of Grass Lakes map area is characterized by metasedimentary and metavolcanic rocks. A laterally continuous marble has been used to define a mappable predominantly upright succession of four units: unit 1, a basal quartzose metaclastic unit containing the marble marker; unit 2, containing mafic metavolcanic rocks, carbonaceous phyllite and quartzite, and quartzofeldspathic metaclastic rocks; unit 3, containing Devono-Mississippian felsic metavolcanic rocks and lesser carbonaceous phyllite and quartzite; and unit 4, a mafic metavolcanic unit similar to unit 2.

Several bodies of primarily felsic metaplutonic rocks, and lesser ultramafic and mafic rocks underlie the remainder of the map area. These include a small body of quartz-feldspar metaporphyry, an extensive body of Mississippian(?) Grass Lakes Orthogneiss, North Lakes Metadiorite, and four bodies of late kinematic biotite-muscovite granite.

All rocks except the ultramafic/mafic rocks are foliated to a greater or lesser extent owing primarily to an intense second-phase of deformation that is associated with regional south-vergent folding.

The **Kudz Ze Kayah** massive sulphide deposit is hosted by felsic metavolcanic rocks of unit 3 and numerous gossans are underlain by the same unit.

Acknowledgements

The authors thank Chris Schultze and Paul MacRobbie of Cominco Exploration for their hospitality, use of the helicopter based at Kudz Ze Kayah, tours of the deposit and discussions about local and regional geology. Our appreciation of the rocks in the area was heightened in these discussions and in discussions with Neil O'Brien and Adam Szybinski also of Cominco. We thank Doug Eaton, Tom Becker, Lee Pigage and Dirk Tempelman-Kluit of Expatriate Resources for their hospitality, a field visit and discussions about the regional geology. DCM thanks Terry Tucker and Harlan Meade of Westmin Resources Ltd. for their hospitality and sharing their insights into the regional geology during a field trip to Wolverine Lake. Jim Mortensen generously shared his wide knowledge of Yukon-Tanana Terrane geology. Julie Hunt, Willem ZanTvoort and Will vanRanden assisted with portions of the mapping. Grant Abbott, Charlie Roots and Dirk Tempelman-Kluit kindly reviewed early versions of this paper and they and Craig Hart showed great patience in the face of persistent rock identification questions. Safe, uneventful and punctual helicopter support and detailed knowledge of the geology, exploration history and wildlife of the area was generously and humourously provided by John Witham of Trans North.

References

I.N.A.C., 1996. Yukon Minfile. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada.

Morin, J.A., 1981. Volcanogenic iron and base metal occurrences in Klondike Schist. In: Yukon Geology and Exploration 1979-80. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 91-97.

Mortensen, J.K., 1992. Pre-mid-Mesozoic tectonic evolution of the Yukon-Tanana Terrane, Yukon and Alaska. Tectonics, v. 11, p. 836-853.

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

Schultze, H.C., 1996. Summary of the Kudz Ze Kayah project, volcanic-hosted massive sulphide deposit, Yukon Territory. In: Yukon Exploration and Geology 1995, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 29-32.

Tempelman-Kluit, D.J., 1977. Quiet Lake (105F) and Finlayson Lake (105G) map areas, Yukon Territory. Geological Survey of Canada, Open File 486.

Tempelman-Kluit, D.J., 1979. Transported cataclasite, ophiolite and granodiorite in Yukon Territory: evidence of arc-continent collision. Geological Survey of Canada, Paper 79-14.

Wheeler, J.O.; Green, L.H. and Roddick, J.A.; 1960. Finlayson Lake map area, Yukon Territory. Geological Survey of Canada, Map 8-1960.

Biogeochemical prospecting in the Yukon-Tanana Terrane, Yukon Territory

by Julie.A. Hunt, Colin.E. Dunn[1], Jay.R.M. Timmerman and W.G. Zantvoort
Yukon Geology Program

HUNT, J.A.; DUNN, C.E.; TIMMERMAN, J.R.M.; ZANTVOORT, W.G., 1997. Biogeochemical prospecting in the Yukon-Tanana Terrane, Yukon Territory. In: Yukon Exploration and Geology 1996, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 74-91

ABSTRACT

Restoration of the 450 km of right lateral movement on the Tintina Fault brings the massive sulphide-rich Finlayson area of the Yukon-Tanana Terrane to a location southeast of Dawson. This suggests that the underlying Yukon-Tanana Terrane geology west of the Tintina Fault, in west-central Yukon, is prospective for massive sulphide mineralization. This area, west of the Tintina fault, largely escaped Pleistocene glaciation and is deeply weathered and covered by a thick mantle of soil and vegetation. This presents problems for traditional geochemical prospecting using soil samples. Alternatively the vegetative cover can be used as a sampling medium.

To test the effectiveness of this technique in the exploration for VMS deposits two areas of the Yukon-Tanana Terrane were chosen for study: Matson Creek and Bradens Canyon. At Matson Creek a biogeochemical signature was obtained from a site with known polymetallic sulphides and data compared with known soil geochemistry. At Bradens Canyon soil and biogeochemical samples were collected. At each sample site in the two locations twigs were collected from both black and white spruce trees according to availability, along several transects. Results indicate that biogeochemical sampling is a viable alternative to soil sampling. The data show that the two species of spruce contain different concentrations of elements, therefore care must be taken during the sampling procedure to identify which species is being sampled. From the data a normalization factor was created by multiplying the white spruce Cu and Pb values by a factor of two in order to obtain an approximate equivalent concentration of these elements in black spruce.

RÉSUMÉ

La reconstitution du mouvement dextre de la faille de Tintina sur 450 km situe la région Finlayson du terrane de Yukon-Tanana, riche en sulfure massif, au sud-est de Dawson, révélant que la géologie sous-jacente du terrane de Yukon-Tanana à l'ouest de la faille de Tintina, dans le centre-ouest du Yukon, recèlerait une minéralisation de sulfure massif d'intérêt. Cette région, à l'ouest de la faille de Tintina, a en grande partie échappé à la glaciation du Pléistocène et est fortement altérée et recouverte d'un épais manteau de sol et de végétation. Cela pose des problèmes pour la prospection géochimique traditionnelle qui est basée sur des échantillons de sol. Le couvert végétal peut être utilisé comme milieu d'échantillonnage de remplacement. Pour vérifier l'efficacité de cette technique dans la recherche de gisements de SMV, on a choisi deux sites du terrane de Yukon-Tanana : le ruisseau Matson et le canyon Bradens. Au ruisseau Matson, une signature biogéochimique a été recueillie dans un site réputé contenir des sulfures polymétalliques et comparée à la signature géochimique d'un sol connu. Dans le canyon Bradens, des échantillons biogéochimiques et de sol ont été prélevés. Dans chacun des deux sites, des pousses d'épinette noire et d'épinette blanche ont été prélevées le long de plusieurs transects, selon leur abondance. Les résultats indiquent que l'échantillonnage biogéochimique est une solution valable de remplacement de l'échantillonnage du sol. Les données montrent que les deux espèces d'épinette contiennent différentes concentrations d'éléments, de sorte qu'il importe de distinguer quelle espèce est prélevée pendant l'échantillonnage. Un facteur de normalisation approché a été établi à partir des données, en multipliant les teneurs en Cu et en Pb des épinettes blanches par un facteur de deux afin d'obtenir une concentration équivalente approchée de ces éléments dans l'épinette noire.

[1] Geological Survey of Canada, 601 Booth St., Ottawa Ontario K1A 0E4

Introduction

Metavolcanic and metasedimentary rocks which make up the southeast portion of the Yukon-Tanana Terrane (Finlayson Lake area), east of the Tintina Fault, are known to contain volcanic hosted massive sulphide (VHMS) deposits (Figure 1). Restoring the 450 km of right lateral movement along the Tintina Fault brings the Finlayson Lake area adjacent to the Dawson area suggesting that the underlying geology in west-central Yukon, west of the Tintina Fault, has similarities to that in the Finlayson area (Figure 2). Yukon-Tanana strata in west central Yukon host several "exhalite showings" suggesting the presence of VHMS deposits similar to those in the Finlayson Lake area. Unlike that area however, in west-central Yukon the bedrock is deeply weathered and masked by a thick mantle of soil, consequently outcrops are few. In general this area escaped Pleistocene glaciation (Hughes et al., 1969). This makes the results of traditional soil geochemical sampling difficult to interpret (see Hart and Jober, this volume). Thick forest and shrub cover compounds the difficulty of obtaining representative, reliable results from soil samples.

The vegetative cover can however be used productively to characterize bedrock geochemistry and thus provide a focus for more detailed exploration (Dunn, 1995 a,b; Dunn and Ray, 1995; Fedikow and Dunn, 1996). Trees and shrubs can be considered as the above-ground extension of the chemistry of the underlying geology because they contain elements drawn from soils, sediments, rocks and groundwater. A concentration of metals in the ground results in enrichment of these metals in the vegetation (Dunn, 1995 a,b). Consequently in many areas samples of the vegetation can be substituted for soil samples.

To test the effectiveness of this technique in the exploration for VMS deposits two areas of the Yukon-Tanana Terrane were chosen: Matson Creek and Bradens Canyon (Figure 1).

Purposes of the Pilot Project

There is no published record of the application of biogeochemical methods to the exploration for VMS deposits in unglaciated northern climates. Hence, prime objectives were to provide some fundamental baseline data on the composition of spruce twigs, and to determine the biogeochemical signature of known mineralization (Matson Creek). From this information an assessment would be made to determine if this technique is a feasible alternative to soil sampling.

Secondly, biogeochemical sampling was undertaken in an area of the Yukon-Tanana Terrane that has regional silt geochemistry indicative of VMS deposits (Bradens Canyon; Hornbrook and Friske, 1986) in order to determine the value of tree chemistry in defining zones of suspected but undiscovered concealed mineralization.

Localities Chosen for Investigation

MATSON CREEK (Minfile # 115N 100; 63° 31′ N 139° 50′ W) lies in an area unaffected by glaciation, southwest of Dawson City. It was first explored in the late 1970's for its VHMS potential. There is a significant copper-zinc-lead soil geochemical anomaly and "exhalite" horizons in drill core (Ocean Home Exploration Co. Ltd., 1978; Archer, Cathro & Associates (1981) Limited, 1990, 1991, 1993). Bedrock geology is mapped as Permian Klondike Schist and Devono-Mississippian Nasina Assemblage, the upper and middle units, respectively, of the Yukon-Tanana Terrane (Tempelman-Kluit, 1974; Mortensen, 1996).

The BRADENS CANYON sample sites (62° 51.0′N; 136° 51.5′W) are located about 25 km west of Pelly Crossing on the south bank of the Pelly River, west of the restored portion of the Yukon-Tanana Terrane (Figure 2). This area lies just inside the limit of the Reid glaciation (Hughes et al., 1969). Anomalous concentrations of Pb, Zn, Cd, Fe, Mn, Sb, As, Ba and Cu occur in stream sediment samples in this area (Hornbrook and Friske, 1986), and there is a Cu showing hosted by chlorite schist in the Canyon itself (Ron Berdahl, pers. comm., 1996). Bedrock geology is mapped as the Nisutlin allochthon of the Yukon Cataclastic

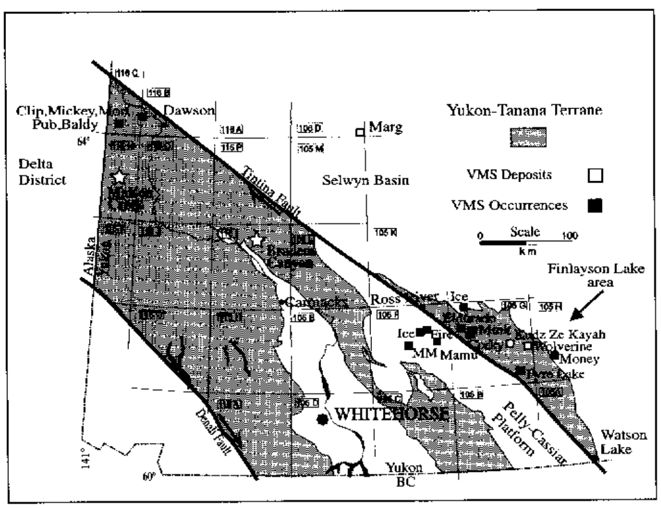


FIGURE 1: Location of biogeochemical sampling localities: Matson Creek and Bradens Canyon, in west-central Yukon.

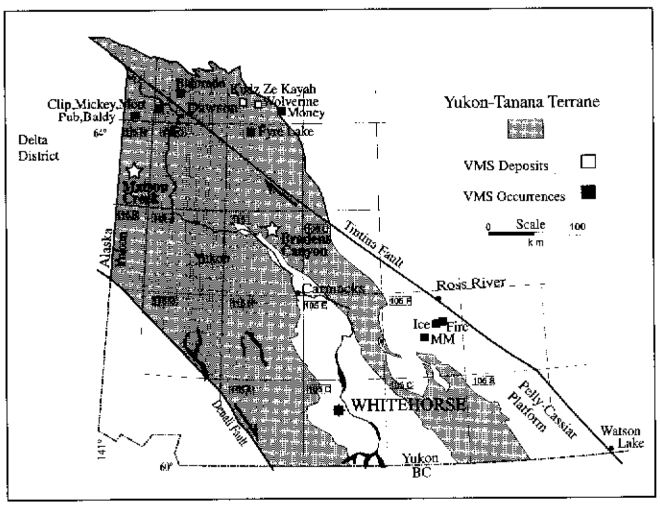


FIGURE 2: Map showing the distribution of the Yukon-Tanana Terrane when the 450 km of right lateral movement along Tintina Fault is restored.

Terrane (Tempelman-Kluit, 1984; Monger et al., 1992) which is now considered to be part of the Yukon-Tanana Terrane (Mortensen, 1992).

SAMPLING AND ANALYTICAL PROCEDURES

Sampling procedures are simple, but it is important to be consistent in sample collection. At all sample stations the same type of plant tissue, the same amount of growth, from the same species of similar appearance and state of health should be collected (Dunn, 1995 a). To avoid problems related to seasonal changes in plant chemistry all samples of plant tissue should be collected at the same time of year. Springtime is preferable because metals are most highly concentrated in the new growth (Dunn, 1995 a,b), therefore showing the greatest contrast between background and anomalous values. However, samples can be collected at any time of the year provided they are obtained in a short period of time (about three weeks). Samples collected in the spring should not be compared with those collected in the summer unless a normalization factor is applied because of seasonal changes in plant chemistry.

At the Matson Creek and Bradens Canyon localities spruce trees were sampled at 100 m intervals on lines spaced 1 km apart, covering an area of about 3 km^2 (Tables 1 and 2). Duplicate samples were collected towards the beginning and end of each line. There was uneven coverage of the preferred sample species, black spruce *(Picea mariana)*, this required that white spruce *(Picea glauca)* be sampled where the former were absent. Both species were collected, according to availability, along the sample traverses, in order to provide baseline information on white and black spruce in this terrane.

At each sample site eight branches, each about 25 cm long and of consistent diameter, were collected at chest height from around the chosen tree. This length of twig represents about 10 - 12 years growth in this and most other northern forests.

The samples were air dried, and the needles removed. At the Geological Survey of Canada laboratories in Ottawa 50 - 60 g samples of dry twig were weighed into aluminum trays and reduced to ash in a pottery kiln by slowly raising the temperature to 470°C then maintaining this temperature for 12 hours. This quantity of dry spruce twigs provides approximately 1 g of ash (i.e. 2% ash yield). Duplicate and standard samples were inserted to assess accuracy and precision of the analyses. Ashing volatilizes a few highly volatile elements (e.g. Hg, I, some Br) but it is useful for preconcentrating metals prior to analysis. Approximately 0.5 g of each ash sample was weighed into a polyethylene vial for instrumental neutron activation analysis (INAA) of 35 elements at Activation Laboratories Ltd. (Ancaster, Ontario). The remaining 0.5 g portion of the ash was submitted to the same laboratory for

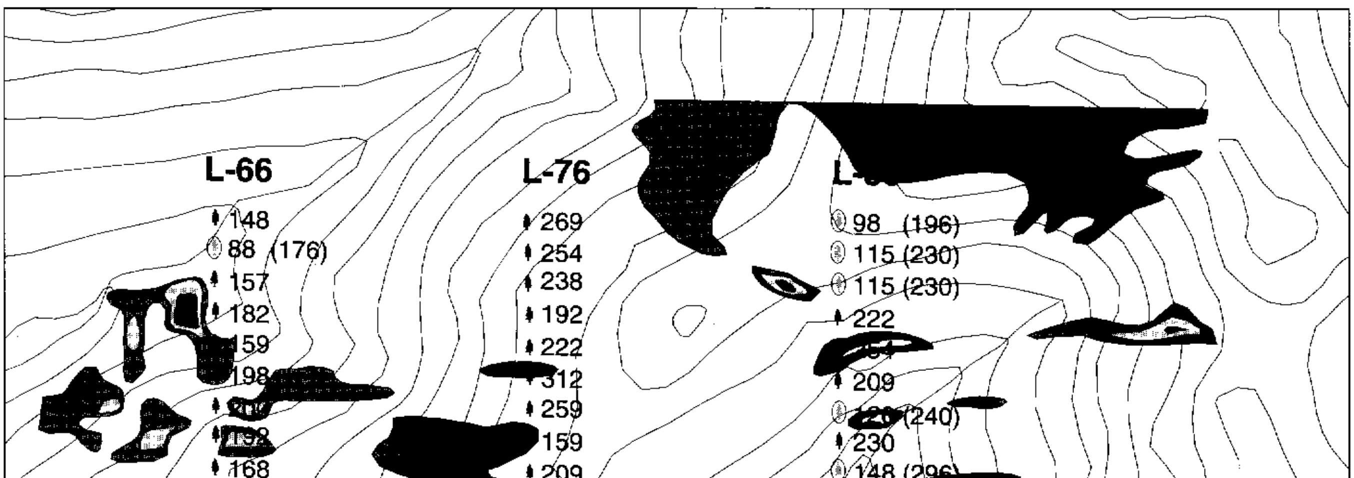


FIGURE 3: Copper concentrations in ashed spruce twigs along three sampling lines at Matson Creek, overlain on soil copper anomaly map from Ocean Home Exploration Co. Ltd., (1978). Numbers in parentheses indicate the black spruce equivalent (normalization factor, see text). All values in ppm.

the determination of an additional 32 elements by inductively coupled plasma emission spectrometry (ICP-ES). The latter technique provides data for certain elements not readily determined by INAA - notably Ag, Pb, Ni, Cu, Cd, V, P, Mg, Mn, and Al.

For comparative purposes soil samples were also collected at each sample site in the Bradens Canyon area (Table 3). Most soil samples were collected from the B Horizon, although soil profiles are not sufficiently developed to be reliably differentiated. The samples were dried and screened to 175 microns (-80 mesh) and analysed for 32 elements by ICP-ES using a nitric-aqua-regia leach package at Chemex Labs Ltd. (North Vancouver, B.C). This method of dissolution only partially digests Al, Ba, Be, Ca, Cr, Ga, La, Mg, Sc, Na, Sr, Tl, Ti and W, hence these results should be interpreted with caution. Results for As, Be, Bi, Ga, Hg, La, Sb, Tl, U and W have been omitted from Table 3 as they were below or close to detection limits of 2, 0.5, 2, 1, 10, 10, 2, 10, 10 and 10 ppm respectively, and therefore unreliable.

Soils from the Matson Creek area were collected in 1977 and 1978 from the B Horizon where recognized and analysed by Resource Associates of Alaska Inc. in Fairbanks (Ocean Home Exploration Co. Ltd., 1978). These samples were dried and sieved to -80 mesh; Cu, Pb, Zn and Ag were determined using atomic absorption spectroscopy (AA) on aqua-regia digestions of 2 gram samples.

Results

Data obtained by INAA and ICP-ES are shown in Tables 1 and 2 for the biogeochemical samples. Table 3 contains ICP-ES and Au (fire assay) results for soil samples collected at Bradens Canyon. Figures 3 to 5 show biogeochemical analyses superimposed on contoured soil geochemistry plots for Cu, Pb and Zn at Matson Creek. Biogeochemical and soil geochemistry results for Cu, Pb and Zn at Bradens Canyon are depicted on figures 6 to 8.

Caution: Care must be taken when interpreting the biogeochemical results because different spruce species take up different amounts of certain elements. Table 2 compares the average element concentrations in each species along each of the three transects. In general, black spruce concentrates most elements to a greater degree than white spruce. For example black spruce contains almost twice as much Cu as white spruce. Among the elements listed, only the alkali metals K and Rb are consistently higher in the white spruce twigs; Ca concentrations are generally similar between the two species. Thus the type of species must be considered in order to eliminate false anomalies.

A normalization factor was created by multiplying the white spruce Cu and Pb data by a factor of two in order to obtain an approximate equivalent concentration of these elements in the black spruce. Such `normalized' data are shown in parentheses

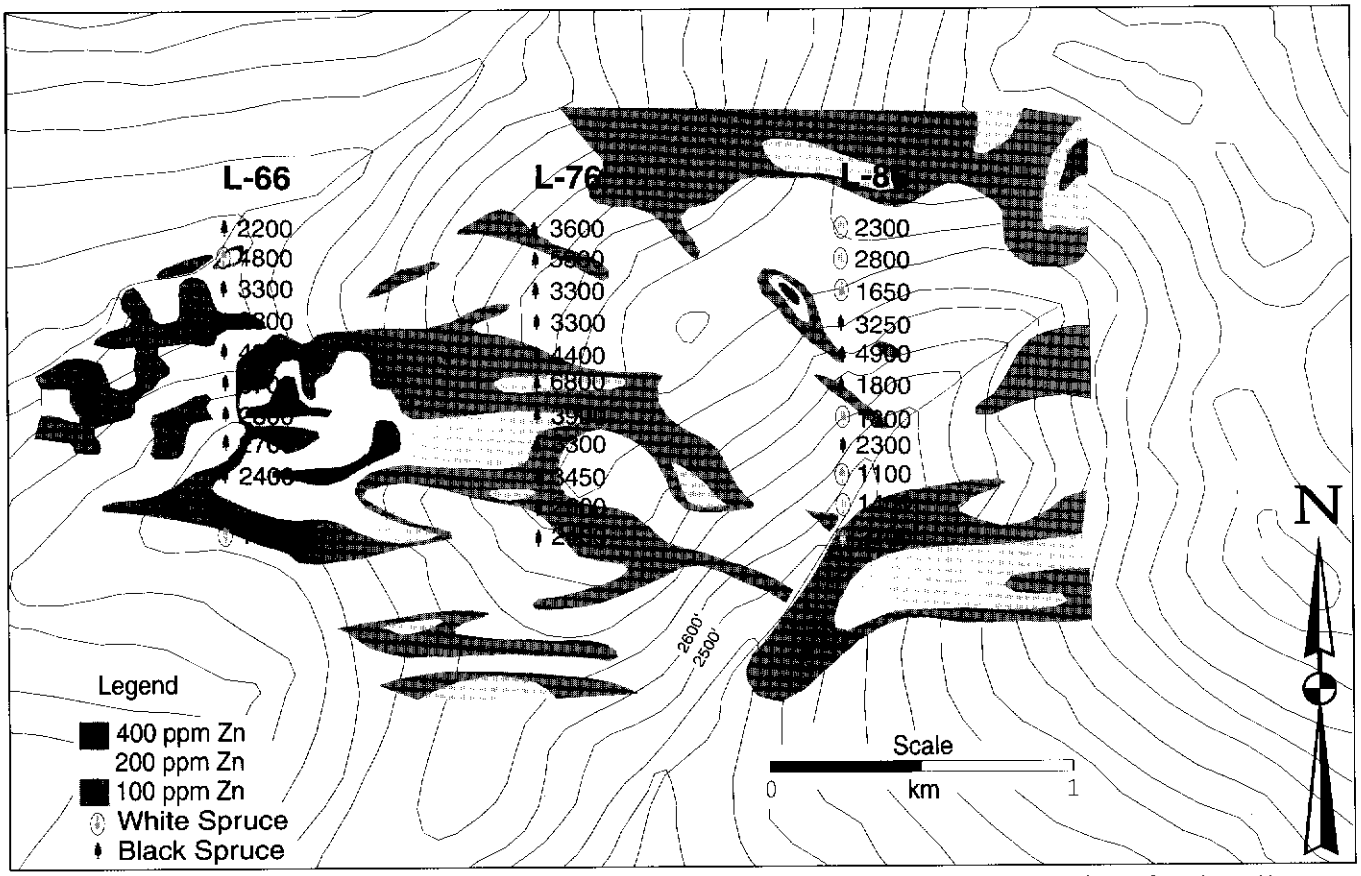


Figure 4: *Zinc concentrations in ashed spruce twigs along three sampling lines at Matson Creek, overlain on soil zinc anomaly map from Ocean Home Exploration Co. Ltd., (1978). All values in ppm.*

after each white spruce analysis in figures 3 and 5. The differences between the two species are more erratic for Zn and so normalization has not been attempted.

The Matson Creek data show a reasonably good correlation between soil and biogeochemical results for Zn and Cu (Figures 3 and 4). The offset in location of soil anomalies and biogeochemical anomalies suggests down-slope dispersion of soils. The biogeochemical samples should therefore more closely define the source of mineralization as the roots may tap bedrock, or soils that have undergone little transport. Similarly, the Pb in twigs appears to correlate roughly with soil geochemistry, even though spruce trees less readily absorb Pb than Cu or Zn. Concentrations of other elements in the spruce trees at Matson Creek are close to normal background levels except for general enrichment of Ag along all three transects, and especially on L-76 from 400 - 600 N where values of 6.6 - 7.4 ppm Ag are coincident with enrichment of Cd, Zn and Cu. This area may be worthy of closer investigation.

The Bradens Canyon area was chosen because the NGR data (National Geochemical Reconnaissance stream sediment) show metal associations and concentrations indicative of mineralization and there is a Cu showing in the canyon itself. However, the soil sampling grid failed to identify any areas with anomalous element concentrations and no correlation between soil geochemistry and biogeochemical results (Figures 6 to 8) is apparent. Metal concentrations in spruce twigs are generally low and close to background values. Only two soil samples, on line 3, yielded above background concentrations of Cu (L-3, 118 and 75 ppm in Table 3, Figure 6), whereas the highest `black spruce equivalent' value (based on the white spruce value x 2) on line 3 was 242 ppm (Figure 6). The spruce samples show a local weak enrichment of Cu and Zn in the centre of line 2. There is elevated Zn at the southern end of line1. Lead values show a weak enrichment at the southern end of all three lines.

Although the geochemical evidence for mineralization in the Bradens Canyon area is at best subtle, the wide sample spacing limits the likelihood of encountering an anomaly. Mineral potential should not be assessed without more detailed studies.

CONCLUSIONS

These two orientation surveys in unglaciated (Matson Creek) and glaciated (Bradens Canyon) boreal forest terrane provide a first indication of biogeochemical concentrations of elements to be expected in areas of known and suspected base metal mineralization in the Yukon-Tanana Terrane . Spruce twig data have been compared, to a limited extent, with metal concentrations obtained from soil surveys of the same areas.

Black spruce are considerably enriched in most trace elements

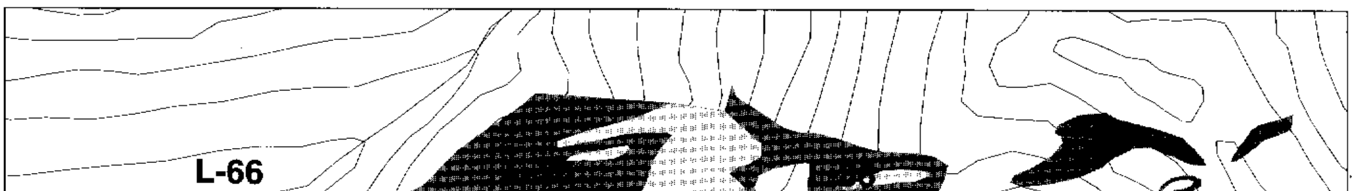


FIGURE 5: Lead concentrations in ashed spruce twigs along three sampling lines at Matson Creek, overlain on soil lead anomaly map from Ocean Home Exploration Co. Ltd., (1978). Numbers in parentheses indicate the black spruce equivalent (normalization factor, see text). All values in ppm

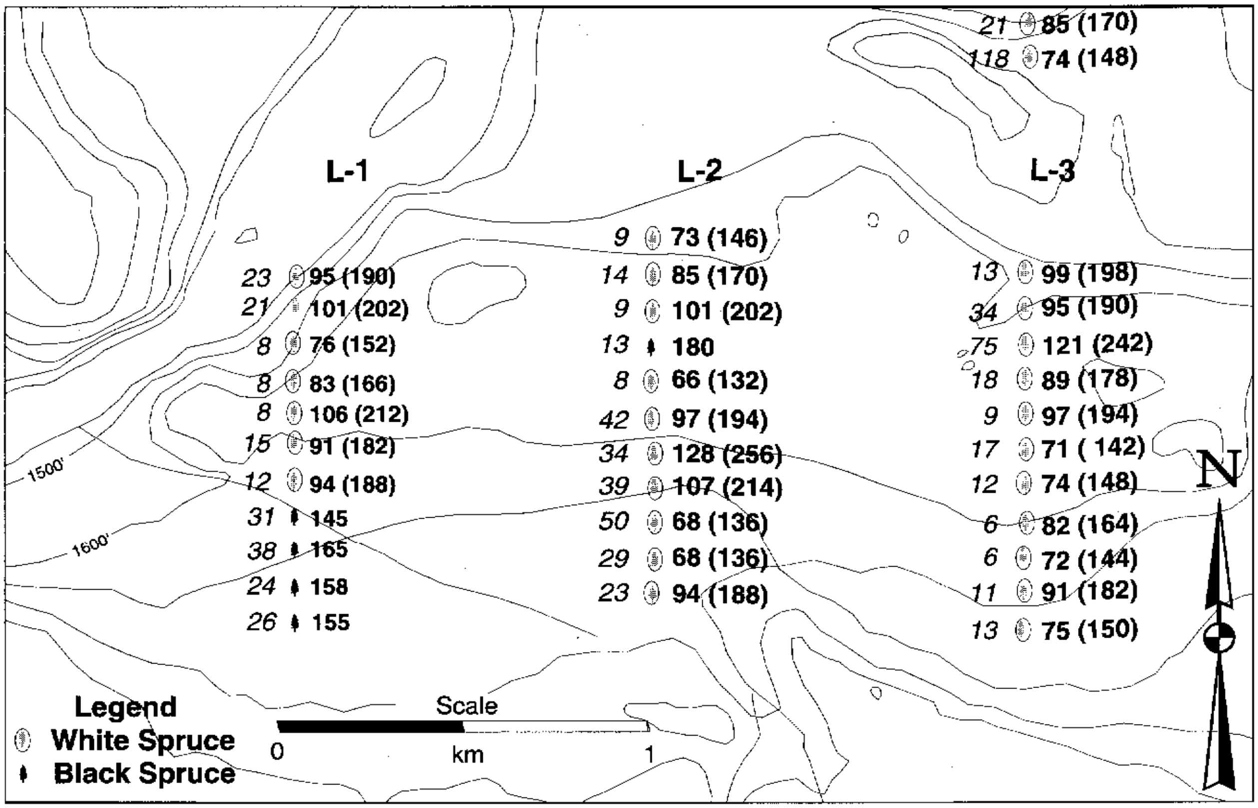


FIGURE 6: *Map comparing Bradens Canyon biogeochemistry Cu results with soil geochemistry Cu results. Left of symbol: soil geochemistry result. Right of symbol: biogeochemistry result; Brackets is the black spruce equivalent. All values in ppm.*

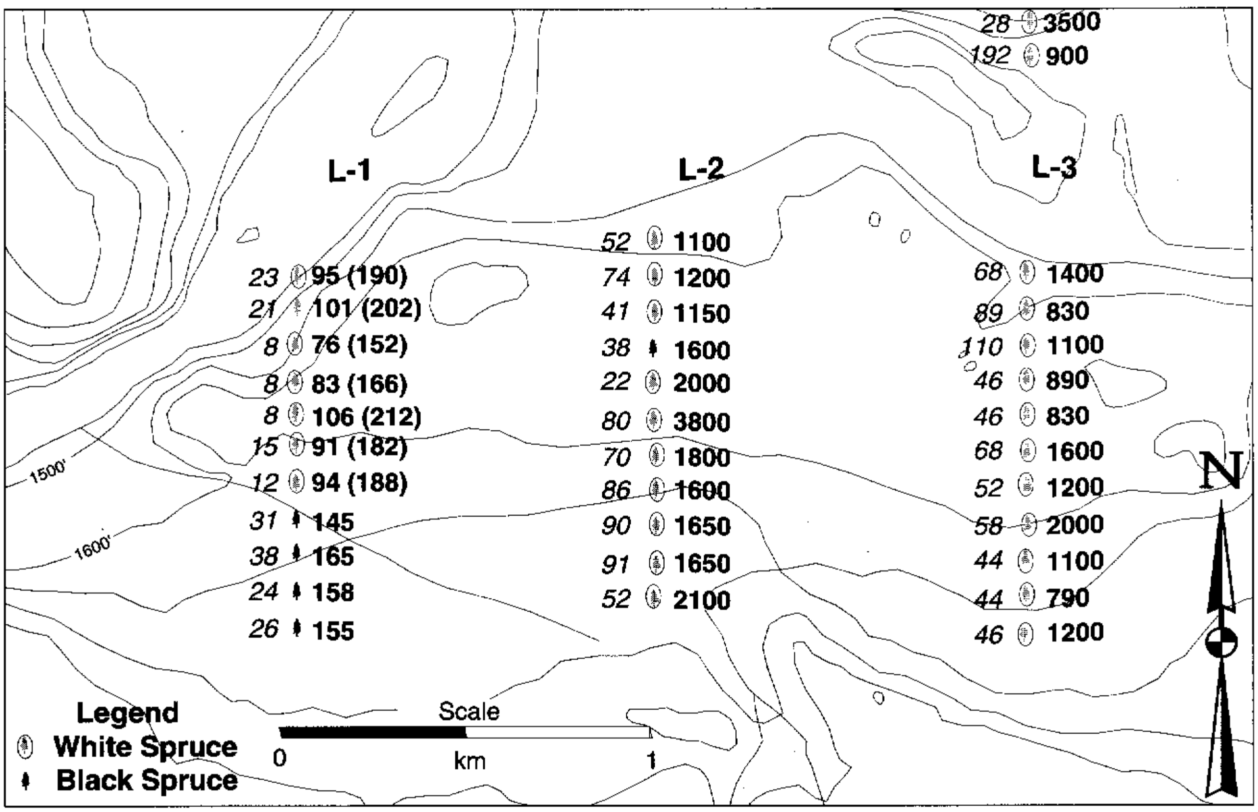


FIGURE 7: *Map comparing Bradens Canyon biogeochemistry Zn results with soil geochemistry Zn results.*
Left of symbol: soil geochemistry result. Right of symbol: biogeochemistry result; Brackets is the black spruce equivalent. All values in ppm.

compared to white spruce; exceptions are Ca, Ba, K and Rb. The concentrations of Cu and Pb in black spruce are approximately twice those of the white spruce.

Within the area of known mineralization at Matson Creek, biogeochemical and soil anomalies of base metals are generally coincident, but tree chemistry appears to locate the zone of mineralization more precisely than that of the soil because tree roots penetrate through surface soil that is subject to downslope movement. Copper, Zn, Ag and Cd and, to a lesser degree, Pb provide the best focus for locating mineralization. In particular, concentrations of metals in the trees along line 76, stations 400 - 600 N suggest that this is a zone worthy of closer investigation. The moderately high Cd values may reflect concealed zones of mineralization because of the high mobility of Cd and the tolerance of spruce and other conifers to moderate Cd concentrations. Cadmium is commonly associated with zinc in nature and is therefore, a good indicator of Zn-enriched base metal mineralization.

At Bradens Canyon, where there is a Cu showing, and stream sediment indications of possible mineralization in the area, the concentrations of metals in both soil and spruce twigs are generally close to those found in typical background areas, with only subtle enrichments of Cu and Zn at a few sites. The coarse sample spacing was insufficient to detect significant base metal mineralization within the area surveyed.

Data obtained from these surveys demonstrate the worthiness of carefully applied biogeochemical sampling in unglaciated and glaciated forested terrane of northern North America. It provides a potentially valuable aid to exploration for base metals in large prospective areas of little outcrop.

ACKNOWLEDGEMENTS

Fieldwork for this project was undertaken by the senior author, J.R.M. Timmerman and W.G. Zantvoort. Sample preparation was carried out at the Geological Survey of Canada in Ottawa. Many thanks are extended to Ron Berdahl and Bert and Sheila Savage for their help and co-operation throughout this project; without their help, completing the project would have been difficult, impossible perhaps, and certainly miserable.

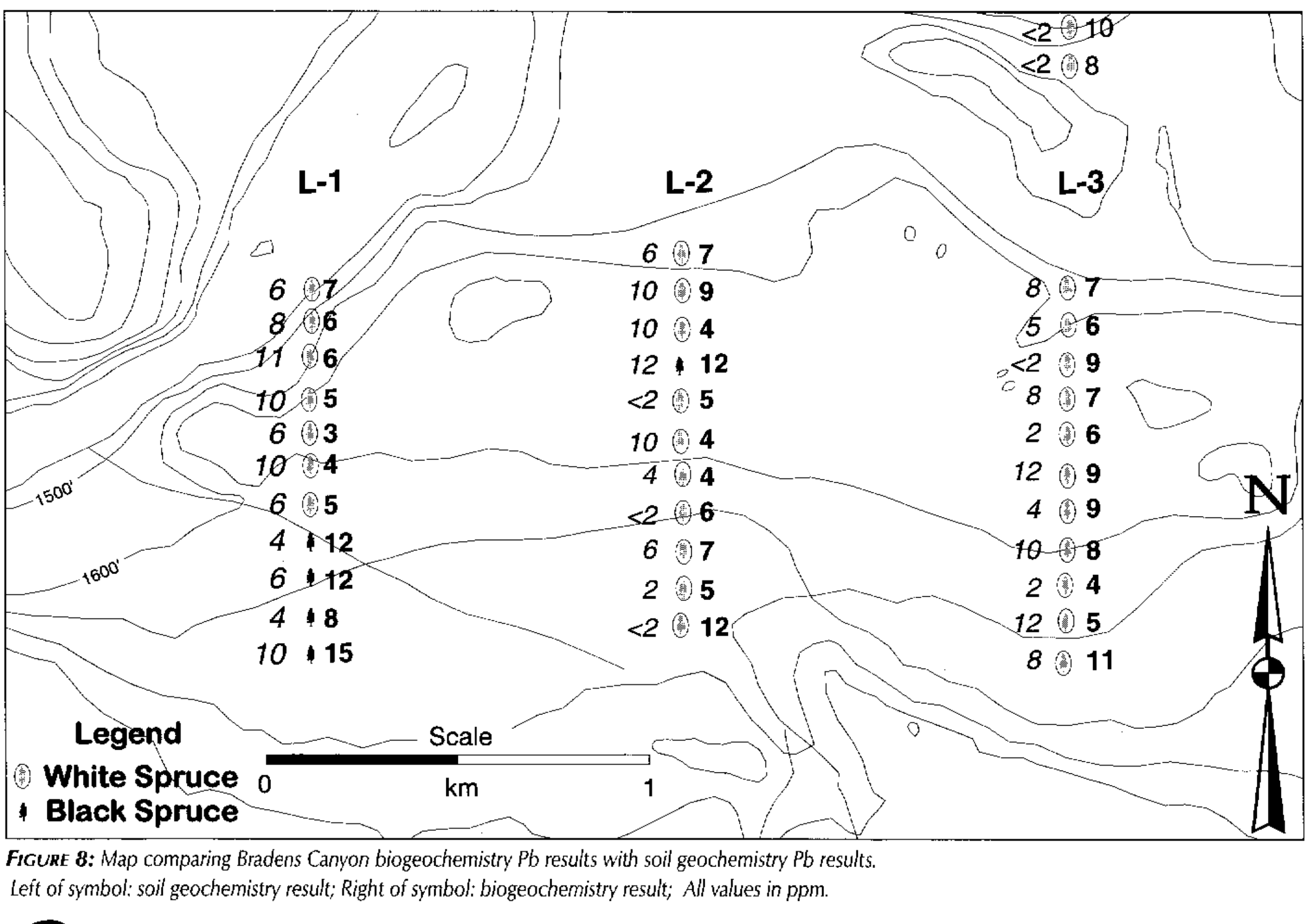


FIGURE 8: Map comparing Bradens Canyon biogeochemistry Pb results with soil geochemistry Pb results. Left of symbol: soil geochemistry result; Right of symbol: biogeochemistry result; All values in ppm.

REFERENCES

Archer, Cathro and Associates (1981) Limited, 1990. Summary report on 1990 exploration, Matson Creek Property, Dawson Mining District. Confidential Assessment Report 092953 written by K. Sax and R.C. Carne for YGC Resources Ltd.

Archer, Cathro and Associates (1981) Limited, 1991. Summary report on 1991 exploration, Matson Creek Property, Dawson Mining District. Confidential Assessment Report 093000 written by R.C. Carne for YGC Resources Ltd.

Archer, Cathro and Associates (1981) Limited, 1993. Summary report on 1992 exploration, Matson Creek Property, Dawson Mining District. Confidential Assessment Report 093099 written by R.C. Carne for YGC Resources Ltd.

Dunn, C.E., 1995a. Biogeochemical prospecting in drift-covered terrain of British Columbia. In: Drift exploration on the Canadian Cordillera, Eds. P.T. Bobrowsky, S.J. Sibbick, J.M. Newell and P.F. Matysek. Province of British Columbia, Ministry of Energy, Mines and Petroleum Resources, Mineral Resources Division, Geological Survey Branch, Paper 1995-2, p. 229-237.

Dunn, C.E., 1995b. Mineral exploration beneath temperate forests: the information supplied by trees. Exploration Mining Geology Journal, Volume 4, # 3, p. 197-204.

Dunn, C.E. and Ray, G.E., 1995. A comparison of lithogeochemical and biogeochemical patterns associated with gold mineralization in mountainous terrain of southern British Columbia. Economic Geology, Volume 90, p. 2232-2243.

Fedikow, M.A.F. and Dunn, C.E., 1996. The geochemistry of vegetation growing over the deeply buried Chisel North Zn-rich massive sulphide deposit, Snow Lake area. In: EXTECH I: A multidisciplinary approach to massive sulphide research in the Rusty Lake-Snow Lake Greenstone belts, Manitoba, Eds. G.F. Bonham-Carter, A.G. Galley and G.E.M. Hall. Geological Survey of Canada, Bulletin 426, p. 225-255.

Hornbrook, E.H.W. and Friske P.W.B., 1986. Regional stream sediment and water geochemical reconnaissance data for 115I, Carmacks map area. Geological Survey of Canada Open File 1220, NGR 85-1985.

Hughes, O.L., Campbell, R.B., Muller, J.E., and Wheeler, J.O., 1969. Glacial limits and flow patterns, Yukon Territory, south of 65 degrees north latitude. Geological Survey of Canada Paper 68-34, map 6-1968 and 9 p. report.

Monger, J.H.W., Wheeler, J.O., Tipper, H.W., Gabrielse, H., Harms, T., Struik, L.C., Campbell, R.B., Dodds, C.J., Gehrels, G.E. and O'Brien, J., 1992. Chapter 8: Upper Devonian to Middle Jurassic Assemblages. Part B. Cordilleran Terranes. In: Geology of the Cordilleran Orogen in Canada, Eds. H.Gabrielse and C.J. Yorath. Geological Survey of Canada, Geology of Canada, no. 4, p. 284-286.

Mortensen, J.K., 1992. Pre-mid-Mesozoic tectonic evolution of the Yukon Tanana Terrane, Yukon and Alaska. Tectonics, vol. 11, p. 836-853.

Mortensen, J.K., 1996. Geological Compilation Maps of the Northern Stewart River map area, Klondike and Sixty Mile districts (115N/15,16; 115O/13,14 and parts of 115O/15, 16). INAC (Yukon Region) Open File 1996-1G. 6 Maps, 1: 50, 000 scale and 41 p. report.

Ocean Home Exploration Co. Ltd., 1978. Borden Creek prospect, Bord Claims. Assessment Report 090437 written by R.E. Haverslew.

Tempelman-Kluit, D.J., 1974. Reconnaissance geology of Aishihik Lake, Snag and part of Stewart River map areas, west-central Yukon. Geological Survey of Canada Paper 73-41, 97p.

Tempelman-Kluit, D.J., 1984. Geology, Laberge and Carmacks map areas, Yukon Territory. Geological Survey of Canada Open File 1101, 2 maps 1: 250,000 scale and 10 p. legend.

Table 1: Biogeochemical Results, Matson Creek Inductively Coupled Plasma Emission Spectrometry. Note: 0.5g sample was used

Line #	Lab #	Sample #	Species	Elements / Units									
				Ag/ppm	Cd/ppm	Cu/ppm	Mn/ppm	Ni/ppm	Pb/ppm	Al/%	Mg/%	P/ppm	V/ppm
L-66	AL96/305	00N	W	0.6	2	89	3540	6	2	0.13	1.32	17500	2
	AL96/315	900N	W	1.3	1.5	88	1960	6	8	0.25	1.01	12700	7
			Average W	**0.95**	**1.75**	**88.5**	**2750**	**6**	**5**	**0.19**	**1.165**	**15100**	**4.5**
	AL96/306	200N	B	2.3	4.4	166	7010	15	7	0.25	1.47	28200	6
	AL96/307	200N	B	4.5	8.1	170	7970	15	20	0.43	1.54	25500	11
	AL96/308	300N	B	4.1	3.3	192	11600	18	9	0.3	2	36300	6
	AL96/309	400N	B	5.1	2.1	200	16400	12	16	0.42	1.77	20600	12
	AL96/310	500N	B	3	2.6	198	14600	23	20	0.39	2.37	22700	9
	AL96/311	600N	B	4.5	2.2	159	21900	18	12	0.31	1.89	15700	8
	AL96/312	720N	B	3.9	4.4	182	13500	19	13	0.42	1.67	20700	10
	AL96/313	800N	B	4.1	5.4	163	25900	22	11	0.33	2.09	30700	9
	AL96/314	800N	B	3.9	4.6	152	24400	21	9	0.28	2.05	30700	7
	AL96/316	1000N	B	2.2	2.6	148	13700	18	8	0.33	1.85	23200	9
			Average B	**3.76**	**3.97**	**173**	**15698**	**18.1**	**12.5**	**0.346**	**1.87**	**25430**	**8.7**
L-76	AL96/317	00N	B	3.3	4.3	147	19200	20	2	0.24	1.96	26900	5
	AL96/318	100N	B	3.3	4.1	204	20700	28	6	0.35	1.96	29300	6
	AL96/319	200N	B	3.1	2.5	219	17400	12	8	0.35	1.4	26800	6
	AL96/320	200N	B	3.6	2.6	198	18600	14	9	0.4	1.43	25100	8
	AL96/321	300N	B	3.8	4.4	159	10300	16	8	0.29	1.51	24700	5
	AL96/322	400N	B	7	27.2	259	28500	25	3	0.2	1.665	34300	5
	AL96/323	500N	B	7.4	14.7	312	16100	14	7	0.19	2	46100	7
	AL96/324	600N	B	6.6	13.7	222	33600	12	6	0.24	2.69	37400	6
	AL96/325	700N	B	3.6	7	192	19900	16	3	0.23	1.72	26900	5
	AL96/326	800N	B	3.8	2.2	238	14100	28	8	0.26	2.11	32100	5
	AL96/327	800N	B	4.2	2.6	239	15400	30	8	0.26	2.17	33100	5
	AL96/328	900N	B	5.3	3.1	254	18000	35	16	0.43	2.32	35600	10
	AL96/329	1000N	B	5	7	269	18700	21	14	0.35	1.88	27000	9
			Average B	**4.51**	**7.34**	**224**	**19269**	**20.85**	**7.54**	**0.291**	**1.91**	**31177**	**6.31**
L-86	AL96/330	00n	W	1.7	1.8	123	2840	9	6	0.16	1.16	18400	3
	AL96/331	00N	W	1.6	1.8	118	27740	10	6	0.16	1.14	18200	3
	AL96/333	100N	W	0.7	1.7	161	330	20	3	0.19	1.42	20800	3
	AL96/334	100N	W	0.7	1.5	145	2830	14	4	0.19	1.31	17300	3
	AL96/335	200N	W	1	1.7	148	7250	14	3	0.11	1.58	23100	2
	AL96/295	400N	W	1.1	2.1	120	3440	13	5	0.29	1.65	23800	4
	AL96/300	800N	W	0.8	1.4	118	2420	11	5	0.24	1.7	20800	3
	AL96/301	800N	W	0.8	1.5	113	2270	10	4	0.24	1.62	20300	3
	AL96/303	900N	W	0.8	2.9	115	4470	8	4	0.17	1.03	21500	3
	AL96/304	1000N	W	1	2	98	5250	8	4	0.19	1.38	17900	3
			Average W	**1.02**	**1.84**	**125.9**	**5884**	**11.7**	**4.4**	**0.19**	**1.4**	**20210**	**3**
	AL96/294	300N	B	3.6	2.9	230	16200	38	5	0.16	1.89	34500	4
	AL96/296	500N	B	2.3	5.5	209	9920	69	5	0.2	1.81	40700	4
	AL96/297	600N	B	5.4	14	254	16000	39	9	0.31	1.88	33800	6
	AL96/298	700N	B	5.4	5.1	221	16000	25	9	0.31	1.64	32900	7
	AL96/299	700N	B	6	5.1	224	15600	23	9	0.3	1.55	30100	6
			Average B	**4.54**	**6.52**	**227.6**	**14744**	**38.8**	**7.4**	**0.26**	**1.75**	**34400**	**5.4**

***TABLE 1:** Locations, species and analytical data listings of spruce twig ash samples from the Bradens Canyon and Matson Creek areas, Yukon Territory. (INAA and ICP-ES analyses of elements yielding precise data with concentrations significantly above detection limits). W = white spruce; B = black spruce*

Table 1: Biogeochemical Results, Matson Creek Instrumental Neutron Activation Analysis, page 1 of 2

Line #	Lab #	Sample #	Species	Au/ppb 5	As/ppm 0.5	Ba/ppm 10	Br/ppm 1	Ca/% 0.2	Co/ppm 1	Cr/ppm 1	Cs/ppm 0.5	Fe/% 0.05
L-66	AL96/305	00N	W	7	1.3	3400	10	18.7	3	15	0.7	0.22
	AL96/315	900N	W	8	1.9	3400	12	20.5	3	23	-0.5	0.61
			Average W	**7.5**	**1.6**	**3400**	**11**	**19.6**	**3**	**19**	**0.1**	**0.415**
	AL96/306	200N	B	16	2	4200	35	22.5	9	17	-0.5	0.5
	AL96/307	200N	B	16	3.4	4900	24	18.6	9	23	-0.5	0.82
	AL96/308	300N	B	13	1.6	3900	34	18.6	9	18	0.6	0.45
	AL96/309	400N	B	9	2.9	2600	16	20.1	6	27	0.9	0.83
	AL96/310	500N	B	7	2.1	2000	16	20.1	7	26	0.7	0.59
	AL96/311	600N	B	11	2	1200	13	22.4	4	20	0.9	0.58
	AL96/312	720N	B	18	2.6	1300	27	20.6	7	24	-0.5	0.81
	AL96/313	800N	B	13	2	3600	20	19.9	10	23	0.7	0.61
	AL96/314	800N	B	16	2.1	3400	19	17.8	10	24	-0.5	0.58
	AL96/316	1000N	B	15	2.6	7000	13	21.6	11	25	0.9	0.78
			Average B	**13.4**	**2.33**	**3410**	**21.7**	**20.22**	**8.2**	**22.7**	**0.27**	**0.655**
L-76	AL96/317	00N	B	13	1.7	4700	49	22	15	13	1.1	0.39
	AL96/318	100N	B	11	2.9	6700	40	19.9	17	27	1.8	0.56
	AL96/319	200N	B	28	3.2	3900	52	20.3	8	13	2	0.5
	AL96/320	200N	B	20	3.1	4700	42	19.7	8	23	2.9	0.6
	AL96/321	300N	B	26	2	2600	22	24.8	5	18	1.2	0.5
	AL96/322	400N	B	17	2.3	3600	23	21	9	22	1.1	0.44
	AL96/323	500N	B	15	2.5	3100	14	17.8	4	17	-0.5	0.46
	AL96/324	600N	B	28	3	3100	23	18.4	8	30	1.6	0.55
	AL96/325	700N	B	9	1.7	3200	23	22.2	7	17	-0.5	0.45
	AL96/326	800N	B	36	1.4	4100	20	23.6	6	23	-0.5	0.41
	AL96/327	800N	B	11	2.1	3600	19	22.7	6	21	0.6	0.49
	AL96/328	900N	B	16	3.2	2300	38	18.7	7	20	-0.5	0.79
	AL96/329	1000N	B	17	2.6	2500	21	21.6	8	22	0.8	0.73
			Average B	**19**	**2.44**	**3700**	**29.69**	**20.98**	**8.31**	**20.46**	**0.85**	**0.53**
L-86	AL96/330	00n	W	17	9.4	3200	13	20.3	3	14	-0.5	0.31
	AL96/331	00N	W	11	8.5	3400	14	21.2	3	16	-0.5	0.33
	AL96/333	100N	W	26	9.5	1900	14	17.9	3	13	-0.5	0.23
	AL96/334	100N	W	20	7.8	2300	16	19.6	4	11	-0.5	0.28
	AL96/335	200N	W	11	6.2	2200	12	18.2	5	11	0.7	0.22
	AL96/295	400N	W	24	4.8	2700	44	16.1	6	11	-0.5	0.31
	AL96/300	800N	W	18	7.4	3200	12	16.2	4	8	-0.5	0.25
	AL96/301	800N	W	19	13	3300	13	16.4	4	12	-0.5	0.29
	AL96/303	900N	W	11	2.5	3500	26	18	3	18	-0.5	0.28
	AL96/304	1000N	W	9	3.4	3800	12	21.2	3	14	0.9	0.29
			Average W	**16.6**	**7.25**	**2950**	**17.6**	**18.51**	**3.8**	**12.8**	**-0.24**	**0.279**
	AL96/294	300N	B	20	19	4800	21	18.6	7	9	-0.5	0.28
	AL96/296	500N	B	13	8.6	4600	50	18.8	26	18	0.8	0.29
	AL96/297	600N	B	19	32	3400	18	17	20	28	-0.5	0.51
	AL96/298	700N	B	20	16	6000	26	19	14	29	-0.5	0.47
	AL96/299	700N	B	21	16	6300	22	19.8	14	29	1.2	0.47
			Average B	**18.6**	**18.32**	**5020**	**27.4**	**18.64**	**16.2**	**22.6**	**0.1**	**0.404**

Table 1: Biogeochemical Results, Matson Creek Instrumental Neutron Activation Analysis, page 2 of 2

Line #	Lab #	Sample #	Species	Elements / Units / Detection Limits								
				K/% 0.05	Na/ppm 10	Rb/ppm 5	Sb/ppm 0.1	Sc/ppm 0.1	Sr/ppm 300	Th/ppm 0.1	Zn/ppm 20	La/ppm 0.1
L-66	AL96/305	00N	W	27	901	130	0.2	0.7	750	-0.1	1700	1.5
	AL96/315	900N	W	16.6	2690	160	0.3	2.1	2000	0.4	4800	4
			AverageW	**21.8**	**1795.5**	**145**	**0.25**	**1.4**	**1375**	**0.15**	**3250**	**2.75**
	AL96/306	200N	B	16.7	2270	93	1.3	1.7	870	0.5	2400	3.8
	AL96/307	200N	B	13	3780	77	0.8	2.8	870	0.9	2400	6.5
	AL96/308	300N	B	19.2	1900	73	0.3	1.5	1000	0.2	2700	3.6
	AL96/309	400N	B	14.1	3760	59	0.6	2.9	1100	0.6	2800	6.2
	AL96/310	500N	B	16.9	2580	120	0.5	2	1100	0.3	3700	4.8
	AL96/311	600N	B	10.5	2550	55	0.4	2	920	0.6	4200	4
	AL96/312	720N	B	13.7	3770	51	0.4	3	880	1	2800	5.6
	AL96/313	800N	B	17.4	2590	67	0.4	1.9	930	0.5	3400	4.6
	AL96/314	800N	B	16.9	2330	80	0.5	1.8	740	0.4	3200	4.2
	AL96/316	1000N	B	15.5	3340	39	0.5	2.6	1300	0.6	2200	5.6
			AverageB	**15.39**	**2887**	**71.4**	**0.57**	**2.22**	**971**	**0.56**	**2980**	**4.89**
L-76	AL96/317	00N	B	18.6	1720	200	0.3	1.3	1400	0.5	2400	2.9
	AL96/318	100N	B	16.7	2500	230	0.4	1.9	1600	0.5	2600	4.1
	AL96/319	200N	B	18.6	2210	210	0.7	1.7	1500	0.6	3300	4.1
	AL96/320	200N	B	16.9	2790	210	0.6	2	1100	0.9	3600	4.9
	AL96/321	300N	B	16.6	2150	140	1.1	1.6	1400	0.6	3300	3.5
	AL96/322	400N	B	18.6	1950	230	0.3	1.4	910	0.3	3900	3.1
	AL96/323	500N	B	22.3	2010	140	0.3	1.4	1300	0.2	6800	2.8
	AL96/324	600N	B	19.9	2510	330	0.5	1.8	1300	0.3	4400	3.7
	AL96/325	700N	B	15.5	2060	57	0.3	1.5	1200	0.3	3300	3.7
	AL96/326	800N	B	16.5	1890	77	0.3	1.4	940	0.3	3200	3.2
	AL96/327	800N	B	15.6	1990	110	0.3	1.4	940	0.3	3400	2.9
	AL96/328	900N	B	16.7	3540	120	0.8	2.7	880	0.6	5300	5.6
	AL96/329	1000N	B	14.1	3510	80	0.4	2.6	960	0.8	3600	5.4
			AverageB	**17.43**	**2371.54**	**164.15**	**0.48**	**1.75**	**1186.92**	**0.48**	**3776.92**	**3.84**
L-86	AL96/330	00n	W	22.7	1960	190	0.5	1.1	1500	0.1	2700	2.7
	AL96/331	00N	W	25	1960	200	0.5	1.1	1400	0.2	2700	2.7
	AL96/333	100N	W	25.1	1480	96	0.4	0.8	1300	0.2	1400	2
	AL96/334	100N	W	23.1	1860	91	0.4	0.9	1500	0.3	1400	2.5
	AL96/334	200N	W	24.5	1460	110	0.3	0.7	1300	0.2	1100	2.1
	AL96/295	400N	W	27.1	1780	98	0.5	1.1	1300	0.3	1800	2.7
	AL96/300	800N	W	26.5	1390	150	0.5	0.9	930	-0.1	1600	2.9
	AL96/301	800N	W	27	1430	150	0.9	0.9	1200	-0.1	1700	3
	AL96/303	900N	W	28.6	1550	210	0.2	0.9	960	0.2	2800	2.2
	AL96/304	1000N	W	24.3	1490	200	0.2	1	1200	-0.1	2300	2.6
			AverageW	**25.39**	**1636**	**149.5**	**0.44**	**0.94**	**1259**	**0.12**	**1950**	**2.54**
	AL96/294	300N	B	22.7	2290	76	0.6	0.9	1600	0.2	2300	2.2
	AL96/296	500N	B	22.4	1720	88	0.7	0.9	1300	0.4	1800	2.7
	AL96/297	600N	B	20.1	3690	54	3.1	1.7	1100	0.4	4900	3.6
	AL96/298	700N	B	19.3	4420	120	0.9	1.6	1200	0.3	3100	3.7
	AL96/299	700N	B	18.2	3160	110	0.8	1.6	1200	0.5	3400	3.6
			AverageB	**20.54**	**3056**	**89.6**	**1.22**	**1.34**	**1280**	**0.36**	**3100**	**3.16**

Table 1: Biogeochemical Results, Bradens Canyon Inductively Coupled Plasma Emission Spectrometry. *Note: 0.5g sample was used*

#	Lab #	Sample #	Species	Elements / Units									
				Ag/ppm	Cd/ppm	Cu/ppm	Mn/ppm	Ni/ppm	Pb/ppm	Al/%	Mg/	P/ppm	V/ppm
L-1	AL96/336	00S	W	1.2	2	95	2650	8	7	0.17	0.99	12400	4
	AL96/337	100S	W	0.8	1.6	101	2340	9	6	0.14	0.84	11900	3
	AL96/338	200S	W	1.1	1.6	76	2910	6	6	0.13	1.45	14100	4
	AL96/339	200S	W	1.1	1.4	77	3100	7	7	0.14	1.54	15500	4
	AL96/340	300S	W	1	1.6	83	3440	6	5	0.16	0.91	15500	4
	AL96/341	400S	W	0.6	1.4	108	2350	6	3	0.12	1.23	12600	3
	AL96/342	400S	W	0.6	1.6	104	2430	6	4	0.12	1.26	12800	3
	AL96/344	500S	W	0.6	1.7	91	4640	8	4	0.19	1.12	17500	4
	AL96/345	600S	W	1.2	3.7	94	2460	6	5	0.13	1.03	13400	3
		Average	**W**	**0.91**	**1.84**	**92.11**	**2924**	**6.88**	**5.22**	**0.14**	**1.15**	**13966**	**3.55**
	AL96/346	700S	B	2.5	1.6	145	4000	6	12	0.21	1.53	19500	6
	AL96/347	800S	B	2.4	1.6	168	4870	7	12	0.23	1.43	16700	6
	AL96/348	800S	B	2.5	2.2	162	4980	7	12	0.26	1.44	17100	7
	AL96/349	900S	B	2.3	1.7	158	7890	6	8	0.19	1.49	22300	5
	AL96/350	1000S	B	1.7	2	155	5850	10	15	0.32	1.38	19700	8
		Average	**B**	**2.28**	**1.82**	**157.6**	**5518**	**7.2**	**11.8**	**0.24**	**1.45**	**19060**	**6.4**
L-2	AL96/351	00S	W	1.3	1.6	73	4110	4	7	0.19	0.88	11500	4
	AL96/352	100S	W	0.6	1.2	85	2410	6	9	0.21	1.52	14700	5
	AL96/353	200S	W	0.9	1.6	97	2340	6	4	0.16	1.42	15500	4
	AL96/354	200S	W	1	1.9	106	2570	7	4	0.18	1.42	16900	4
	AL96/356	400S	W	0.7	0.8	66	1560	4	5	0.11	1.31	12300	3
	AL96/357	500S	W	0.7	1.7	97	2580	4	4	0.15	1.41	16600	4
	AL96/358	600S	W	1	1.5	128	1890	5	4	0.13	1.3	15800	3
	AL96/359	700S	W	0.6	1.4	107	985	5	6	0.13	1.16	15300	3
	AL96/360	800S	W	0.4	2.1	67	1080	5	7	0.16	0.97	10100	4
	AL96/361	800S	W	0.5	2.2	69	1140	5	8	0.17	1.01	10700	4
	AL96/363	900S	W	0.4	1.1	69	1180	4	5	0.13	0.73	11800	3
	AL96/364	900S	W	0.4	1.1	67	1140	4	5	0.13	0.71	11300	3
	AL96/365	1000S	W	2	1.4	93.8	2540	6	12	0.21	1.46	14800	5
		Average	**W**	**0.81**	**1.51**	**86.5**	**1963**	**5**	**6.15**	**0.16**	**1.18**	**13638**	**3.77**
	AL96/355	320S	B	1.8	2.4	180	8400	9	12	0.33	1.43	19600	8
L-3	AL96/366	00S	W	0.7	3.4	85	2350	6	10	0.19	1.59	12800	5
	AL96/367	100S	W	0.8	1.6	74	2500	9	8	0.15	0.74	10300	4
	AL96/368	700S	W	1.3	1.4	99	3170	12	7	0.14	0.94	14100	3
	AL96/369	800S	W	0.9	1.6	93	3210	19	6	0.19	0.89	12800	4
	AL96/370	800S	W	1	1.6	98	3330	19	7	0.21	0.88	13100	4
	AL96/371	900S	W	2	1.7	121	2790	39	9	0.23	1.5	16100	4
	AL96/372	1000S	W	1	1.4	89	1530	6	7	0.14	0.91	11700	3
	AL96/373	1100S	W	0.9	1.4	97	3680	8	6	0.16	0.92	14500	3
	AL96/374	1200S	W	0.6	1.2	71	3300	7	9	0.23	1.14	13000	5
	AL96/375	1300S	W	0.9	2.2	74	3780	6	9	0.21	1.09	10800	4
	AL96/376	1400S	W	0.7	1.4	82	2820	5	8	0.2	0.87	13400	5
	AL96/377	1500S	W	0.4	1.7	72	3500	4	4	0.15	0.85	14000	3
	AL96/378	1600S	W	0.9	1.3	91	3480	10	4	0.19	0.97	14800	3
	AL96/379	1600S	W	0.8	1.3	92	3560	10	7	0.23	0.98	14000	4
	AL96/380	1700S	W	1.4	1.4	75	2540	7	11	0.25	0.79	10600	6
	AL96/381	1800S	W	0.7	1.6	157	1340	6	3	0.15	1.3	18500	4
		Average	**W**	**0.94**	**1.64**	**91.87**	**2930**	**10.8**	**7.19**	**0.19**	**1.02**	**13406**	**4**

Table 1: Biogeochemical Results, Bradens Canyon Instrumental Neutron Activation Analysis, page 1 of 2.

Line #	Lab #	Sample #	Species	Au/ppb 5	As/ppm 0.5	Ba/ppm 10	Br/ppm 1	Ca/% 0.2	Co/ppm 1	Cr/ppm 1	Cs/ppm 0.5	Fe/% 0.05
L-1	AL96/336	00S	W	8	1.7	4100	10	21.8	3	16	1	0.4
	AL96/337	100S	W	10	1.2	3200	9	22.3	3	12	0.6	0.28
	AL96/338	200S	W	6	1	3700	12	23.2	3	10	-0.5	0.28
	AL96/339	200S	W	-5	1.1	3800	14	21.4	3	13	-0.5	0.31
	AL96/340	300S	W	6	1.2	2900	13	18.2	3	12	5.7	0.3
	AL96/341	400S	W	11	0.7	3500	12	22.3	3	14	0.6	0.24
	AL96/342	400S	W	14	2.9	3500	14	22.2	3	14	0.6	0.23
	AL96/344	500S	W	8	1.3	4600	21	19.2	4	18	1.1	0.37
	AL96/345	600S	W	7	0.9	4100	26	21.8	3	11	1.3	0.26
			Average W	**7.22**	**1.33**	**3711.11**	**14.56**	**21.38**	**3.11**	**13.33**	**1.10**	**0.30**
	AL96/346	700S	B	13	2.1	2700	17	23.8	3	22	0.9	0.51
	AL96/347	800S	B	7	2.2	3800	14	25.4	3	22	-0.5	0.56
	AL96/348	800S	B	10	2.7	3700	17	25.7	3	18	1.1	0.59
	AL96/349	900S	B	8	1.2	3500	21	24.5	3	17	0.9	0.38
	AL96/350	1000S	B	11	2.5	3200	17	22.8	4	19	1.1	0.67
			Average B	**9.8**	**2.14**	**3380**	**17.2**	**24.44**	**3.2**	**19.6**	**0.7**	**0.542**
L-2	AL96/351	00S	W	8	0.8	3500	9	22.8	3	10	2	0.34
	AL96/352	100S	W	9	2	3800	14	20.8	3	13	0.9	0.38
	AL96/353	200S	W	16	1.4	3500	9	23.6	3	14	1	0.33
	AL96/354	200S	W	9	1.5	3600	13	22.8	3	12	0.7	0.34
	AL96/356	400S	W	28	1.2	3800	12	25.2	2	10	0.7	0.23
	AL96/357	500S	W	14	0.8	3700	9	21	3	10	0.6	0.35
	AL96/358	600S	W	9	0.9	2500	10	18.3	2	14	0.8	0.24
	AL96/359	700S	W	8	1.1	1800	17	19.9	3	8	1.1	0.3
	AL96/360	800S	W	9	1.5	1500	8	19.9	3	8	0.6	0.34
	AL96/361	800S	W	8	2.3	1700	9	20.9	3	10	0.6	0.37
	AL96/363	900S	W	10	2.1	3800	10	20.2	2	12	1	0.27
	AL96/364	900S	W	5	1.3	3900	8	22.1	2	10	0.6	0.27
	AL96/365	1000S	W	22	2	4600	11	24.8	3	28	0.8	0.46
			Average W	**11.92**	**1.45**	**3207.69**	**10.69**	**21.72**	**2.69**	**12.23**	**0.88**	**0.32**
	AL96/355	320S	B	13	2.2	3600	20	24.4	5	22	3	0.67
L-3	AL96/366	00S	W	12	2.1	1900	16	18.4	3	9	0.7	0.47
	AL96/367	100S	W	37	1.4	4600	18	17.4	3	6	1.1	0.36
	AL96/368	700S	W	16	0.7	4200	20	20.3	4	4	1.1	0.29
	AL96/369	800S	W	9	1.6	4100	19	20.5	9	7	0.6	0.33
	AL96/370	800S	W	7	1.7	4000	20	20.7	9	8	0.8	0.37
	AL96/371	900S	W	8	1.5	4400	15	20.4	10	5	0.9	0.36
	AL96/372	1000S	W	12	0.8	3600	10	21.6	3	6	0.6	0.3
	AL96/373	1100S	W	16	1.4	3100	22	20	4	6	1.2	0.27
	AL96/374	1200S	W	8	1.2	5300	12	17.9	3	8	1.1	0.4
	AL96/375	1300S	W	9	1.3	5200	10	21.9	5	8	0.5	0.38
	AL96/376	1400S	W	14	1.5	4900	12	19.8	3	6	0.7	0.37
	AL96/377	1500S	W	6	1.3	4500	14	20.6	4	4	-0.5	0.27
	AL96/378	1600S	W	10	1	4300	13	19.9	6	5	2.9	0.27
	AL96/379	1600S	W	9	1.6	4800	11	21.3	5	7	2.2	0.37
	AL96/380	1700S	W	9	1.8	5600	17	22.6	4	10	0.7	0.5
	AL96/381	1800S	W	12	1.8	4900	10	18.4	3	7	-0.5	0.28
			AverageW	**12.13**	**1.42**	**4337.50**	**14.94**	**20.11**	**4.88**	**6.63**	**0.88**	**0.35**

Table 1: Biogeochemical Results, Bradens Canyon Instrumental Neutron Activation Analysis, page 2 of 2.

Line #	Lab #	Sample #	Species	K/% 0.05	Na/ppm 10	Rb/ppm 5	Sb/ppm 0.1	Sc/ppm 0.1	Sr/ppm 300	Th/ppm 0.1	Zn/ppm 20	La/ppm 0.1
				Elements / Units / Detection Limits								
L-1	AL96/336	00S	W	20.8	1830	85	0.3	1.3	870	0.4	2300	3.2
	AL96/337	100S	W	18.6	1420	54	0.2	1	700	0.4	1100	2.2
	AL96/338	200S	W	18.2	1460	53	0.3	1	790	0.3	1900	2.4
	AL96/339	200S	W	19.4	1470	62	0.2	1	870	0.2	1900	2.5
	AL96/340	300S	W	22.7	1550	250	0.2	1	830	0.2	1100	2.3
	AL96/341	400S	W	18.6	1240	47	0.2	0.8	970	0.1	720	1.8
	AL96/342	400S	W	18.4	1200	49	0.3	0.8	880	0.3	710	1.7
	AL96/344	500S	W	19.3	1730	88	0.2	1.1	1000	0.2	1200	2.6
	AL96/345	600S	W	19.6	1380	140	0.2	0.9	710	0.2	2800	2.1
			AverageW	**19.51**	**1475.56**	**92**	**0.23**	**0.99**	**846.67**	**0.26**	**1525.56**	**2.31**
	AL96/346	700S	B	13	2440	95	0.4	1.7	1000	0.4	2900	3.8
	AL96/347	800S	B	10.6	2690	100	0.3	1.9	1200	0.6	2800	4.1
	AL96/348	800S	B	10.7	2790	100	0.4	2	1000	0.5	2800	4.3
	AL96/349	900S	B	15.6	1700	120	0.2	1.2	1100	0.1	3200	2.7
	AL96/350	1000S	B	13.7	3090	74	0.9	2.1	920	0.7	3500	4.5
			AverageB	**12.72**	**2542**	**97.8**	**0.44**	**1.78**	**1044**	**0.46**	**3040**	**3.88**
L-2	AL96/351	00S	W	14.8	1580	150	0.2	1.1	850	0.2	1100	2.6
	AL96/352	100S	W	19.3	1980	140	0.3	1.3	1400	0.3	1200	2.9
	AL96/353	200S	W	19.2	1560	120	0.2	1	1200	0.2	1100	2.2
	AL96/354	200S	W	19.6	1650	120	0.3	1	1300	0.3	1200	2.5
	AL96/356	400S	W	16.8	1290	62	0.4	0.8	2000	0.2	2000	1.9
	AL96/357	500S	W	19.9	1690	97	0.3	1	1600	0.3	3800	2.3
	AL96/358	600S	W	24	1340	370	0.2	0.8	880	-0.1	1800	1.8
	AL96/359	700S	W	21.7	1420	220	0.2	0.9	950	0.2	1600	1.9
	AL96/360	800S	W	16.8	1660	100	0.2	1.2	1000	0.1	1600	2.3
	AL96/361	800S	W	17.1	1750	100	0.3	1.2	1100	0.3	1700	2.5
	AL96/363	900S	W	16	1240	180	0.3	0.8	1700	-0.1	1600	1.8
	AL96/364	900S	W	15	1290	150	0.2	0.9	1600	-0.1	1700	1.9
	AL96/365	1000S	W	9.9	2080	43	0.3	1.4	1900	0.2	2100	3.2
			Average W	**17.7**	**1579.23**	**142.46**	**0.26**	**1.03**	**1344.62**	**0.15**	**1730.77**	**2.29**
	AL96/355	320S	B	10.1	3000	140	0.8	2	930	0.7	1600	4.3
L-3	AL96/366	00S	W	15.2	2150	77	0.3	1.6	1100	0.4	3500	3.9
	AL96/367	100S	W	18.6	1560	57	0.2	1.1	870	0.1	900	2.5
	AL96/368	700S	W	17.8	1280	110	0.2	0.9	830	0.3	1400	2.1
	AL96/369	800S	W	17	1530	68	0.2	1.1	610	0.2	800	2.3
	AL96/370	800S	W	17	1600	57	0.3	1.1	800	-0.1	860	2.4
	AL96/371	900S	W	17.4	1590	36	0.4	1	840	0.2	1100	3
	AL96/372	1000S	W	17.1	1440	37	1.1	1	680	0.1	890	2
	AL96/373	1100S	W	18.6	1360	80	0.2	0.9	1100	0.3	830	2
	AL96/374	1200S	W	17.9	1990	160	0.3	1.3	1300	0.1	1600	3
	AL96/375	1300S	W	14.6	1720	34	0.2	1.2	1200	0.2	1200	2.9
	AL96/376	1400S	W	17.3	1800	110	0.3	1.2	920	-0.1	2000	2.5
	AL96/377	1500S	W	17.6	1260	45	0.1	0.9	1200	0.2	1100	1.9
	AL96/378	1600S	W	18.2	1450	280	0.4	0.9	870	-0.1	770	2.5
	AL96/379	1600S	W	16.8	1720	240	0.3	1.1	1100	0.2	810	3.1
	AL96/380	1700S	W	12.5	2320	94	0.3	1.5	1200	0.4	1200	3.5
	AL96/381	1800S	W	18.1	1420	37	0.3	1	1600	-0.1	3000	1.9
			Average W	**16.98**	**1636.88**	**95.13**	**0.32**	**1.11**	**1013.75**	**0.14**	**1372.50**	**2.59**

Table 2: Biogeochemical Results-

Elements: Line #	Species	Ag/ppm	Cd/ppm	Cu/ppm	Mn/ppm	Ni/ppm	Pb/ppm	Al/%	Mg/%	P/ppm	V/ppm
MATSON CREEK											
L-66											
	Average W	0.95	1.75	88.50	2750	6.00	5.00	0.19	1.17	15100	4.50
	Average B	3.76	3.97	173.00	15698	18.10	12.50	0.35	1.87	25430	8.70
L-76											
	Average B	4.51	7.34	224.00	19269	20.85	7.54	0.29	1.91	31177	6.31
L-86											
	Average W	1.02	1.84	125.90	5884	11.70	4.40	0.19	1.40	20210	3.00
	Average B	4.54	6.52	227.60	14744	38.80	7.40	0.26	1.75	34400	5.40
BRADENS CANYON											
L-1											
	Average W	0.91	1.84	92.11	2924	6.88	5.22	0.14	1.15	13966	3.55
	Average B	2.28	1.82	157.60	5518	7.20	11.80	0.24	1.45	19060	6.40
L-2											
	Average W	0.81	1.51	86.50	1963	5.00	6.15	0.16	1.18	13638	3.77
	B	1.80	2.40	180.00	8400	9.00	12.00	0.33	1.43	19600	8.00
L-3											
	Average W	0.94	1.64	91.87	2930	10.80	7.19	0.19	1.02	13406	4.00

TABLE 2A: Average concentrations of elements in white spruce (W) and black spruce (B) twig ash samples along each transect at Bradens Canyon and Matson Creek. Inductively Coupled Plasma Emission Spectrometry. Note: 0.5g sample was used.

Table 2 continued

Line # Species	Au/ppb 5	As/ppm 0.5	Ba/ppm 10	Br/ppm 1	Ca/% 0.2	Co/ppm 1	Cr/ppm 1	Cs/ppm 0.5	Fe/% 0.05	K/% 0.05	Na/ppm 10	Rb/ppm 5	Sb/ppm 0.1	Sc/ppm 0.1	Sr/ppm 300	Th/ppm 0.1	Zn/ppm 20	La/ppm 0.1
MATSON CREEK																		
L-66																		
Average W	7.50	1.60	3400	11.00	19.60	3.00	19.00	0.10	0.42	21.80	1795.50	145.0	0.25	1.40	1375.00	0.15	3250.00	2.75
Average B	13.40	2.33	3410	21.70	20.22	8.20	22.70	0.27	0.66	15.39	2887.00	71.4	0.57	2.22	971.00	0.56	2980.00	4.89
L-76																		
Average B	19.00	2.44	3700	29.69	20.98	8.31	20.46	0.85	0.53	17.43	2371.54	164.2	0.48	1.75	1186.92	0.48	3776.92	3.84
L-86																		
Average W	16.60	7.25	2950	17.60	18.51	3.80	12.80	-0.24	0.28	25.39	1636.00	149.5	0.44	0.94	1259.00	0.12	1950.00	2.54
Average B	18.60	18.32	5020	27.40	18.64	16.20	22.60	0.10	0.40	20.54	3056.00	89.6	1.22	1.34	1280.00	0.36	3100.00	3.16
BRADENS CANYON																		
L-1																		
Average W	7.22	1.33	3711.11	14.56	21.38	3.11	13.33	1.10	0.30	19.51	1475.56	92.0	0.23	0.99	846.67	0.26	1525.56	2.31
Average B	9.80	2.14	3380	17.20	24.44	3.20	19.60	0.70	0.54	12.72	2542.00	97.8	0.44	1.78	1044.00	0.46	3040.00	3.88
L-2																		
Average W	11.92	1.45	3207.69	10.69	21.72	2.69	12.23	0.88	0.32	17.70	1579.32	142.5	0.26	1.03	1344.62	0.15	1730.77	2.29
Average B	13.00	2.20	3600	20.00	24.40	5.00	22.00	3.00	0.67	10.10	3000.00	140.0	0.80	2.00	930.00	0.70	1600.00	4.30
L-3																		
Average W	12.13	1.42	4337.50	14.94	20.11	4.88	6.63	0.88	0.35	16.98	1636.88	95.1	0.32	1.11	1013.75	0.14	1372.50	2.59

Table 2B: *Average concentrations of elements in white spruce (W) and black spruce (B) twig ash samples along each transect at Bradens Canyon and Matson Creek. Instrumental Neutron Activation Analysis. Note: 0.5g sample was used.*

Table 3

Elements/units:			Au/ppb	Ag/ppm	Al/%	Ba/ppm	Ca/%	Cd/ppm	Co/ppm	Cr/ppm	Cu/ppm	Fe/%	K/%	Mg/%	Mn/ppm
Line #	Sample #	Species													
L-1	L1 00S	W	<5	<.2	0.81	580	1.22	0.5	10	21	23	2.07	0.08	0.75	440
	L1 100S	W	<5	<.2	0.83	480	0.32	0.5	10	28	21	2.13	0.07	0.37	280
	L1 200S (A)	W	<5	<.2	1.08	520	0.3	<.5	10	25	8	2.25	0.08	0.35	445
	L1 200S (B)	W	<5	<.2	1.07	520	0.3	0.5	8	24	8	2.21	0.08	0.34	445
	L1 300S	W	<5	<.2	0.98	310	0.28	<.5	8	23	8	1.98	0.11	0.31	355
	L1 400S	W	<5	<.2	1.04	390	0.25	<.5	8	22	8	1.92	0.06	0.31	410
	L1 500S	W	25	<.2	1.54	290	0.31	<.5	11	34	15	2.81	0.27	0.47	245
	L1 600S	W	<5	<.2	0.73	180	0.55	<.5	8	32	12	2.58	0.04	0.39	315
	L1 700S	B	<5	<.2	0.67	440	2.64	1	6	15	31	1.12	0.03	0.39	440
	L1 800S	B	<5	<.2	1.42	490	1.02	1	16	35	38	2.58	0.06	0.56	3500
	L1 900S	B	<5	<.2	0.95	240	1.7	<.5	7	20	24	1.62	0.06	0.51	470
	L1 1000S	B	<5	<.2	1.42	250	0.72	<.5	11	36	26	2.5	0.08	0.63	350
L-2	L2 00S	W	<5	<.2	1.59	290	0.26	<.5	7	26	9	2.43	0.07	0.4	200
	L2 100S	W	<5	<.2	1.32	480	0.34	<.5	11	28	14	2.52	0.06	0.47	440
	L2 200S (A)	W	<5	<.2	1.15	530	0.52	<.5	8	22	11	2	0.06	0.34	410
	L2 200S (B)	W	<5	<.2	1.09	430	0.36	<.5	7	21	7	1.96	0.05	0.34	260
	L2 320S	B	<5	<.2	1.22	600	0.7	<.5	9	22	13	2.02	0.03	0.39	305
	L2 400S	W	<5	<.2	0.12	250	2.34	<.5	5	3	8	0.17	0.03	0.3	1150
	L2 500S	W	<5	<.2	1.39	370	1.12	0.5	12	40	42	2.49	0.07	0.65	540
	L2 600S	W	<5	<.2	1.32	320	1.3	<.5	8	35	34	2.3	0.05	0.61	410
	L2 700S	W	<5	<.2	1.58	450	1.31	0.5	20	46	39	2.85	0.06	0.71	1590
	L2 800S	W	<5	<.2	1.71	540	1.86	<.5	13	46	50	2.76	0.08	0.8	1050
	L2 900S (A)	W	<5	<.2	1.54	330	1.11	<.5	10	50	27	2.57	0.04	0.82	845
	L2 900S (B)	W	<5	<.2	1.61	390	1.31	<.5	12	48	31	2.62	0.04	0.81	1200
	L2 1000S	W	<5	<.2	1.23	230	0.44	<.5	7	44	23	1.88	0.08	0.62	230
L-3	L3 00S	W	<5	<.2	0.37	450	2.81	2	5	6	21	0.49	0.02	0.99	710
	L3 100S	W	<5	<.2	3.3	710	0.5	0.5	26	167	118	4.88	0.54	2.03	665
	L3 700S	W	<5	<.2	1.39	280	0.21	<.5	10	31	13	2.54	0.08	0.38	220
	L3 800S (A)	W	<5	<.2	2.41	250	0.34	<.5	20	98	33	3.43	0.28	1.6	250
	L3 800S (B)	W	<5	<.2	2.66	280	0.4	<.5	22	105	36	3.72	0.35	1.86	310
	L3 900S	W	<5	<.2	2.04	440	0.18	<.5	23	84	75	3.31	0.33	1.11	340
	L3 1000S	W	<5	<.2	1.13	640	0.56	<.5	11	26	18	2.35	0.12	0.35	805
	L3 1100S	W	<5	<.2	1.04	290	0.26	<.5	6	21	9	2.03	0.07	0.36	300
	L3 1200S	W	<5	<.2	1.23	510	0.38	<.5	9	26	17	2.52	0.06	0.39	360
	L3 1300S	W	<5	<.2	1.37	320	0.22	<.5	8	28	12	2.33	0.09	0.37	180
	L3 1400S	W	<5	<.2	1.12	460	0.29	<.5	8	22	6	1.94	0.05	0.33	325
	L3 1500S	W	<5	<.2	1.23	450	0.28	<.5	7	22	6	1.77	0.04	0.33	255
	L3 1600S	W	<5	<.2	1.44	430	0.22	<.5	8	26	11	2.22	0.04	0.38	270
	L3 1700S	W	<5	<.2	1.46	500	0.41	<.5	11	28	13	2.44	0.07	0.36	810

TABLE 3: *Analyses of soil geochemical samples from the Bradens Canyon area, Yukon Territory. W = White spruce, B = Black spruce. Page 1 of 2.*

Table 3 continued

Elements/units			Mo/ppm	Na/%	Ni/ppm	P/ppm	Pb/ppm	Sc/ppm	Sr/ppm	Ti/%	V/ppm	Zn/ppm
Line #	Sample #	Species										
L-1	L1 00S	W	<1	<.01	32	980	6	2	57	0.01	38	122
	L1 100S	W	<1	<.01	30	900	8	3	30	0.01	42	84
	L1 200S (A)	W	1	<.01	20	630	10	2	21	0.03	42	112
	L1 200S (B)	W	1	<.01	19	650	12	2	22	0.03	42	106
	L1 300S	W	<1	<.01	15	340	10	1	21	0.04	40	34
	L1 400S	W	<1	<.01	14	470	6	2	18	0.03	39	38
	L1 500S	W	<1	<.01	21	320	10	4	20	0.07	57	44
	L1 600S	W	<1	<.01	17	950	6	3	28	0.05	70	48
	L1 700S	B	1	0.01	25	990	4	<1	106	0.01	22	42
	L1 800S	B	1	0.01	42	1140	6	4	50	0.05	52	64
	L1 900S	B	1	0.01	20	800	4	2	72	0.04	36	52
	L1 1000S	B	<1	0.01	27	820	10	4	38	0.07	58	70
L-2	L2 00S	W	<1	<.01	15	360	6	2	20	0.05	60	52
	L2 100S	W	1	<.01	23	360	10	3	31	0.04	47	74
	L2 200S (A)	W	1	<.01	17	420	8	2	37	0.03	40	42
	L2 200S (B)	W	<1	<.01	14	300	12	2	27	0.02	37	40
	L2 320S	B	<1	<.01	21	350	12	3	47	0.02	37	38
	L2 400S	W	2	<.01	7	1310	<2	<1	128	<.01	3	22
	L2 500S	W	<1	<.01	39	1160	10	5	69	0.04	50	80
	L2 600S	W	<1	<.01	34	990	4	4	66	0.05	47	70
	L2 700S	W	1	0.01	47	940	<2	5	71	0.06	62	86
	L2 800S	W	<1	0.01	56	1050	6	5	101	0.05	55	90
	L2 900S (A)	W	1	0.01	39	810	2	5	63	0.06	57	86
	L2 900S (B)	W	<1	0.01	43	830	2	5	73	0.06	57	96
	L2 1000S	W	1	<.01	35	570	<2	4	28	0.05	42	52
L-3	L3 00S	W	<1	<.01	59	1190	<2	<1	134	<.01	10	28
	L3 100S	W	7	<.01	157	370	<2	12	35	0.1	158	192
	L3 700S	W	<1	<.01	25	420	8	3	14	0.05	48	68
	L3 800S (A)	W	1	<.01	83	460	2	5	17	0.14	90	86
	L3 800S (B)	W	3	<.01	91	590	8	6	20	0.15	96	92
	L3 900S	W	3	<.01	158	260	<2	5	21	0.1	68	110
	L3 1000S	W	<1	<.01	27	520	8	3	21	0.04	41	46
	L3 1100S	W	1	<.01	16	570	2	1	18	0.04	39	46
	L3 1200S	W	<1	<.01	26	680	12	4	24	0.03	40	68
	L3 1300S	W	<1	<.01	21	260	4	3	16	0.03	42	52
	L3 1400S	W	<1	<.01	16	410	10	1	20	0.02	38	58
	L3 1500S	W	<1	<.01	13	300	2	1	21	0.04	44	44
	L3 1600S	W	<1	<.01	20	280	12	3	16	0.03	45	44
	L3 1700S	W	<1	<.01	20	330	8	3	27	0.05	52	46

TABLE 3 continued : Analyses of soil geochemical samples from the Bradens Canyon area, Yukon Territory. W = White spruce, B = Black spruce. Page 2 of 2.

THE CARMACKS HYDROTHERMAL EVENT: AN ALTERATION STUDY IN THE SOUTHERN DAWSON RANGE, YUKON

Katherine A. Smuk, A.E. Williams-Jones and Don Francis
Department of Earth and Planetary Sciences, McGill University
3450 University St., Montréal, Québec, H3A 2A7

SMUK, K.A., WILLIAMS-JONES, A.E., and FRANCIS, D., 1997. The Carmacks hydrothermal event: An alteration study in the southern Dawson Range, Yukon. In: Yukon Exploration and Geology 1996, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 92-106.

ABSTRACT

Gold-rich polymetallic vein deposits, and gold-copper porphyry deposits, occur along a northwesterly trend across the southern Dawson Range. Vein mineralization is hosted by lithologic units ranging from the Proterozoic-Paleozoic Basement Metamorphic Complex, through the mid-Cretaceous Mt. Nansen volcanics, to the Late Cretaceous Carmacks volcanics. The mineralized areas also contain numerous porphyry dykes that are spatially associated with gold veins, and historically have been thought to be genetically linked to them. Dykes belonging to both the Mt. Nansen and Carmacks Groups are present, although Mt. Nansen dykes are the more common. Dykes proximal to mineralized veins are strongly altered to sericite and clay.

Volcanic and subvolcanic rocks of the Mt. Nansen and Carmacks Groups can be distinguished chemically on the basis of their K content; the Mt. Nansen Group is a high-K calc-alkaline suite while the Carmacks Group is a shoshonitic suite. Radiometric age determinations constrain the age of the Carmacks Group to approximately 70 Ma, while the age of the Mt. Nansen Group is approximately 105 Ma. K/Ar dates for altered Mt. Nansen dykes, however, range from 94 to 61 Ma, reflecting resetting of Mt. Nansen ages by a Carmacks-age hydrothermal event. This hydrothermal event appears to have been responsible for much of the mineralization in the southern Dawson Range.

Alteration in porphyritic dykes proximal to mineralization is characterized by a strong depletion of Na, reflecting the replacement of feldspar by sericite and clay minerals. Altered dykes also display a general depletion in the ore metals Pb, Zn, and Cu, suggesting that these elements were mobilized from the host rocks during alteration and precipitated in nearby gold-rich base metal veins. As, Sb, and Au, however, appear to have been introduced directly from the hydrothermal fluid.

RÉSUMÉ

On trouve des gisements filoniens polymétalliques riches en or et du porphyre à or et cuivre suivant un axe nord-ouest qui traverse le chaînon Dawson au sud. La minéralisation filonienne est incluse dans des unités lithologiques allant du complexe métamorphique du socle du Protérozoïque-Paléozoïque aux roches volcaniques de Carmacks du Crétacé tardif, en passant par les roches volcaniques de Mount Nansen du Crétacé moyen. Les zones minéralisées renferment aussi de nombreux dykes de porphyre qui sont associés dans l'espace à des filons d'or et dont on a présumé historiquement qu'ils y sont associés génétiquement. On trouve des dykes appartenant aux groupes de Mount Nansen et de Carmacks, mais les premiers sont plus abondants. Les dykes proches des filons minéralisés sont fortement altérés en séricite et en argile.

On peut distinguer chimiquement les roches volcaniques et subvolcaniques des groupes de Mount Nansen et de Carmacks selon leur teneur en K; le groupe de Mount Nansen est une suite calco-alcaline riche en K, tandis que le groupe de Carmacks est une suite shoshonitique. Les datations radiométriques font remonter le groupe de Carmacks à quelque 70 Ma, et le groupe de Mount Nansen à 105 Ma environ. Les datations au K/Ar situent toutefois les dykes altérés de Mount Nansen entre 94 et 61 Ma, indiquant un remaniement des âges de Mount Nansen en fonction d'un événement hydrothermal de l'époque de Carmacks. Cet événement hydrothermal semble être la cause principale de la minéralisation dans le sud du chaînon Dawson.

L'altération en dykes porphyriques près de la minéralisation est caractérisée par un épuisement du Na, indiquant le remplacement du feldspath par de la séricite et de l'argile. Les dykes altérés présentent un appauvrissement général en métaux exploitables tels Pb, Zn et Cu, indiquant que ces éléments ont été mobilisés dans la roche hôte en cours d'altération et ont précipité dans les filons de métal commun riches en or. Il semble toutefois que le fluide hydrothermal ait fourni un apport direct en As, Sb et Au.

Introduction

Since the early twentieth century the southern Dawson Range has been extensively explored and exploited for its precious and base metal deposits. Placer gold production has spanned the last century, although the local lode sources for this gold are still poorly understood. Several deposits in the area have been exploited historically (e.g. Mount Nansen, Laforma) and, after many years, these same deposits are again being considered for their gold potential.

The majority of the known gold showings in the southern Dawson Range are associated with nearby mid- and Late Cretaceous volcanic rocks and related intrusions, which comprise the Mt. Nansen and Carmacks Group respectively. There has been considerable confusion as to the ages and the distinction between the two volcanic groups (Sawyer and Dickinson, 1976; Carlson, 1987; McInnes et al., 1988), but subvolcanic porphyry dykes and stocks associated with mineralization have generally been assigned to the Mt. Nansen Group (mid-Cretaceous). Exploration prospects in this part of the Dawson Range occur along a northwesterly trend for a distance of approximately 50 km in a common sequence of host rocks. The styles of mineralization hosted by these lithologies, however, range in character from those of porphyry copper-gold to epithermal vein deposits. Vein mineralization predominates, and varies in character from precious metal to polymetallic. There appears to be no visible pattern to the distribution of the different vein types, although all appear to be genetically related.

The important question from an exploration perspective is whether there is a genetic relationship between mineralization and magmatism. The distinction between Mt. Nansen and Carmacks porphyry dykes is essential to an understanding of the gold mineralization in the Dawson Range, as porphyry dykes have long been recognized to be spatially associated with vein mineralization (Yukon Minfile, 1996). This paper examines the relationships between the gold occurrences and igneous rocks of the Mt. Nansen, Freegold Mtn., and Prospector Mtn. areas in terms of the alteration developed in porphyry dykes proximal to mineralization, and presents evidence that suggests the majority of lode gold mineralization is in fact related to the Late Cretaceous Carmacks magmatic event, rather than the Mt. Nansen event to which porphyry dykes associated with mineralization have traditionally been assigned.

GENERAL GEOLOGY

The rocks of the Mt. Nansen and Carmacks Groups overlap the Yukon-Tanana and Stikine Terranes in the Dawson Range of central Yukon (Fig. 1). The general stratigraphy of the southern

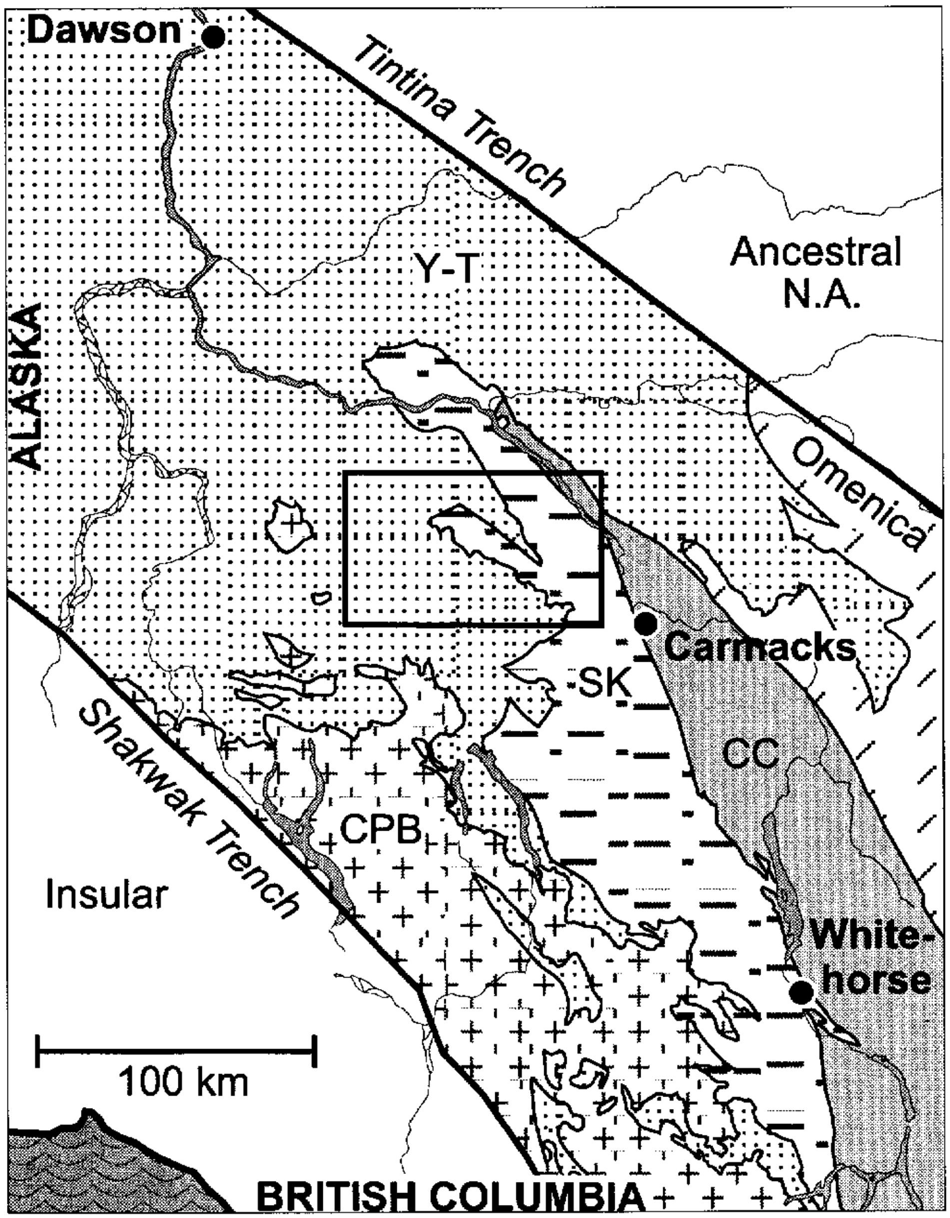


FIGURE 1: Regional tectonic setting of south-central Yukon and location of the southern Dawson Range study area (outlined; Fig.2). Terrane boundaries interpreted from Journeay and Williams (1995). Y-T -Yukon-Tanana Terrane; N.A. -North America; SK -Stikine Terrane; CC -Cache Creek Terrane; CPB -Coast Plutonic Belt.

Dawson Range described here differs somewhat from that in previous geological reports (Carlson, 1987; Payne et al., 1987) largely due to recent radiometric age determinations that have refined the stratigraphy of the Mt. Nansen Volcanic Group (Table 1) and resulted in a re-evaluation of the Klotassin Suite.

The Paleozoic-Proterozoic Basement Metamorphic Complex comprises the oldest rocks in the area and outcrops primarily around Mt. Nansen (Fig. 2). Its lower metasedimentary unit (Unit 1) consists of quartzites, schists and gneisses, while the upper schist and gneiss unit (Unit 2) includes foliated plutonic rocks and amphibolites. The prominent Big Creek meta-plutonic Suite (Unit 4), which occurs mainly in the Freegold Mtn. area, was emplaced at approximately 184 Ma (Templeman-Kluit, 1984). This unit comprises the weakly foliated Big Creek syenite (actually a monzonite) as well as a hornblendite. This intrusion was followed by eruption of the Mount Nansen Group (Unit 7) at approximately 105 Ma (Templeman-Kluit, 1984; Carlson, 1987; Hunt and Roddick, 1991). The Mt. Nansen Group consists of bimodal volcanic breccias (andesite and rhyolite fragments) now covering a relatively small area around the Mt. Nansen mining camp. Few true lava flows have been identified by the authors, although these have been reported by earlier workers (e.g. Carlson, 1987). A swarm of intermediate to felsic quartz-feldspar porphyry dykes and stocks (Unit 9) found throughout the map area is associated with this volcanic suite. The Dawson Range Batholith (Unit 3) includes the the Klotassin Suite Granodiorite, the Casino Granodiorite and the Coffee Creek Quartz Monzonite, and ranges in age from 105 to 90 Ma (Templeman-Kluit and Wanless, 1975; LeCouteur and Templeman-Kluit, 1976). This unit is likely to be comagmatic with the Mt. Nansen suite.

The last unit to be emplaced was the Late Cretaceous Carmacks Group, dated at approximately 70 ± 4 Ma (Stevens et al., 1982; Templeman-Kluit, 1984; Johnston, 1995). This suite comprises two volcanic units, a thick lower succession of andesitic tuffs and breccias (Units 12 and 13), and an upper series of extensive basaltic flows (Unit 14). The Prospector Suite (Unit 15) is represented by a contemporaneous granitic plug exposed at Prospector Mountain. Porphyritic dykes of mafic to intermediate composition of the Carmacks Group are also found throughout the map area, although they appear to be less numerous than the Mt. Nansen quartz-feldspar porphyry dykes.

Mineralization comprises a regional trend of gold- and copper-bearing porphyry deposits, interspersed with a large number of polymetallic vein prospects, aligned along the Big Creek Fault. Locally, both polymetallic veins and porphyry dykes are also aligned in northwesterly-trending directions and probably follow small parallel structures.

Ore samples collected for this study are, for the most part, from vein deposits in the Mt. Nansen camp, the Freegold Mtn. camp and the Prospector Mtn. area. Typical ore assemblages include, in order of decreasing abundance; pyrite, galena, sphalerite, and chalcopyrite, with variable amounts of arsenopyrite, tetrahedrite-tennantite, boulangerite, jamesonite, proustite-pyrargyrite, and hematite. Gold is typically refractory in pyrite and arsenopyrite. The wide-spread occurrence of this assemblage suggests that many of these veins are genetically related. Local differences in mineralogy appear to reflect differences in the host rocks, which range from the Basement Metamorphic Complex through to the Lower Carmacks Group.

The porphyry deposits are characterized by disseminated and veinlet pyrite and chalcopyrite, as well as of supergene copper oxides and sulphides. Porphyry-style mineralization in the southern Dawson Range is hosted almost exclusively by Mt. Nansen quartz-feldspar porphyry stocks and granodiorites of the Dawson Range Batholith / Klotassin Suite. An important exception is the Casino porphyry deposit (north-west of the study area) which has a well-constrained age of 70 Ma (Godwin, 1976), indicating that Carmacks intrusions also host porphyry-style mineralization.

VOLCANIC SUITES AND PORPHYRY DYKES

It is reasonable to assume that Dawson Range gold mineralization is related spatially and temporally to either the Mt. Nansen or the Carmacks magmatic suites, as the deposits are intimately associated with porphyry dykes and because these magmatic events provided sources of heat at the time of eruption.

A compilation of available age determinations for the two magmatic suites (Table 1) indicates that while Carmacks volcanic and intrusive samples record a consistent Late Cretaceous age of 70 ± 4 Ma, Mt. Nansen volcanic and subvolcanic rocks show a bimodal distribution of ages. Unaltered Mt. Nansen samples taken from areas that do not host known mineralization, and altered samples that have been dated by U/Pb methods give an average age of 105 ± 3 Ma. Geological field relationships support this mid-Cretaceous age for the Mt. Nansen suite (Carlson, 1987). By contrast, altered Mt. Nansen samples, or samples found at the Mt. Nansen mining camp, yield ages ranging from 94 to 61 Ma. These Late Cretaceous dates are interpreted to indicate of partial resetting due to the alteration of these rocks, rather than the crystallization ages (Carlson, 1987; McInnes et al., 1988). The K/Ar technique used for the bulk of the samples is interpreted to date the formation of sericite during hydrothermal alteration, while the U/Pb technique dates magmatic zircons which are resistant to alteration. The dates of the altered Mt. Nansen dykes approach the age of the Carmacks suite. The implication of these dates is that a regional hydrothermal event of Late Cretaceous age related to Carmacks igneous activity altered the Mt. Nansen porphyritic dykes and formed precious and base metal mineralized veins in all lithologies older than the Upper Carmacks volcanic unit.

The question that arises is whether one is confident in assigning rocks with Late Cretaceous dates to the mid-Cretaceous Mt. Nansen Group rather than to the Carmacks Group. These two volcanic suites have similar calc-alkaline characteristics but can be distinguished in the Dawson Range on the basis of potassium content (Fig. 3). The Mt. Nansen Group is a high-K, calc-alkaline volcanic suite which trends to high silica values, while the

Sample Number	Rock Type	Location	X	Y	UTM Zone	Technique	Age (Ma)	Error (Ma)	Source
Carmacks Group									
SR-4	Basalt	Smoky Ridge	367690	6927780	8	40Ar/39Ar	71.4	1.1	*
SR-9	Ankaramitic Basalt	Smoky Ridge	366600	6930580	8	40Ar/39Ar	70.9	1.4	*
SR-14	Ankaramitic Basalt	Smoky Ridge	367160	6929850	8	40Ar/39Ar	70.5	0.5	*
AX-2	Andesite-Basalt	Apex Mtn.	652100	6930250	7	40Ar/39Ar	67.8	0.6	*
AX-22	Ankaramitic Basalt	Apex Mtn.	654160	6920000	7	40Ar/39Ar	70.9	0.6	*
ML-15	Ankaramite	Miller's Ridge	420100	6886340	8	40Ar/39Ar	68.5	1.0	*
na	Dacite Plug	Mt. Pitts	364650	6939650	8	K/Ar Biotite	71.7	1.7	Templeman-Kluit, 1984
na	Unit #13	Mt. Pitts	367500	6939450	8	K/Ar Biotite	68.0	3.4	Johnston, 1995
GSC 81-15	Basalt Plug	"Smoky Ridge"	366100	6932300	8	K/Ar Hornblende	78.4	3.2	Stevens et al., 1982
GSC 81-50	Basalt Plug	"Smoky Ridge"	366100	6932300	8	K/Ar Biotite	65.8	1.6	Stevens et al., 1982
na	Quartz Monzonite	Prospector Mtn.	355150	6926550	8	K/Ar Whole Rock	68.2	1.6	Templeman-Kluit, 1984
						AVERAGE	70.2		
Mount Nansen Group									
C-1125	Unit #9b	Mt. Nansen	na	na	8	U/Pb Zircon	105.1		Carlson, 1987
C-1083	Altered Qtz-Fp Porphyry	Mt. Nansen	na	na	8	U/Pb Zircon	101.5		Carlson, 1987
C-1115	Porphyritic Monzonite	Mt. Nansen	na	na	8	U/Pb Zircon (+64 um)	104.2		Carlson, 1987
C-1115	Porphyritic Monzonite	Mt. Nansen	na	na	8	U/Pb Zircon (-64 um)	102.8		Carlson, 1987
GSC 81-57	Felsite	Klaza Mtn.	370300	6910200	8	K/Ar Whole Rock	109	3	Templeman-Kluit, 1984
GSC 90-84	Fp-Hb Porphyry Dyke	Bow Creek	374700	6898800	8	K/Ar Whole Rock	107.9	1.6	Hunt and Roddick, 1991
						AVERAGE	105.1		
MN-24	Andesite Dyke	Mt. Nansen	381390	6888080	8	40Ar/39Ar	76.3	1.2	*
MN-30	Andesite Agglomerate	Mt. Nansen	379940	6887960	8	40Ar/39Ar	89.7	2.0	*
GSC 81-37	Bt-Fp Porphyry Dyke	Mt. Nansen	379400	6886800	8	K/Ar Biotite	70.5	2.2	Stevens et al., 1982
GSC 90-80	Altered Qtz-Fp Porphyry Dyke	Mt. Nansen	374300	6886900	8	K/Ar Whole Rock	69.7	1.4	Hunt and Roddick, 1991
GSC 90-81	Altered Bt-Fp Porphyry Dyke	Mt. Nansen	379400	6886800	8	K/Ar Whole Rock	61.2	1.2	Hunt and Roddick, 1991
GSC 90-82	Altered Qtz-Fp Porphyry Dyke	Mt. Nansen	385000	6881700	8	K/Ar Whole Rock	69	1.7	Hunt and Roddick, 1991
GSC 90-85	Trachyte Flow	Mt. Nansen	385300	6898300	8	K/Ar Whole Rock	93.7	1.5	Hunt and Roddick, 1991
F85-33B	Altered Qtz-Fp Porphyry Dyke	Laforma-Freegold Mtn.	389500	6906250	8	K/Ar Whole Rock	77.5	6.2	McInnes et al., 1985

* indicate 40Ar/39Ar age determination performed for this study by D. Lux at the University of Maine; na: not available

TABLE I: *Volcanic and plutonic dates.*

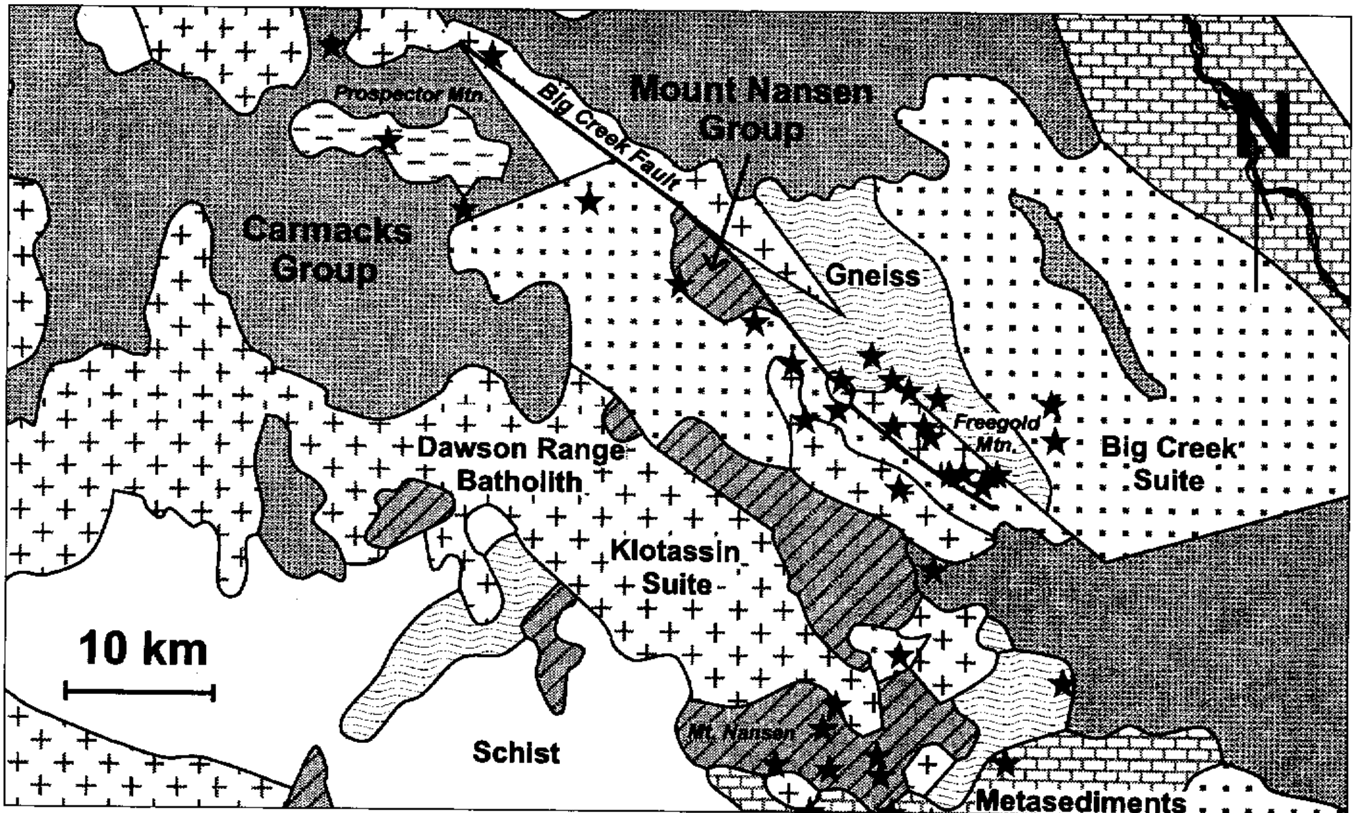


FIGURE 2: General geology of Dawson Range study area. Unit boundaries are modified from Journeay and Williams (1995). Stars indicate deposits or prospects listed in Yukon Minfile (1996).

Carmacks volcanic Group is a shoshonitic suite that does not attain the evolved compositions of the felsic members of the Mt. Nansen suite. Furthermore, the lava compositions of the Carmacks suite extend to higher Mg values than those of the Mt. Nansen suite (Fig. 4). It should be cautioned, however, that this distinction between the Carmacks and the Mt. Nansen suites on the basis of potassium is only applicable to Carmacks rocks in the Dawson Range. Carmacks rocks occurring in the Dawson City area to the north and the Miners Range to the south do not exhibit a shoshonitic character, and are indistinguishable from the Mt. Nansen suite on a K_2O against SiO_2 or MgO diagram.

In general, the dykes of the Mt. Nansen Group tend to be more felsic than those of the Carmacks Group, and dykes of both suites are more felsic than the lavas. As there is extensive overlap in the compositions of the subvolcanic members of the two suites (including dykes and stocks), however, this criterion cannot be used as an effective discriminant between dykes of the two groups in the field. Although Mt. Nansen dykes extend to higher silica values than Carmacks dykes, the most evolved rocks of both suites contain quartz as a major phase. In general, the porphyritic dykes or stocks of the Mt. Nansen Group contain quartz as a phenocryst phase equal in proportion to feldspar (plagioclase and orthoclase), whereas the phenocrysts of the Carmacks dykes are predominantly feldspar with few or no quartz phenocrysts. Mafic phenocryst phases are more common in the Carmacks Group, although this observation may be biased by the fact that many of the samples of Mt. Nansen subvolcanic rocks were altered, and the less numerous Carmacks dykes tend to be more mafic in composition. The most striking observation is that it is difficult to distinguish the subvolcanic rocks of the Mt. Nansen suite from those of the Carmacks suite in hand sample.

The "lavas" of the Mt. Nansen suite are typically agglomerates, as is the lower unit of the Carmacks suite. The Mt. Nansen agglomerate is a well-consolidated, heterolithic rock with a bimodal population of felsic and more mafic fragments (Plate 1a). In contrast, the Carmacks agglomerate is a friable, monolithic rock consisting of andesitic fragments (Plate 1b). There are many different types of fragmental units in the lower Carmacks member, however, including agglomerates, mud flows, and water-reworked deposits. Any true mafic lava flow may be recognized almost immediately as belonging to the Carmacks Group.

ALTERATION

Dykes and stocks spatially associated with mineralized veins in the southern Dawson Range are invariably altered, many intensely. The main alteration minerals present in the altered dykes are sericite (here used broadly to indicate either the fine-grained K-mica muscovite or the Na-mica paragonite) and kaolinite (also possibly pyrophyllite). In addition to these ubiquitous minerals, there are variable amounts of carbonate, recrystallized quartz, and, especially in mafic dykes, clay minerals such as nontronite. Altered felsic porphyritic rocks retain quartz phenocrysts, although these are generally more rounded than in fresh dykes. In thin section, a narrow reaction rim of fine-grained recrystallized quartz typically surrounds each quartz phenocryst (Plate 1d). Feldspar phenocrysts turn white with alteration, reflecting their new mica, clay, and carbonate mineralogy. Altered rocks are typically white to buff and have an extremely fine-grained matrix, in contrast to fresh samples that are typically pink in colour with coarser-grained matrices. Mafic porphyritic dykes display the same general alteration characteristics, with a lightening in colour due to alteration being the most striking feature. Mafic phenocrysts (amphiboles, pyroxenes and biotite) are altered to carbonate and Mg- or Fe-bearing clay minerals.

Analysis of chemical changes due to alteration is difficult to validate because altered and fresh dykes cannot been sampled in close proximity to each other; in mineralized areas dykes are invariably altered and no fresh equivalents remain. This problem is compounded by the wide range in magmatic compositions of both fresh and altered dykes, and the uncertainty that a fresh equivalent for each altered rock has been sampled. Established methods for quantitatively estimating chemical changes due to alteration, such as Grant's (1986) isochon method or that of MacLean and Kranidiotis (1987), require the identification of a fresh precursor rock.

In order to evaluate the chemical changes which have occurred during alteration of dykes adjacent to mineralization, it is necessary to consider the Mt. Nansen and Carmacks suites separately, because the fractionation trends for the two series are quite different (Fig. 5). While the Mt. Nansen suite defines a linear trend in plots of aluminum versus other immobile elements, the Carmacks data are ambiguous with respect to aluminum. In the Mt. Nansen rocks there is a continuous decrease in Al with fractionation, reflecting the fact that feldspar is a phe-

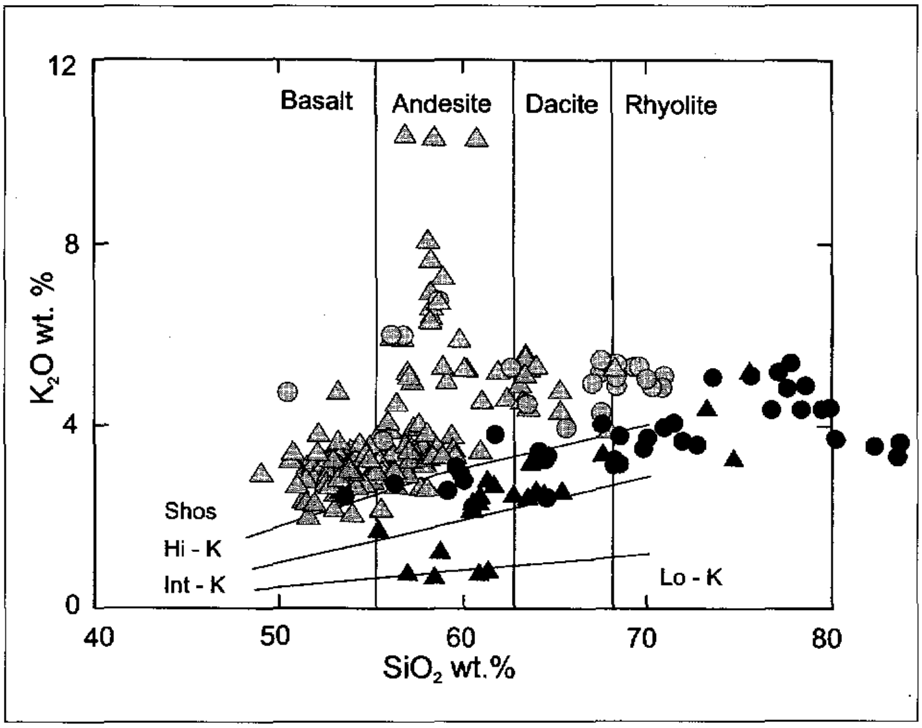


FIGURE 3: K_2O-SiO_2 plot of fresh volcanic and plutonic rocks of the Mt. Nansen Group (black symbols) and the Carmacks Group (grey shaded symbols). Symbols: triangles -lavas; circles -dykes and intrusive rocks. Potassium field boundaries taken from Pecerillo and Taylor (1976). Additional data from Carlson (1987), McInnes et al. (1988), and Payne et al. (1987).

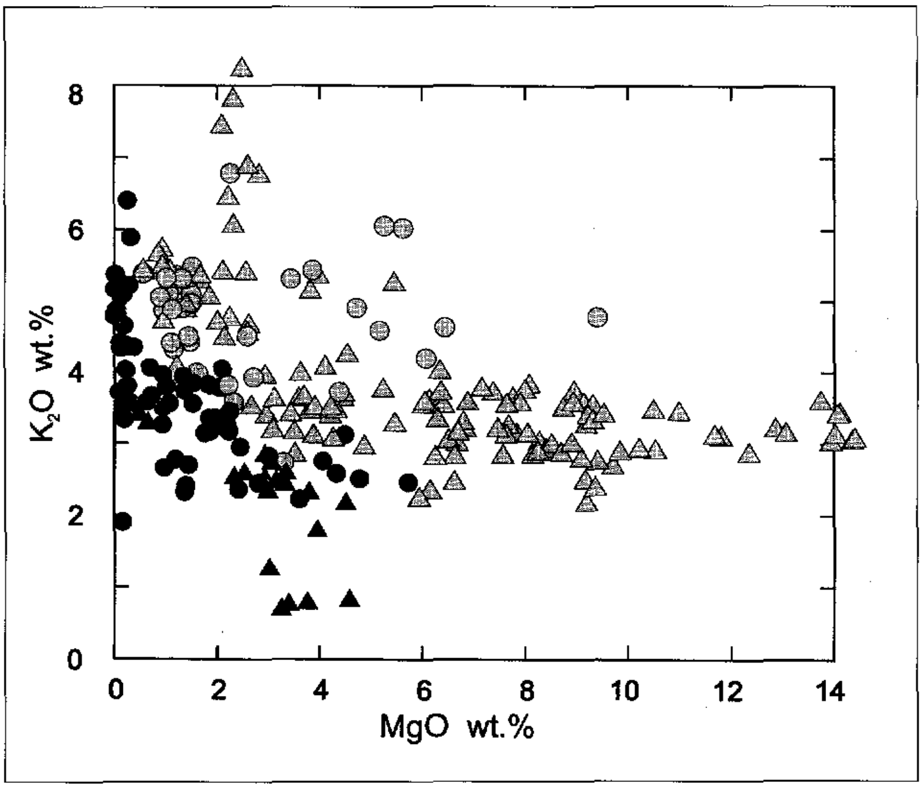


FIGURE 4: K_2O-MgO plot of all volcanic and plutonic rocks of the Mt. Nansen and the Carmacks Groups. Symbols as in Figure 3.

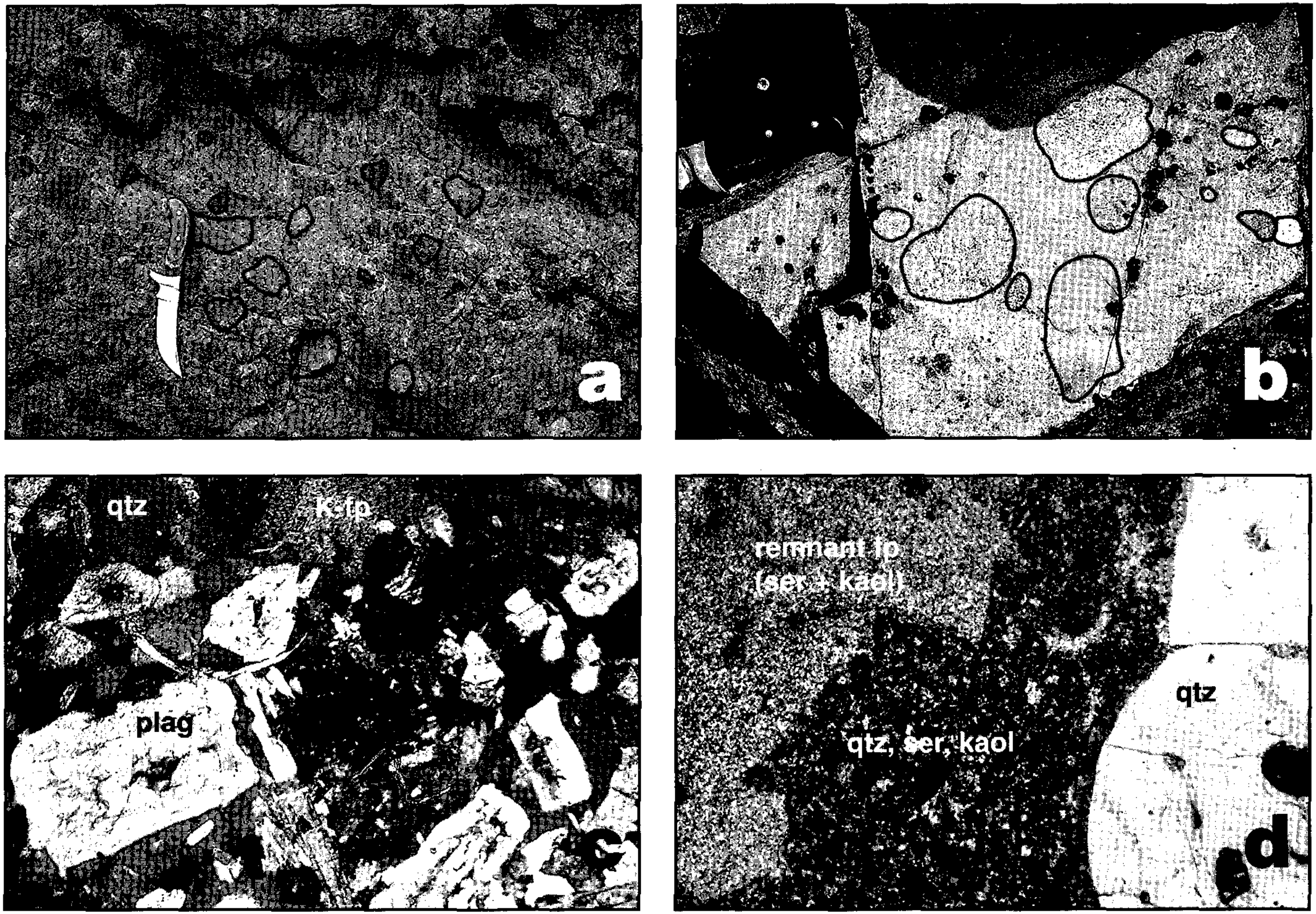


PLATE 1: ***a)*** *Agglomerate from the lower Carmacks volcanic unit exposed at Miller's Ridge north-east of the town of Carmacks. Some fragments have been outlined for greater visibility.* ***b)*** *Mt. Nansen agglomerate exposed at Mt. Nansen above Discovery Creek. Some fragments have been outlined for greater visibility.* ***c)*** *Thin section of fresh Carmacks dyke (sample PR-26) under crossed polarizers. The field of view is ≈ 5 mm. qtz -quartz; K-fp -K-feldspar; plag -plagioclase.* ***d)*** *Thin section of altered Mt. Nansen dyke (sample FG-1) under crossed polarizers. The field of view is ≈ 2 mm. fp -feldspar; ser -sericite; kaol -kaolinite.*

nocryst phase even in the most mafic rocks. The behaviour of Al in the Carmacks lavas is controlled by the appearance of feldspar as a phenocryst phase, where Al rises with fractionation until the point at which feldspar begins to crystallize, after which Al decreases with continued fractionation.

Mt. Nansen Dykes

The well-behaved Al trend in the Mt. Nansen rocks allows the alteration of Mt. Nansen dyke rocks to be studied quantitatively. As seen in Figure 5, aluminum appears to behave as an immobile element during alteration, as well as monitors fractionation in the Mt. Nansen suite. Fresh and altered rocks fall on the same trend, indicating that Al and Ti were not affected by alteration. Implicit in this interpretation is that not only were Al and Ti immobile but also that there was no significant change in the overall mass during alteration. Plots of mobile elements against Al can therefore be used to distinguish between the effects of alteration and those due to crystal fractionation.

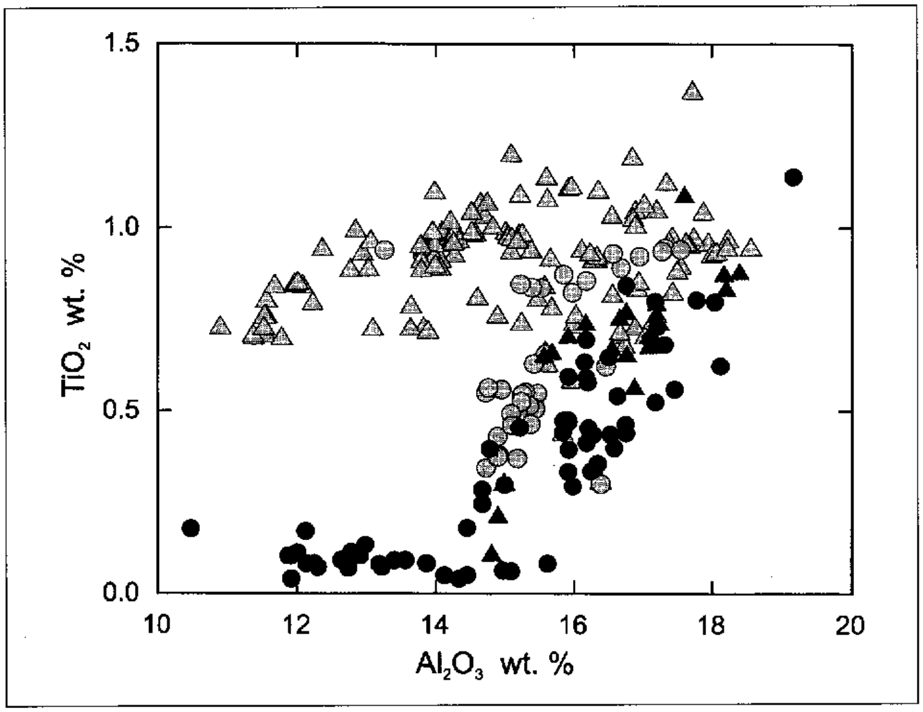


FIGURE 5: TiO_2-Al_2O_3 plot showing fractionation trends for Mt. Nansen and Carmacks Groups. Symbols as in Figure 3.

The largest chemical change during alteration is in sodium, which has undergone extreme depletion in the intensely altered samples (Fig. 6). These samples retain no textural evidence of their primary magmatic mineralogy. On the basis of this natural break in sodium values we filtered the data for Mt. Nansen dyke samples into two Na groups (Fig. 6); an altered group with less than 0.5 wt. % Na, and a fresh group containing over 3 wt. % Na. Grouping the data in this fashion enabled us to identify changes in other elements in the altered rocks, assuming that Al remained constant during alteration. Potassium shows a slight decrease in many altered samples, although a few appear to have undergone K addition, and the overall change is small. The parallel decrease in calcium content with aluminum concentration reflects fractionation in the Mt. Nansen suite, but the most altered samples also clearly show calcium depletion. Silicon is unambiguously added in all altered samples, reflecting the ubiquitous silicification evident in thin section.

Magnesium and iron are not consistent in their behaviour during alteration, although their relative changes are consistent with the degree of fractionation. At the mafic end of dyke compositions (i.e. those with higher aluminum contents) iron and magnesium appear slightly depleted during alteration, while in the more felsic samples these two elements are enriched. To summarize, in altered Mt. Nansen dykes proximal to mineralization, Na is extremely depleted, Ca is depleted, K is generally somewhat depleted, Si is added, and Mg and Fe are depleted in mafic dykes and enriched in felsic dykes, relative to their fresh equivalents.

The lead, copper, and, to a lesser extent, zinc data (Fig. 7) for the altered Mt. Nansen dykes show considerable scatter, but suggest a slight overall depletion relative to fresh Mt. Nansen dykes. Arsenic and antimony, known to be present in appreciable concentrations in mineralized veins, display an unambiguous enrichment in all the altered dykes.

Carmacks Dykes

The Carmacks dyke swarm is less extensive than the Mt. Nansen dyke swarm, and relatively few Carmacks dykes have been found in mineralized areas. Most of the felsic Carmacks dykes are the intrusive rocks of the Prospector Mtn. Pluton, and the few altered dykes found in mineralized areas all have basaltic to andesitic precursors. Altered dykes in the Carmacks suite are recognized petrographically by the development of sericite, clay and carbonate alteration minerals, and are characterized chemically by extreme sodium depletion.

A 7 metre-wide Carmacks basaltic dyke, sampled in DDH 95-151 on the Mount Nansen property, displays a range of alteration, thereby enabling a quantitative evaluation of the chemical changes due to alteration. The dyke is relatively fresh close to one of its margins (MN 95-33), somewhat altered (MN 95-34) in its interior, and intensely altered at the opposite margin (MN 95-35), immediately adjacent to a mineralized vein. These three samples represent a suite for which chemical changes due to alteration associated with mineralization can be confidently evaluated, because uniform initial composition and emplacement age are assured.

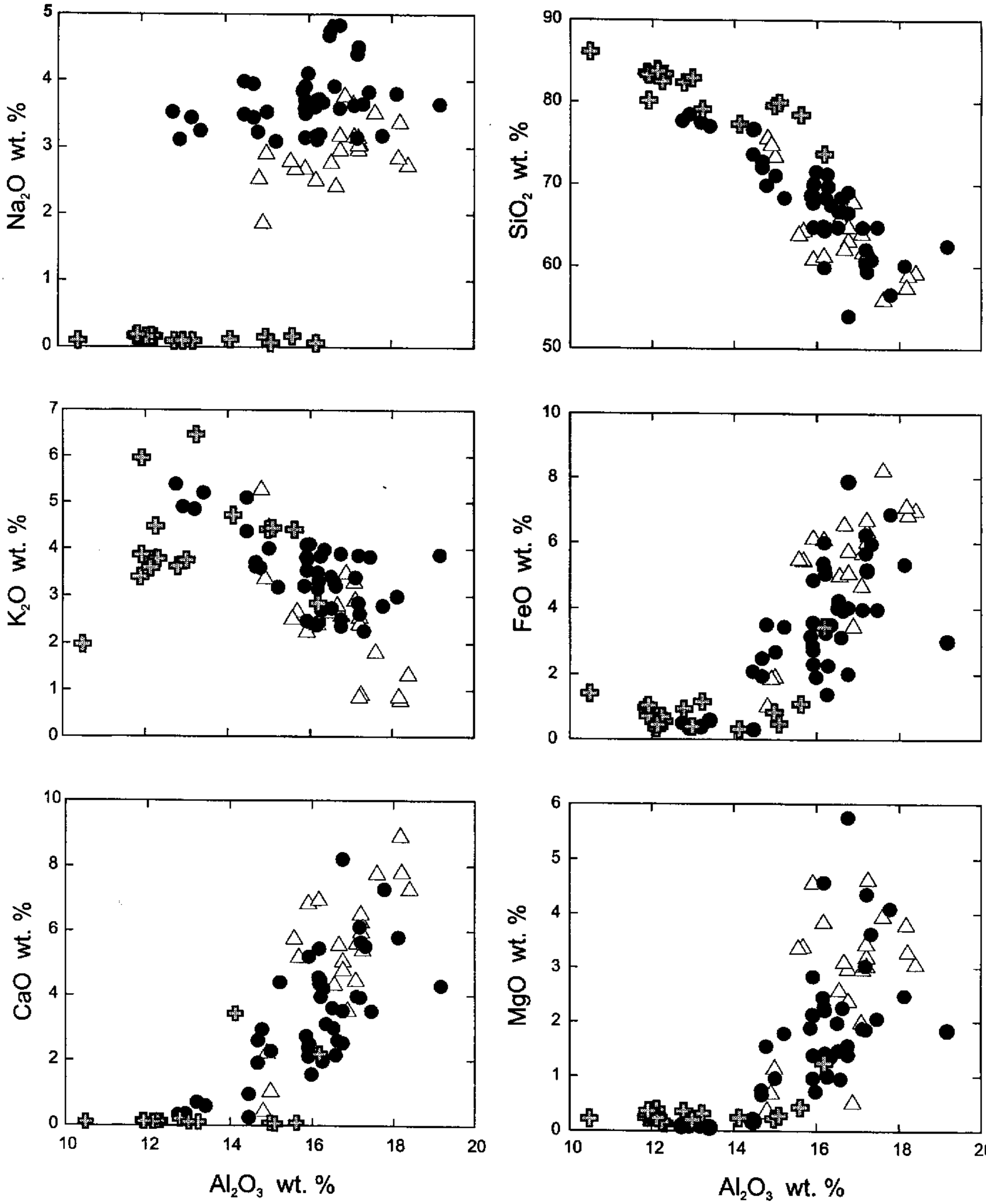


FIGURE 6: Major element oxides plotted against alumina to emphasize mass changes due to alteration for the Mt. Nansen suite. Symbols: open triangles -lavas; solid circles -unaltered dykes; shaded crosses -altered dykes.

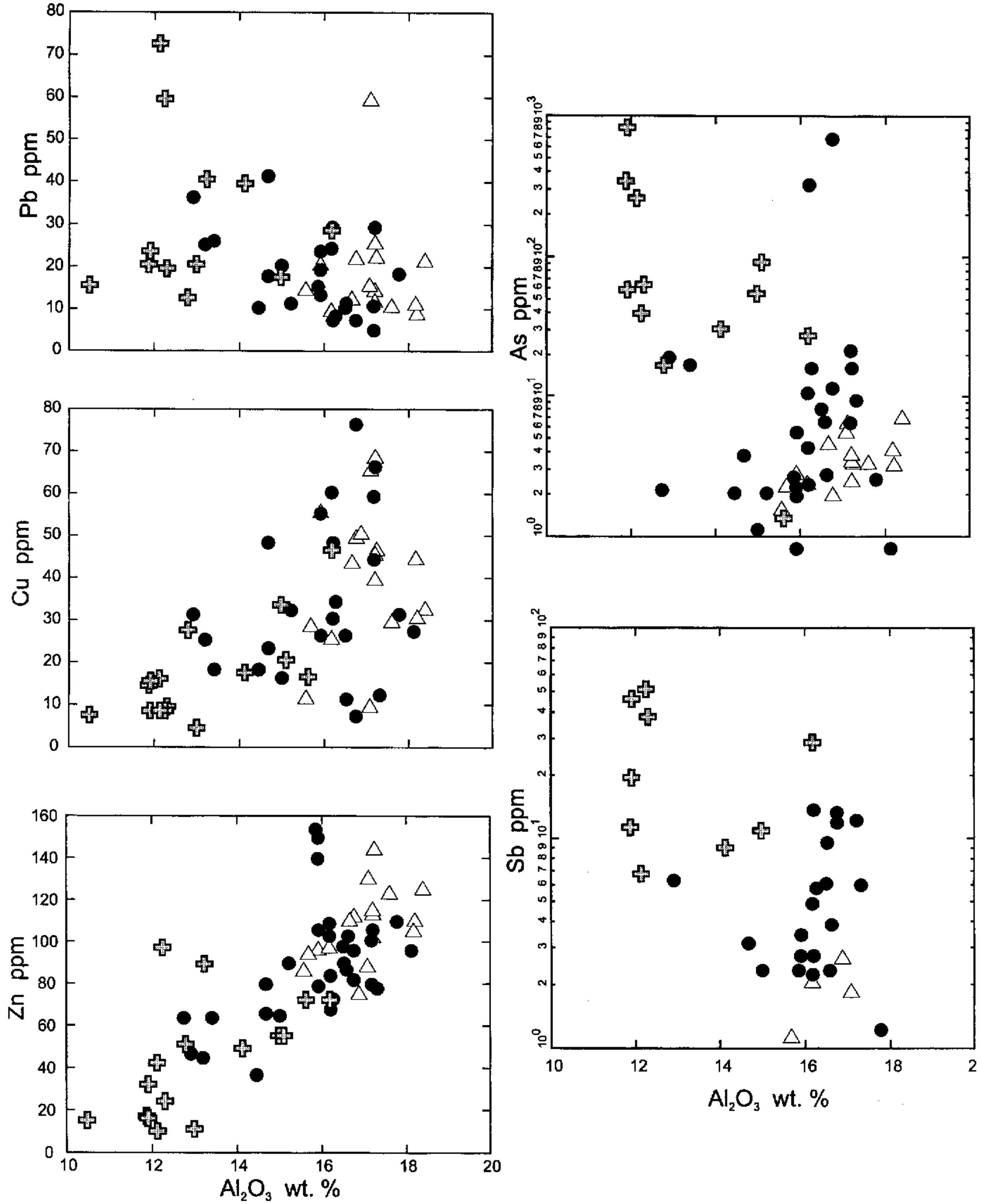


FIGURE 7: Base metals plotted against alumina to show mass changes due to alteration for the Mt. Nansen Group. Symbols as in Figure 6.

For this dyke the method of mass change calculation described by MacLean and Kranidiotis (1987) and MacLean (1990) was utilized to quantify the changes in the two altered samples relative to the freshest sample (Figs. 8 and 9). In this method the masses of elements in the altered samples are recalculated to the concentration of a monitor immobile element in the fresh sample. Aluminum was chosen as the monitor because it is a major element and therefore not subject to nugget effects, because it is known to be relatively immobile during alteration (MacLean, 1990), and for consistency with the preceding approach used for Mt. Nansen samples.

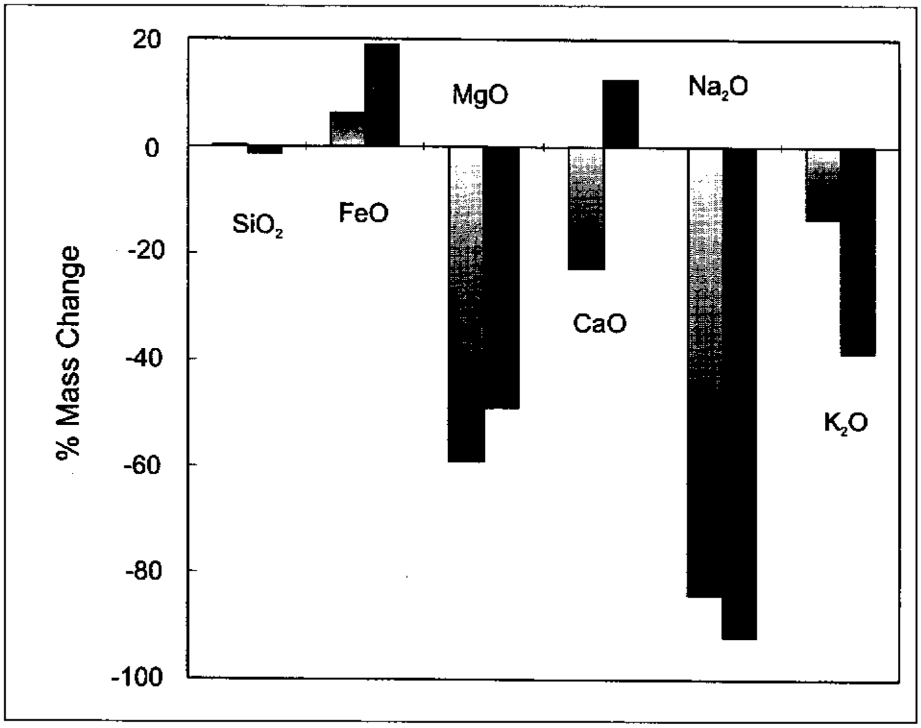


FIGURE 8: Mass changes of major element oxides due to alteration of a Carmacks dyke following the method discussed in text. Slightly altered sample MN 95-34 (shaded) and strongly altered sample MN 95-35 (solid) are plotted with respect to unaltered sample MN 95-33 (baseline).

The results for the Carmacks dyke are similar to those for the Mt. Nansen dykes. Na shows a strong depletion in both altered samples, as does Mg and to a lesser degree K. However, the concentration of Si is essentially constant, while Fe is enriched. Ca is depleted in the slightly altered dyke sample, but enriched in the intensely altered sample. Ore metals are consistently enriched in the intensely altered sample. In the slightly altered dyke sample, however, Pb, Cu and Zn are somewhat depleted, but As and Sb are strongly enriched.

DISCUSSION

The most significant chemical change that accompanied alteration in both suites of altered dykes is an extreme depletion in sodium. This may be readily explained by the leaching of sodium released during feldspar breakdown by a hydrothermal fluid undersaturated with respect to sodium. Preliminary fluid inclusion data indicate a low salinity for the mineralizing fluid. Fresh dyke rocks are rich in feldspar, both as a phenocryst phase (Mt. Nansen) and as a groundmass mineral (Carmacks), and the most common alteration minerals are sericite and kaolinite. The chemical change taking place during alteration may be represented by the reactions:

$$3\ NaAlSi_3O_8 + 2\ H^+ (aq.) \rightarrow (\ NaAl_3Si_3O_{10}(OH)_2 + 6\ SiO_2 + 2\ Na^+ (aq.)$$
albite — paragonite — quartz

$$2\ NaAl_3Si_3O_{10}(OH)_2 + 2\ H^+ (aq.) + 3\ H_2O \rightarrow (\ 3\ Al_2Si_2O_5(OH)_4 + 2\ Na^+ (aq.)$$
paragonite — kaolinite

Equivalent reactions involving K-feldspar and muscovite may explain the slight depletion in K observed in both suites of altered dykes because orthoclase and/or anorthoclase typically alters to muscovite and then to kaolinite under acidic conditions.

Potassium is an important element to consider in evaluating the alteration, for two important reasons. Firstly, because we have shown that alteration and mineralization were contemporaneous with shoshonitic Carmacks magmatism, the behaviour of K during alteration may provide an indication of the nature of circulating hydrothermal fluids. Magmatic water derived from a shoshonitic magma might be expected to be richer in K than typical meteoric water. As K is slightly depleted in the altered dykes of both suites, the hydrothermal fluid responsible for alteration and mineralization could have been dominantly meteoric, or undersaturated with respect to K. Secondly, because the chemical classification between the Carmacks and Mt. Nansen suites is based upon potassium, significant K change would render this criterion useless for classifying altered rocks. Since the K change estimated for both suites of altered dykes is less than 20% for all but the most altered Carmacks sample (MN 95-35), however, by their K content Carmacks dykes can be readily distinguished from Mt. Nansen rocks.

Although the alteration of Mt. Nansen and Carmacks dykes was similar in terms of the behaviour of alkalis, other elements behaved differently in each suite. For example, Si is enriched in altered Mt. Nansen dykes, but is slightly depleted in the most altered Carmacks dyke. Conversely, Ca was depleted during alteration of Mt. Nansen dykes, but enriched in the most altered Carmacks dyke. In altered mafic Mt. Nansen dykes, Fe and Mg are depleted, while in the altered felsic Mt. Nansen dykes, these two elements are enriched. In the altered Carmacks samples (all mafic), Mg is leached, but Fe is slightly enriched.

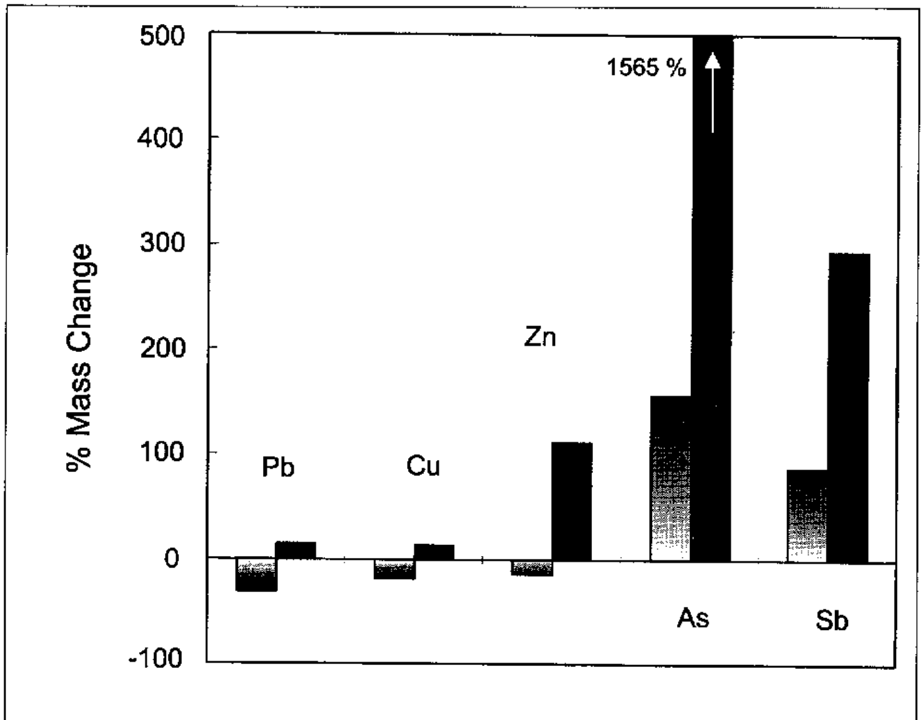


FIGURE 9: Mass changes in base metal concentrations resulting from alteration of a Carmacks dyke. Colours and technique as in Figure 8.

No Mt. Nansen dykes were sampled immediately proximal to a mineralized vein, as was the case for the intensely altered Carmacks sample MN 95-35. Thus, the Mt. Nansen altered samples are better compared with the slightly altered Carmacks dyke sample MN 95-34, reflecting interaction with a mineralizing fluid distal to areas of ore deposition. The mass changes estimated for the altered Mt. Nansen samples are the same as those calculated for Carmacks sample MN 95-34, with the exception of that for Fe.

Comparison between Mt. Nansen samples and Carmacks sample MN 95-34 becomes particularly significant when assessing the changes in ore metals resulting from alteration. In the Mt. Nansen dykes, Pb, Zn, and Cu are depleted during alteration, and As and Sb are highly enriched. Except for As and Sb, ore metals in the Carmacks dyke are depleted in the slightly altered sample of the Carmacks dyke, but enriched in the most altered sample directly adjacent to the mineralized vein. It is possible that the fluid responsible for mineralization has leached Pb, Cu and Zn from the dyke and deposited them in the adjacent vein. The consistent enrichment in As and Sb with alteration, however, indicates that these elements were introduced by the hydrothermal fluid and were not leached from the precursor dykes. The fact that Au and Sb are transportable under similar conditions by hydrothermal solutions may indicate that the Au was also introduced by the hydrothermal fluid (Williams-Jones and Normand, 1996).

SUMMARY AND CONCLUSIONS

The results of this study suggest that there is a genetic relationship between Carmacks magmatism, alteration and gold mineralization in the southern Dawson Range. Mineralization in the form of precious- and base-metal veins and gold-copper porphyries is abundant in all rock units older than the upper Carmacks in the southern Dawson Range, particularly in the areas of Mt. Nansen, Freegold Mtn. and Prospector Mtn. This area is noteworthy for its large concentration of porphyry dykes and stocks, many in areas of intense alteration. The dykes have generally been ascribed to the Mt. Nansen magmatic suite, but it is now evident that dykes of Carmacks affinity are present in the same locations, albeit in smaller numbers.

Lavas, dykes and stocks in the southern Dawson Range may be identified as belonging to either the Mt. Nansen or the Carmacks magmatic suites on the basis of their potassium content. The Carmacks Group is a shoshonitic suite while the Mt. Nansen Group is a high-K calc-alkaline suite. The Carmacks lavas extend to higher Mg contents than the Mt. Nansen suite, while the Mt. Nansen suite extends to relatively higher Si. The most mafic Mt. Nansen rocks are only andesitic in composition, while the Carmacks suite extends to primitive magnesian basalts.

The Mt. Nansen suite is well-constrained to a mid-Cretaceous age of 105 Ma, while the Carmacks suite is a 70 Ma, Late Cretaceous event. Altered Mt. Nansen dykes have been dated at between 94 and 61 Ma, and previous studies have explained these altered rocks in terms of a second Mt. Nansen event (Carlson, 1987; McInnes et al., 1988); however we attribute these young ages to the resetting of Mt. Nansen ages by a Carmacks-age hydrothermal event that was responsible for much of the mineralization in the southern Dawson Range. The close spatial relationship between mineralized veins and Mt. Nansen dykes appears to be fortuitous because alteration of these dykes, and thus mineralization, is a Late Cretaceous, Carmacks event.

This relationship may only be true for vein mineralization, however, as it is appears that porphyry-style mineralization in Mt. Nansen stocks is a Mt. Nansen event (Sawyer and Dickinson, 1976; fluid inclusion study in progress). Carmacks intrusions also host porphyry-style mineralization, and because Mt. Nansen porphyry stocks appear to have been altered by the Carmacks hydrothermal event, the exact relationship between vein and porphyry mineralization must be examined in more detail. The strong Na and slight K depletion of altered Mt. Nansen and Carmacks dykes contrasts with the typical K-rich alteration associated with porphyry copper mineralization (Beane and Titley, 1981), and may provide a basis for evaluating the Dawson Range mineralization as representing a possible "porphyry copper to epithermal transition" type system (Cyr et al., 1984; Panteleyev, 1986; Schroeter and Panteleyev, 1986).

The most significant change due to alteration in the dykes of both suites is an extreme loss of sodium, mineralogically represented by the replacement of feldspar by sericite and clay minerals. This Na depletion is an effective guide to identifying areas of intense alteration and therefore proximal mineralization. Other common changes include addition of Si and a variably small depletion of K. Altered dykes display general depletion in Pb, Zn and Cu, suggesting that these elements were mobilized during alteration for subsequent deposition in base metal veins. As and Sb are greatly enriched in all altered dykes, and are likely to have been introduced together with gold by hydrothermal solutions responsible for the mineralization.

ACKNOWLEDGEMENTS

We are indebted to many individuals who have facilitated field work and provided valuable resources or discussion during this study: Steve Johnston and Craig Hart from the Yukon Geoscience Office, Mike Burke and Bill LeBarge from DIAND, Dave Melling and Bill Mann from B.Y.G. Natural Resources, Doug Eaton from Archer, Cathro and Associates, Ltd., Ted Tullis, and Mr. and Mrs. John Gow.

REFERENCES

Beane, R.E. and Titley, S.R., 1981. Porphyry copper deposits, Part II. Hydrothermal Alteration and Mineralization. Economic Geology, 75th Anniversary Volume, p. 235-269.

Carlson, G.G., 1987. Geology of Mount Nansen (115-I/3) and Stoddart Creek (115-I/6) Map Areas, Dawson Range, Central Yukon. Indian and Northern Affairs Canada, Northern Affairs: Yukon Region Open File 1987-2.

Cyr, J.B., Pease, R.P. and Schroeter, T.G., 1984. Geology and Mineralization at Equity Silver Mine. Economic Geology, v. 79, p. 947-968.

Journeay, J.M. and Williams, S.P., 1995. GIS Map Library: A Window on Cordilleran Geology. Geological Survey of Canada, Open File 2948 (v. 1.0).

Godwin, C.I., 1976. Casino. Paper 35, Part B - Porphyry Copper and Copper-Molybdenum deposits of the Calc-Alkaline Suite; in Porphyry Deposits of the Canadian Cordillera, CIM Special Volume 15, p. 344-354.

Grant, J.A., 1986. The Isochon Diagram - A Simple Solution to Gresens' Equation for Metasomatic Alteration. Economic Geology, v. 81, p.1976-1982.

Hunt, P.A. and Roddick, J.C., 1991. A Compilation of K-Ar Ages, Report 20; in Radiogenic Age and Isotopic Studies: Report 4. Geological Survey of Canada, Paper 90-2, p. 113-143.

Johnston, S.T., 1995. Geological Compilation with Interpretation from Geophysical Surveys of the Northern Dawson Range, Central Yukon (115 J/9 and 10, 115 I/12, 1:100 000 Scale Map). Exploration and Geological Services Division, Department of Indian and Northern Affairs Open File 1995-2(G).

Le Couteur, P.C. and Templeman-Kluit, D.J., 1976. Rb/Sr ages and a profile of initial 87Sr/86Sr ratios for plutonic rocks across the Yukon Crystalline Terrain. Canadian Journal of Earth Sciences, v. 13, p. 319-330.

MacLean, W.H., 1990. Mass change calculations in altered rock series. Mineralium Deposita, v. 25, p. 44-49.

MacLean, W.H. and Kranidiotis, P., 1987. Immobile Elements as Monitors of Mass Transfer in Hydrothermal Alteration: Phelps-Dodge Massive Sulfide Deposit, Matagami, Quebec. Economic Geology, v. 82, p. 951-962.

McInnes, B.I.A., Goodfellow, W.D., Crocket, J.H., and McNutt, R.H., 1988. Geology, geochemistry and geochronology of subvolcanic intrusions associated with gold deposits at Freegold Mountain, Dawson Range, Yukon; in Current Research, Part E, Geological Survey of Canada, Paper 88-1E, p. 137-151.

Panteleyev, A., 1986. Ore Deposits #10. A Canadian Cordilleran Model for Epithermal Gold-Silver Deposits. Geoscience Canada, v. 13, p. 101-111.

Payne, J.G., Gonzalez, R.A., Akhurst, K. and Sisson, W.G., 1987. Geology of Colorado Creek (115-J/10), Selwyn River (115-J/9), and Prospector Mountain (115-I/5) Map Areas, Western Dawson Range, West-Central Yukon. Indian and Northern Affairs Canada, Northern Affairs: Yukon Region Open File 1987-3.

Pecerillo, A. and Taylor, S.R., 1976. Geochemistry of some calc-alkaline volcanic rocks from the Kastamonu area, northern Turkey. Contributions to Mineralogy and Petrology, v. 58, p. 63-81.

Sawyer, J.P.B. and Dickinson, R.A., 1976. Mount Nansen. Paper 34, Part B - Porphyry Copper and Copper-Molybdenum deposits of the Calc-Alkaline Suite; in Porphyry Deposits of the Canadian Cordillera, CIM Special Volume 15, p. 336-343.

Schroeter, T.G. and Panteleyev, A., 1986. Lode gold-silver deposits in northwestern British Columbia; in Mineral Deposits of Northern Cordillera, CIM Special Volume 37, p. 178-190.

Stevens, R.D., Delabio, R.N., and Lachance, G.R., 1982. Age determinations and geological studies; K-Ar isotopic ages, Report 16. Geological Survey of Canada, Paper 82-2, 52 p.

Templeman-Kluit, D.J., 1984. Geology of the Lebarge and Carmacks Map Sheets, Geological Survey of Canada, Open File 1101.

Templeman-Kluit, D.J. and Wanless, R.K., 1975. Potassium-argon age determinations of metamorphic and plutonic rocks in the Yukon Crystalline Terrane. Canadian Journal of Earth Sciences, v. 12, p. 1895-1909.

Williams-Jones, A.E. and Normand, C., 1996. Physiochemical Controls on the Mineralogy of Hypogene Antimony Deposits in the System Fe-Sb-S-O. GAC-MAC Programs with Abstracts, v. 21, p. A102.

Yukon Minfile, 1996. Version 2.05, May 31, 1996. Exploration and Geological Services Division, Indian and Northern Affairs Canada.

Sample No.	MN-21	KZ-7	MN-52	SR-1	FG-1	MN 95-31
Description	Lava	Lava	Fresh Dyke	Fresh Dyke	Altered Dyke	Altered Dyke
Location	Mt. Nansen	Klaza Mtn.	Mt. Nansen	"Smoky Ridge"	Freegold Mtn.	
X	382730	370260	386840	367140	388610	387455
Y	6887950	6906150	6886675	6926410	6908600	6881700
UTM Zone	8	8	8	8	8	8
Major Elements in wt. % (XRF–McGill University)						
SiO2	55.54	63.52	63.71	77.32	77.70	68.07
TiO2	1.08	0.65	0.64	0.08	0.06	0.38
Al2O3	17.57	15.54	16.27	13.19	14.73	15.01
FeO	8.14	5.34	3.91	0.33	0.39	3.11
MnO	0.17	0.09	0.07	0.01	0.01	0.07
MgO	3.89	3.31	1.92	0.05	0.22	1.10
CaO	7.69	5.08	3.51	0.66	0.01	2.00
Na2O	3.48	2.62	4.59	3.42	0.02	0.02
K2O	1.76	2.60	3.32	4.82	4.28	2.58
P2O5	0.21	0.12	0.29	0.02	0.02	0.11
LOI	0.27	0.85	1.24	0.40	2.11	6.54
Total	99.80	99.71	99.47	100.30	99.55	99.00
Trace Elements in ppm (Ba, Rb, Sr, Y, Zr, Nb, Cr, Ni by XRF McGill, others by ICP-MS)						
Ba	1146.0	1108.0	1834.0	437.0	1171.0	1831.0
Rb	42.6	81.1	100.8	233.8	154.0	80.5
Sr	677.0	319.5	733.1	62.3	17.3	41.3
Sc	26.0	19.0	9.0	0.0	3.0	4.0
Y	23.2	24.5	14.7	24.4	11.7	17.5
Zr	112.1	173.9	194.3	57.6	46.8	193.5
Nb	6.5	9.8	12.4	21.6	12.3	9.7
V	223.0	116.0	67.0	7.0	0.0	37.0
Ta	0.0	0.0	0.9	0.0	0.0	0.6
Hf	3.6	0.0	4.8	3.3	4.3	5.2
Th	0.0	0.0	12.0	22.2	8.3	32.0
U	0.0	0.0	3.1	2.4	3.5	4.1
Pb	10.0	0.0	10.0	24.9	0.0	28.0
Cu	29.0	28.0	26.0	25.0	20.0	46.0
Zn	122.0	93.0	97.0	44.0	54.0	71.0
Cr	17.1	89.6	44.5	0.0	0.0	4.8
Co	21.0	10.0	10.0	0.0	5.0	10.0
As	3.2	2.2	7.9	0.0	88.2	26.3
Sb	0.0	1.1	6.0	0.0	0.0	28.1
Rare Earth Elements in ppm (ICP-MS–Activation Laboratories Ltd.)						
La	0.00	0.00	42.07	10.18	10.96	67.63
Pr	0.00	0.00	7.21	2.00	1.84	9.66
Ce	53.00	0.00	75.14	19.59	20.12	108.10
Nd	0.00	0.00	32.95	7.90	7.29	37.00
Sm	0.00	0.00	5.28	1.52	1.30	4.62
Eu	0.00	0.00	1.49	0.48	0.38	1.12
Gd	0.00	0.00	3.81	1.65	1.22	3.95
Tb	0.00	0.00	0.52	0.33	0.22	0.50
Dy	0.00	0.00	2.50	1.95	1.02	2.55
Ho	0.00	0.00	0.41	0.57	0.22	0.52
Er	0.00	0.00	1.14	1.43	0.57	1.50
Tm	0.00	0.00	0.15	0.29	0.10	0.26
Yb	0.00	0.00	1.02	1.64	0.56	1.53
Lu	0.00	0.00	0.15	0.24	0.08	0.29

APPENDIX I: *Representative chemical analyses, Mount Nansen suite.*

Sample No.	MN-21	KZ-7	MN-52	SR-1	FG-1	MN 95-31
Description	Lava	Lava	Fresh Dyke	Fresh Dyke	Altered Dyke	Altered Dyke
Location	Mt. Nansen	Klaza Mtn.	Mt. Nansen	"Smoky Ridge"	Freegold Mtn.	
X	382730	370260	386840	367140	388610	387455
Y	6887950	6906150	6886675	6926410	6908600	6881700
UTM Zone	8	8	8	8	8	8
Major Elements in wt. % (XRF–McGill University)						
SiO2	55.54	63.52	63.71	77.32	77.70	68.07
TiO2	1.08	0.65	0.64	0.08	0.06	0.38
Al2O3	17.57	15.54	16.27	13.19	14.73	15.01
FeO	8.14	5.34	3.91	0.33	0.39	3.11
MnO	0.17	0.09	0.07	0.01	0.01	0.07
MgO	3.89	3.31	1.92	0.05	0.22	1.10
CaO	7.69	5.08	3.51	0.66	0.01	2.00
Na2O	3.48	2.62	4.59	3.42	0.02	0.02
K2O	1.76	2.60	3.32	4.82	4.28	2.58
$P2O_5$	0.21	0.12	0.29	0.02	0.02	0.11
LOI	0.27	0.85	1.24	0.40	2.11	6.54
Total	99.80	99.71	99.47	100.30	99.55	99.00
Trace Elements in ppm (Ba, Rb, Sr, Y, Zr, Nb, Cr, Ni by XRF McGill, others by ICP-MS)						
Ba	1146.0	1108.0	1834.0	437.0	1171.0	1831.0
Rb	42.6	81.1	100.8	233.8	154.0	80.5
Sr	677.0	319.5	733.1	62.3	17.3	41.3
Sc	26.0	19.0	9.0	0.0	3.0	4.0
Y	23.2	24.5	14.7	24.4	11.7	17.5
Zr	112.1	173.9	194.3	57.6	46.8	193.5
Nb	6.5	9.8	12.4	21.6	12.3	9.7
V	223.0	116.0	67.0	7.0	0.0	37.0
Ta	0.0	0.0	0.9	0.0	0.0	0.6
Hf	3.6	0.0	4.8	3.3	4.3	5.2
Th	0.0	0.0	12.0	22.2	8.3	32.0
U	0.0	0.0	3.1	2.4	3.5	4.1
Pb	10.0	0.0	10.0	24.9	0.0	28.0
Cu	29.0	28.0	26.0	25.0	20.0	46.0
Zn	122.0	93.0	97.0	44.0	54.0	71.0
Cr	17.1	89.6	44.5	0.0	0.0	4.8
Co	21.0	10.0	10.0	0.0	5.0	10.0
As	3.2	2.2	7.9	0.0	88.2	26.3
Sb	0.0	1.1	6.0	0.0	0.0	28.1
Rare Earth Elements in ppm (ICP-MS–Activation Laboratories Ltd.)						
La	0.00	0.00	42.07	10.18	10.96	67.63
Pr	0.00	0.00	7.21	2.00	1.84	9.66
Ce	53.00	0.00	75.14	19.59	20.12	108.10
Nd	0.00	0.00	32.95	7.90	7.29	37.00
Sm	0.00	0.00	5.28	1.52	1.30	4.62
Eu	0.00	0.00	1.49	0.48	0.38	1.12
Gd	0.00	0.00	3.81	1.65	1.22	3.95
Tb	0.00	0.00	0.52	0.33	0.22	0.50
Dy	0.00	0.00	2.50	1.95	1.02	2.55
Ho	0.00	0.00	0.41	0.57	0.22	0.52
Er	0.00	0.00	1.14	1.43	0.57	1.50
Tm	0.00	0.00	0.15	0.29	0.10	0.26
Yb	0.00	0.00	1.02	1.64	0.56	1.53
Lu	0.00	0.00	0.15	0.24	0.08	0.29

APPENDIX II: *Representative chemical analyses, Carmacks suite.*

Soil Geochemistry above Deeply weathered Porphyry Deposits in Unglaciated Terrain, Dawson Range, central Yukon

Craig J.R. Hart and Shellie A. Jober
Yukon Geology Program

ABSTRACT

Much of west-central Yukon escaped glaciation and is underlain by leached and oxidized, deeply weathered bedrock. Background and anomalous metal values in these soils are presumed to be lower than normal and therefore increase the challenge of interpreting soil geochemical surveys. It is suspected that the geochemical contrast between background and anomalous values can be maximized by sampling a particular soil horizon or analysing a specific size fraction.

One hundred and sixteen samples were collected from soil profiles at ten sites above four porphyry-style mineral deposits —Antoniuk, Revenue, Nucleus and Casino in the Dawson Range of the Yukon-Tanana Terrane. B-horizon soils are locally clay-rich, thin and poorly developed. C-horizon soils are unconsolidated and very coarse grained. Samples from B- and C-horizons were split into -35+80, -80, and -200 mesh size fractions (n=96). Bedrock samples from each site were crushed and analysed for comparison. All samples were analysed using the "Au plus 32" (FA-AA and ICP) package which is a popular and economical method currently employed in most exploration programs.

The results were generally consistent within the few samples taken at each deposits, but vary considerably overall and probably reflect the variable physio-chemical conditions between the deposits. Gold and copper are emphasized in the evaluation of the data, but gold data from the fine-grained fraction are incomplete due to insufficient material from the generally coarse-grained soils. Although statistical accuracy cannot be confirmed with such a small sample set, the following trends are recognized:

- *the highest gold values typically occur in the lowest soil horizon (C2) and in the -200 mesh fraction;*
- *the highest copper values were found in both the -35+80 and -200 mesh fractions (deposit dependent) but were consistently richer in the C2 horizon;*
- *metal values are commonly depleted in the highest B-horizon (B1), particularly in the +35-80 fraction;*
- *metal values are most commonly enriched in the B2 and C2 horizons;*
- *metal depletion is most pronounced in the -35+80 fraction;*
- *there is a strong positive correlation between gold, copper and molybdenum ;*
- *in addition, As, Bi, P, and to a lesser extent, Sb and Sr have a strong positive correlation with gold, As, Sb, Sr and to a lesser extent Ba and Pb have a strong positive correlation with copper.*

RÉSUMÉ

La plus grande partie du centre-ouest du Yukon a échappé à la glaciation et repose sur un substratum fortement altéré par lessivage et oxydation. Les teneurs naturelles et anormales en métaux de ces sols seraient inférieures à la normale, rendant ainsi plus difficile l'interprétation des levés géochimiques des sols. Il serait possible de maximiser le contraste géochimique entre les valeurs naturelles et les valeurs anormales en échantillonnant un horizon de sol particulier ou en analysant une tranche granulométrique particulière.

Cent-seize échantillons ont été prélevés de profils pédologiques dans dix endroits au-dessus de quatre gisements de minéraux porphyritiques (Antoniuk, Revenue, Nucleus et Casino). Les sols des horizons B sont par endroits riches en argile, minces et peu développés. Les sols des horizons C sont meubles et ont un grain très grossier. Les 96 échantillons des horizons B et C ont été répartis en tranches granulométriques de -35+80, de -80 et de -200 mesh. Les échantillons de substratum rocheux de chaque site ont été broyés et analysés pour fin de comparaison. Tous les échantillons ont été analysés par la méthode populaire et économique «Au plus 32» (FA-AA et ICP) qui est couramment utilisée dans la plupart des programmes d'exploration.

Les résultats sont en général uniformes pour les quelques échantillons prélevés dans chaque gisement, mais varient considérablement dans l'ensemble, indiquant sans doute que les conditions physico-chimiques varient d'un gisement à l'autre. L'évaluation des données met l'accent sur l'or et le cuivre, mais les données sur l'or sont incomplètes à cause de l'insuffisance des échantillons d'analyse provenant de sols à grain grossier. Même si l'exactitude statistique de l'analyse ne peut être confirmée avec une population d'échantillon aussi faible, les tendances suivantes ont été relevées :

- *les plus fortes concentrations d'or se trouvent en général dans la tranche de -200 mesh et dans l'horizon le plus bas (C2);*

- *les plus fortes concentrations de cuivre se trouvent dans les deux tranches de -35+80 et de -200 mesh (selon le gisement), mais sont systématiquement plus élevées dans l'horizon C2;*
- *Les plus faibles concentrations de métaux se trouvent dans l'horizon B1, surtout dans la tranche de +35-80;*
- *Les plus fortes concentrations de métaux se trouvent dans les horizons B2 et C2;*
- *Les plus faibles concentrations de métaux se trouvent dans la tranche de -35+80;*
- *Il y a une forte corrélation positive entre l'or, le cuivre et le molybdène;*
- *De plus, il y a une forte corrélation positive entre, d'une part, l'or et, d'autre part, As, Bi, P et, dans une moindre mesure, Sb et Sr; et il y a une forte corrélation positive entre, d'une part, le cuivre et, d'autre part, As, Sb, Sr et, dans une moindre mesure, Ba et Pb.*

Introduction

The Dawson Range in central Yukon, hosts more than 150 mineral occurrences—primarily copper-gold ± molybdenum porphyries and epithermal gold veins. Eight deposits have defined reserves with a current combined in-ground metal value in excess of C$12 billion dollars. The largest deposit, the Casino porphyry, has a geological resource of more than 675 Mt of 0.24% Cu, 0.48 g/t Au and 0.024% Mo. The region also contains numerous deposits of placer gold.

Unlike most of the Cordillera, the Dawson Range escaped Quaternary glaciation (Hughes et al., 1968). As a result, the bedrock is deeply weathered and intensely leached. Outcrop exposures account for less than 1% of the surface area and are largely limited to the most competent and least altered units. These factors diminish the effectiveness of surface prospecting but dramatically increase the importance of soil and silt geochemical surveys in exploration programs. Metal values in soils are typically only a fraction of those in underlying mineralized rock and are presumed to be even lower in soils above intensely leached bedrock. These values may even be too small to recognize as anomalous.

The mobility of metallic elements are largely controlled by the physio-chemical conditions within the soil. It is expected that some elements are preferentially enriched in specific soil horizons or particular size fractions of the soil. In order to test this hypothesis, various size fractions from various soil horizons from several deposits throughout the Dawson Range were sampled and analysed. Metal values in the soils are anomalously high since the samples were taken from above known mineralization. However, specific fractions or horizons may yield values that are "more" anomalous and therefore provide a mechanism to enhance the effectiveness of soils surveys throughout the unglaciated portions of the Territory, specifically the Dawson Range. Alternatively, biogeochemisty may also provide a useful mechanism (see Hunt et al., 1997, this volume).

One hundred and sixteen samples were collected from soil profiles at ten sites above four porphyry-style mineral deposits—Antoniuk, Revenue, Nucleus and Casino in the Dawson Range of the Yukon-Tanana Terrane (Fig. 1). This report focuses on gold and copper values because these elements are of prime economic interest in the Dawson Range. In addition, an attempt is made to determine the nature of relationships of gold and copper with other elements in order to suggest potential pathfinder elements.

Location and Access

The Dawson Range extends northwesterly for approximately 200 km between Carmacks and the Donjek River. The Antoniuk, Revenue, Nucleus (all 115I/6) and Casino (115J/10) deposits are located northwest of Carmacks approximately 200 km north of Whitehorse, and except for the Casino, are accessible via the Freegold road. The first 65 km of road is maintained, although beyond Freegold Mountain, the road is not serviced, and a 4WD vehicle may be required during rainy and winter weather conditions. Access to the Casino deposit is restricted to either fixed-wing or rotary aircraft.

Physiography and Climate

The Dawson Range is located within a semi-arid/sub-arctic climate, characterized by a mean annual temperature of approximately 5°C, and a low mean annual precipitation of approximately 40 cm with most precipitation during the summer months. Vegetation consists mainly of mosses, grasses, shrubs, spruce, birch and aspen. Considerably less vegetation (grasses and aspen) occurs on the dryer south-facing slopes than north-facing slopes which are mantled by a thick accumulation of mosses, black spruce, sparse birch and underlain by permafrost. Soil sampling on

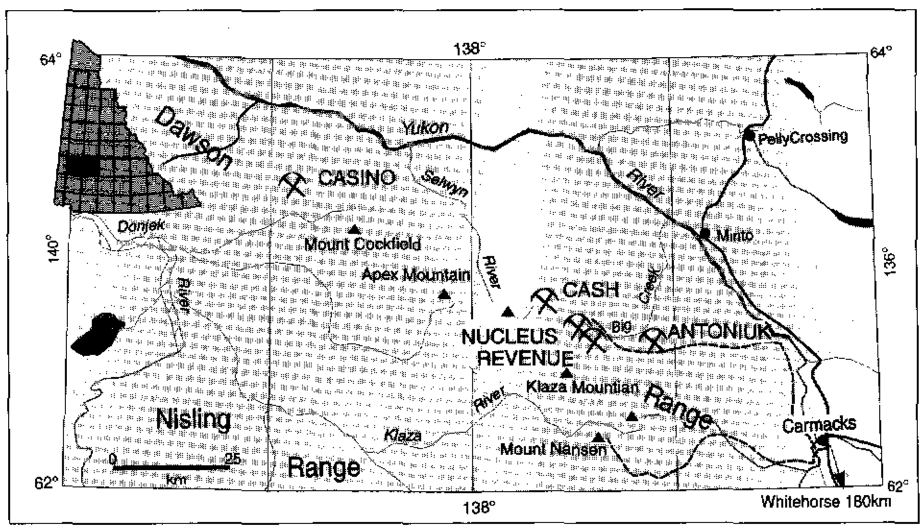


FIGURE 1: Location of the mineral deposits (crossed pickaxes) in the Dawson Range sampled for this report.

north-facing slopes is best performed late in the summer when some surface melting has occurred. Thawing may be enhanced by stripping the moss off of potential sample sites early in the season.

The terrain of the region is somewhat subdued, with elevations rarely exceeding 4500 feet above sea level. Treeline occurs between 3500 - 4000 feet. Outcrops in the area are sparse, and predominately restricted to torres and felsenmeer on ridge tops. The soil profiles generally include a thin (2-10 cm) horizon of the White River ash which was deposited approximately 1200 years ago.

Previous studies

Studies on the elemental behaviour of soils above mineral deposits in deeply weathered terrain are common in arid regions (i.e. Davy and Mazzucchelli, 1984) but rare for temperate and periglacial environments. None have been previously undertaken, or published, for the Dawson Range, but the soil geochemical characteristics of the Cash and Casino deposits are mentioned in the reports of Sinclair et al. (1981) and Bower et al., (1995) and summarized in Table 1.

ppm except Au in ppb	strongly anomalous	background
Casino Au	200	<50
Cash Au		<30
Casino Cu	200	<50
Cash Cu	200	<20
Casino Mo	20	<10
Cash Mo	10	<2
Cash Pb	60	<30
Cash Zn	150	<75

Table 1: Published geochemical results from the Casino and Cash properties

Geological Setting

The Dawson Range is underlain by a basement of Early Mississippian and older metamorphic rocks of the Yukon-Tanana Terrane. These rocks are divisible into packages of mainly metasedimentary and mainly meta-igneous rocks. The metasedimentary rocks are typified by variably carbonaceous quartzites and micaceous quartz-feldspar schists and gneiss which together comprise the Nasina assemblage. The metaigneous package is dominated by biotite-hornblende feldspar gneiss and coarse-grained granodiorite orthogneiss, lesser felsic metavolcanics and amphibolite.

The metamorphic rocks are intruded by several plutonic suites that range from Early Jurassic to Early Tertiary in age. The oldest plutonic suite includes the Early Jurassic Big Creek, Granite Mountain and Minto batholiths (192-188 Ma) of the eastern study area. Mid-Cretaceous plutonic rocks form large batholiths, collectively known as the Dawson Range Batholith (110 Ma), which spans the study area. Several small, mafic, K-rich Late Cretaceous plugs associated with Carmacks volcanism, dot the region. Early Tertiary high-level alaskite bodies form the Nisling Range plutonic suite (54 Ma) in the western study area.

Mount Nansen Group comprises local centres of explosive volcanism of intermediate composition that are mid-Cretaceous in age (110 Ma). Carmacks Group includes extensive flows and volcanoes of shoshonitic basalt that likely covered the region during their deposition in Late Cretaceous time (69-73 Ma).

Most of the Dawson Range escaped all episodes of Quaternary glaciation. This allowing the development of thick colluvial regoliths and deeply weathered outcrops during the Late Tertiary period. Placer gold deposits were also formed during this pre-glacial interval.

Geochemical Study

The goal of any soil sampling program is to determine regions with anomalous metal values. Most programs begin with little consideration of the nuances of the site, the soil or elements of interest. Typically any B-horizon soil is collected and screened to -80 mesh and analysed. The purpose of this study is to determine whether a specific size fraction, or particular soil horizon potentially provides maximum geochemical contrast using the Au+32 ICP analytical package. In addition it may be possible to assess the elemental relationships with gold or copper in order to determine possible pathfinder elements. This would be particularly useful information because some elements may be more mobile, more concentrated or more widely distributed than the element of interest. This data cannot be used to determine threshold or anomalous values however, because background values from unmineralized localities were not determined.

Field Methods

Four localities were chosen for sampling - Antoniuk, Revenue, Nucleus and Casino (Fig. 1). The four localities span much of the length of the Dawson Range, encompass porphyry-style gold, copper-gold and copper-gold-molybdenum deposits, and include sites above and below tree line. All deposits are deeply oxidized, locally to depths of 150 m.

Two to three sites were chosen at each location (Fig. 2). Sites were chosen in areas with trenching and known or suspected

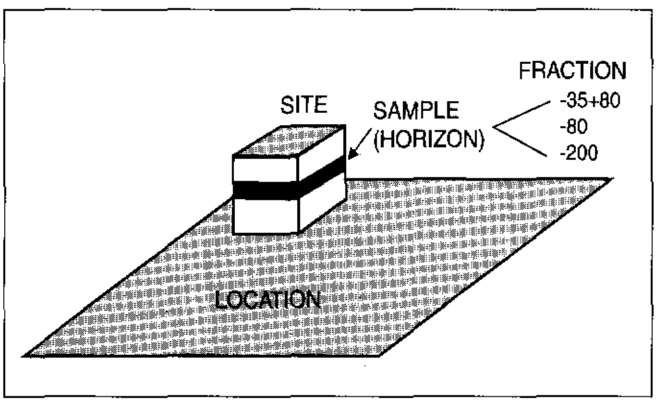


Figure 2: Sampling methodology: Four locations, each contained two to three sites, for a total of ten. One or more sample(s) are taken from each horizon for a total of 52. Each site included a rock sample and an A-horizon soil, leaving 32 B and C horizon soil samples. Each B and C horizon sample was divided into three size fractions for a total of 96.

Au-in-soil anomalies. Sites were chosen in areas with minimal downslope creep and no permafrost. Soil pits were dug on the walls of bulldozer trenches where good soil profiles were exposed. Four to seven samples were taken at each site with representatives taken from each of the A, B, and C horizons as well as bedrock fragments. Soil bags were filled such that they contained approximately 0.3-0.5 kg of material. Site locations are given in Appendix 1.

SOIL DESCRIPTION

The soil profiles are relatively thin and poorly developed at most localities (Fig. 3). Average thickness rarely exceed 0.5 metres. The soil profile consists of a thin and discontinuous A-horizon, a thin and immature B-horizon, and a well developed C-horizon. Contacts between all horizons are gradational. Soils are typically well drained, and contain an abundant clast content. Site specific soil descriptions are in Appendix 2.

Horizon A, composed of dry, partially decomposed organic matter consisting mainly roots and mosses, is typically underlain by a thin layer (2-10 cm) of White River ash. The B-horizon has an average thickness of 20-30 cm and can usually be divided into B1 and B2 on the basis of texture, colour, and clast content. B1 tends to be darker, finer-grained and contains sparse organic matter. B2 is lighter in colour, coarser-grained and often intermixed with the C horizon. The C horizon is typically gradational with B2 and comprises coarse and granular unconsolidated soils (essentially talus fines), which were assigned to C2-horizon. Rock fragments, which comprise up to 50% of the C2-horizon, were labeled as C1. Site 7 has no B2 horizon and therefore lacks samples and the C2-horizon sample from Site 6 was lost.

LABORATORY METHODS

All sample preparation and analyses were undertaken at Chemex Labs Ltd. in North Vancouver, British Columbia. Organic-rich, A horizon soils were sieved to -80 mesh. B and C horizon soils were sieved to -35+80, -80, and -200 mesh fractions (75, 180 and 500 (μm nominal aperture respectively) and weighed. The -35+80 fraction was pulverized in a non-steel, Zr ring crusher to reduce grain size to approximately <150 mesh. Rock samples, consisting of approximately 0.5 kg of >1.0 cm rock fragments were crushed to approximately -150 mesh in non-steel Zr ring and pulverized alternately with a "wash" of pure silica to reduce within-run contamination.

All samples were analysed using a "Au plus 32" package which is a popular and economical approach currently used by most exploration companies. Gold was analysed by 30g fire assay with an atomic absorption finish (FA-AA). In some cases less than 30g were available for analysis, or there was insufficient sample for analysis. Values for the 32 elements, including Ag, As, Cu, Pb, Zn, W etc... were obtained by digestion in aqua regia-nitric acid and analysis using inductively coupled plasma-argon emission spectroscopy (ICP-AES).

The nitric-acid aqua regia digestion is incomplete for some mineral species. As a result, analyses reported for Al, Ba, Be, Ca, Ga, K, La, Mg, Na, Sr, Ti, Tl and W are probably lower than the actual values of the material. Some elements, such as W, consistently yielded values which were less than the detection limit of 10 ppm. In this case, any value greater than 10 ppm is considered an indication that the element is much more plentiful than the actual value.

FIGURE 3A: Photo of typical soil profile in the deeply weathered Dawson Range (site 4, Revenue deposit). Note the rocky and relatively immature nature of the soil profile. The A-horizon extends to 5cm and is underlain by a 3cm interval of White River ash (top right). The B-horizon includes 2-4 cm rock fragments; the B1-B2 transition is gradational and irregular, and above the hammerhead. The C-horizon, poorly developed at this site, is below the hammerhead and contains sparse fine-grained detritus interstitial to broken bedrock.

Results

The analytical results are in Appendix 3. There are 52 samples, 10 are from A-horizon soils and 10 are of rocks (C1), leaving 32 from B and C horizon soils which each yielded 3 fractions for a total of (10+10+(3x32))=116 analyses. Although data for 32 elements was received from the lab, many elements have no known genetic association with mineralization (i.e. Sc, La) and

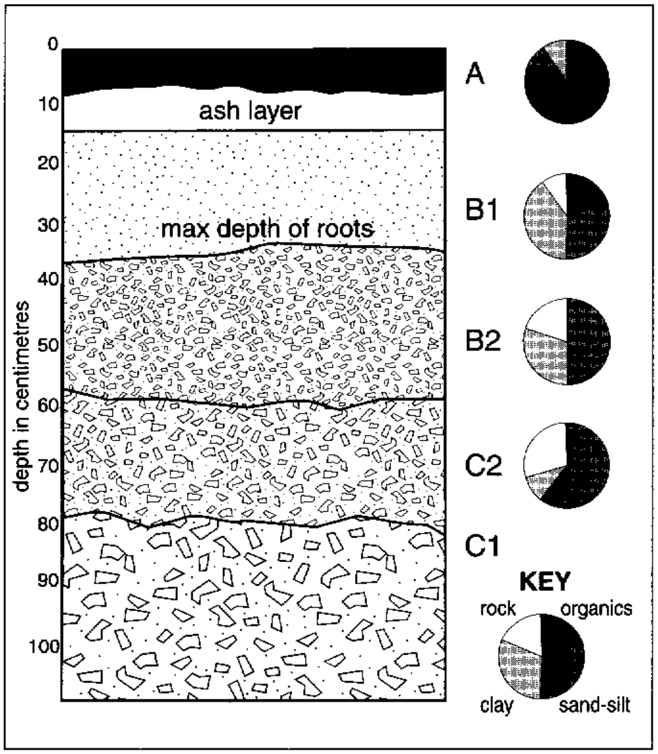


***FIGURE 3B:** Generalized soil profile constructed from observations in the Dawson Range. Pie diagrams show relative proportions of soil forming components in each horizon.*

are therefore not included. It should be noted that the -80 fraction also includes all the material that makes it to the -200 fraction.

Evaluation of the data using frequency, averages and medians leads to complicated, often contradictory results. This is partly a function of the large variability of analytical values between the deposits and a relatively small data set. The result is a statistically disorderly dataset with large standard deviations. To provide some order to the presentation of the data, evaluation is first given according to frequency by sites, then frequency by total sample population, averages and medians.

GOLD

Gold values in the soils range from 30 to 3000 ppb. Unfortunately, many samples did not yield enough material in the finer size fractions for fire assay gold analysis. This resulted in only 69, rather than the full compliment of 96 analyses. All horizons from all sites yielded a -35+80 mesh fraction, but finer mesh sizes have incomplete sample sets—particularly from Antoniuk and Revenue. This diminishes the opportunity to provide meaningful statistical analysis. Overall average values are of limited usefulness since there is a large range of values between deposits. Standard deviations are commonly larger than the average value. Data comparisons between sites are calculated for only those samples that yielded analyses in all three size fractions. The incomplete data set, and a bias resulting from a large number of samples with extremely high values from Casino, produce complicated results which must be interpreted with extreme caution.

Size Fraction

The highest gold values at each site, irrespective of horizon, were most frequently determined (5 of 9) in the +35-80 fraction (Fig. 4a). However, this result is biased by the comparatively fewer samples from finer-grained fractions. Evaluation of only samples that yielded all three size fractions (n=20) indicates that the highest gold values occurred most frequently in the -200 mesh size (Fig. 4b). This result was heavily biased by the Casino deposit which yielded nine samples with all fractions analysed and typically had higher values in the -200 mesh fraction. By deposit (Fig. 4c), the Nucleus (n=5) shows no bias to a preferred size fraction while most of the Antoniuk's (n=4) highest values were in the -80 mesh fraction.

Not surprisingly, overall average values are also highest for the -200 fraction but the highest median values are in the -35+80 fraction (Table 2; Fig. 5a). The discrepancy again results from the influence of the high values at Casino where the soils show a 40% increase in average value from the -35+80 to the -200 fraction (Fig. 5b). A similar trend is mirrored by the few Revenue samples whereas the Antoniuk result is ambiguous and the Nucleus has its highest average values in the -80 fraction.

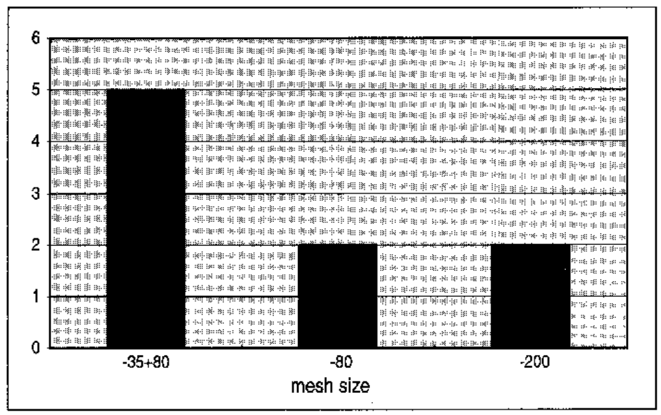


***FIGURE 4A:** Frequency of highest gold value according to size fraction from each site. The result is biased since several samples yielded only a +35-80 fraction and therefore lack analyses for the smaller sized fractions.*

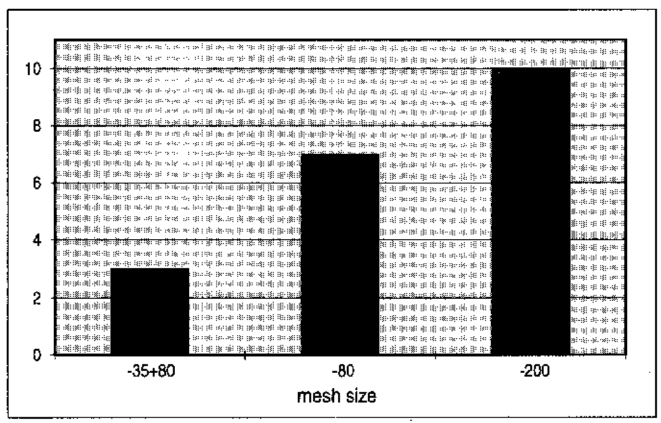


***FIGURE 4B:** Frequency of highest gold value according to size fraction from all samples that yielded results from all size fractions (n=20).*

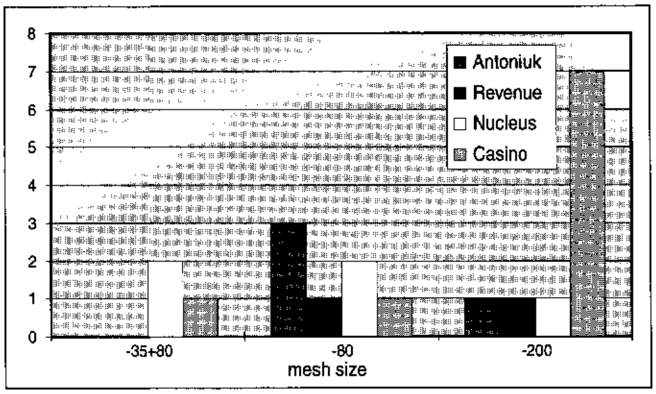


FIGURE 4C: Frequency of highest gold values according to size fraction from samples that yielded results from all size fractions (n=20) broken down according to location.

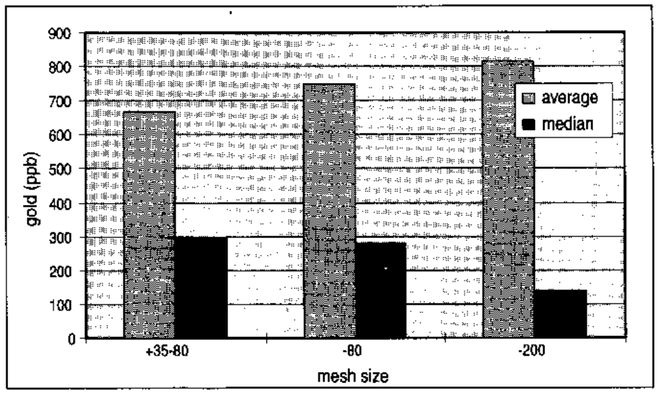


FIGURE 5A: Average and median gold values according to size fraction.

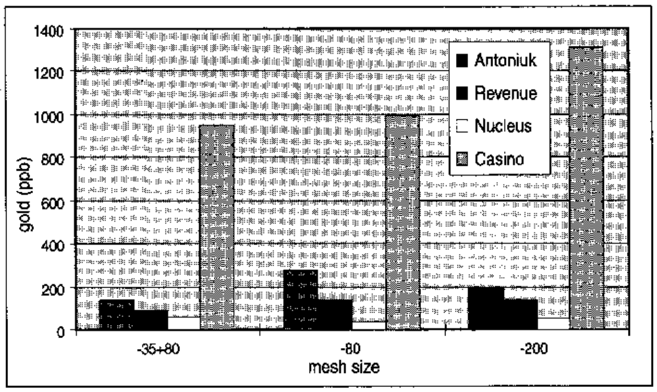


FIGURE 5B: Average gold values according to size fraction broken down according to location. The very high values from the Casino deposit strongly influence Fig. 5a.

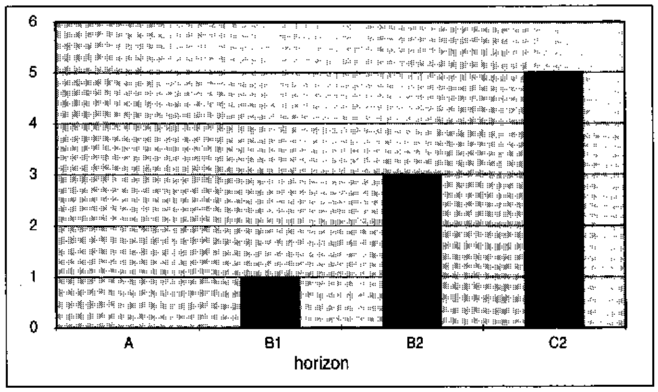


FIGURE 6: Frequency of highest gold values according to soil horizon from all sites.

Horizon

The highest gold values at each site, irrespective of size fraction, were most frequently found in the C2 horizon (Fig. 6). Similar results were determined using average and median values for each deposit.

Size Fraction and Horizon

Within the -38+80 fraction the C2 horizon most commonly yields the highest results and the B1 the least (Fig. 7). The -80 and -200 fractions lack full representation of the soil horizons and are therefore not discussed. Within the B1 horizon, the highest values are most frequently in the -200 fraction soils (Fig. 8). The highest average gold values for the B1 and B2-horizons are in the -200 fraction but the highest medians were in the -80 and +35-80 fractions respectively (Table 2). When the Casino data were excluded, however the highest averages and medians were all in the -80 fraction.

Enrichment/Depletion from Rocks

Rock collected from within and beneath the C-horizon yielded values between 100 and 1200 ppb. These values are similar to overall geological reserve grades of the properties of 300 to 2000

ppb	+35-80	-80	-200
average	669	750	815*
median	295*	280	140
average B1	407	468	581*
median B1	90	200*	140
average B2	634	676	840*
median B2	720*	373	110
average C2	688	935*	640
median C2	645	935*	640

TABLE 2: Average and median gold values for Dawson Range soils. Note the conflict between the size fraction of the highest average and median values (asterisk in each case).

ppb. When compared to the values in the soils some trends can be recognized. Within the B1-horizon, gold is depleted with respect to rock values at five sites and enriched at five sites. In the B2-horizon, gold is depleted in only two sites and enriched at seven. In the five sites with values from the C2-horizon, all are enriched. Profiles of gold values at three sites show net enrichments from rock values with notable decreases in the B1 horizon within all size fractions (Fig. 9). B1-horizon depletion is most pronounced in the +35-80 fraction and diminished

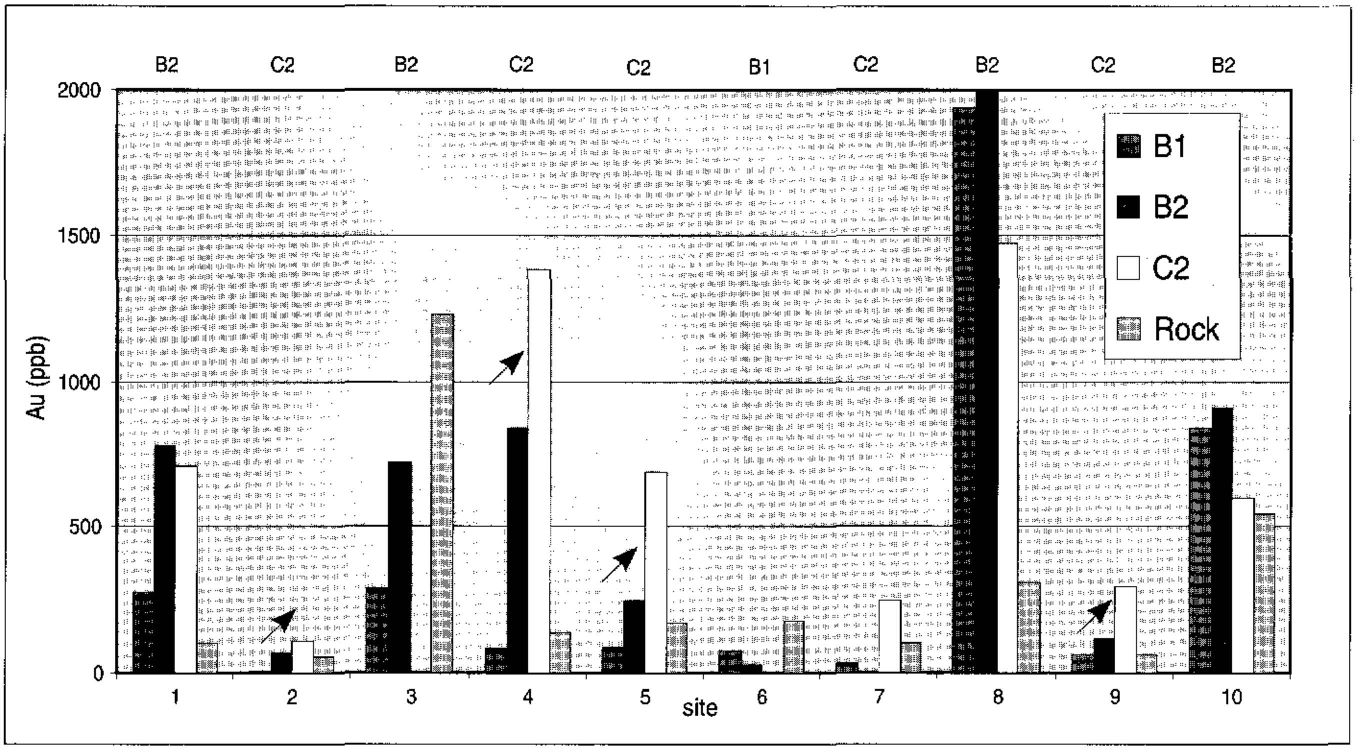


FIGURE 7: *Gold values from the -35+80 fraction according to soil horizon plotted according to site. The numbers along the top denote the horizon with the highest value; which is C2 at 5 sites, B2 at 4 and B1, once. Arrows emphasize trend, within the soil profile, of increased grades. Note the strong bias to deeper horizons. Sites 3 and 6 lack data from the C2 horizon. Insufficient data exist to plot similar graphs for the -80 or -200 fractions.*

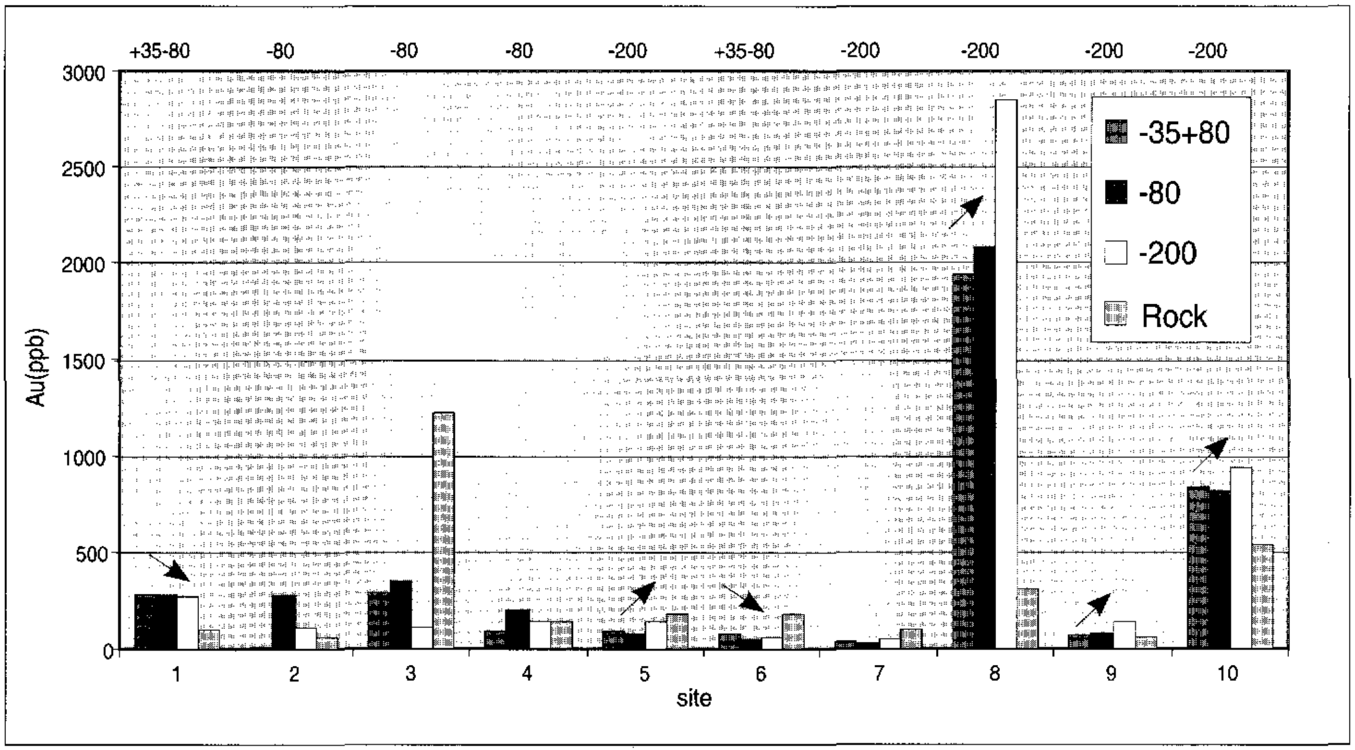


FIGURE 8: *Gold values from the B1 horizon according to size fraction plotted according to site. The numbers along the top denote the size fraction with the highest values (+35-80 twice, -80 twice, and -200 five times. Arrows emphasize trend of increased grades. Four sites show increasing grades with finer grain sizes, two sites show decreasing grades and the remainder are ambiguous.*

tion is most pronounced in the +35-80 fraction and diminished in the finer grained fractions. Site 8 at Casino gave soils that have gold enrichments of almost 10 times compared to a rock values of 310 ppb.

COPPER

Copper values in the B- and C-horizon soils range from 5 to 1620 ppm. Average values from the sites indicate a wide variation that makes statistical comparisons difficult: Revenue ≈ 900 ppm, Casino 320 ppm, Nucleus 64 ppm and Antoniuk 41 ppm. Unlike gold, values are available for all size fractions of all soil horizons at all sites.

Size Fraction

The highest copper values from each site were most commonly found in the -200 mesh fraction (Fig. 10a). Overall, the highest copper values occurred most frequently in the -35+80 mesh size, but the other two fractions account for 60% of the samples, thus when the full suite of samples (n=31) is considered, the result is different (Fig. 10b). The ambiguity is better understood when the data are displayed by deposit (Fig. 10c), where it is obvious that the Casino data dominate the earlier result as 7 of its 11 samples are richest in the -35+80 fraction . Data from the Antoniuk are equivocal, but each of the Revenue and the Nucleus have most of their highest values in the -200 mesh fraction. Overall average and median values are most commonly highest in the -35+80 and -80 fractions (Table 3).

Horizon

The highest copper values at each site occurred most frequently in the C2 horizon (Fig. 11)--all locations have at least one site with its highest values in the C2 horizon including both Antoniuk sites and all three Casino sites. Both average and median copper values increase with depth through the soil horizons, further confirming that the C2 horizon is the richest (Table 3).

Horizon and Size Fraction

The C2-horizon yields the highest copper values at 5 or more of the 10 sites for all size fractions. Within the various horizons, the +35-80 fraction yielded the highest values most frequently, but only slightly. The high values of the +35-80 fraction contradict frequency data which suggest that the highest values most commonly occur in the -200 mesh fraction, a direct result of the very high values in the +35-80 mesh fraction from the Casino deposit.

ppb	+35-80	-80	-200
average	322	338*	337
median	84*	78	74
average B1	176*	127	158
median B1	34	37	55*
average B2	376*	360	352
median B2	72	73	68
average C2	444	495	477
median C2	131	118	111

Table 3. Average and median copper values from Dawson Range soils. Horizon-C2 yields the highest average and median values. Asterisks denote the highest value.

Enrichment/Depletion from Rocks

Rocks collected within and beneath the C-horizon from each of the sites yielded values between 8 and 682 ppb--considerably lower than grades of 0.1 to 0.5% Cu reported for oxide zone reserves. Rock values were lower than the average soil values reported for seven of the ten sites. Stated another way, the soils were enriched in copper relative to the rocks at all but three sites; at one site the values were approximately equivalent and at two sites there was notable depletion (Fig. 12). Enrichment is most pronounced in the -200 fractions of the C2-horizons. Depletion is

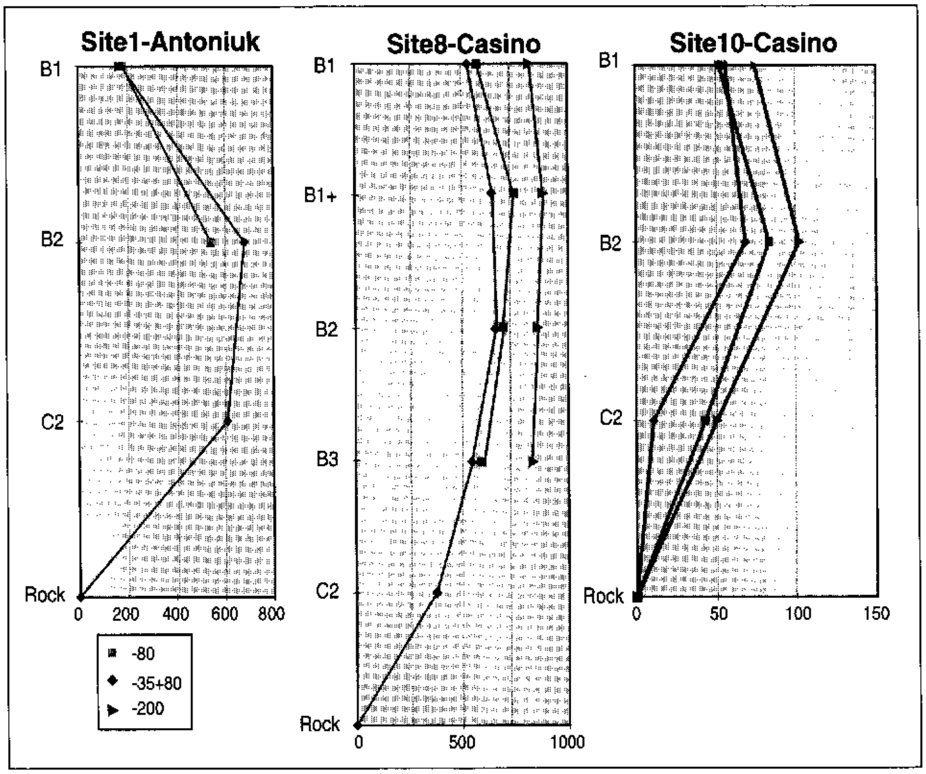


***FIGURE 9:** Profiles of gold distribution in the various soil horizons as normalized to the rock value at each site. Values are represented as a percentage of the rock value with enrichment as positive numbers and depletion as negative numbers. Although the scales vary between the sites, note the shape of the curves. Enrichment is notable in the C2 and B2 horizons. The B1-horizons show less enrichment, especially at the Antoniuk site. Both Casino sites have higher values in the -200 fraction.*

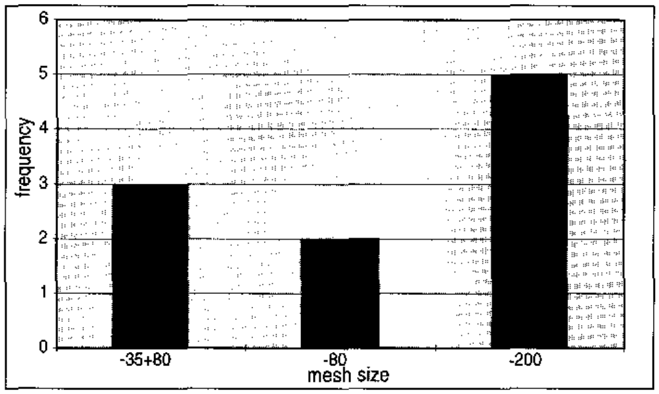


FIGURE 10A: *Frequency of highest copper value according to size fraction from each site.*

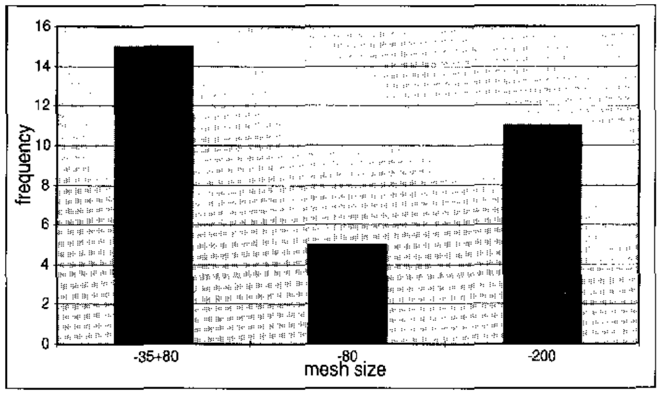


FIGURE 10B: *Frequency of highest copper value according to size fraction from all samples (n=31).*

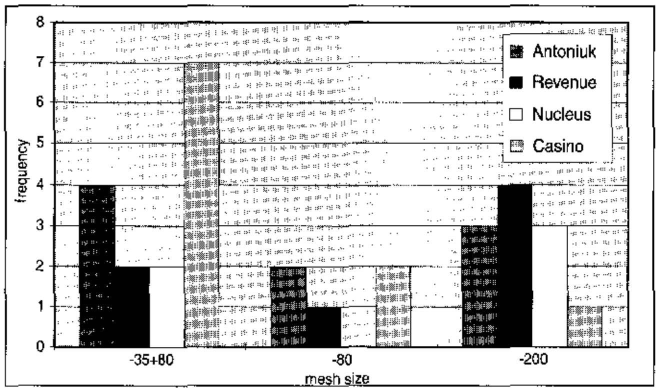


FIGURE 10C: *Frequency of highest copper values according to size fraction from all samples broken down according to location. Note the bias of the Casino samples in the -35+80 fraction.*

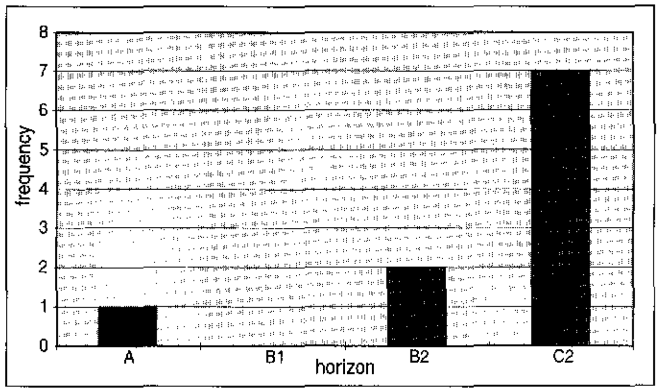


FIGURE 11: *Frequency of highest copper values according to soil horizon from all ten sites.*

most pronounced in the B1-horizons and slightly greater in the -200 fraction.

OTHER ELEMENTS

In addition to Au and Cu, other elements are anomalous or show enrichment or depletion trends. Mo values range from >1ppm to 232 ppm Silver values are typically low (3 ppm) at all sites except at Antoniuk and Site 8 from Casino where values range from 5 to 18 ppm. Soils from the Antoniuk yielded high As (av. 2000 ppm) and Zn (av. 144 ppm) values. W values were 10 ppm at all sites except Revenue which gave values up to 260 ppm. Bi values are particularly anomalous (>30 ppm) at four sites with higher values in the C2-horizons. Although most metallic elements in the soils are enriched with respect to rock values, Ag, Mo and W occasionally show a depletion. Soils containing >0.01% Na did not yield elevated metal values suggesting that metals were probably only deposited in rocks that endured extreme sodic depletion during mineralization.

CORRELATIONS

Correlation coefficients for gold, copper and molybdenum were determined with all the elements (Appendix 3). As expected, strong correlations exist at most sites between Au Cu and Mo. In addition, As, Bi, P, and to a lesser extent, Sb and Sr have a strong positive correlation with gold. As, Sb, Sr and to a lesser extent Ba and Pb have a strong positive correlation with copper. Many other strong positive and negative correlations exist at specific sites or locations but are not common across the sample population.

Discussion

Although the region escaped Quaternary glaciation and has been exposed to surface weathering since Late Tertiary time, the immature nature of the soil profiles and lack of paleosols at the four localities suggest that the soil is comparatively youthful. It is likely that a lack of vegetative cover during glacial and possibly interglacial periods encouraged solifluction and erosion of most or all of the existing soil at higher topographic levels. The result is that the present soils have developed only since the last deglaciation (≈10,000 years ago). Thin A horizons beneath and above the White River ash attest to meager organic contributions to the soil. However, the bedrock is intensely weathered and readily decomposes to clays and sand, thus yielding a relatively thick C-horizon. Conversely, soil horizons at lower levels, and those preserved in drainages, are thick, mature, contain numerous paleosols and record a rich and varied, multi-million year and interglacial history. These soils are therefore poor geochemical recorders of the underlying bedrock.

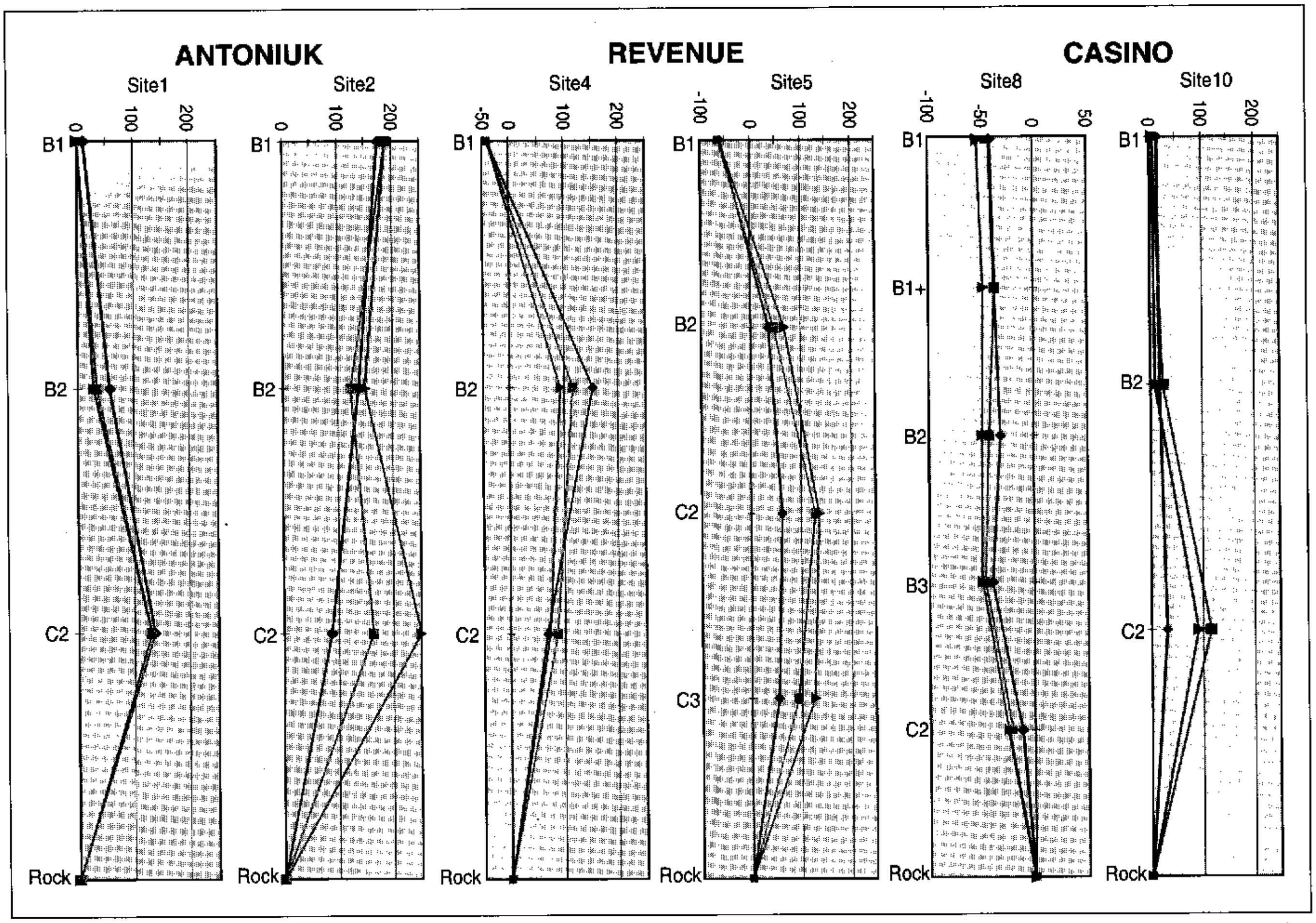


FIGURE 12: Profiles of copper distribution in the various soil horizons as normalized to the rock value at each site. Values are represented as a percentage of the rock value with enrichment as positive numbers and depletion as negative numbers. Although the scales vary between the sites, it is the shape of the curves that is important. Five of the six sites shown have enrichment in the B2- and C2-horizons, whereas Site 8 is depleted throughout. Note the depletion of copper in the B1-horizons at Sites 4 and 5 and the relative enrichment of the C2-horizon compared to the B1-horizon at Site 1 and 2. The difference in the values between the various size fractions are most strongly emphasized in the deeper horizons. At sites 2 and 5 the -200 mesh values are higher, whereas at site 10, the -80 fraction has the highest value. Symbols diamonds -35-80 mesh; squares -80 mesh, triangles -200 mesh.

CONCLUSIONS

The dataset presented in this report is too small and too variable to provide meaningful results from averages, and to a lesser extent, medians. The following conclusions are made with an emphasis on frequency data, and with the proviso that site specific soil geochemical characteristics are probably more important than these general conclusions.

Gold, copper, molybdenum and other metals are commonly enriched in soil with respect to leached and oxidized bedrock. As a result, soils may record evidence of mineralization that is no longer present at surface, but remains beneath the oxidized leached cap. Metal values are typically higher in the deeper soil horizons, C2 and B2. Metal values in the B1-horizon are comparatively lower and locally depleted with respect to the bedrock values—especially in the -35+80 fraction. This likely results from metal stripping by acidified waters percolating through the organic-rich A-horizon and is evidenced at sites 4 and 5. Furthermore, the enrichment shown in the B2 and C2 horizons may result from metal precipitation in the finer-grained fractions by the percolating waters as they are buffered by the soil and bedrock. Locally soils give multi-gram gold values reflecting significant enrichment.

The soil horizon sampled is more important than size fraction that is analysed. However, the -200 fraction most commonly yields a slightly higher value, although the -35+80 fraction is preferable in some deposits. This is probably a reflection of the maturity of the soils where metals, gold in particular, are eventually stripped from the sand-size rock grains and chemically transferred to the clay fraction.

Maximum geochemical contrast can be obtained by sampling the deepest soil horizon possible and analysing the -200 fraction. Rocks in the soil horizon typically contain values lower than the soils. Analysis of finer-grained fractions requires obtaining greater amounts of soil during field sampling to ensure adequate material for analyses. If there is concern about inadequate amounts of material, analyse for gold first if that is the element of primary interest. If time and resources permit, perform a site specific pilot study before undertaking a large geochemical survey.

REFERENCES

Bower, B., Payne, J., Delong, C., and Rebagliati, C.M., 1995. The oxide-gold supergene and hypogene zones at the Casino gold-copper-molybdenite deposit, west-central Yukon. In: Porphyry Deposits of the Northwestern Cordillera of North America, T. G. Schroeter (ed), Canadian Institute of Mining, Metallurgy and Petroleum, Special Volume 46, p. 352-366.

Davy, R., and Mazzucchelli, R.H., eds, 1984. Geochemical Exploration in Arid and Deeply Weathered Environments. Association of Exploration Geochemists Special Publication No. 12, Elsevier, Amsterdam.

Hunt, J.A., Dunn, C.E., Timmerman, J.R.M, and Zantvoort, W.G., 1997. Biogeochemical prospecting in the Yukon-Tanana Terrane, Yukon Territory. Yukon Exploration and Geology, 1996. Yukon Geology Program, p.74-91.

Hughes, O.L., Campbell, R.B., Muller, J.E., and Wheeler, J.O., 1968. Glacial limits and flow patterns, Yukon Territory, south of 65 degrees North latitude. Geological Survey of Canada, Paper 68-43, 9 p. and map.

Sinclair, W.D., Cathro, R.J., and Jensen, E.M., 1981. The Cash porphyry copper-molybdenum deposit, Dawson Range, Yukon Territory. CIM Bulletin, v. 74, p.67-75.

Site	Location	UTM-all Zone 7, except Casino, Zone 8		Locality
Site 1	Antoniuk	391340E	6905470N	15m NNW of PDH 88-11
Site 2	Antoniuk	391290E	6905530N	25m NNE of PDH 88-07
Site 3	Antoniuk	391400E	6905610N	10m N of PDH 88-25
Site 4	Revenue	382750E	6913380N	25m W of PDH 91-9
Site 5	Revenue	382650E	6913410N	140m W of DDH 80-2
Site 6	Nucleus	379415E	6913750N	10m NW of PDH 91-2
Site 7	Nucleus	379450E	6913830N	5m NW of PDH 89-1
Site 8	Casino	610880E	6957970N	20m E of PDH 93-135
Site 9	Casino	610980E	6958250N	15m W of DDH 94-297
Site 10	Casino	610990E	6958400N	5m E of DDH 94-309

APPENDIX 1: *Location of sites*

Site 1: Antoniuk

slope: 15° to south | site drainage: good | vegetation: moss, shrubs

sample horizon	A	B1	B2	C1	C2
texture	dry, organic matter	silty	sandy silt	bedrock	coarse sand
colour	dark brown-black	dark brown	rusty brown orange	purple-brown	purple-brown
sample depth	3-5 cm	15-20 cm	75-80 cm	80-85 cm	80-85cm
roots	yes	yes	no	no	no
clasts	25%	50%	50%	85%	85%
Notes:	rhyolite bedrock is hydrothermally altered and oxidized				

Site 2: Antoniuk

slope: 12° to south | site drainage: good | vegetation: moss, lichen, shrubs

sample horizon	A	B1	B2	C1	C2
texture	dry-organic	silty-clay	clay-silt-sand	bedrock	coarse sand
color	dark brown-black	dark brown	rusty brown orange	green-purple	greenish-orange
sample depth	12-15 cm	25-30 cm	55-60 cm	100-110 cm	100-110 cm
roots	yes	yes	no	no	no
clasts	10%	30-35%	55%	85%	85%
Notes:	distinct contact between B and C horizons, 10 cm ash layer, bedrock is hydrothermally altered and oxidized rhyolite				

Site 3: Antonuik

slope: 12° to south | site drainage: poor | vegetation: moss, shrubs

sample horizon	A	B1	B2	C1	C2
texture	dry organic	silty	clay-silt-sand	bedrock	coarse sand
color	dark brown-black	dark brown	rusty orange	light brown	light brown
sample depth	10-12 cm	30-33 cm	45-48 cm	75-80 cm	75-80 cm
roots	yes	yes	no	no	no
clasts	5%	10%	35%	70%	70%
Notes:	rhyolite bedrock is hydrothermally altered and oxidized, minor malachite and azurite ash layer is present				

Site 4: Revenue

slope : 12° to north | site drainage: good | vegetation: moss, shrubs, spruce

sample horizon	A	B1	B2	C1	C2
texture	dry organics	clay-silt	coarse sand	bedrock	coarse sand
color	dark brown-black	dark brown	red-brown	light brown	light brown
sample depth	10-15cm	25-30cm	45-50cm	100-105cm	100-105cm
roots	yes	yes	yes	no	no
clasts	5%	20%	50%	75%	75%
Notes:	oxidized and hydrothermally altered felsic breccia bedrock, thin ash layer				

Site 5: Revenue

slope: 20° to north | site drainage: moderate | vegetation: moss and shrubs, spruce, birch

sample horizon	A	B1	B2	C1	C2-1	C2-2
texture	dry organic	clay-silt	clay-silt-sand	bedrock	coarse sand	clay-silt-sand
color	dark brown-black	dark brown	red-brown	light brown	light brown	light brown
sample depth	12-15cm	30-35cm	45cm	85-90cm	110-115cm	110-115cm
roots	yes	yes	yes	no	no	no
clasts	-	30%	40%	80%	80%	70%
Notes:	granite bedrock is oxidized, thin ash horizon; samples C2-(1,2) taken at same depth to increase sample population					

Site 6: Nucleus

slope: 15° to | site drainage: good | vegetation: moss, shrubs, Picea

sample horizon	A	B1	A2	B2	C1
texture	dry organic	mixed ash	sandy silt	sandy silt	bedrock
color	dark brown-black	light brown	dark brown	light brown	white-light grey
sample depth	13-15cm	25-30cm	43-45cm	60-65cm	80-85 cm
roots	yes	yes	yes	yes	-
clasts	-	-	15%	35%	60%
Notes:	aplite bedrock is hydrothermally altered and oxidized, contains oxidized pyrite, thin ash layer				

APPENDIX 2A: Descriptive information for soil samples from the ten sample sites.

Site 7: Nucleus

slope: 20° to | site drainage: good | vegetation: moss, shrubs, spruce

sample horizon	A	B	C1	C2
texture	dry organic	sandy silt	bedrock	silty and sandy
color	dark brown-black	dark brown	light bluish white	light brown
sample depth	13-15 cm	35-38cm	105-110cm	105-110cm
roots	yes	yes	no	no
clasts	-	30%	70%	70%

Notes: bedrock is oxidized aplite, B horizon is very thin,only one sample taken from this horizon, thin ash layer

Site 8: Casino

slope: 22° to north | site drainage: good | vegetation: sparse grass and moss

sample horizon	A	B1	B2-C2-(1,2,3)	C1	C2
texture	dry organics	silty to sandy	silty sandy	bedrock	silty sand
color	dark black	dark brown	medium brown	light grey/brown	light brown
sample depth	10cm	10-20cm	20-25cm	65cm	50cm
roots	yes	yes	yes	no	no
clasts	-	40%	45%	70%	70%

Notes: oxidized and hydrothermally altered granite bedrock
B2-C2-(1,2,3) are a mix of the lower most unit of the B horizon and the upper most unit of the C horizon

Site 9: Casino

slope: 20° to north | site drainage: good | vegetation: sparse grass and moss

sample horizon	A	B1	B2	C1	C2
texture	dry organics	silty: some sands	sandy silt	bedrock	arse sands and silts
color	dark black	dark brown	medium brown	light brown/grey	light brown
sample depth	15-20cm	25-30cm	35-40cm	50-55cm	60-65cm
roots	yes	yes	yes	no	no
clasts	-	40%	45%	50%	50%

Notes: oxidized and hydrothermally altered granite bedrock
B2 is thin and intermixed with B1

Site 10: Casino

slope: 18-20° to north | site drainage: good | vegetation: sparse grass and moss

sample horizon	A	B1	B2	C1	C2
texture	dry organics	silty: some sands	sandy silt	bedrock	arse sands and silts
color	dark black	dark brown	medium brown	light brown/grey	light brown
sample depth	10-15cm	22-25cm	35-40cm	70-75cm	70-75cm
roots	yes	yes	yes	no	no
clasts	-	40%	45%	65%	65%

Notes: oxidized and hydrothermally altered granite bedrock

Appendix 2B: *Descriptive information for soil samples from the ten sample sites.*

Sample	size fraction	Au ppb	weight grams	Ag ppm	As ppm	Ba ppm	Bi ppm	Co ppm	Cr ppm	Cu ppm	Mn ppm	Mo ppm	Ni ppm	P ppm	Pb ppm	Sb ppm	Sr ppm	V ppm	W ppm	Zn ppm	Al %	Ca %	Fe %	K %	Mg %	Na %	Ti %
Antoniuk																											
1-A1	-80	460	\	1.8	296	170	<2	6	20	16	345	1	11	380	32	2	33	64	<10	114	1.6	0.26	3.18	0.12	0.28	0.01	0.05
1-B1	-35 +80	275.0	30.0	5.2	1025	90	<2	8	28	34	620	1	18	340	90	12	22	45	<10	150	2.25	0.13	3.75	0.11	0.52	<.01	0.04
1-B1	-80	280.0	15.0	5.2	926	90	<2	8	31	31	560	2	19	320	78	8	21	49	<10	134	2.22	0.14	3.58	0.11	0.54	<.01	0.05
1-B1	-200	270.0	15.0	5.4	876	90	<2	9	35	31	555	2	21	320	76	8	23	53	<10	124	2.33	0.17	3.62	0.11	0.57	<.01	0.06
1-B2	-35 +80	780.0	5.0	5.2	1985	120	6	5	17	49	590	<1	9	600	184	32	81	33	<10	204	2.09	0.1	5.43	0.24	0.39	<.01	0.01
1-B2	-80	645.0	10.0	5.4	1740	120	6	6	20	42	555	1	10	530	172	26	76	36	<10	164	1.95	0.11	4.89	0.24	0.4	<.01	0.02
1-B2	-200	not ss	not ss	5.4	1650	120	6	6	25	40	555	<1	12	520	176	24	80	40	<10	148	2.03	0.14	4.87	0.26	0.43	<.01	0.03
1-C2	-35 +80	710.0	15.0	6.8	1230	140	8	2	6	73	430	2	3	840	212	46	119	12	<10	268	1.54	0.08	5.64	0.29	0.28	<.01	<.01
1-C2	-80	not ss	not ss	7.4	1280	170	10	3	11	75	485	3	5	910	236	44	139	16	<10	258	1.63	0.09	5.95	0.36	0.3	0.01	<.01
1-C2	-200	not ss	not ss	7.8	1150	210	10	3	15	72	400	4	8	910	278	38	174	20	<10	220	1.66	0.11	5.76	0.43	0.32	0.01	<.01
1-C1	\	100	\	1.6	210	60	<	<1	1	31	80	1	<1	210	80	6	28	1	<10	78	0.8	0.04	1.55	0.25	0.1	0.01	<.01
2-A	-80	<5	\	1.4	32	70	<2	4	8	9	75	<1	5	380	6	<2	14	57	<10	38	0.36	0.1	1.84	0.03	0.07	0.03	0.06
2-B1	-35 +80	5.0	30.0	2.8	374	350	<2	6	23	22	685	2	14	210	24	2	27	45	<10	124	2.15	0.22	3.19	0.1	0.42	<.01	0.02
2-B1	-80	280.0	15.0	2.8	348	360	<2	8	27	23	670	2	15	200	24	2	31	50	<10	126	2.36	0.25	3.21	0.11	0.46	<.01	0.03
2-B1	-200	110.0	15.0	2.8	338	370	<2	8	29	23	645	2	16	200	22	2	32	53	<10	126	2.43	0.26	3.21	0.11	0.47	<.01	0.03
2-B2	-35 +80	70.0	5.0	1.2	442	240	<2	9	27	19	975	1	16	170	28	6	22	46	<10	104	1.81	0.21	2.94	0.12	0.52	<.01	0.04
2-B2	-80	90.0	10.0	1	376	210	<2	9	28	18	775	<1	16	160	24	4	21	46	<10	94	1.67	0.2	2.88	0.1	0.52	<.01	0.05
2-B2	-200	90.0	not ss	1	394	220	<2	9	33	20	790	<1	18	180	22	2	21	52	<10	96	1.77	0.22	3.07	0.1	0.55	<.01	0.05
2-C2	-35 +80	110.0	15	2.2	660	100	<2	<1	3	15	140	1	1	150	82	12	15	4	<10	84	0.38	0.04	1.79	0.13	0.05	<.01	<.01
2-C2	-80	not ss	not ss	3	850	140	2	1	6	21	185	2	4	200	126	12	20	6	<10	112	0.56	0.06	2.44	0.17	0.07	<.01	<.01
2-C2	-200	not ss	not ss	4	1010	190	2	1	13	28	210	2	7	250	164	16	29	9	<10	130	0.78	0.09	3.02	0.24	0.1	<.01	<.01
2-C1	\	55.0	\	4	280	70	2	<1	2	8	35	2	<1	90	60	10	7	1	<10	30	0.39	0.02	1.09	0.27	0.02	0.01	0.01
3-A	-80	not ss	\	7.6	534	220	<2	4	13	50	215	<1	11	820	38	2	31	48	<10	88	0.99	0.19	2.24	0.11	0.16	0.03	0.04
3-B1	-35 +80	290.0	30	8.4	890	140	<2	3	10	32	215	<1	6	570	38	6	19	33	<10	120	1.13	0.15	1.68	0.1	0.15	0.05	0.02
3-B1	-80	345.0	10	9.8	1050	150	<2	4	15	37	225	1	9	650	44	8	19	36	<10	144	1.29	0.16	1.97	0.1	0.16	0.05	0.02
3-B1	-200	not ss	not ss	9.2	1065	160	<2	3	18	34	205	1	10	600	48	8	18	17	<10	144	1.32	0.13	1.51	0.11	0.16	0.06	0.01
3-B2	-35 +80	720.0	15	18.2	2740	340	4	5	24	72	355	1	13	730	102	16	34	47	<10	178	2.19	0.25	3.51	0.17	0.38	0.01	0.02
3-B2	-80	not ss	not ss	18.2	2760	340	4	5	27	73	340	1	14	730	104	16	34	49	<10	180	2.24	0.25	3.57	0.17	0.39	0.01	0.02
3-B2	-200	not ss	not ss	16.4	2650	330	2	5	31	68	320	1	16	700	98	18	34	43	<10	176	2.22	0.24	3.35	0.17	0.4	0.01	0.01
3-C2	-35 +80	not ss	not ss	11.8	>10000	260	26	1	9	59	165	3	4	650	220	32	36	19	<10	94	0.63	0.17	4.45	0.47	0.15	0.01	0.01
3-C2	-80	not ss	not ss	10.2	9730	230	24	1	14	54	170	2	6	680	230	34	38	22	<10	98	0.7	0.2	4.39	0.48	0.18	0.01	0.01
3-C2	-200	not ss	not ss	10.6	8970	270	22	1	20	53	165	3	9	730	228	32	40	25	<10	100	0.79	0.24	4.45	0.5	0.21	0.01	0.01
3-C1	\	1230	\	5.8	10 000	220	14	1	5	66	65	9	3	570	104	20	70	12	<10	54	0.54	0.1	5.76	0.65	0.08	0.01	0.01
av. B & C soils		316.9		6.9	1788.8	205.6	9.4	5.0	20.2	41.4	443.9	1.8	11.1	483.3	116.4	17.3	45.4	33.6		144.4	1.63	0.16	3.63	0.21	0.34	0.02	0.03
Corr. Au		1.000		0.501	0.837	-0.019	0.905	-0.797	-0.251	0.847	-0.296	0.649	-0.518	0.784	0.660	0.686	0.737	-0.150		0.381	-0.061	-0.140	0.770	0.739	-0.203	-0.234	-0.446
Corr. Cu		0.847		0.763	0.444	0.316	0.180	-0.501	-0.046	1.000	-0.157	0.361	-0.244	0.884	0.674	0.736	0.652	-0.173		0.638	0.154	0.102	0.102	0.692	0.596	0.015	-0.387
Corr. Mo		0.649		-0.050	0.223	0.088	0.349	-0.419	-0.305	0.361	-0.254	1.000	-0.380	0.227	0.303	0.325	0.407	-0.297		-0.168	-0.319	-0.175	0.560	0.759	-0.255	-0.263	-0.264
Revenue																											
4-A	-80	10.0	\	1	2	90	<2	1	4	88	25	<1	4	440	<2	<2	20	11	<10	14	0.5	0.11	0.61	0.03	0.04	0.06	0.01
4-B1	-35 +80	85.0	30	1.6	20	210	<2	7	24	317	335	2	11	280	12	<2	17	56	<10	54	1.78	0.2	2.92	0.07	0.38	0.01	0.05
4-B1	-80	200	15	1.6	16	220	<2	7	27	317	300	3	12	260	12	<2	18	58	<10	56	1.89	0.22	2.9	0.08	0.4	0.01	0.05
4-B1	-200	140	15	1.8	14	230	<2	7	29	321	285	3	13	250	14	<2	19	56	<10	58	1.97	0.23	2.79	0.08	0.41	0.01	0.05
4-B2	-35 +80	840	15.0	1.8	142	340	10	9	10	1350	300	24	11	720	48	4	18	34	260	102	0.74	0.18	4.56	0.08	0.14	<.01	<.01
4-B2	-80	not ss	not ss	1.4	136	420	12	8	15	1155	260	18	12	700	42	2	20	38	160	90	0.99	0.19	4.17	0.09	0.2	<.01	<.01
4-B2	-200	not ss	not ss	1.8	122	440	12	6	20	1030	250	14	12	860	40	2	25	40	130	88	1.24	0.22	3.82	0.11	0.24	<.01	<.01
4-C2	-35 +80	1360.0	15.0	3.2	336	430	16	14	5	888	180	15	11	1170	46	2	33	17	50	98	0.49	0.31	3.78	0.11	0.07	<.01	<.01
4-C2	-80	not ss	not ss	2.6	352	440	16	13	7	988	185	19	11	1610	54	2	45	22	70	106	0.64	0.41	4.11	0.14	0.09	<.01	<.01
4-C2	-200	not ss	not ss	2.8	386	390	16	10	12	921	165	19	11	1690	52	2	41	21	90	90	0.61	0.44	3.73	0.13	0.1	<.01	<.01
4-C1	\	135	\	1.2	600	180	<2	8	4	536	265	6	6	710	22	<2	37	11	<10	34	0.54	0.22	2.52	0.18	0.05	0.01	0.01
5-A	-80	<5	\	0.4	<2	10	<2	1	3	7	25	<1	1	120	<2	<2	6	20	<10	12	0.22	0.03	0.64	0.03	0.03	0.05	0.03
5-B1	-35 +80	90.0	30.0	2	34	120	<2	9	29	271	185	8	19	330	8	<2	26	77	<10	62	2.59	0.21	4.16	0.1	0.6	<.01	0.08
5-B1	-80	80.0	15.0	2	30	120	<2	9	31	245	190	7	20	330	12	<2	28	80	<10	60	2.68	0.23	4.04	0.1	0.59	<.01	0.09
5-B1	-200	140.0	15.0	2.2	34	140	<2	10	38	259	205	8	23	370	10	<2	32	90	<10	66	3.08	0.28	4.47	0.11	0.64	<.01	0.1
5-B2	-35 +80	250.0	30.0	1	82	80	8	18	11	926	170	24	12	450	10	4	40	63	<10	40	2.01	0.17	6.08	0.15	0.42	0.01	<.01
5-B2	-80	not ss	not ss	1.4	80	90	8	19	15	1000	180	27	14	460	10	2	41	66	<10	46	2.27	0.19	6.38	0.15	0.45	0.01	0.01
5-B2	-200	not ss	not ss	1.4	96	100	6	20	20	1130	190	29	16	510	14	2	47	72	<10	50	2.61	0.22	6.8	0.17	0.5	0.01	0.01
5-C2-1	-35 +80	690.0	15.0	1.2	74	120	26	12	12	1100	285	18	9	800	36	2	23	92	10	48	1.91	0.26	6.41	0.49	0.89	<.01	0.13
5-C2-1	-80	not ss	not ss	1.8	112	160	26	17	19	1565	360	25	13	980	54	4	34	120	20	66	2.53	0.32	8.43	0.63	1.1	<.01	0.16
5-C2-1	-200	not ss	not ss	1.4	124	180	24	17	24	1620	345	26	15	1040	56	6	38	128	20	70	2.82	0.35	8.74	0.68	1.17	<.01	0.17
5-C2-2	-35 +80	1170.0	15.0	0.4	78	130	46	13	12	1050	275	17	9	610	54	2	23	98	10	52	1.9	0.23	7.01	0.41	0.89	<.01	0.12
5-C2-2	-80	not ss	not ss	1	96	160	32	15	16	1320	310	22	11	660	64	2	29	118	10	66	2.37	0.26	8.46	0.5	1.07	<.01	0.14
5-C2-2	-200	not ss	not ss	1	114	190	36	16	20	1540	335	25	13	710	74	6	34	130	10	72	2.83	0.29	9.42	0.58	1.19	<.01	0.16
5-C1	\	175.0	\	2.6	12	80	<2	4	9	682	115	7	4	680	6	<2	9	54	40	26	1.2	0.2	3.16	0.28	0.65	0.03	0.04
av. B & C soils		433.3		1.7	139.9	222.3	19.6	12.0	18.2	902.2	252.5	16.3	12.9	694.5	33.8	2.9	30.4	67.5	70.0	66.9	1.84	0.26	5.26	0.23	0.53	0.01	0.09
Corr. Au		1.000		0.091	0.288	0.588	0.457	0.541	-0.442	0.766	0.218	0.620	-0.172	0.772	0.929	-0.669	0.100	-0.006	-0.010	0.584	-0.333	0.469	0.536	0.429	0.049	-0.661	0.664
Corr. Cu		0.766		-0.038	0.190	0.295	0.399	0.707	-0.143	1.000	0.571	0.880	0.098	0.552	0.782	0.761	0.452	0.487	-0.085	0.502	0.224	0.484	0.832	0.722	0.509	-0.601	0.880
Corr. Mo		0.620		-0.268	0.092	-0.004	-0.170	0.827	-0.351	0.880	0.089	1.000	0.015	0.408	0.546	0.514	0.590	0.331	-0.001	0.248	0.142	0.226	0.780	0.492	0.302	-0.192	0.393
Nucleus																											
6-A1	-80	<.5	\	0.4	6	80	<2	3	8	18	100	<1	6	640	<2	<2	22	22	<10	26	0.47	0.17	0.96	0.06	0.1	0.03	0.01
6-A2	-35 +80	10.0	30.0	<.2	146	120	4	6	23	44	190	1	11	200	10	<2	22	51	<10	40	1.17	0.25	2.4	0.07	0.42	0.02	0.06
6-A2	-80	5.0	15.0	<.2	132	120	2	6	25	43	175	1	12	170	14	<2	23	51	<10	40	1.18	0.27	2.17	0.07	0.44	0.01	0.07
6-A2	-200	5.0	15.0	<.2	134	130	2	6	29	46	185	2	14	180	16	<2	26	56	<10	44	1.36	0.32	2.31	0.07	0.48	0.02	0.08
6-B1	-35 +80	75.0	30.0	<.2	10	20	<2	1	3	5	40	<1	1	340	<2	<2	9	24	<10	12	0.27	0.1	0.75	0.04	0.05	0.08	0.03
6-B1	-80	50.0	30.0	<.2	12	30	<2	1	4	6	40	<1	2	350	<2	<2	9	25	<10	14	0.3	0.1	0.78	0.04	0.05	0.09	0.03
6-B1	-200	80.0	15.0	<.2	16	30	<2	<1	6	7	25	<1	3	250	<2	<2	9	7	<10	8	0.33	0.08	0.31	0.05	0.04	0.11	0.01
6-B2	-35 +80	30.0	30.0	0.2	192	150	4	9	38	37	295	1	17	230	8	2	23	69	<10	52	2.36	0.28	3.16	0.09	0.6	0.02	0.09
6-B2	-80	80.0	15.0	0.2	176	140	2	9	40	35	280	1	18	210	8	<2	24	67	<10	52	2.33	0.3	2.94	0.08	0.61	0.02	0.09
6-B2	-200	30.0	15.0	0.2	174	140	2	9	41	35	275	<1	19	200	8	2	24	67	<10	52	2.3	0.3	2.9	0.08	0.6	0.02	0.09
6-C1	\	180.0	\	0.2	624	110	10	3	14	58	85	1	6	190	8	4	24	27	<10	22	0.93	0.13	2.8	0.24	0.22	0.03	0.02
7-A	-80	40	\	0.8	74	140	6	5	14	55	255	<1	10	1200	2	<2	30	37	<10	32	0.87	0.22	1.91	0.1	0.16	0.04	0.02
7-B	-35 +80	35.0	30.0	0.2	270	120	6	7	25	78	245	2	11	370	6	2	29	50	<10	34	1.37	0.25	2.72	0.14	0.39	0.02	0.05
7-B	-80	30.0	15.0	0.2	242	110	6	7	27	75	220	1	12	340	6	<2	27	49	<10	34	1.3	0.25	2.51	0.13	0.39	0.02	0.06
7-B	-200	45.0	10.0	0.2	240	120	6	6	30	77	225	1	13	330	6	2	29	50	<10	36	1.4	0.28	2.53	0.14	0.42	0.03	0.06
7-C2	-35 +80	245	30	0.6	824	130	42	5	23	151	160	1	7	380	4	6	38	45	<10	30	1.01	0.15	4.25	0.33	0.4	0.04	0.04
7-C2	-80	1100	30	0.6	834	150	36	4	27	155	145	1	8	410	6	6	43	50	<10	30	1.15	0.18	4.38	0.36	0.47	0.04	0.05
7-C2	-200	470	15	0.4	850	170	40	4	33	167	145	1	10	440	6	8	49	58	<10	34	1.39	0.24	4.72	0.43	0.56	0.04	0.06
7-C1	\	100	\	1.6	210	60	<2	<1	1	31	80	1	4	190	6	2	24	20	<10	14	0.74	0.08	2.32	0.27	0.2	0.03	0.01
av. B & C soils		151.3		0.3	283.5	112.0	12.7	5.7	24.9	64.1	176.3	1.2	10.5	293.3	8.2	4.0	25.6	47.9		34.1	1.28	0.22	2.59	0.14	0.39	0.04	0.06
Corr. Au		1.000		0.139	0.753	0.308	0.757	-0.275	0.104	0.711	-0.168	-0.231	-0.169	0.115	-0.260	0.701	0.623	0.069		-0.105	-0.047	-0.170	0.593	0.732	0.178	0.062	-0.078
Corr. Cu		0.711		-0.014	0.919	0.652	0.964	0.022	0.412	1.000	0.201	-0.133	0.126	0.143	-0.408	0.910	0.932	0.384		0.186	0.201	0.175	0.874	0.872	0.474	-0.260	0.161
Corr. Mo		-0.231		-0.192	-0.264	-0.006	-0.274	0.126	0.055	-0.133	0.188	1.000	0.163	-0.022	0.364	-0.338	-0.093	0.116		0.144	0.004	0.344	-0.247	-0.287	0.015	-0.284	0.150

***APPENDIX 3A:** Analytical results by "Gold plus 32" analytical package. Gold by FA-AA, all others by ICP. Analyses by Chemex Laboratory Ltd., North Vancouver.*

Sample	size fraction	Au ppb	weight grams	Ag ppm	As ppm	Ba ppm	Bi ppm	Co ppm	Cr ppm	Cu ppm	Mn ppm	Mo ppm	Ni ppm	P ppm	Pb ppm	Sb ppm	Sr ppm	V ppm	W ppm	Zn ppm	Al %	Ca %	Fe %	K %	Mg %	Na %	Ti %
Casino																											
8-A	-80	2140	\	6	72	240	48	5	21	90	190	58	11	990	26	<2	22	54	10	44	0.97	0.16	6.49	0.6	0.25	0.01	0.05
8-B2-C2-1	-35 +80	2340.0	30.0	6.8	72	150	58	4	18	95	195	60	9	970	32	<2	21	50	10	44	0.97	0.14	6.33	0.68	0.23	0.01	0.04
8-B2-C2-1	-80	2960.0	15.0	6.6	68	160	58	5	22	94	225	55	11	1000	32	<2	23	57	10	48	1.09	0.18	6.24	0.64	0.29	0.01	0.05
8-B2-C2-1	-200	2260.0	15.0	5.8	58	270	44	5	27	79	230	46	13	960	24	2	22	60	<10	50	1.15	0.23	5.5	0.52	0.33	0.01	0.07
8-B2-C2-2	-35 +80	2000.0	30.0	6.8	76	160	60	5	18	103	235	60	9	990	34	2	22	50	10	42	0.99	0.14	6.53	0.7	0.24	0.01	0.04
8-B2-C2-2	-80	2140.0	30.0	5.8	68	170	52	5	21	86	250	52	11	970	30	<2	21	52	10	44	1.06	0.17	5.9	0.6	0.29	0.01	0.05
8-B2-C2-2	-200	2880.0	15.0	5.2	60	220	42	6	26	76	270	45	14	970	26	<2	21	57	10	48	1.15	0.21	5.43	0.51	0.34	0.01	0.06
8-B2-C2-3	-35 +80	2300.0	30.0	7.4	72	130	64	4	18	90	210	58	10	930	34	<2	20	49	10	42	0.97	0.14	6.16	0.65	0.25	0.01	0.04
8-B2-C2-3	-80	2620.0	30.0	7.2	66	140	52	5	21	80	230	53	10	920	30	2	20	53	10	44	1.05	0.17	5.93	0.59	0.29	0.01	0.05
8-B2-C2-3	-200	3040.0	15.0	6.6	62	250	48	6	27	76	265	49	13	970	28	<2	23	63	<10	50	1.25	0.23	5.78	0.55	0.36	0.01	0.07
8-B1	-35 +80	1940.0	30.0	6.8	76	140	60	4	17	89	195	61	8	980	36	<2	20	50	10	44	0.93	0.13	6.6	0.65	0.23	0.01	0.04
8-B1	-80	2080.0	15.0	6.2	88	190	58	4	21	82	215	57	10	970	28	4	21	54	10	44	1	0.17	6.09	0.6	0.28	0.01	0.05
8-B1	-200	2850.0	10.0	5.4	70	300	46	4	26	71	230	47	13	940	22	2	21	60	<10	48	1.09	0.22	5.39	0.49	0.33	0.01	0.07
8-C2	-35 +80	1470.0	15.0	6.4	116	140	66	2	13	131	180	78	5	970	32	2	20	40	10	38	0.71	0.06	7.09	0.81	0.12	0.01	0.02
8-C2	-80	not ss	not ss	6.2	116	140	62	3	18	118	205	72	8	1030	32	4	20	47	10	44	0.84	0.09	6.82	0.74	0.17	0.01	0.03
8-C2	-200	not ss	not ss	5.8	116	150	54	4	25	111	235	67	11	1030	32	4	23	56	10	48	1.08	0.13	6.68	0.71	0.24	0.01	0.05
8-C1	\	310.0	\	1	62	230	12	2	6	151	125	97	2	510	22	<2	18	39	20	22	0.52	0.01	8.78	0.68	1.25	0.01	0.01
9-A	-80	not ss	\	0.8	6	110	<2	4	18	18	95	5	12	1110	6	<2	22	40	<10	88	0.74	0.21	1.78	0.08	0.15	0.01	0.04
9-B1	-35 +80	65.0	30.0	0.2	18	140	<2	10	36	25	370	13	25	410	12	<2	18	87	<10	88	2.56	0.17	4.7	0.13	0.52	<.01	0.1
9-B1	-80	80.0	15.0	0.2	8	130	<2	10	38	26	365	10	26	400	12	<2	18	87	<10	88	2.52	0.18	4.5	0.11	0.53	<.01	0.1
9-B1	-200	140.0	15.0	0.2	8	120	<2	10	37	25	340	9	25	360	10	<2	16	82	<10	82	2.35	0.17	4.17	0.09	0.52	<.01	0.1
9-B2	-35 +80	115.0	30.0	0.4	16	130	2	10	35	25	365	13	23	340	12	2	18	77	<10	74	2.42	0.15	4.2	0.14	0.54	<.01	0.1
9-B2	-80	100.0	15.0	0.2	14	130	2	10	37	25	370	11	24	330	12	2	19	79	<10	76	2.49	0.17	4.19	0.12	0.58	<.01	0.11
9-B2	-200	110.0	15.0	0.2	6	120	<2	10	39	25	365	9	25	310	12	<2	21	80	<10	76	2.41	0.19	3.97	0.11	0.56	<.01	0.12
9-C2	-35 +80	295.0	30.0	1.4	20	140	10	4	17	17	180	34	10	350	44	<2	24	34	<10	40	1.1	0.08	3.12	0.29	0.27	<.01	0.05
9-C2	-80	not ss	not ss	1.4	22	150	10	7	29	25	280	33	16	410	44	2	28	54	<10	60	1.64	0.13	3.93	0.28	0.44	<.01	0.07
9-C2	-200	not ss	not ss	1.4	20	150	8	8	35	27	315	29	19	420	38	4	29	63	<10	68	1.95	0.16	4.18	0.29	0.51	<.01	0.09
9-C1	\	60.0	\	1.4	10	120	14	<1	3	16	25	16	<1	180	52	<2	20	5	<10	10	0.47	0.01	1.7	0.42	0.05	0.01	0.01
10-A	-80	20	\	2	14	150	<2	3	18	83	50	18	12	1040	12	<2	22	39	<10	58	0.79	0.2	1.85	1.06	0.11	0.01	0.03
10-B1	-35 +80	840.0	30.0	3.2	42	160	10	6	26	785	130	170	12	520	30	2	19	58	<10	84	1.7	0.13	6.17	0.21	0.36	<.01	0.05
10-B1	-80	820.0	30.0	3.4	42	160	10	6	26	727	130	161	13	490	26	2	18	57	<10	80	1.65	0.14	5.88	0.19	0.36	<.01	0.05
10-B1	-200	940.0	30.0	3.4	42	170	14	6	31	722	150	156	15	470	28	2	21	63	<10	78	1.96	0.18	5.87	0.21	0.43	<.01	0.07
10-B2	-35 +80	905.0	30.0	3	60	200	14	5	21	799	160	166	11	520	26	2	20	50	<10	76	1.33	0.12	5.59	0.26	0.31	<.01	0.04
10-B2	-80	1000.0	30.0	3.4	56	220	12	6	24	832	180	171	13	550	30	6	22	56	<10	82	1.43	0.13	5.87	0.26	0.35	<.01	0.05
10-B2	-200	1090.0	30.0	3.4	50	220	14	6	27	745	190	156	15	520	26	6	22	57	<10	76	1.48	0.14	5.45	0.25	0.39	0.01	0.05
10-C2	-35 +80	600.0	30.0	3.4	42	440	10	7	27	1560	160	160	13	800	20	6	36	49	<10	100	1.52	0.16	7.11	0.38	0.36	0.01	0.03
10-C2	-80	770.0	15.0	2.6	32	370	10	7	24	1455	140	130	11	700	16	4	30	45	<10	98	1.29	0.13	6.42	0.32	0.33	0.01	0.03
10-C2	-200	810.0	10.0	3.8	44	460	10	6	26	1290	160	156	13	750	24	6	37	45	<10	92	1.48	0.16	6.4	0.38	0.37	0.01	0.04
10-C1	\	540		2.4	28	160	2	3	6	677	40	232	3	460	14	<2	16	16	<10	44	0.62	0.01	5.37	0.46	0.04	0.01	0.01
av. B & C soils		1364		3.9	52.4	191.5	33.1	6.1	25.8	318.7	233.9	74.2	14.1	704.5	26.4	3.2	22.2	58.2		63.5	1.47	0.15	5.58	0.41	0.36	0.01	0.06
Corr. Au		1.000		0.916	0.768	0.131	0.857	-0.452	-0.173	-0.225	0.034	-0.065	-0.426	0.814	0.406	-0.232	0.058	-0.050		-0.427	-0.459	0.402	0.444	0.527	-0.307		-0.160
Corr. Cu		0.758		0.820	0.752	0.867	0.292	-0.303	-0.137	1.000	-0.436	0.813	-0.543	0.575	-0.158	0.565	0.520	-0.186		0.614	-0.229	0.017	0.859	0.041	-0.166		-0.530
Corr. Mo		0.873		0.871	0.851	0.493	0.238	-0.555	-0.322	0.813	-0.558	1.000	-0.740	0.357	-0.055	0.380	0.110	-0.289		0.346	-0.342	-0.242	0.799	0.005	-0.331		-0.576

Note: not ss = insufficient material for analysis; Corr.=correlation coefficient

APPENDIX 3B: *Analytical results by "Gold plus 32" analytical package. Gold by FA-AA, all others by ICP. Analyses by Chemex Laboratory Ltd., North Vancouver.*

Paleomagnetic Study of the mid-Cretaceous Mount McIntyre pluton, Whitehorse map area (105D), southern Yukon Territory

Mike J. Harris[1], David T.A. Symons[2], W.H. Blackburn[2] and Craig J.R. Hart[3]

HARRIS, M.J.; SYMONS, D.T.A.; BLACKBURN, W.H.; HART, C.J.R., 1997. Paleomagnetic study of the mid-Cretaceous Mount McIntyre pluton, Whitehorse map area (105D), southern Yukon Territory. In: Yukon Exploration and Geology 1996, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 122-130.

ABSTRACT

The paleomagnetic signature of the mid-Cretaceous Mount McIntyre Pluton, west of Whitehorse, was evaluated to develop a better understanding of the motion history of Cordilleran terranes though time. Excluding an anomalous result from the Carmacks Group, all previous tectonic estimates for terranes in the Yukon have been extrapolated from Alaska, British Columbia or the northwestern United States. The Mount McIntyre Pluton (109 Ma) and the adjacent Whitehorse Pluton (112 Ma), are granitic bodies that intrude Triassic and Jurassic sedimentary strata of the Stikine Terrane.

Paleomagnetic measurements on samples from 20 granitic sites yielded three clusters of ChRM directions. Each cluster is specific to a geographical area of the Mount McIntryre pluton. The two most northeasterly sites are from a region of mixed igneous rocks between the Mount McIntyre and Whitehorse Plutons and thus are not considered. The other 11 northern sites give a well-defined mean ChRM direction that is steeply down and northeast. Seven sites in the southern part of the pluton gave a well-defined ChRM direction that is directed steeply down and to the northwest.

The mean paleopole for the southern sites gives an estimate of ~3900 km of northward or poleward translation with no rotation. In contrast, the paleopole for the northern sites in the Mount McIntyre Pluton suggests a poleward translation ~1600 km with ~80° of clockwise rotation. The motion must have occurred between 109 Ma and 45 Ma because earlier studies have shown that Stikine Terrane was fixed with respect to North America by Eocene time.

The southern sites of the Mount McIntyre pluton support an estimate of ~2300 km of northward displacement between ~70 Ma and 45 Ma as derived from the ~70 Ma Carmacks Group volcanics. The result from the northern sites is statistically similar to the value determined for the Whitehorse Pluton, as do several other igneous units in southern British Columbia. Geobarometric estimates, made to determine the nature of any post-crystallization tilting of the pluton, were inconclusive. The contrast in tectonic motion estimates for the northern and southern portions of the Mount McIntyre pluton can be accommodated by a large fault between the portions, but a more definitive explanation requires the accumulation of more paleomagnetic sampling, age dating and structural information.

RÉSUMÉ

Il s'est avéré que la signature paléomagnétique du pluton de Mount McIntyre du milieu du Crétacé, à l'ouest de Whitehorse, permet de mieux comprendre l'évolution dans le temps des mouvements des terranes de la Cordillère. À l'exception d'un résultat anormal du Groupe de Carmacks, toutes les estimations tectoniques précédentes concernant les terranes du Yukon ont été extrapolées à partir de l'Alaska, de la Colombie-Britannique ou du nord-ouest des États-Unis. Le pluton de Mount McIntyre (109 Ma) et le pluton voisin de Whitehorse (112 Ma) sont des corps granitiques qui pénètrent les couches sédimentaires du Trias et du Jurassique du terrane de Stikine.

[1] Department of Earth Sciences, University of Western Ontario, London, ON N6A 5B8, mharris@julian.uwo.ca

[2] Department of Earth Sciences, University of Windsor, Windsor, ON N9B 3P4, dsymons@uwindsor.ca, blackbu@uwindsor.ca

[3] Yukon Geology Program, Government of Yukon, Box 2703 (F-3), Whitehorse, YT Y1A 2C6, cjrhart@yknet.yk.ca

Les mesures paléomagnétiques effectuées sur des échantillons de 20 sites granitiques ont révélé trois groupes de directions ChRM. Chaque groupe est spécifique d'une région géographique du pluton de Mount McIntyre. Les deux sites situés les plus au nord-est appartiennent à une région de roches ignées mixtes gisant entre les plutons de Mount McIntyre et de Whitehorse. Les 11 autres sites septentrionaux donnent une direction moyenne ChRM bien définie qui s'enfonce brusquement vers le nord-est. Sept sites dans la partie méridionale du pluton ont donné une direction ChRM bien définie qui s'enfonce brusquement vers le nord-ouest.

Le paléopôle moyen pour les sites méridionaux indique une translation estimative de quelque 3900 km vers le nord ou le pôle sans rotation. Par ailleurs, le paléopôle pour les sites septentrionaux du pluton de Mount McIntyre indique une translation vers le pôle de quelque 1600 km avec une rotation d'environ 80° dans le sens horaire. Le mouvement a dû se produire il y a entre 109 et 45 Ma car des études antérieures ont révélé que le terrane de Stikine s'est stabilisé dans le contexte nord-américain à l'époque de l'Éocène.

Les sites méridionaux du pluton de Mount McIntyre indiquent un déplacement estimatif de quelque 2300 km vers le nord il y a de 70 à 45 Ma environ, comme il découle de l'étude des roches volcaniques du Groupe de Carmacks datant de quelque 70 Ma. Le résultat provenant des sites septentrionaux est statistiquement similaire à la valeur déterminée pour le pluton de Whitehorse, comme c'est le cas de plusieurs autres unités ignées du sud de la Colombie-Britannique. Les estimations géobarométriques, établies pour déterminer la nature de tout basculement post-cristallisation du pluton, n'étaient pas concluantes. L'écart entre les mouvements tectoniques estimatifs pour les parties nord et sud du pluton de Mount McIntyre s'explique par la présence d'une grande faille entre ces deux régions, mais une explication plus définitive exigerait davantage de données d'échantillonnage paléomagnétique, de données de datation et de données structurales.

Introduction

Paleomagnetism can be used to determine the geotectonic motions of a tectonic plate because rock magnetism in most rocks withstands the effects of time, temperature and pressure better than many other physical properties of rocks. The technique is based on measuring the magnetic directions and intensities of oriented drill core segments in a magnetometer. For rocks which have not been altered, metamorphosed or heated to any significant temperature (i.e. <200°C), the rock usually carries a magnetic remanence that is aligned by the geomagnetic field at the time the rock was formed. In order to determine the paleomagnetic pole for a tectonic element, tens to a few hundred remanence directions are measured from a given rock unit which represents a particular time interval. The data are averaged to obtain a mean direction (declination and inclination) and used to calculate the paleomagnetic pole for that area or tectonic block. This pole can be compared to a coeval pole from an adjacent craton or other tectonic block, and the difference is a measure of the relative tectonic displacement and rotation. Ideally, a number of poles spanning a period of time for a block can be joined to form an apparent polar wander path (APWP) for the block. The path can be compared or fitted to the reference APWP for the adjacent craton or block. Should the resulting paths be similar then no relative motion has occurred. If, however, they define different paths then the relative translation and rotation estimates can be calculated over the time period. Although this type of study has been ongoing in the terranes of the North American Cordillera for over 20 years,

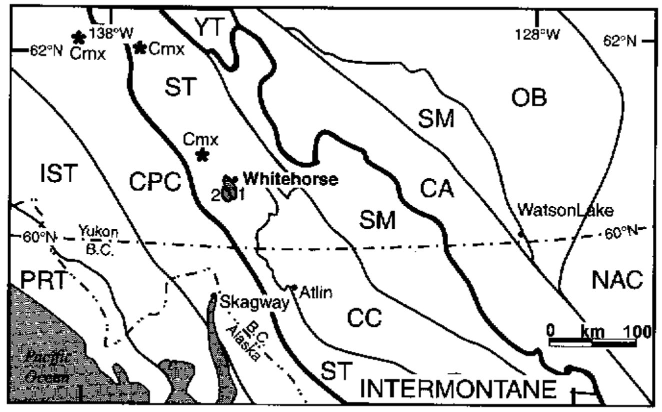


FIGURE 1: Tectonic subdivisions of the northern Canadian Cordillera. NAC - North American craton; OB - Omineca fold belt; CA - Cassiar Terrane; YT - Yukon-Tanana Terrane; Intermontane Superterrane includes SM - Slide Mountain, CC - Cache Creek, ST - Stikine Terrane (all bounded by the thick lines); CPC - Coast Plutonic Complex; IST - Insular superterrane; PRT - Pacific Rim terranes; 1 - Whitehorse Pluton; 2 - Mount McIntyre Pluton; Cmx - Carmacks volcanics paleomagnetic sites.

very few studies have been done in the Yukon. This paleomagnetic study of Mount McIntyre Pluton was undertaken to estimate the tectonic motion of the Stikine Terrane relative to the North American craton since mid-Cretaceous time.

The Mount McIntyre Pluton is a post-tectonic granitic body of mid Cretaceous age that is centred ~14 km southwest of the city of Whitehorse, Yukon Territory (Fig. 1). It is one of several intrusions being studied to examine the geotectonics of the northern Intermontane Superterrane. The Paleomagnetic Laboratory at the University of Windsor has undertaken the study as part of the LITHOPROBE-SNORCLE project (Cook and Erdmer, 1995, 1996).

The paleomagnetism of two units in the northern Intermontane region have been studied previously. One is the ~70 Ma Carmacks Group volcanics (Fig. 1), reported on first by Marquis and Globerman (1988) and subsequently by Johnston et al. (1996) who estimate over 1900±700 km of poleward motion from ~70 Ma to ~45 Ma. This large displacement contrasts with the result from the ~112 Ma Whitehorse Pluton which gave a smaller estimate of 1220±530 km (Harris et al., 1995; Symons et al., 1996; Harris et al., submitted) which is more consistent with studies in the southern Intermontane Superterrane (Monger and Irving, 1980; Symons, 1983; Irving et al., 1995).

The Mount McIntyre Pluton was sampled to obtain a second paleomagnetic estimate for mid- Cretaceous time. The Mount McIntyre Pluton is undeformed and unmetamorphosed as shown by granitoid mineralogy and primary igneous textures. Further, the Mount McIntyre Pluton locally intrudes the Whitehorse Pluton is similarly undeformed and unmetamorphosed, retains a primary remanence and preserves primary temperature and pressure values for its emplacement depth (Harris et al., submitted). Accordingly, we expected that the Mount McIntyre Pluton would show similar characteristics.

GEOLOGY

The Mount McIntyre Pluton was first described by Wheeler (1961) and subsequently remapped and characterised as the defining member of the Mount McIntyre plutonic suite (Hart and Pelletier 1989; Hart and Radloff 1990; Hart 1995).

The Mount McIntyre Pluton intrudes Whitehorse Trough strata of the Upper Triassic Lewes River Group and the Lower to Middle Jurassic Laberge Group, which represent Stikine Terrane in the Yukon. The Lewes River Group includes the Hancock Member, comprising up to 600 m of limestone and minor siltstone, and the overlying Mandanna Member, comprising up to several hundred metres of crystal-rich volcanogenic lithic greywacke and shale with minor red bioturbated siltstone and pebble conglomerate (Hart and Radloff, 1990). In the study area the Laberge Group consists of two interfingering units: a sandstone unit of up to 450 m thick composed of immature feldspar and lithic greywacke, arkose and arenite; and an argillite unit up to 300m thick composed of thin layers of interbedded argillaceous mudstone, siltstone and minor fine-grained sandstone.

Deformation of Stikine Terrane rocks occurred during the Middle Jurassic. The Mount McIntyre pluton apparently intruded into the core of an anticline since bedding contacts generally dip away from the intrusive contacts at angles of 20° to 60°. Subsequent tectonic disturbances were localised and largely limited to strike-slip and normal faulting (Hart and Radloff, 1990).

The Mount McIntyre Pluton shows a wide variation in mineralogy and composition, including granite, quartz monzonite and quartz syenite (Morrison 1981; Hart and Pelletier 1989; Hart and Radloff 1990; Hart 1995). Based on thin sections from each of the 21 paleomag sampling sites (Fig. 2), the main mineral assemblage

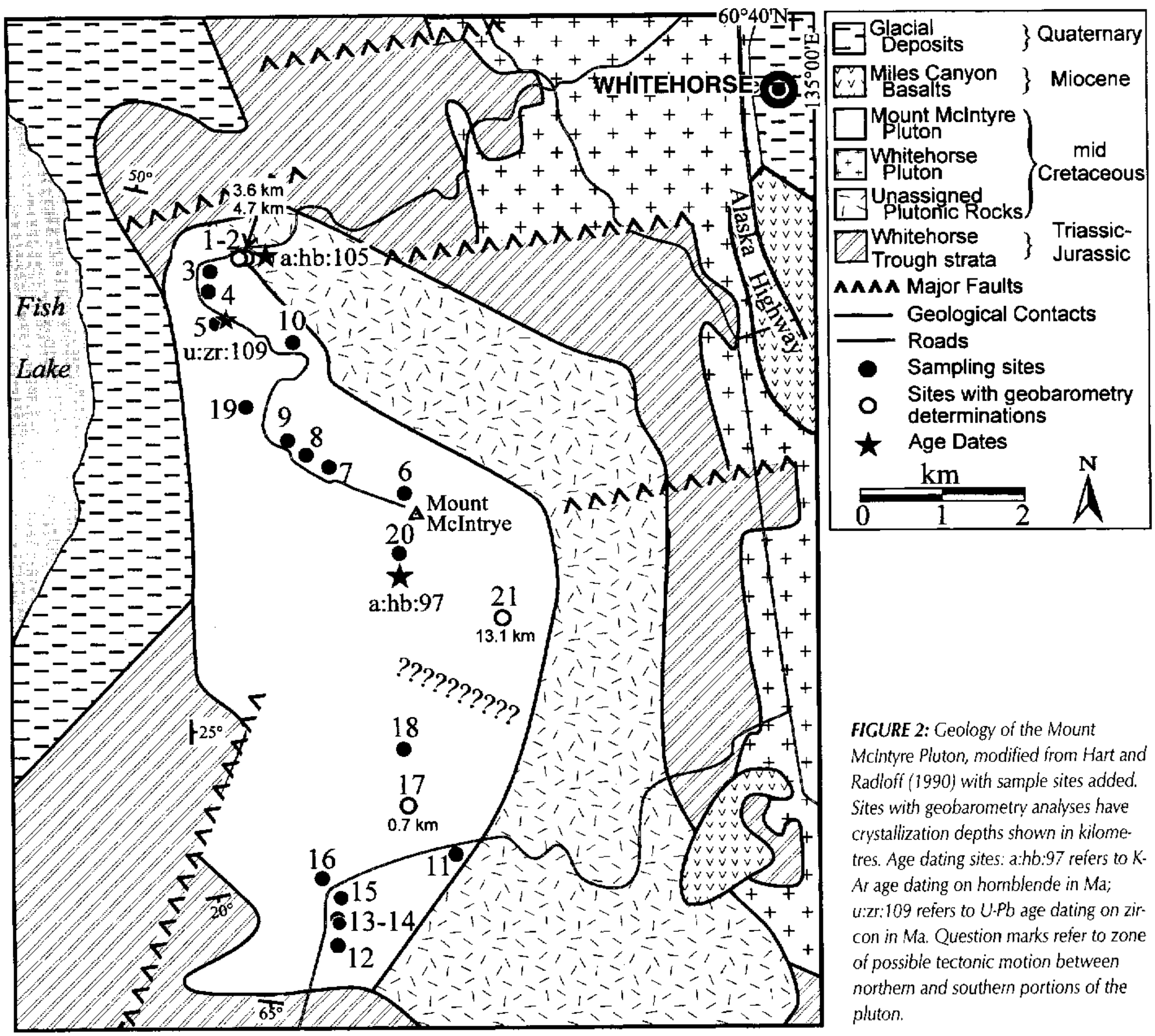


FIGURE 2: Geology of the Mount McIntyre Pluton, modified from Hart and Radloff (1990) with sample sites added. Sites with geobarometry analyses have crystallization depths shown in kilometres. Age dating sites: a:hb:97 refers to K-Ar age dating on hornblende in Ma; u:zr:109 refers to U-Pb age dating on zircon in Ma. Question marks refer to zone of possible tectonic motion between northern and southern portions of the pluton.

is quartz, plagioclase (average An_{18}), microcline, perthite, amphibole and biotite. Clinopyroxene cores within the amphiboles are common. Plagioclase is locally altered to sericite and/or carbonate, whereas amphibole and biotite may be altered to chlorite. The textural and lithological variations, including miarolitic cavities and myrmekitic textures, led Hart (1995) to classify the Mount McIntyre Pluton as epizonal. The eastern margin of the pluton is characterized by a several-kilometre wide "unassigned" zone (Fig. 2) which represents either a marginal phase of the Mount McIntyre Pluton, a hybrid zone between the Mount McIntyre and Whitehorse Plutons or part of the Whitehorse Pluton that was recrystallized by the subsequent intrusion of the Mount McIntyre Pluton.

A concordant U-Pb zircon age of 108.6 +1.2/-0.4 Ma has been determined from the northern section of the pluton (Fig. 2) (Hart 1995). Two K-Ar hornblende age have been determined (Fig. 2). One from the central part of the pluton gave an age of 97.3±3.3 Ma (Morrison et al. 1979). Hart (1995) suggested, on the basis of low whole-rock δO^{18} values (Dagenais, 1984), that this youthful K-Ar age resulted from excessive post-intrusion low temperature hydrothermal alteration of the granite. A second K-Ar determination on hornblende from a sample near sites 01 and 02 in the unassigned plutonic rocks, gave an age of 105±4 Ma (Morrison et al. 1979).

Geothermobarometry

In order for the paleomagnetic data to be interpreted with confidence, the paleohorizontal plane within the rock body should be known to provide a datum from which tectonic-tilt deviations can be calculated. With sediments, bedding planes are generally used, but this is not possible for intrusive rocks. Hence geobarometric techniques are used to calculate the pressures of crystallization for particular mineral assemblages in the plutonic rocks. The horizontal pressure gradient through the pluton is then obtained from which any post-crystallization tilting can be calculated. For granitic plutons, the aluminum-in-hornblende geobarometer is the most convenient system to use because the required mineral and chemical systems are generally available in orogenic granitic rocks. The system is based on measuring the content of aluminum in hornblende crystals because the total aluminum content is directly related to the pressure of crystallization (Hammarstom and Zen, 1986). The experimental techniques are described in detail in Harris et al. (submitted).

Only four sites in the pluton (Fig. 2) were found to have a mineralogy suitable for this technique which assesses possible post-magnetization tilting of the paleohorizontal plane within the pluton. The final temperatures, pressures and calculated depths are given in Table 1. Sites 01 and 02 are situated next to each other at the north end of the pluton (Fig. 2) and give an average value of 1.2 kbar which corresponds to an emplacement depth of ~4.2 km. Site 17 is at the south end of the pluton, and gives a result of 0.2 kbar which equals ~0.7 km depth of intrusion. At the eastern side of the pluton, site 21 gives a much higher pressure of 3.6 kbar, equaling ~13.1 km of depth. Pressures corrections for topographic variation between the sites are 0.1 kbar. The contrasts in geobarometric estimates are discussed later.

Paleomagnetism

As plutonic magmas cool, the magnetism acquired by certain minerals, considered the primary remanence of the rock, is parallel to the geomagnetic field at that time. Magnetite, for example, acquires its stable magnetism between about 580°C and 520°C, depending on the purity of the mineral. Over time a less-stable secondary remanent magnetization component can be superimposed on the primary remanence. In most rocks the secondary direction contrasts with the first because tectonic motions have moved the rock with respect to its original magnetic field. Secondary remanance is commonly similar to the Earth's present magnetic field. In order to remove secondary remanence , the specimens are demagnetized by alternating field (AF) or thermal treatments. In AF treatments, the specimen is exposed to progressively more intense alternating magnetic fields in a series of steps, while in a zero magnetic field with the remaining remanence being measured after each step. The alternating field randomizes the magnetic moments of all the magnetic domains in the specimen that are weaker than the applied field, leaving the generally more stable primary remanent magnetization components unaffected. This method is generally preferred over thermal treatments because of its ease of operation and speed. When AF treatments are not sufficient to isolate the primary remanence, thermal treatments are used. Similar in theory to AF treatments, the specimens are exposed to a series of increasing temperature steps in a zero magnetic field, and their remanence is measured after each step. Although much slower than AF treatments, this

Site	Plag (Ab #)	Amph (Si)	Amph (Al^{TOT})	P (Sch) (kbar) (±1.0kbar)	T (B&H) (°C) (±50°C)	P (A&S) (kbar) (±0.6 kbar)	Depth (km) (±2.2 km)
MM01	22.1	7.1	0.9	0.9	680	1.0	3.6
MM02	22.3	7.1	0.9	1.3	681	1.3	4.7
MM17	3.5	7.2	0.7	0.1	633	0.2	0.7
MM21	17.5	6.2	1.6	5.9	791	3.6	13.1

TABLE 1: *Site averaged compositions of co-existing amphibole and plagioclase edges and thermobarometric data for the Mount McIntyre Pluton. P(Sch) is from Schmidt (1992), T(B&H) is from Blundy and Holland (1992) and P(A&S) is from Anderson and Smith (1995).*

method provides more information on the magnetic minerals that carry the remanence in the specimen.

Twenty-one sites were sampled for paleomagnetic analyses to represent the pluton both spatially and lithologically (Fig. 2). An mafic dike (~1m wide) at site 13 cuts the pluton and was collected with site 14, the dyke's baked zone, to provide a paleomagnetic contact test.

After measuring the natural remnant magnetization (NRM) or the magnetization of the rock before any laboratory treatments are performed, two specimens having average magnetic intensities and directions were selected as pilots for each site. One pilot was demagnetized by AF treatments in 9 steps up to 130 mT, while the other was thermally demagnetized in 10 steps up to 580°C.

Thermal unblocking temperatures of the pilot specimens for most sites are preferentially in the 520° to 565°C range which shows that the dominant magnetic carrier is relatively pure and fine-grained magnetite (Fig. 3a). Minor pyrrhotite is present in a few specimens with unblocking temperatures preferentially between 275° and 325°C (Fig. 3a). The thermal pilot specimens isolate the same population of characteristic remnant magnetization (ChRM) directions as found for the AF pilots. Therefore, for efficiency, all remaining granitoid specimens were AF demagnetized to isolate their ChRM. The mafic dike specimens from site 13 did not lose much intensity with AF treatments, and therefore they were subjected to five thermal steps from 500° to 580°C to further demagnetize them.

Saturation isothermal remnant magnetization (SIRM) testing was performed to determine or provide more details on the magnetic minerals and their respective magnetic domain size. Previously demagnetized specimens are subjected to an isothermal magnetic field for 13 steps up to 900 milliTesla (mT) and its remanence measured after each step. The specimens are then demagnetized with AF treatments in 10 steps to 140 mT. Curves for both procedures are plotted and compared to reference curves(Fig. 3b). SIRM tests on 10 specimens from the Mount McIntyre Pluton augments the thermal demagnetization data. It shows that the dominant magnetic carrier is mostly multidomain to pseudosingle domain magnetite although two specimens (1301, 1501) showed single domain magnetite characteristics.

All 160 granitoid specimens show normal polarity, as expected for a primary remanence in 109 Ma rocks which formed during the Cretaceous normal superchron (~118 to ~84 Ma). Although all of the site mean directions plot in a relatively loose group, there appears to be three separate clusters (Fig. 4a). These clusters reflect a geographic distribution. The sites which show a mean ChRM direction to the northwest (NW) and steeply down (Fig. 4a; Table 2) are all from the south part of the pluton (sites 11-18). The sites which show a mean ChRM direction to the northeast (NE) and steeply down (Fig. 4a; Table 2) are all from the northern part of the pluton (sites 1-10 and 19-21). Site 17 lies in between the two clusters despite its geographical position in the south part of the pluton. For this discussion it is included in the NW cluster. The mean ChRM directions for sites 01 and 02 are directed somewhat more easterly and shallowly than the rest of the sites in the NE cluster, obviously different from the NW cluster (Fig. 4a). An outlier test was used to determine if sites 01 and 02 should be included with the NE cluster. When all 13 site mean directions are averaged they have a circular standard deviation (CSD) of 3.9° about their overall mean. Site mean directions that deviate from the overall mean by more than 3 times the CSD (11.7°) can be excluded as outliers of the population. The mean directions for sites 01 and 02 deviate by 4.5 and 5.6 times the CSD, respectively, and thus may be excluded. The F-statistic of McFadden and Lowes (1981) was used to check to see if the NW and NE clusters of site mean ChRM directions could be from the same population. The

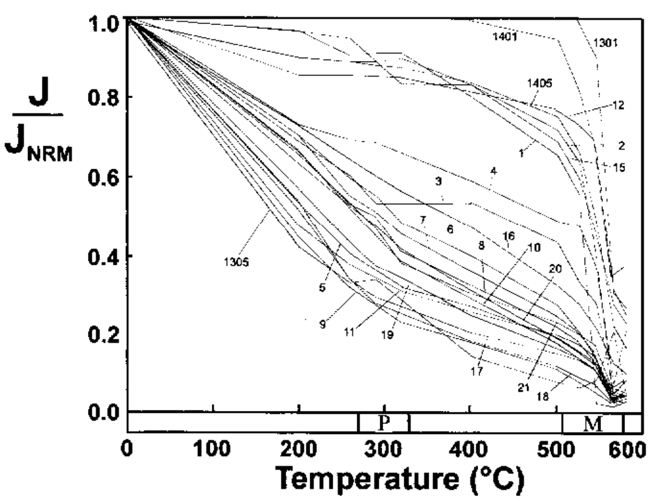


***FIGURE 3-A:** Thermal demagnetization decay curves of thermal pilots for the Mount McIntyre Pluton. Numbers refer to the site (and core) of the treated specimen. The preferential unblocking temperatures diagnostic of pyrrhotite and magnetite are indicated at the bottom by the P and M respectively.*

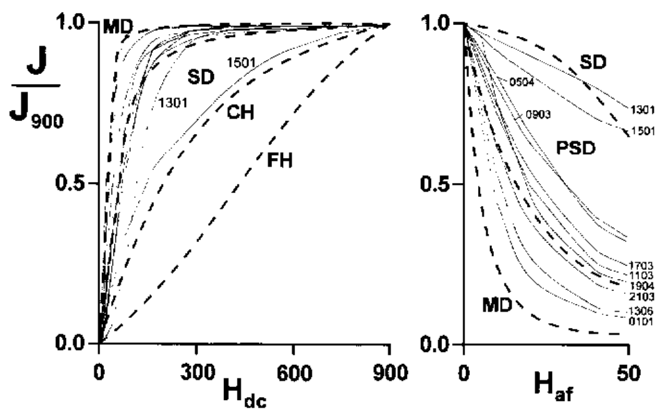


***FIGURE 3-B:** SIRM acquisition (right) and decay (left) curves. H_{dc} and H_{af} axes measured in mT. MD - multidomain magnetite; SD - single domain magnetite; CH - coarse grained hematite; FH - fine grained hematite; PSD - psuedosingle domain magnetite.*

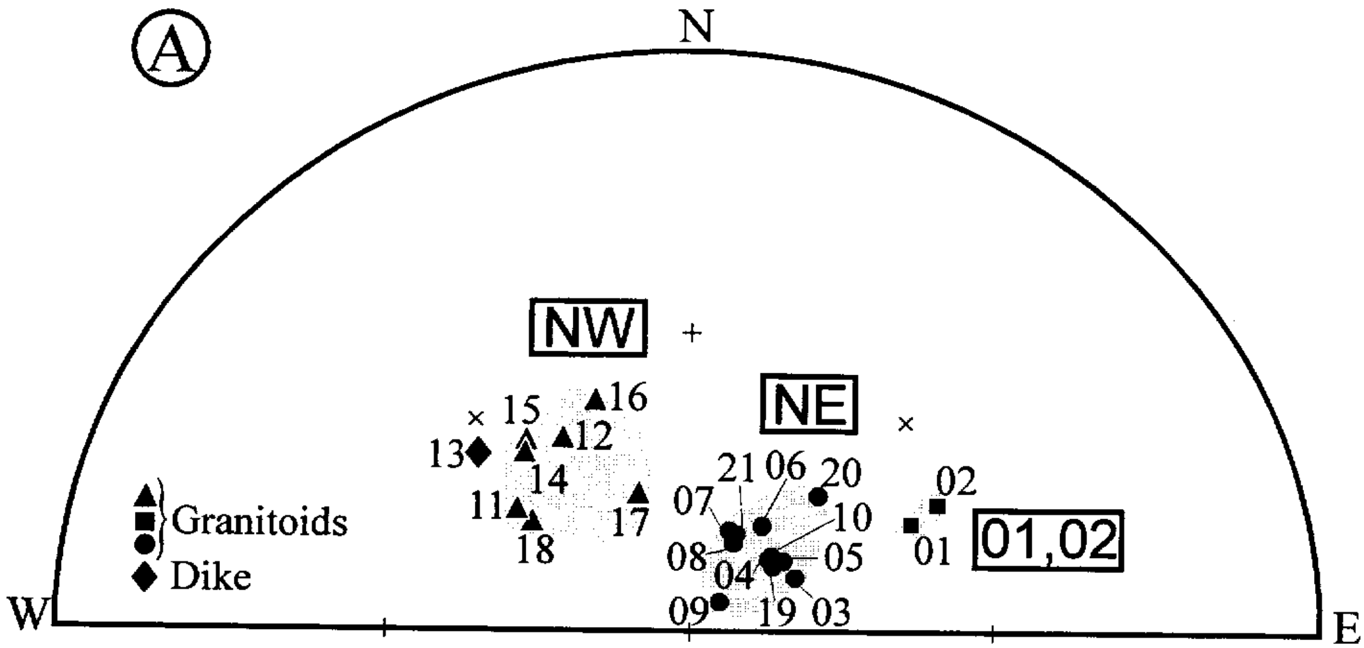
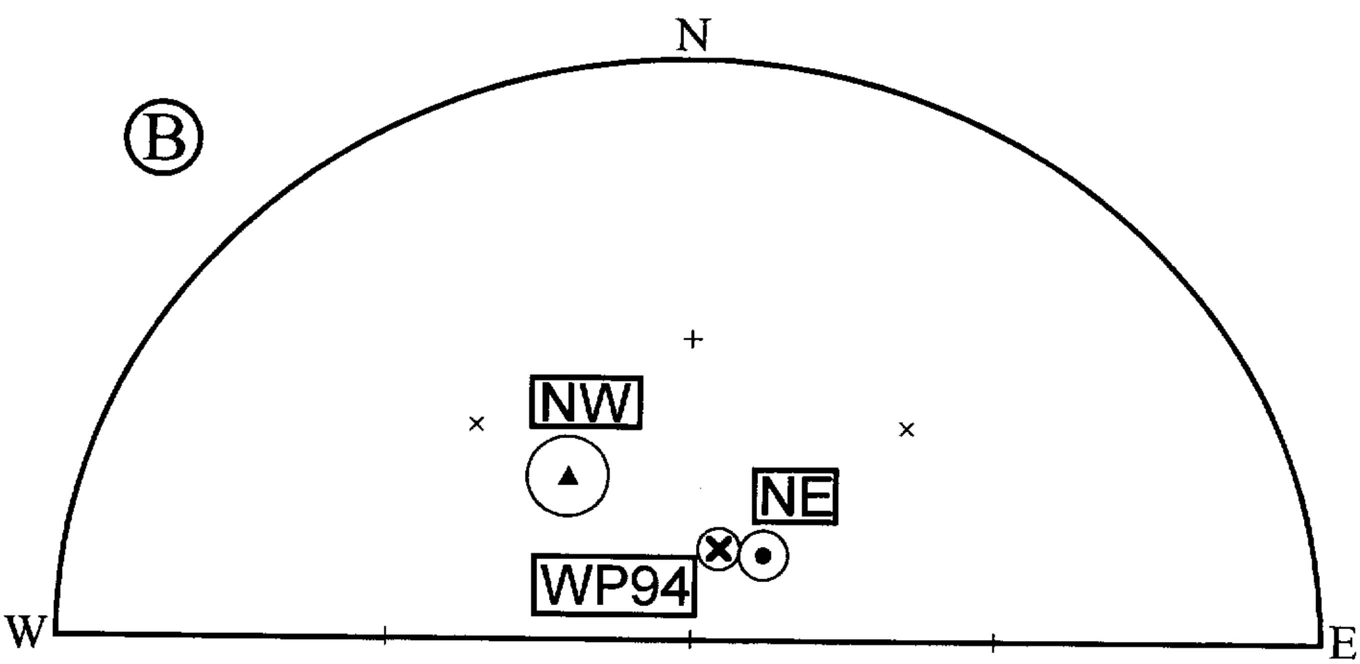


***Figure 4:** Equal area stereonet plots of; a) site mean ChRM directions and b) cluster mean ChRM directions with their respective 95% cone of confidence. NW - northwest cluster; NE - northeast cluster; 01,02 - sites 01 and 02; WP94 - pluton mean ChRM direction of the Whitehorse pluton.*



statistic shows that there is a significant difference at the 95% confidence level between the two clusters because the calculated F-statistic is greater than the tabulated comparison value (i.e. NW/NE: F_{stat}=4.57/F_{tab}=3.32). Therefore it is concluded that the NW cluster of ChRM directions cannot be drawn from the same population as the NE cluster and that they should be considered separately (Fig. 4b).

Site 13 is in an ~1 m wide mafic dike that was collected as a paleomagnetic contact test. The dike gives a similar site mean ChRM direction to the NW cluster of granitoids (Fig. 4; Table 2) although the specimen ChRM directions are not tightly clustered with an α_{95} of 10.4°. About one-quarter of the specimens give reversed remanence directions, however the site fails the reversal test because they are not antiparallel to the normal directions. The dike's baked zone was collected as site 14 and it gives an almost identical mean ChRM direction to the dike with both means fitting into the NW cluster of site mean ChRM directions (Fig. 4; Table 2). The finding of the same ChRM direction for the dike, baked zone and host rock results in the conclusion that the contact test is negative. This implies that either the dike is about coeval with the host pluton or that both were remagnetized by some process after the dike was emplaced.

DISCUSSION

As previously discussed, sites 01 and 02 give ChRM directions that are distinct from the other sites. In thin sections, rocks from these sites contain less quartz and potassium feldspar, but more plagioclase and mafic minerals than the rest of the sites in the Mount McIntyre Pluton. These two sites also appear to be recrystallized. Geobarometry from these two sites (~1.2 kbar) is similar to the values reported for the Whitehorse Pluton (~1.9 kbar, Harris et al., submitted) but is not supported by pressures found at sites 17 and 21. In addition, the NRM intensities of sites 01 and 02 are about half an order of magnitude higher, with a median of ~1.0E-3 emu compared to the median of 7.0E-4 emu for the other northern sites. These sites are within the zone of unassigned plutonic rocks between the Mount McIntyre Pluton and the Whitehorse Pluton, and are not considered further.

The geothermobarometry data from the two other sites in the Mount McIntyre Pluton does not correlate well either with each other or with the Whitehorse Pluton. Site 17 to the south gave very poor results with only one of four sets of analyses giving useful data and it gives a very low positive pressure of 0.2 kbar. In contrast, site 21 gives a much higher pressure of 3.6 kbar. Since sites 17 and 21 within the Mount McIntyre Pluton are separated by only ~3 km,

		Demagnetizing Range		Mean Direction				
Site	n/N	Lo Step mT/°C	Hi Step mT/°C	Dec	Inc	α_{95}	k	Comment
1	8/8	35/400	100/580	62.8	53.8	3.2	304	undiff. Int.
2	11/11	20/400	100/580	61.7	48.9	2.3	393	undiff. Int.
3	6/6	30/400	80/580	60.7	72.6	4.6	212	NE group
4	6/6	30/400	100/580	45.3	74.1	2.1	998	NE group
5	6/6	30/400	80/580	50.9	72.9	3.5	376	NE group
6	8/8	30/400	80/580	32.7	71.2	3.9	204	NE group
7	7/7	30/400	80/580	19.7	73.7	4.4	189	NE group
8	8/8	30/400	60/580	24.4	75.3	3.8	220	NE group
9	7/8	30/400	60/565	41.0	83.6	7.3	70	xenolith/NE
10	9/9	35/400	100/580	45.1	73.9	3.8	181	NE group
11	10/11	30/400	80/565	304.7	58.5	5.4	82	NW group
12	11/11	40/400	120/580	326.8	56.4	2.7	288	NW group
13	14/17	20/500	70/580	310.8	49.0	10.4	23	dike
14	8/9	35/400	100/580	316.8	54.5	4.1	187	baked zone/NW
15	6/7	35/400	100/580	319.1	53.1	7.6	78	NW group
16	6/6	20/400	100/580	338.3	53.5	15.5	20	NW group
17	9/9	30/400	80/565	340.7	68.6	5.5	89	NW group
18	7/8	30/525	80/580	304.3	61.3	10.2	36	NW group
19	6/6	30/400	80/580	49.4	74.5	4.0	280	NE group
20	7/7	30/400	80/545	41.9	62.3	8.3	54	NE group
21	8/9	40/400	120/545	23.8	73.7	2.6	443	NE group
Overall	18/21			356.6	72.5	7.6	22	
NW Group	7/21			321.1	58.6	6.9	78	
NE Group	11/21			39.8	73.8	3.4	178	

***TABLE 2:** Site-averaged paleomagnetic data for the Mount McIntyre Pluton. n/N are the number of specimens used in the average from the number of specimens measured; Lo and High Steps refer to the range of demagnetizing steps included in the average; Dec=declination, Inc=inclination in degrees; α_{95}=radius of the cone of 95% confidence ; k= precision parameter of Fisher, 1953.*

tectonic accommodation of these geobarometric results would require the pluton to have been tilted by 80° upwards to the northeast. This is geologically unrealistic because the host rock bedding has not been shown to have a tilt of more than 60° (Hart and Radloff, 1990) and because the neighbouring Whitehorse Pluton has been shown to have negligible tilt (Harris et al., submitted). Therefore, either considerable low temperature hydrothermal alteration has disturbed the hornblende-plagioclase mineral chemistry, or an unmapped fault with substantial (~12 km) vertical motion, or rotation lies between the northern sites and the southern sites.

The discordance in site mean ChRM directions between the southern and northern parts of the Mount McIntyre Pluton is also difficult to explain since differences in their mineralogy or magnetic mineral characteristics are not apparent. The only notable difference is that the seven southern sites have a lower median NRM intensity of ~8.0E-05 whereas the median value of ~7.0E-04 for the northern sites is an order of magnitude greater. Possible causes for the difference between the mean ChRM directions from the southern and northern sites include: 1) the southern part of the pluton is an older second pluton; and, 2) the southern part of the Mount McIntyre Pluton has been steeply tilted along a fault that may lie between the two parts of the pluton.

The mean ChRM directions for the NE and NW clusters as well as the combined mean were used to calculate possible tectonic motions of the Mount McIntyre Pluton, with an assumption of no post-emplacement tilting. The NE mean ChRM direction from the northern sites of the pluton corresponds to a paleopole situated at 299.6°E, 70.5°N (α_{95} = 3.4°, d_p=5.5, d_m=6.1). This pole is compared to the 109 Ma reference pole for the North American craton of 194°E, 70.5°N (α_{95} = 5.2°) that is interpolated from the APWP of Besse and Courtillot (1991). From this comparison it is estimated that the pluton has been translated polewards or northwards by 14.3°±5.0° and rotated clockwise 79°±16°. Thus the northward translation is calculated to be 1590±550 km relative to North America at an average rate of 2.5±0.9 cm/a from 109 Ma to 45 Ma (Table 3). These values for northward motion and rotation are statistically the same as those calculated for the Whitehorse Pluton (Table 3; Harris et al. submitted) and for several other studies done in the southern Intermontane Superterrane (Monger and Irving 1980; Symons 1983; Irving et al. 1995).

The NW mean ChRM direction from the southern sites of the pluton corresponds to a paleopole of 111.1°E, 57.9°N (α_{95} = 6.9°, d_p=7.6, d_m=10.2). This pole shows virtually no rotation and ~3900 km of poleward motion over a 74 Ma time period from 109 Ma to 45 Ma at an average rate of 6.0 cm/a (Table 3). This is much greater than the estimate obtained from the Whitehorse Pluton and other units in the southern Intermontane region, but it does correlate better with the very fast rate of 9.2 cm/a derived from the Carmacks Group volcanics for the interval between 70 and 45 Ma (Table 3).

The combined mean for the two clusters of site mean ChRM directions from the Mount McIntyre Pluton, if it is assumed that more sampling would infill the gap between them to form only one population, corresponds to a paleopole of 79.4°E, 86.8°N (α_{95} = 7.6°, d_p=12.0, d_m=13.5). When this paleopole is compared to the reference pole, it gives an estimate of ~2500 km of poleward motion with ~27° of clockwise rotation (Table 3). The average rate of motion and translation distance are about twice those obtained from the Whitehorse Pluton. If the combined Mount McIntyre pole is compared to the Carmacks Group's pole, then it implies that the terranes in the northern Intermontane region barely moved for the period from 109 Ma to ~70 Ma and then raced northward at ~9.2 cm/a between ~70 Ma and 45 Ma.

In summary, the Mount McIntyre Pluton paleomagnetic and geobarometric results are not conclusive. The paleomagnetic results

Unit	Age	Paleolatitude/ Translation[1]	Average Rate of Motion[2]	Rotation[1]	Reference
Carmacks Group volcanics	70 Ma	20.6°±7.4° N 2290±650 km	9.2±2.6 cm/a	20°±10° CW	Johnston et al., 1996
Mount McIntyre Pluton	109 Ma	14.3°±5.0° N 1590±550 km	2.5±0.9 cm/a	79°±16° CW	NE Group sites 3-10, 19-21
		34.8°±6.9° N 3870±770 km	6.0±1.2 cm/a	1°±17° CW	NW Group sites 11,12, 14-18
		22.1°±7.4° N 2450±820 km	3.8±1.3 cm/a	27°±18° CW	combined groups sites 3-12, 14-21
Whitehorse Pluton	112 Ma	11.0°±4.8° N 1220±530 km	1.8±0.8 cm/a	59°±17° CW	Harris et al., 1996

[1] Calculations are from Butler (1992, Appendix A) with reference poles interpolated from Besse and Courtillot (1991).
[2] Rate calculated by dividing the translation distance by the unit age less the accretion age (45 Ma; Irving et al. 1996).

Table 3: *Displacements of mid to Late Cretaceous rock units in the southern Yukon.*

from the northern sites of the pluton give translation and rotation estimates for Stikine Terrane and the amalgamated Intermontane terranes that support the estimates obtained from the Whitehorse Pluton and from several studies in the southern Intermontane region. On the other hand, the estimates obtained from the southern sites of the pluton give results that are discordant with those from the northern sites but are closer to those from the Carmacks Group volcanics. More paleomagnetic sampling and geobarometric analyses would be needed to obtain a better spatial coverage to strengthen the Mount McIntyre Pluton data. Age dates from the southern part of the pluton may limit the options and help in solving some of the conflicting results. Also, other sorts of petrophysical or geophysical evidence could lead to the detection of faults which may account for the paleomagnetic and geobarometric inconsistencies between the two parts of the pluton.

REFERENCES

Anderson, J.L., and Smith, D.R. 1995. The effects of temperature and fo_2 on the Al-in-hornblende barometer. American Mineralogist, v. 80, p. 549-559.

Besse, J., and Courtillot, V. 1991. Revised and synthetic apparent polar wander paths of the African, Eurasion, North American and Indian Plates, and true polar wander since 200 Ma. Journal of Geophysical Research, v. 96, B3, p. 4029-4050.

Blundy, J.D., and Holland, T.J.B. 1990. Calcic amphibole equilibria and a new amphibole-plagioclase geothermometer. Contributions to Mineralogy and Petrology, v. 104, p. 208-224.

Butler, R.F. 1992. Paleomagnetism: Magnetic Domains to Geologic Terranes. Blackwell Scientific Publications, Boston.

Cook, F. and Erdmer, P., eds, 1995. Slave-Northern Cordillera Lithospheric Evolution (Snorcle) Transect and Cordilleran Tectonics Workshop Meeting, University of Calgary. Lithoprobe Report No. 44.

Cook, F. and Erdmer, P., eds, 1996. Slave-Northern Cordillera Lithospheric Evolution (Snorcle) Transect and Cordilleran Tectonics Workshop Meeting, University of Calgary, Lithoprobe Report No. 50.

Dagenais, G.R., 1984. The oxygen isotope geochemistry of granitoid rocks from southern and central Yukon. M.Sc. thesis, University of Alberta, 170 p.

Fisher, R.A., 1953. Dispersion on a sphere. Proceedings of the Royal Astonomical Society of London, v. A217, p. 295-305.

Hammarstrom, J.M., and Zen, E., 1986. Aluminium in hornblende: An empirical igneous geobarometer. American Mineralogist, v. 71, p. 1297-1313.

Harris, M.J., Symons, D.T.A., and Hart, C.J.R. 1995. Paleomagnetism of the Cretaceous Whitehorse and Mount McIntyre Plutons, Stikinia Terrane, Yukon Territory. In: F. Cook and P. Erdmer (eds), Slave-Northern Cordillera Lithospheric Evolution (SNORCLE) Transect and Cordilleran Tectonics Workshop Meeting 1995, University of Calgary, Lithoprobe Report No. 44: p. 92-96.

Harris, M.J., Symons, D.T.A., Blackburn, W.H. and Hart, C.J.R., submitted. Paleomagnetic and geobarometric study of the mid Cretaceous Whitehorse Pluton, Yukon Territory. Canadian Journal of Earth Sciences.

Hart, C.J.R. 1995. Magmatic and tectonic evolution of the Intermontane Superterrane and Coast Plutonic Complex in southern Yukon Territory. M.Sc. thesis, University of British Columbia, Vancouver, 196 p.

Hart, C.J.R., and Pelletier, K.S. 1989. Geology of Whitehorse (105D/11) map area. Exploration and Geological Services, Indian and Northern Affairs Canada, Yukon Region, Open File 1989-2.

Hart, C.J.R., and Radloff, J.K. 1990. Geology of Whitehorse, Alligator Lake, Fenwick Creek, Carcross and part of Robinson map areas (105D/11, 6, 3, 2 & 7). Exploration and Geological Services, Indian and Northern Affairs Canada, Yukon Region, Open File 1990-4.

Irving, E., Thorkelson, D.J., Wheadon, P.M., and Enkin, R.J. 1995. Paleomagnetism of the Spences Bridge Group and northward displacement of the Intermontane Belt, British Columbia: A second look. Journal of Geophysical Research, v. 100, B4, p. 6057-6071.

Irving, E., Wynne, P.J., Thorkelson, D.J., and Schiarizza, P., 1996. Large (1000 to 4000 km) northward movements of tectonic domains in the northern Cordillera, 83 to 45 Ma. Journal of Geophysical Research, v. 101, B8, p. 17901-17916.

Johnston, S.T., Wynne, P.J., Francis, D., Hart, C.J.R., Enkin, R.J., and Engebretson, D.C., 1996. The Whitehorse hotspot: The Late Cretaceous Carmacks Group. In: F. Cook and P. Erdmer (eds), Slave-Northern Cordillera Lithospheric Evolution (Snorcle) Transect and Cordilleran Tectonics Workshop Meeting 1996, University of Calgary, Lithoprobe Report No. 50: p. 117.

Marquis, G., and Globerman, B.R. 1988. Northward motion of the Whitehorse Trough: paleomagnetic evidence from the Upper Cretaceous Carmacks Group. Canadian Journal of Earth Sciences, v. 25, p. 2005-2016.

McFadden, P.L., and Lowes, F.J., 1981. The discrimination of mean directions drawn from Fisher distributions. Geophysical Journal of the Royal Astronomical Society, v. 67, p. 19-33.

Monger, J.W.H., and Irving, E. 1980. Northward displacement of north-central British Columbia. Nature, v. 285, p. 289-294.

Morrison, G.W. 1981. Setting and origin of skarn deposits in the Whitehorse Copper Belt, Yukon. Ph.D. thesis, University of Western Ontario, London.

Morrison, G.W., Godwin, C.I., and Armstrong, R.L. 1979. Interpretation of isotopic ages and $^{87}Sr/^{86}Sr$ initial ratios for plutonic rocks in the Whitehorse map area, Yukon. Canadian Journal of Earth Sciences, v. 16, p. 1988-1997.

Schmidt, M.W. 1992. Amphibole composition in tonalite as a function of pressure: an experimental calibration of the Al-in-hornblende barometer. Contributions to Mineralogy and Petrology, v. 110, p. 304-310.

Symons, D.T.A. 1983. Further paleomagnetic results from the Jurassic Topley intrusions in the Stikinia subterrane of British Columbia. Geophysical Research Letters, v. 10, p. 1065-1068.

Symons, D.T.A, Harris, M.J., Blackburn, W.H., and Hart, C.J.R. 1996. Paleomagnetic determination of the geotectonic displacement of the northern Intermontane, Yukon: Progress report and preliminary results from the Whitehorse pluton. In: F. Cook and P. Erdmer (eds), Slave-Northern Cordillera Lithospheric Evolution (SNORCLE) Transect and Cordilleran Tectonics Workshop Meeting 1996, University of Calgary. Lithoprobe Report No. 50: p. 118-131.

Tarling, D.H. 1983. Paleomagnetism, Principles and Applications in Geology, Geophysics and Archaeology. Chapman and Hall, New York.

Wheeler, J.O. 1961. Whitehorse map-area, Yukon Territory. Geological Survey of Canada, Memoir 312, 156 p.

Geology and geochemistry of the Teslin Crossing Pluton: A gold-rich alkalic porphyry target

Craig J.R. Hart
Yukon Geology Program

HART, C.J.R., 1997. Geology and geochemistry of the Teslin Crossing Pluton: A gold-rich alkalic porphyry target. In: Yukon Exploration and Geology 1996, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 131-137

ABSTRACT

The Teslin Crossing Pluton is a small (~75 km^2), elliptical body which intrudes Jurassic Whitehorse Trough strata of Stikine Terrane. The pluton consists of a border phase, a lithologically and texturally complex central phase, and associated sills and dyke swarms. The border phase consists of a grey, crowded hornblende-plagioclase porphyry. The central phase.consists of pink, medium to coarse grained, equigranular monzonite and syenite. Pyroxene and hornblende are essential constituents. Abundant accessory minerals include magnetite (up to 5%), titanite, apatite, rutile and zircon. Modal quartz is absent. Dykes and sills have compositions similar to the border phase. All phases contain a large amount of pea- to cobble-sized xenoliths including coarse-grained pyroxenite, coarse-grained gabbro and fine-grained diorite. The border phase also include sedimentary xenoliths. Locally there are zones of brecciation and potassic alteration.

Geochemically the pluton is alkalic with 3.1-4.3% K_2O, 60-68% SiO_2 and minor normative quartz. Most rocks are metaluminous but more evolved phases are slightly peraluminous. The pluton is classified as a slightly silica-saturated, pyroxenite-associated syenite. New and existing collections of macrofossils from the sedimentary rocks adjacent to the pluton indicate an age range of Pliensbachian to Aalenian, and provide a maximum age constraint for the pluton. A preliminary U-Pb date from the sill complex yields an age of approximately 175 Ma which is younger than the K-Ar ages of 181-186 Ma from the pluton. The Teslin Crossing pluton is an Early Jurassic alkalic plutonic complex in Stikine Terrane, and as such, is an excellent target for gold-rich, porphyry copper mineralization.

RÉSUMÉ

Le pluton de Teslin Crossing est un petit corps elliptique (Ç75 km^2) qui pénètre les couches de la charnière synclinale jurassique de Whitehorse du terrane de Stikine. Le pluton comprend une bordure, un centre complexe sur les plans de la lithologie et de la texture, ainsi que des sills et des groupes de dykes associés. La bordure est constituée de porphyre gris chargé de hornblende et de plagioclase. Le centre est constitué de monzonite et syénite équigranulaires roses à grain moyen à grossier. Le pyroxène domine dans certaines phases, et le hornblende dans d'autres. Les minéraux accessoires abondent : magnétite (jusqu'à 5 %), monazite, apatite, rutile et zircon. Aucun quartz. Les dykes et les sills ont des compositions semblable à celle de la bordure. Toutes les phases contiennent beaucoup de xénolithes dont la taille va de celle de petits pois à celle de cailloux; il s'agit depyroxénite à gros grain, de gabbro à gros grain et de diorite à grain fin. La bordure contient aussi des xénolithes sédimentaires. On trouve par endroits des zones de bréchification et d'altération potassique.

Géochimiquement, le pluton est alcalin, contenant de 3,1 à 4,3 % de K_2O, de 60 à 68 % de SiO_2 et un peu de quartz normatif. la plupart des phases sont métalumineuses, mais les phases les plus évoluées sont hyperalumineuses. Le pluton est classé comme une syénite saturée en silice et associée à la pyroxénite. Les collections nouvelles et existantes de macrofossiles provenant de l'ensemble de roches sédimentaires adjacentes au pluton indiquent que ce dernier se situe entre le Pliensbachien et l'Aalénien et permettent d'en fixer l'âge maximal. Une première datation U-Pb du complexe de sills situe l'âge du pluton à 175 Ma environ, ce qui est plus récent que les quelque 181 à 186 Ma de la datation Kar. Le pluton de Teslin Crossing est un complexe plutonique alcalin du Jurassique précoce du terrane de Stikine, constituant ainsi une excellente cible pour une minéralisation de cuivre porphyrique riche en or.

INTRODUCTION

Gold-rich porphyry copper deposits in the Canadian Cordillera are associated with latest Triassic and Early Jurassic alkalic intrusives of Stikinia and Quesnellia (Barr et al., 1976, McMillan et al., 1995; Lang et al., 1995). However, deposits have only been found in British Columbia and none have been discovered north of the Stikine River at 58°N latitude. The reason for this incongruity is uncertain considering that large portions of Stikinia, and lesser Quesnellia, are exposed in southern Yukon (Wheeler et al., 1991).

The Teslin Crossing pluton (NTS 105E/7; 61°20'N, 134°48'W) pluton is located 65 km north-northeast of Whitehorse between Lake Laberge and the Teslin River (Fig. 1). The pluton is 10 km north-northwest from the point where the Livingston winter road crosses the Teslin River. The pluton was identified by Tempelman-Kluit (1984) as a Middle Jurassic stock of monzonite, syenite and granite. The pluton hosts a small copper porphyry showing known as the TUV (Yukon Minfile 105E 002; Pangman and VanTassell, 1972). As such, this pluton is considered a possible candidate for the gold-rich Early Jurassic alkalic suite. In order to confirm this candidacy, the alkalic geochemistry and an Early Jurassic age must be confirmed.

Maps and available fossil data from the host sedimentary rocks surrounding the pluton indicate a Toarcian or Aalenian depositional age. Existing K-Ar dates younger from the pluton and allied rocks range from 164 to 186 Ma. The petrology of the Teslin Crossing pluton was the focus of a thesis by Pangman (1973).

This paper reports on the findings of a reconnaissance geological investigation. The geochemistry of the pluton is documented. The potential age of the Teslin Crossing pluton is evaluated in light of existing data, and a new, but preliminary isotopic constraint. The paleomagnetic character of the pluton is currently being evaluated by Dr. David Symons and Mike Harris at the University of Windsor, as part of a Lithoprobe-SNORCLE funded program.

TECTONIC SETTING AND REGIONAL GEOLOGY

Much of the Canadian Cordillera is a composite of crustal fragments, or terranes, of uncertain origin which accreted to the ancient margin of North America during the Middle Jurassic. The largest terrane underlying the Intermontane region of the Cordillera is Stikinia. Stikinia consists of an Upper Paleozoic volcanic arc basement upon which the Lewes River volcanic arc was built during the Middle and Late Triassic. Detritus from the uplifted arc accumulated up to seven kilometres of strata in the adjacent marginal basin through to Middle Jurassic time. This basin, known as the Whitehorse Trough, is composed of Late Triassic volcanic-rich detritus and carbonate of the Lewes River Group and Jurassic intrusive-rich clastics of the Laberge Group. The Whitehorse Trough was closed from the open ocean during amalgamation with Cache Creek Terrane and accretion to North America. This process also resulted in the deformation of the Whitehorse Trough and Lewes River arc strata.

The Teslin Crossing Pluton forms an isolated body which intrudes a thick sequence of Whitehorse Trough strata near the axial portion of the basin (Fig. 1). Although an array of associated dykes, sills and small stocks occur along a 15 km-long region northwest of the pluton and at Tanglefoot and Porphyry mountains 20 km south of Carmacks, the pluton is not part of an extensive plutonic suite

The pluton's host rocks are dominated by fissile, black, well-bedded, carbonaceous, variably limy, poorly-indurated shale and siltstone with lesser, thin chert-rich sandstone beds. Coally fragments are common in some horizons; fossil ammonites and bivalves are sparse. The strata were assigned to the Middle Jurassic Tanglefoot Formation (Tempelman-Kluit, 1984). These strata occur within a large, irregularly-shaped block that is faulted against dominantly older strata. The eastern margin of the fault block, and the pluton, are cut by younger north and north-northwesterly faults the largest is the southerly continuation of the Chain Fault (Tempelman-Kluit, 1984). There are no known volcanic rocks associated with the Teslin Crossing Pluton but Aalenian-aged, water-lain acid tuff and fine volcaniclastic breccia observed ten kilometres north-northwest of the pluton (Poulton and Tipper, 1991, p. 23) may have be genetically related.

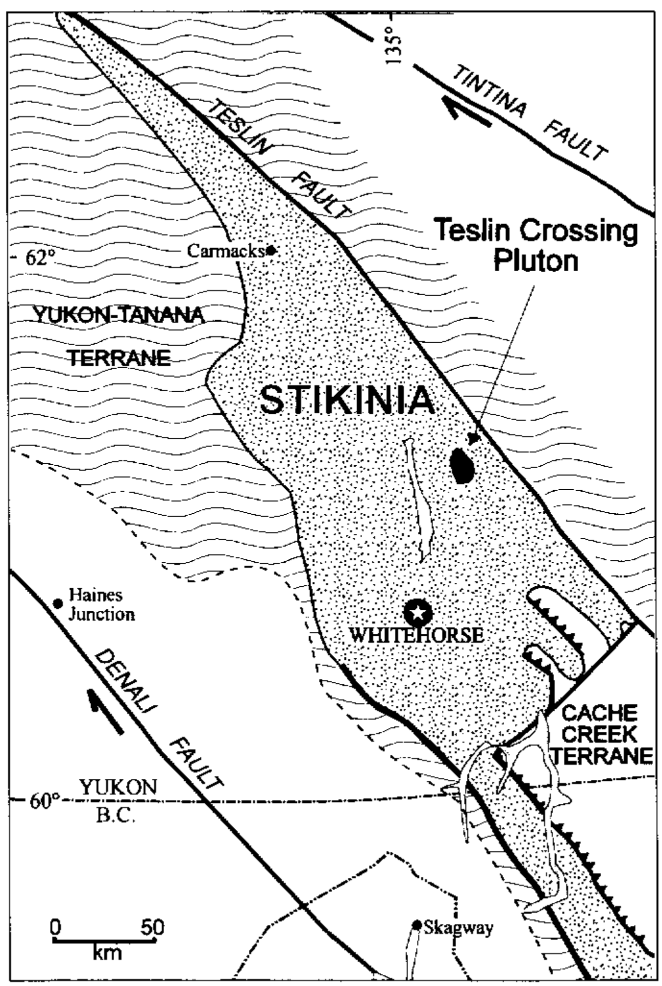


FIGURE 1: Location and tectonic setting of the Teslin Crossing Pluton

Geology of Teslin Crossing pluton

Although it forms a high-standing topographic region relative to the surrounding area, the physiography of the pluton is subdued with broad rounded ridges and knobby plateaus above treeline at approximately 4500'. The peak, at 4867', is informally known as Windy Mountain. The pluton weathers to form pink-orange soil. Most outcrops are on the south-facing slopes.

The Teslin Crossing pluton is a slightly elliptical body with exposed surface dimensions of 8.5 x 7 kilometres. However, the pluton's strong positive magnetic signature indicates a slightly greater, though unexposed extent of 12 x 8 kilometres (Fig. 2). The pluton intrudes shallowly-dipping Laberge Group siltstone and shale except along its eastern margin where it is in fault contact with Lewes River Group carbonate. Country rocks immediately adjacent to the pluton dip steeply away from it. Contacts are irregular and locally follow (or control) topography.

Central Phase

The pluton consists of a central phase, a border phase and associated dyke swarms and sill complexes (Fig. 2). The central phase is characterized by pink, medium- to coarse-grained, equigranular monzonite and syenite. Three main lithologies are recognize:

1) The dominant lithology is a medium to light grey-pink monzonite characterized by the presence of fine-grained hornblende (Fig. 3a). A typical rock is composed of 40% euhedral medium-grained, plagioclase set in a matrix of finer-grained orthoclase and slightly chloritized hornblende. Petrographically, hornblende is anhedral and associated with magnetite. Biotite is rare but oxidized. Plagioclase is strongly zoned. This phase contains xenoliths. Alteration along numerous hairline fractures imparts a lighter pink colour to this rock.

2) The secondary lithology is leucocratic, tan-pink syenite and characterized by a complete lack of mafic minerals. It is composed almost entirely of equigranular orthoclase with 5-10%, slightly pink euhedral plagioclase (Fig. 3b). Fine and medium grained phases occur although plagioclase is always slightly larger and randomly distributed within the alkalic matrix. Locally plagioclase is strongly zoned, sausseritized and greenish. This phase cuts the first but is cut by dykes of fine-grained alkali feldspar syenite. Xenoliths are rare in this phase.

3) A much less extensive lithology, which occurs as small stocks (~200 m^2) and dykes, consists of leucocratic, light pink, coarse-grained, equigranular alkali feldspar syenite (Fig. 3c). It is composed of 90% orthoclase, 6% euhedral, lath-like hornblende, a few percent plagioclase, and 1% coarse (1 mm) magnetite crystals.

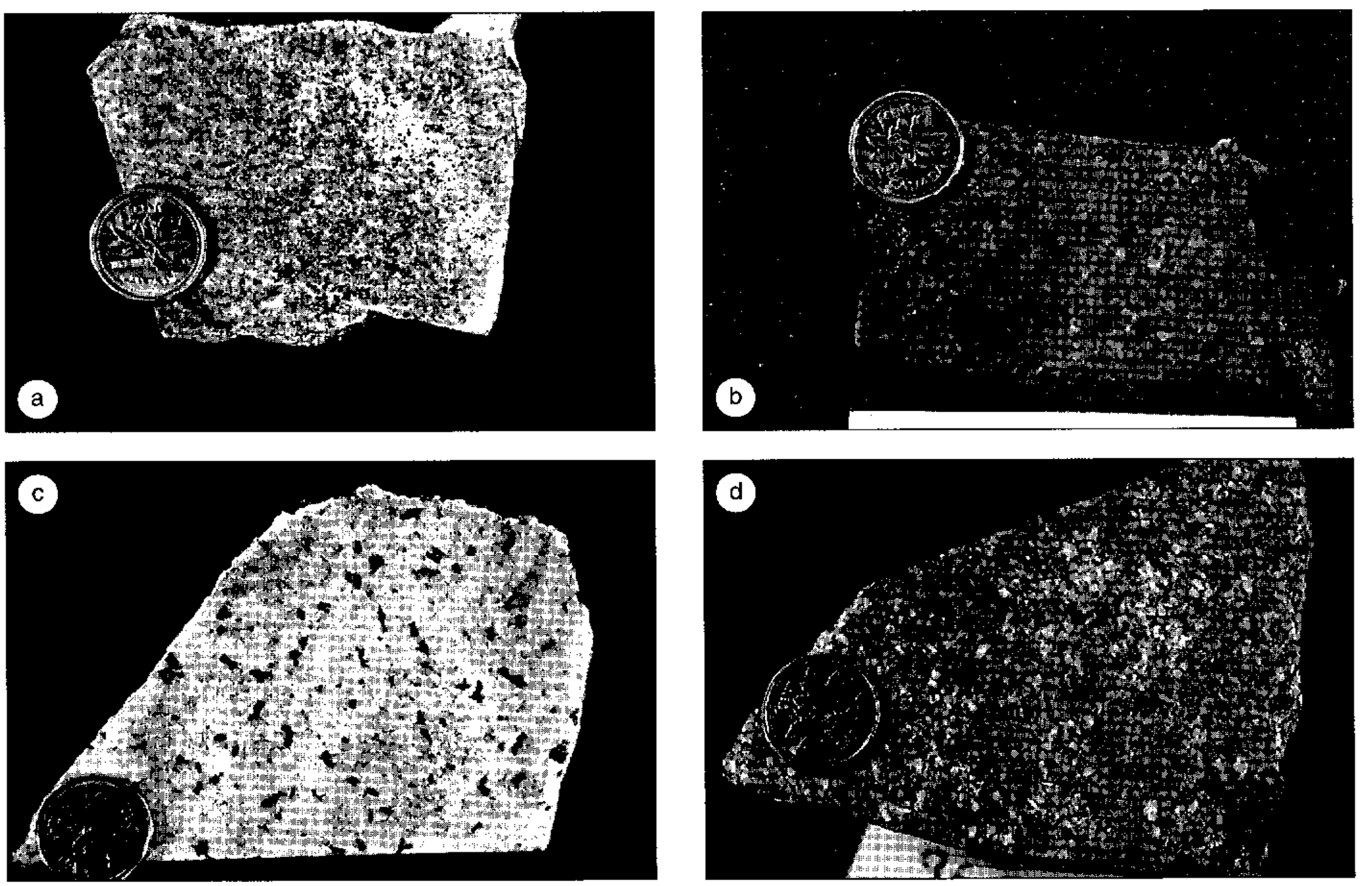


Figure 3: *Photos of typical lithologies of the Teslin Crossing pluton and allied rocks. a) fine-grained, hornblende monzonite; b) leucocratic syenite; c) coarse-grained syenite; d) porphyritic monzonite-monzodiorite typical of the border phase, sills and dykes.*

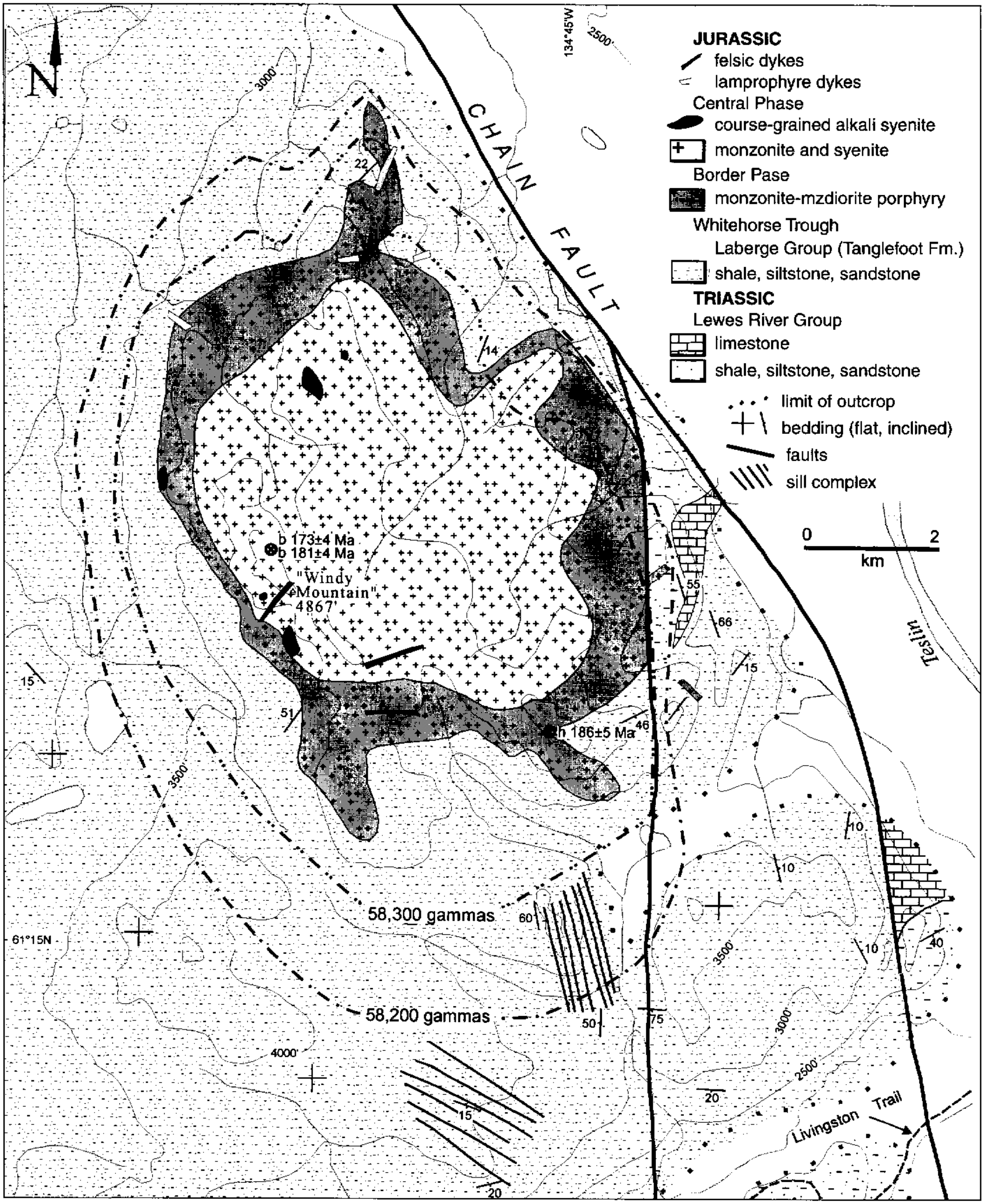


FIGURE 2: Geology of Teslin Crossing Pluton, compiled and modified from maps of Pangman and VanTassell (1972), Pangman (1973) and Tempelman-Kluit (1984). Aeromagnetic contours (dashed and dotted lines) from Geological Survey of Canada maps. K-Ar age date sites, b=biotite, h=hornblende.

Accessory minerals found within all phases include titanite, apatite, biotite, hypersthene and rutile. Late-stage fine-grained felsic dykes, and thin, alkali-feldspar pegmatitic dykes cut all phases. Lamprophyre porphyry dykes were noted by Pangman (1973) in the northern portion of the pluton. Pangman (1973) also emphasizes the presence of diopside as an important rock-forming mineral, although only xenocrystic and xenolithic pyroxene were observed during this study. Furthermore, he notes plagioclase in early phases as An_{46} and as An_{20} in later phases.

Border Phase

The border phase is also texturally variable but dominated by medium grey porphyritic and granophyric, monzodiorite to monzonite. It consists of crowded accumulations of euhedral plagioclase (50%) and hornblende (5%) phenocrysts in a fine-grained orthoclase-plagioclase matrix (Fig. 3d). Phenocrysts are between 1 and 4 mm long. In some respects this phase is similar to lithology #1 of the central phase but the matrix is grey and finer grained. Accessory minerals include magnetite, apatite, titanite, pyroxene and pyrite.

Sills

Numerous (>10), west-dipping (54°-64°) sills occur within the well-bedded black shales immediately south of the pluton, many more may occur further south. The sills are 3-15 metres thick and strike for several kilometres. Despite the density of sills and their proximity to the pluton, hornfelsed country rock is rare and baked margins are very narrow (<1 cm). The chilled margins of the sills are also very narrow (<1 cm). The light grey weathering sills are lithologically similar to the border phase porphyry but are finer grained, slightly more mafic, more crowded and locally trachytic.

Since the pluton's western contacts are concordant with topography, and the presence of numerous sills in the region, it is possible that the pluton is a large sill. This hypothesis is supported by parallel map contacts and contour lines and the fact that outcrops of the pluton are rare beneath 4000' in the south and 3500' in the north suggesting that the contacts may be the footwall of a shallowly north-dipping sill. However, the pluton's magnetic pattern shows a steep eastern margin and gradual western and southern margins indicating that the pluton is cut by a fault on the east and flares out slightly at depth on the other margins. In addition, the country rock adjacent to the pluton dips steeply away from the pluton suggesting forceful upwards intrusion.

Xenoliths

Ultramafic and fine- to medium-grained mafic xenoliths are common in all phases except the leucocratic #2 lithology of the central phase. Ultramafic xenoliths are up to 15 cm across and typically composed of medium- to coarse-grained, black pyroxenite. Mafic xenoliths include coarse-grained pyroxene gabbro and fine-grained diorite. The border phases and sills contain up to 5% pebble to cobble-sized xenoliths, and locally larger, wall-rock sedimentary xenoliths.

Brecciation and Alteration

Most localities show evidence of brecciation in the form of networks of hairline fractures. The acquisition of small diametre drill core samples for paleomagnetic research was made difficult by the nearly ubiquitous fractures. Pangman (1973) reports extensive brecciation in the northern portion of the pluton and localized zones of intense brecciation.

Extensive potassium metasomatism, in association with extensive brecciation was recognized by Pangman (1973). Extensive networks of orange-weathering carbonate veinlets occur at many localities, locally with calcite veins and chalcopyrite. Quartz veins occur locally and are typically white, structureless and barren of mineralization.

Geochemistry

Whole rock geochemical analyses were undertaken on sixteen samples. The analyses are preliminary and therefore the data are not presented but will be included in a later publication. Attempts were made to chose a wide range of compositions and include xenoliths (n=2), sills (n=4), mafic dykes (n=1), felsic dykes (n=1) and the pluton (n=8). Loss on ignition (LOI) values of the sills are slightly higher than the values from the pluton (~1%), yet still indicate negligible alteration.

SiO_2 , Na_2O and K_2O values for the pluton range from 60 to 68%, 6.2 to 7.4% and 3.1 to 4.3% respectively. The samples follow a calc-alkaline fractionation trend that does not indicated iron-enrichment (Fig. 4a). Total combined alkalis relative to SiO_2 indicate that the pluton is alkalic in nature (Fig. 4b) a ternary diagram of CaO, Na_2O and K_2O indicates fractionation towards a slightly sodium-rich end member (Fig. 4c). Most phases are metaluminous but the more evolved phases are slightly peraluminous (Fig. 4d). Normative values indicate that the pluton and sills are slightly silica-saturated; the pyroxenite xenolith is nepheline normative.

Age of the Teslin Crossing pluton

Biostratigraphic Constraints

The pluton and sills intrude a series of black shales, chert-rich sandstone and pebbly conglomerate of the Tanglefoot Formation and assigned an age range of Toarcian to Bajocian (Tempelman-Kluit, 1984). Collections of macrofossils from host strata south and north of the pluton indicate a probable Aalenian age, but allow for an age as old as Toarcian (Poulton and Tipper, 1991).

Isotopic Age

Four K-Ar dates from the Teslin Crossing pluton and allied dikes and plugs range between 164 and 186 Ma (Stevens et al., 1982, Tempelman-Kluit, 1984). The crystallization age of these magmas is interpreted as 186±5 which is the age given by hornblende from the southeastern portion of the pluton and supported by a nearly concordant biotite date of 181±4 Ma from the western part of the pluton. Since the pluton gives an apparently reliable K-Ar date, a sill intruding a section of fossil-bearing sediments south of the pluton was selected for U-Pb dating. A preliminary U-Pb age of the sill, based upon the weighted Pb-Pb age of two slightly discordant zircon fractions, is 175.6 ± 2.0 Ma, (J.K. Mortensen, pers. comm., 1996).

The reason for the 10 Ma age discrepancy between the U-Pb and K-Ar ages is uncertain. The possibility of excess Ar in the biotite and hornblende samples is remote since more ancient rocks which could potentially supply the excess Ar do not exist. The possibility of the pluton and sills representing two distinct magmatic pulses must be considered but geological, lithological, geochemical and petrographic similarities demand that the two are comagmatic. The maximum possible age of the pluton as constrained by the host rocks, is earliest Toarcian (187 Ma[1]), although it is probable that it pre-dates the youngest strata therefore post-Aalenian (<173.5 Ma). Although these constraints allow for the older K-Ar age, they favour the younger U-Pb age, which if correct, require that the host sediments are pre-Aalenian.

The presence of igneous dykes cutting nearly time-equivalent fossiliferous strata provide an opportunity to refine part of the Jurassic time scale. Finalization of the U-Pb dating is essential, but the region may supply other localities for such attempts to improve the absolute Toarcian and Aalenian age and error ranges.

MINERALIZATION

Initial exploration of the Teslin Crossing pluton occurred in 1971 during regional reconnaissance programs by Archer, Cathro and Associates, and United Keno Exploration who followed up with exploration efforts in 1972 and 1973. Copper mineralization was discovered by following up stream sediment anomalies with prospecting and soil sampling. Copper occurs primarily as chal-

[1] *using the Time Scale of Harland et al., 1989. It should be noted that the Early Jurassic portion of most time scales have large errors.*

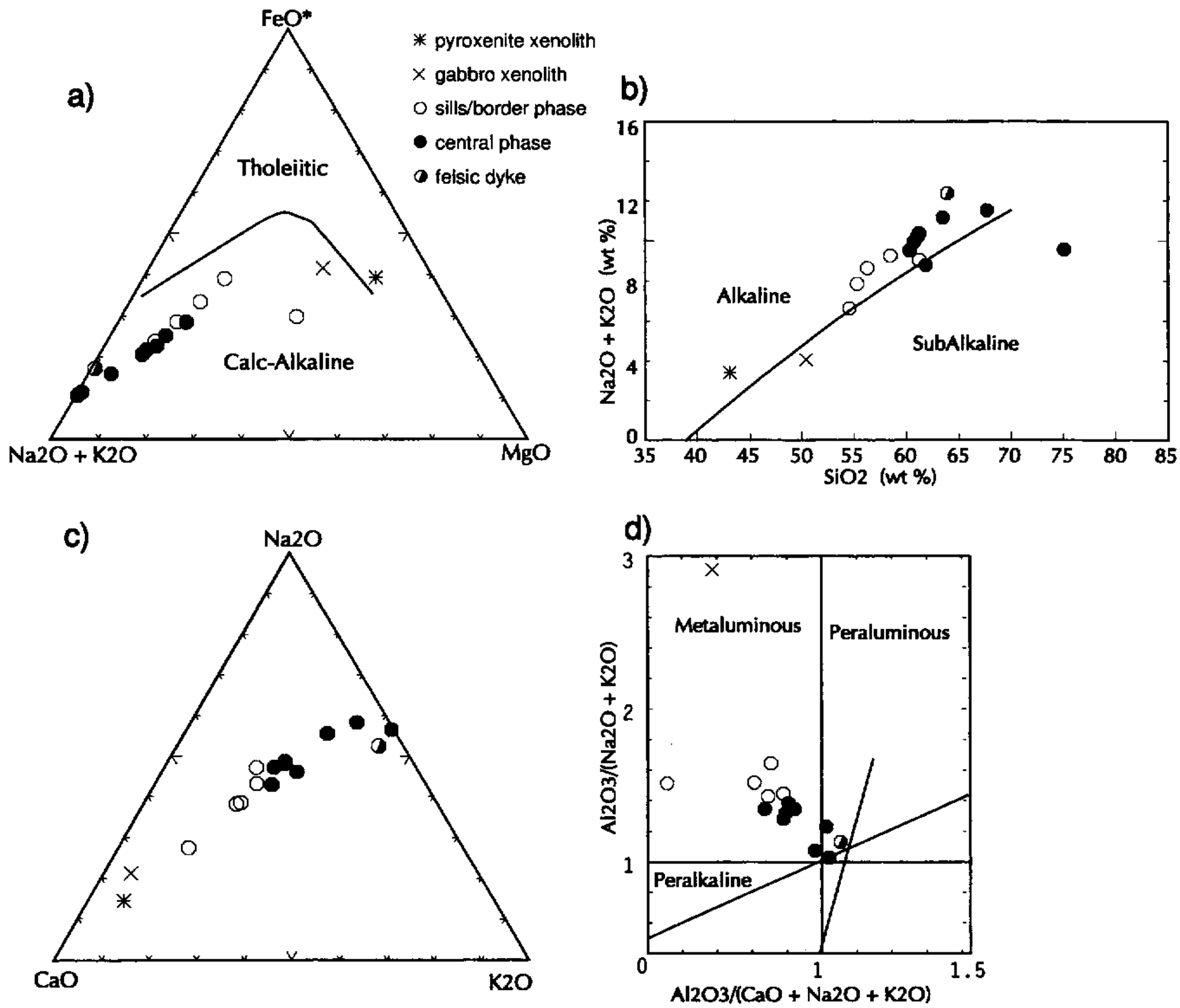


***FIGURE 4:** Geochemical discriminant diagrams: a) AFM plot (Irving and Barager, 1971); b) Alkali - silica plot (Irving and Baragar, 1971); c) CaO-Na2O-K2O ternary diagram; d) Alumina-alkali plot (Maniar and Picolli, 1989).*

copyrite with magnetite and pyrite on thin fractures, or in thin veinlets of quartz or calcite (Pangman and VanTassell, 1972). Oxidation is common with limonite, malachite and azurite occurring on fracture surfaces in the mineralized regions. Grab samples with visible copper mineralization yielded values of 0.1-0.4% Cu and ~4 g/t Ag (Pangman and VanTassell, 1972). Massive pyrite veins, massive anastomosing magnetite veins, rare scheelite and fluorite were recognized by Pangman (1973).

Discussion and Conclusions

The geology of the Teslin Crossing pluton indicates that it is a small, zoned pluton with a border phase and associated sills. Dominant lithologies include grey, porphyritic monzodiorite to monzonite and a complex central phase dominated by pink, medium to coarse-grained monzonite to syenite. Although hornblende is an important constituent, pyroxene is also present. The pluton also hosts considerable primary magnetite, as well as rutile, titanite and apatite.

The Teslin Crossing pluton has an alkalic chemistry. The large number of pyroxenite xenoliths suggests that either pyroxenite crystallized as an earlier phase or that pyroxenite is part of the crustal basement to the region. As such, this pluton is classified as a pyroxenite-associated, silica-saturated alkali syenite.

The geology and geochemistry of the Teslin Crossing pluton is consistent with other plutons of the alkalic variety which host gold-rich porphyry copper deposits (Lueck and Russell, 1994; Lang et al., 1995; McMillan et al., 1995). A possible age range of 176-186 Ma, does not fit the 210-201 Ma age range determined for most alkalic porphyry deposits in British Columbia, but is essentially identical to the age of the Mount Milligan alkalic porphyry system (Mortensen et al., 1995), which is also normative silica-saturated.

Acknowledgments

Discussions with Lori Walton contributed to the information presented here. Edits by Don Murphy are appreciated.

REFERENCES

Barr, D.A., Fox, P.E., Northcote, K.E., and Preto, V.A., 1976. The alkaline suite porphyry deposits A summary. In: Porphyry Deposits of the Canadian Cordillera. CIM Special Volume 15, p. 359-367.

Harland, W.B., Armstrong, R.L., Cox, A.V., Craig, L.E., Smith, A.G., and Smith, D.G., 1990. A Geologic Time Scale. Cambridge University Press, 263 p.

Irving, T.N., and Baragar, W.R.A., 1971. A guide to the chemical classification of the common volcanic rocks. Canadian Journal of Earth Sciences, v. 8, p. 523-548.

Lang, J.R., Lueck, B., Mortensen, J.K., Russell, J.K., Stanley, C.R., and Thompson, J.F.H., 1995. Triassic-Jurassic silica undersaturated and silica saturated alkalic intrusions in the Cordillera of British Columbia: Implications for arc magmatism. Geology, v. 23, p. 451-454.

Lueck, B.A., and Russell, J.K., 1994. Silica-Undersaturated, zoned, alkaline intrusions within the British Columbia Cordillera. In: Geological Fieldwork 1993. B.C. Ministry of Energy, Mines and Petroleum Resources, Paper 1994-1, p. 311-315.

Maniar, P.D., and Piccoli, P.M., 1989. Tectonic discrimination of granitoids. Geological Society of America, Bulletin, v. 101, p. 635-643.

McMillan, W., Thompson, J.F.H., Hart, C.J.R., and Johnston, S.T., 1995. Regional geological and tectonic setting of porphyry deposits in British Columbia and Yukon Territory. In: Porphyry Deposits of the Northwestern Cordillera of North America, T. G. Schroeter (ed), Canadian Institute of Mining, Metallurgy and Petroleum, Special Volume 46, p. 40-57.

Mortensen, J.K., Ghosh, D.K, and Ferri, F., 1995. U-Pb geochronology of intrusive rocks associated with copper-gold porphyry deposits in the Canadian Cordillera. In: Porphyry Deposits of the Northwestern Cordillera of North America, T. G. Schroeter (ed), Canadian Institute of Mining, Metallurgy and Petroleum, Special Volume 46, p. 142-158.

Pangman, P.G., 1973. A petrologic study of the Windy Mountain pluton, Yukon Territory. B.Sc. thesis, Queen's University, Kingston, Ontario, 69 p.

Pangman, P.G., and VanTassell, R.E., 1972. Geological and geochemical report on the TUV 1 to 24 mineral claims, Miller Creek area. Yukon Assessment Report 060152, 10 p.

Poulton, T.P., and Tipper, H.W., 1991. Aalenian ammonites and strata of western Canada. Geological Survey of Canada, Bulletin 411, 71 p.

Stevens, R.D., Delabio, R.N., and Lachance, G.R., 1982. Age determinations and geological studies: Geological Survey of Canada Paper 82-2, 56 p.

Tempelman-Kluit, D.J., 1984. Geology map of Laberge (105E) and Carmacks (115I) map areas, 1:250 000 maps and legend. Geological Survey of Canada Open File 1101.

Wheeler, J.O., Brookfield, A.J., Gabrielse, H., Monger, J.W.H., Tipper, H.W. and Woodsworth, G.J., 1991. Terrane Map of the Canadian Cordillera. Geological Survey of Canada Map 1713. 1:2 000 000 scale with legend.

Upper Paleozoic strata with potential for massive sulphide mineralization, northwestern Lansing map area (105N), Yukon

Charlie F. Roots[1]
Yukon Geology Program

ROOTS, C. F., 1997. Upper Paleozoic strata with potential for massive sulphide mineralization, northwestern Lansing map area (105N), Yukon In: Yukon Exploration and Geology, 1996, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 138-146

ABSTRACT

Northwestern Lansing map area, 120 km east of Mayo, lacks known mineral occurrences yet contains Upper Paleozoic stratigraphic units similar to those at volcanic-hosted and sedimentary exhalative deposits such as Marg and Macmillan Pass. Pyritic and locally baritic Earn Group and (previously unmapped) younger strata underlie most of the area. The sedimentary rocks are cleaved and folded but less strained than equivalent rocks in adjacent Mayo map area, and most contain abundant iron sulphide laminae, nodules, and replacements. A muscovite granite intrudes the grey-green phyllite. The Robert Service Thrust at the southern boundary of the Upper Paleozoic units, appears offset by steep, northwest-trending faults.

RÉSUMÉ

La région de la carte du nord-ouest de Lansing, située à 120 km à l'est de Mayo, ne contient aucune occurrence de minéraux connue, mais renferme des unités stratigraphiques du Paléozoïque supérieur semblables à celles des gisements exhalatifs sédimentaires et inclus dans des roches volcaniques, à Marg et dans le col Macmillan. Le Groupe pyritique et, par endroits, barytinique d'Earn, et les couches plus récentes, non cartographiées jusqu'alors, constituent la plus grande partie du sous-sol de la région. Le siltstone phylliteux gris-vert, peut-être d'origine volcanique, a une nette signature aéromagnétique. Les roches sédimentaires sont clivées et plissées, mais moins déformées que les roches équivalentes de la région voisine de la carte de Mayo, et la plupart regorgent de lames, nodules et matériaux de substitution constitués de sulfure de fer. Un granite à muscovite pénètre l'unité phylliteuse gris-vert. La faille inverse Robert Service, qui forme la limite sud des unités du Paléozoïque supérieur, semble compensée par des failles abruptes de direction nord.

[1] *Geological Survey of Canada, Vancouver Division*

INTRODUCTION

Lansing map area, midway between the mineral districts of Elsa-Keno Hill and Macmillan Pass, contains 30 mineral occurrences (Yukon Minfile, 1996), surprisingly few for an area of its size within Selwyn Basin. The area is distant from road-accessible settlement, and many of these occurrences were discovered during large grass-roots exploration programs. The Hess Project (a 1967-69 joint venture between Atlas Exploration Ltd., Quebec Cartier Mining Ltd and Phillips Bros.) discovered at least 12 occurrences. One of these became the Plata-Inca property which produced 2800 tonnes of high grade silver-lead ore between 1976 and 1985 (Abbott, 1986). Follow-up of reconnaissance silt geochemistry anomalies (Friske et al, 1990) and favourable Earn Group stratigraphy by Kennecott Exploration Ltd. in 1991 and 1992 led to 6 new mineral occurrences. No mineral occurrences are known in the northwest quarter of the map area, southeast and on trend with the Marg volcanogenic massive sulphide deposit (Turner and Abbott, 1990) and Upper Devonian metavolcanic and baritic strata (Abbott, 1990a; Gordey, 1990a). This area is probably worth careful search for sedimentary and volcanic exhalative mineralization. A lack of geological information and maps, coupled with poor exposure, hamper this search.

The Geological Survey of Canada began systematic regional mapping of Lansing (105N) map area in 1993 with the cooperation of the Canada-Yukon Geoscience Office and initial funding from the Canada-Yukon Economic Development Agreement (1991-96). Interim reports and maps include Roots and Brent, (1994 a, b, c) and Roots et al. (1995 a, b). In 1996 many outcrops in the northwest quadrant (covered by 1:50,000 scale maps 105N/11, 12, 13 and 14) were examined during foot traverses with logistical support by float-plane, helicopter and river-boat. Highlights of mapping included delineation of a previously unknown, 30 km long, up to 3 km wide exposure of Keno Hill quartzite, a granitic intrusion, as well as numerous exposures of green-grey phyllitic siltstone.

This report contains an overview of regional structure and summary lithological descriptions for three Upper Paleozoic rock units (no stratigraphic sections are exposed), as well as two localities which have implications for mineral exploration and structural interpretation. Correlations are tentative, rock analyses and age determinations are in progress, and this report will be supplanted by a final manuscript and map for Lansing map area.

REGIONAL STRATIGRAPHY AND STRUCTURE

Lansing map area lies near the northern edge of the Selwyn Basin, which is the outer part of the Lower Paleozoic miogeocline of ancestral North America (Gordey and Anderson, 1993). Stratigraphic units in the Lansing area are summarized in Table 1. The Late Proterozoic off-shelf depositional environment accumulated grit succeeded by shale and chert. This regime was disrupted by Late Devonian block faulting, deposition of Earn Group

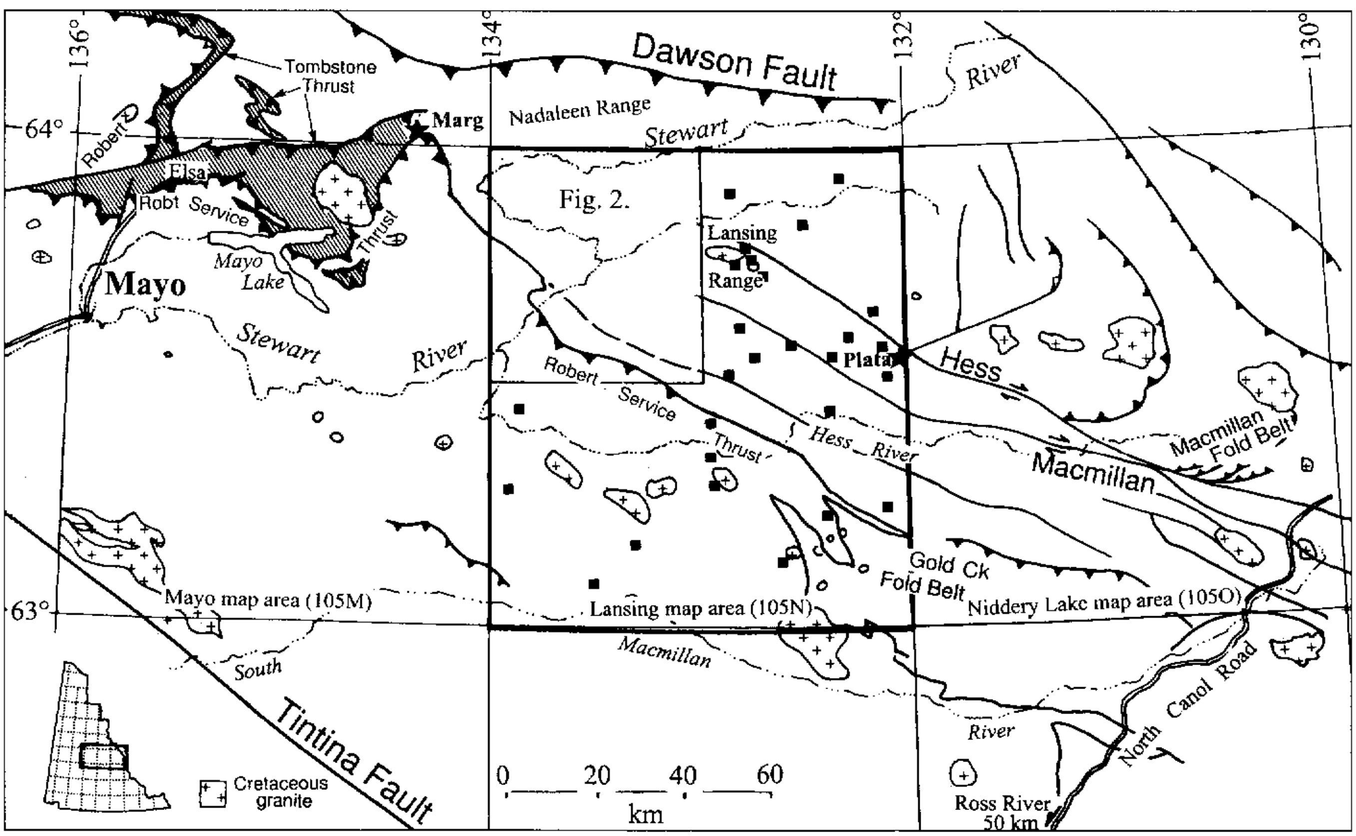


FIGURE 1: Regional faults (adapted from Wheeler and McFeely, 1991) and mineral occurrences (Yukon Minfile, 1996) in Lansing map area (outlined). Tombstone thrust panel is hachured.

Period or Epoch	Formation (if established)	Map unit and lithology	Ref. to nearest described locality
Late Early Createceous	Tombstone Intrusions	**Kr** rhyolite dykes, biotite felsite **KT** quartz monzonite, granodiorite	
		Clastic Shelf (Middle Carboniferous to Triassic)	
Triassic	Jones Lake Formation	**TJps** slate, sandy slate, limestone, calcareous black shale, micaceous, calcareous siltstone, sandstone; grey, non-calcareous shale	Roots et al. 1995
		unconformable	
Mid.Triassic	Mafic intrusions	**Td** metadiorite, gabbro	Mortensen and Thompson, 1990
		intrusive contact	
Permian	Mt. Christie Formation	**PMC** green-grey siltsone, argillite, chert	Roots et al., 1995
		conformable	
Permian-Carboniferous		**CPp** sandstone. argillite, dark grey slate interbedded with laminated quartz sandstone and thick bedded fine-grained quartzite, buff green phyllite.	Roots et al., 1995
Carboniferous	Keno Hill Quartzite	**MKH** quartzite, carbonaceous schist, limestone	Abbott, 1990a
		MKv chloritic phyllite	Turner and Abbott, 1990
		unconformable	
		Turbidite Basin (Middle Devonian to Middle Carboniferous)	
Devonian to Carboniferous	Earn Group	**DME** - black shale, sandstone, chert grit, chert pebble conglomerate,minor limestone, siltstone and mudstone **DMp** - silicious slate, carbonaceous schist, metachert and meta-conglomerate **DMv** - quartz-sericite-chlorite phyllite, quartz-feldspar augen phyllite **uDc**- thick bedded coralline limestone	600 ? Abbott and Turner, 1990 Gordey, 1990a 200; Gordey, in prep
		unconformable	
		Selwyn Basin (Late Precambrian to Middle Devonian)	
	Road River Group		
Silurian	Steel Fm.	**Ss** - grey-green siltstone, chert, minor carbonate	40; Roots et al., 1995
		conformable	
Ordovician to Early Devonian	Duo Lake Fm./ Elmer Creek Fm.	**OSD** -black, brown argillite, grey and black chert, dark siltstone, minor quartz arenite	~200; Gordey and Anderson, 1993 / Cecile, in press.
		unconformable	
Mid. Cambr. - Ordovician	Gull Lake Formation	**COG** - olive and brown siltstone, black argillite and shale; grey dolostone or carbonate breccia at base, minor grey quartzite	100-300; Roots et al., 1995
		conformable	
	Hyland Group (Narchilla, Algae Lake, Yuseyzu formations)		
Late Prot. to Mid. Cambr.	Narchilla Formation	**PCN** - Maroon argillite, grey and brown slate, minor quartz sandstone interbeds	50 ? Roots et al., 1995a,b
	Senoah mbr.	**PCNS** - siltstone, sandstone...	? Cecile, in press
	Algae Lk.Fm.	**PCAL** - Limestone...	? Cecile, in press
Late Proterozoic	Yusezyu Formation	**PY**- Sandstone, grit, psammite, metaconglomerate, chloritic metasiltstone; carbonaceous phyllite or graphitic slate near base; grey limestone, marble lenses near top	3000+ ; Roots et al., 1995a, b

TABLE 1: *Rock stratigraphic units in Lansing map area.*

turbidite and fanglomerate; structurally elevated areas were eroded. The turbidite basin (Gordey et al., 1987) continued into Early Carboniferous (Mississippian) time. The subsequent clastic shelf regime included a sandstone, the Keno Hill quartzite, which forms a 500 km long, relatively narrow (nowhere more than 40 km across structural grain), regional marker. In Middle Jurassic time the sedimentary succession was deformed by folds and thrust faults, perhaps resulting from collision and transpression with far-traveled terranes 300 km southwest (e.g. Tempelman-Kluit, 1979).

Jurassic and Early Cretaceous deformation of the Selwyn Basin is by tight, upright to overturned folds of competent rocks and en-echelon, fault imbrication of incompetent strata, all at sub-greenschist metamorphic grade. In general the structural style suggests thin-skinned contraction and underlying, relatively flat regional detachment faults (e.g. Gordey, in prep). Deformation structures are cut by the Tombstone plutonic suite, whose 92-94 Ma (late Early Cretaceous) age constrains the end of regional deformation.

Northwestern Lansing map area lies between areas with better known, but contrasting structural styles. Northwest of Lansing map area are three regional, southwest-dipping thrusts - the Dawson, Tombstone and Robert Service (Abbott, 1990a, b; Gordey, 1990a, b; Gordey and Thompson, 1991; Roots and Murphy, 1992). These separate three overlapping thrust panels with different sequences of Selwyn Basin and younger strata. The Tombstone thrust panel (Fig. 1) as well as the lower part of the structurally overlying Robert Service thrust panel exhibit a penetrative strain fabric and are referred to as the Tombstone Strain Zone (Murphy and Heon, 1995; Murphy, 1997). This fabric extends southwest in the hanging wall of the Robert Service Thrust in northwestern Lansing map area, but is absent in the footwall, implying that the Tombstone and Robert Service thrusts are no longer closely related.

East of Lansing map area Selwyn Basin strata are deformed in the Macmillan (Abbott, 1982) and other (Cecile, in press) fold belts. The fold belts are juxtaposed along west-trending dextral transcurrent faults (Cecile and Abbott, 1992), two of which are the Hess and Macmillan faults (Abbott and Turner, 1990; Fig. 1). These faults extend westward into Lansing map area (Roots et al., 1995a).

The 1996 mapping in northwestern Lansing established the location of the Robert Service Thrust map area (Fig. 2). The Yusezyu grit (Hyland Group: PCH)) is contorted in east- and west-plunging cylindrical and box folds in the hanging wall of the Robert Service Thrust. A 15 km long strip of Hyland Group strata is separated from the larger area of Hyland Group by a belt of Keno Hill and younger rocks. This strip is bounded on its south side by a vertical, northwest-trending fault. The northern contact, with Earn Group conglomerate, must be a fault and may also be a segment of the Robert Service Thrust. Thus the strip of isolated Hyland Group is interpreted as a klippe preserved by later downfaulting. (see cross-section inset on Fig. 2). The late northwest-trending faults were predominantly dextral transcurrent faults, and where traced southeastward about 9 km of dextral offset is indicated (Roots et al., 1995b).

In Mayo map area the rocks below the Robert Service Thrust (Tombstone thrust panel) are Earn Group and Keno Hill quartzite. In northwestern Lansing map area quartzite underlies a broad-shouldered highland north of Pleasant Creek (the local high point, at 63°35.5'N 133°28.0W, indicated on topographic maps (1984 edition) by the survey control '1815 m', is a reference point), and are overlapped by younger rocks on the southwest side. The gently rolling terrain to the north contains sparse exposure of black shale, slate and siltstone of the Earn Group. Grey-green phyllite of unknown age is found at higher elevations. At the northern edge of the area and extending northward into the Nadaleen Range are steep mountains underlain by Keno Hill quartzite and possibly younger strata, both intruded by 60 m thick, north-dipping metadiorite sills; geology which resembles that described near Mount Westman farther west (Abbott, 1990b).

The Tombstone Fault which separates the Tombstone and Dawson thrust panels has not been determined in northwestern Lansing map area. It may be near the confluence of the Nadaleen and Stewart rivers, and extend southeast to connect with the Hess Fault north of the Plata property. Alternatively the Tombstone Fault may follow the Beaver River drainage, change into a dextral transcurrent fault and link with the Macmillan Fault.

Upper Paleozoic units in northwestern Lansing map area

Earn Group

Carbonaceous siltstone, thin bedded chert and shale, and local conglomerate and carbonate comprise the Earn Group. Monotonous, generally north-dipping dark grey siltstone and shale underlie a broad (40 km from northeast to southwest) area in which the best exposures are Seven Mile Canyon and southwestward flowing tributaries of the Stewart River, as well as those of the Lansing River. In most places the strata dip steeply, contain minor tight upright folds, but are not micaceous or penetratively cleaved. Resistant, strongly flattened chert-cobble conglomerate comprises the core of a fin-shaped peak 4 km north of '1815m'; other conglomerate occurs along strike to the northwest and at the outlet of Penape Lake. Blue-grey weathering black siliceous siltstone, another distinctive lithology of the Earn Group, is common north of '1815 m'. Thick layers of carbonaceous limestone occur on both sides of the Stewart River about 15 km southwest of the Lansing River mouth. White-weathering belts of limestone containing Frasnian (Late Devonian) corals, range from 5-50 m thick and extend 15 km southeast from '1815 m' mountain. Limestone of similar age lies south of Mount Selous in northern Tay River map area (Gordey, in prep.)

Carbonaceous siliciclastic marine strata of the Earn Group host three large zinc-lead stratabound zinc-lead, and 15 stratiform barite deposits in the Macmillan Pass area (e.g. Abbott and Turner, 1990). In Lansing map area iron-coated streambeds, zinc, lead and silver silt anomalies, and stratiform barite constitute 10 mineral occurrences (Yukon Minfile, 1996) in Earn Group rocks. An important feature of the Earn Group, particularly along the Stewart River shoreline from Ortell Creek mouth to Seven Mile Canyon, are abundant iron sulfide nodules, concretions and laminated strata; these are not present or not mentioned at any known mineral occurrences. The nodules consist of fine-grained masses or agglomerated crystals with the marcasite habit. Nodules range from pea-size to 2 cm thick x 5 cm long (Fig. 3) and may be packed in accumulations up to 1 m in diameter, or dispersed and comprise perhaps 1% of large outcrops. Laminated pyritic strata

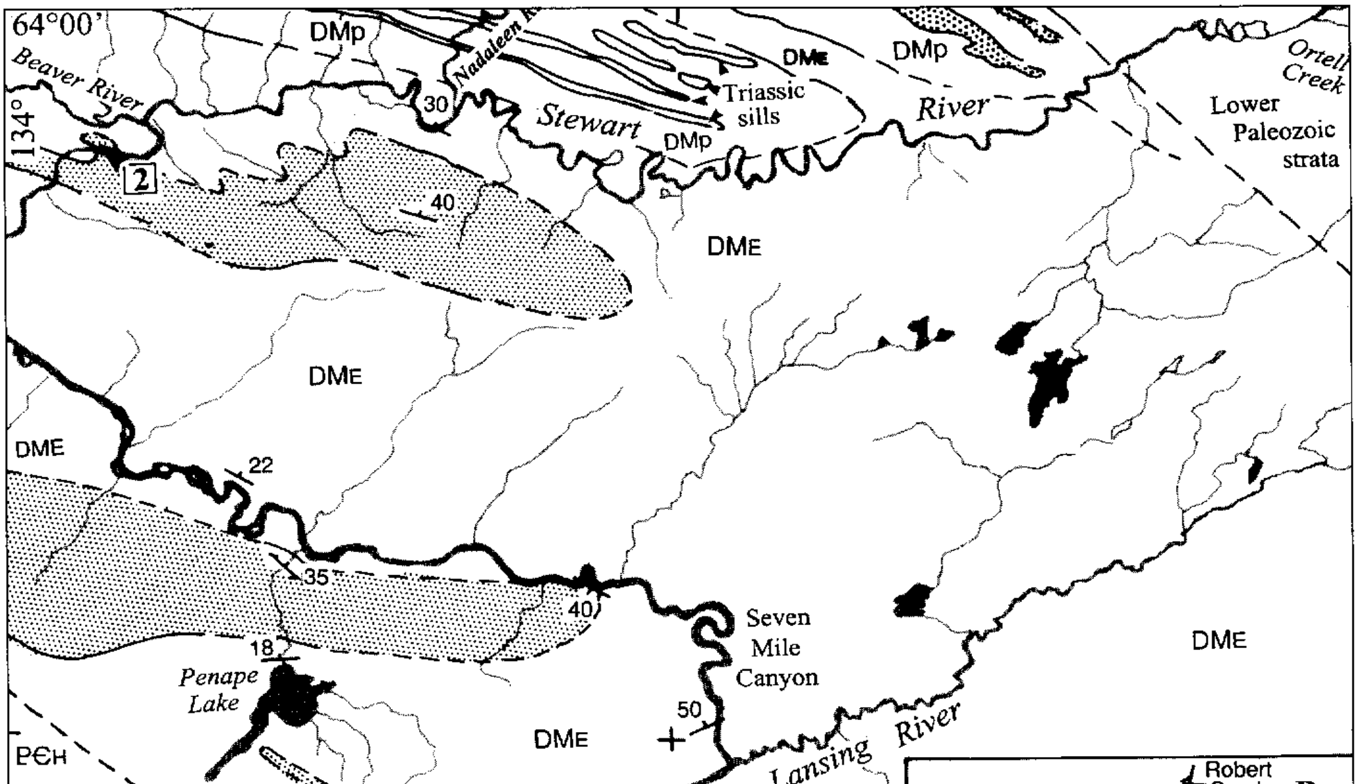


FIGURE 2: Geological units in northwestern Lansing map area.

are either fine grained, thin-bedded and 1-5 cm thick, or reveal syn-sedimentary slump or rip-up textures. The bouldery shoreline of the Stewart River a few kilometres south of the Beaver River mouth, are iron-stained as far downstream as Mayo, The source of the iron is likely pyritic black shale south of the Beaver River. Another characteristic of shoreline Earn Group is white and yellow precipitate and efflorescent encrustations, particularly at Seven Mile Canyon and 15 km downstream of the Lansing River mouth.

A second exploration target is stratabound nickel-platinum in a regionally widespread thin horizon(Nick occurrence; Hulbert et al., 1992; Taiga occurrence east of Dempster Highway; Blackstone Resources; news release 27/6/1996). This horizon can be expected near the base of the Earn Group. The key limestone concretion marker below the sulfide horizon was not noted during mapping in northwestern Lansing area, although limestone beds were encountered. In eastern Lansing map area carbonaceous shale concretions are common at Plata #6 pit and the Roots occurrence (Yukon Minfile, 1996; 105N-030).

Keno Hill quartzite

This distinctive lithologic unit, a black or dark grey vitreous quartzite, is exposed in a zone 30 km long and up to 3.5 km wide. Typical outcrops are massive and lack recognizable detrital grains. Thick ribs outline resistant layers and low-angle trough cross-beds. East of '1815 m mountain' the quartzite is structurally repeated in three belts separated by black shale, chert and white limestone (Fig. 4).

Steep south-facing exposures 2.5 km southeast of 1815 m mountain contain up to 30% white quartz veins but no mineralization was encountered. Unlike elsewhere in the quartzite no meta-diorite intrusions were found.

Grey-green phyllite

This unit (possibly more than one) consists of platy or foliated, commonly crumbly and altered, thin- or medium bedded strata in four northwest-trending belts in northwestern Lansing map area.

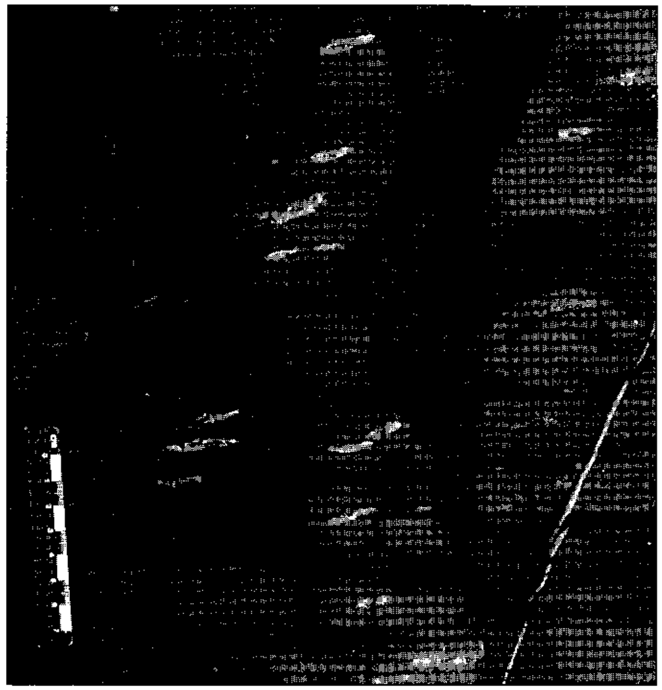


Figure 3: *Iron sulphide nodules (light-coloured) in silty argillite of the Earn Group. Bedding dips 35° north in this straight-down view of a river-polished outcrop (north at top). Dark areas are residual dampness in cracks and vertical faces. From the west bank of Stewart River, 100 m downstream of the mouth of the Beaver River the same width as the standard text columnns*

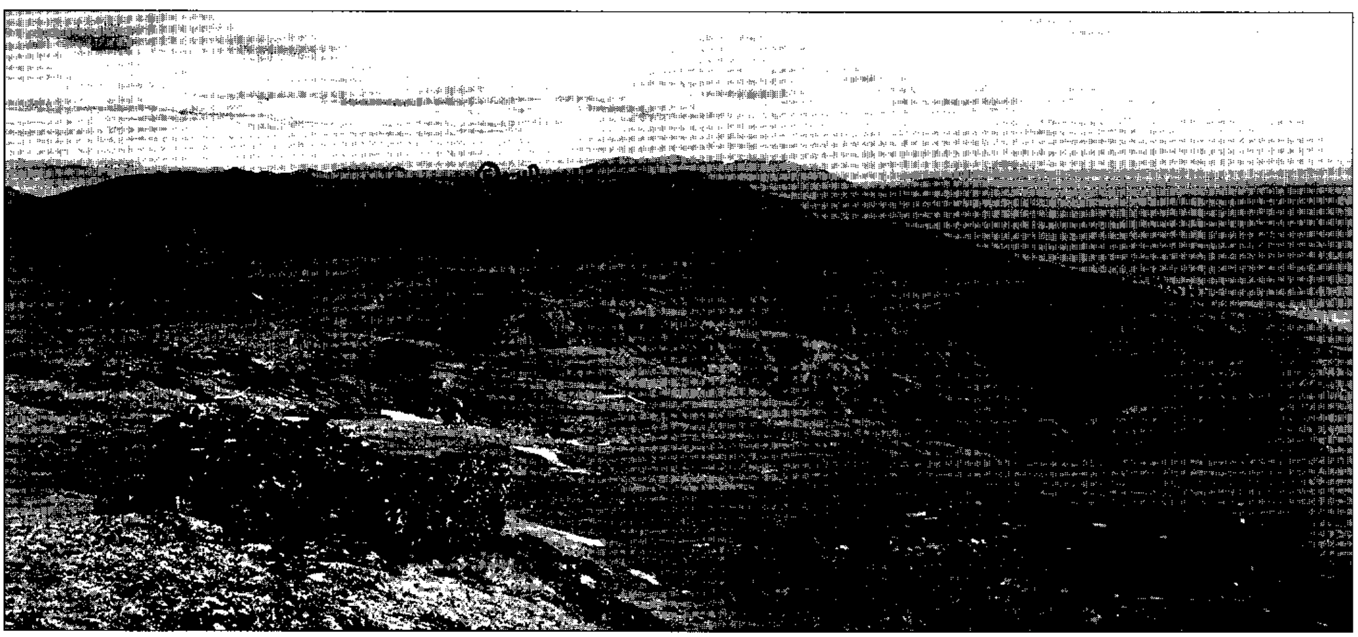


Figure 4: *Southeastward view of Keno Hill quartzite and adjacent units, from the top of '1815 m' mountain. Black lichen covers the vitreous quartzite outcrops in foreground.*

Age (or ages) are unknown, and among the sparse exposures only two contacts with other units were seen. The southern belt overlies Keno Hill quartzite stratigraphically; it may correlate with either the Permian Mount Christie Formation (Gordey and Anderson, 1993), or an un-named Carboniferous-Permian unit recognized in eastern Lansing map area (Roots et al., 1995b). The greenish cast of the rocks in the northern belts may result from chloritic alteration of mafic minerals; if so these rocks could be distal to metavolcanic rock of either Upper Devonian or Lower Carboniferous (Gordey, 1990a,b; Turner and Abbott, 1990) age. Less likely is that these are older rocks thrust over the Earn Group; they might be Steel Formation (Gordey and Anderson, 1993) of Silurian age. The formations mentioned above contain fine-grained, grey-green strata. Until the age is known correlations are speculative, but the rock is described to provoke its recognition by others, perhaps leading to new conclusions about its age and origin.

The most southerly belt is flanked to the northeast by Keno Hill quartzite. Weathering brown with shades of pink or beige, this light green, waxy to flaky textured, siliceous mudstone is distinctive. Iron sulphide nodules up to 1 cm thick are common. Near Locality 1 (next section) gradations between siltstone and fine sandstone laminae indicate upright bedding. Because adjacent Keno Hill quartzite forms an anticlinal structure, the grey-green phyllite probably overlies it.

North of the Stewart River thin-bedded and laminated grey to green and yellow indurated argillite is exposed in two parallel cliff bands, one about 100 vertical metres above the other, 13 km southwest of the confluence of Lansing River. The similar rock type, appearance and approximate thickness revealed by the two cliffs suggest an isoclinal repetition. The regional aeromagnetic map (Teskey, 1995) shows prominent, linear positive anomalies coincident with these cliff bands, perhaps reflecting the abundant disseminated iron sulphide noted many samples. This belt is therefore interpreted as a syncline of younger rocks within Earn Group. The absence of Keno Hill quartzite suggests the phyllite could be as old as Lower Carboniferous, and the age may be resolved if identifiable microfauna are yielded by the thin, discontinuous grey limestone on the ridgetop.

A third area underlain by grey-green cherty argillite and phyllite is interpolated from widely spaced exposures north and west of Penape Lake, as well as along the Stewart River west of Seven Mile Canyon. Bedding in each of four exposures is uncertain, but slaty cleavage dips gently to moderately northeastward. The interpolated map width of this unit is at least 1 km. The best exposure flanks the outlet stream north of Penape Lake, where green and pinkish-brown weathering, greenish yellow indurated phyllite contains abundant weathered-out iron sulphide pockets. At this locality the phyllite appears to structurally overlie Earn Group exposed farther south. The contact between similar rock and Earn Group is exposed farther east on the south shore of the Stewart River 2 km west of the entrance to Seven Mile Canyon. Green-brown phyllite with gently north dipping slaty cleavage is observed at low water levels directly overlain by south dipping beds of black shale and chert. Although a disconformable relationship is possible, expected rip up clasts or coarse-grained basal layer are absent. Instead the contact is interpreted as a minor fault. In Seven Mile Canyon the Earn Group is contorted in large chevron folds with gently south-dipping axes. Minor layer-parallel thrust faults are consistent with this structural style.

The fourth area, possibly the most extensive of grey-green phyllite, comprises high hills several kilometres south of Stewart River, south of the Nadaleen River confluence. Tops of the hills expose flaggy pink-brown and green-grey weathering, dark grey and green argillite and phyllitic siltstone; iron sulphide nodules are common. Thick, moderately north-dipping layering is locally discernible; more prominent is a poorly developed foliation, defined by flattened silicate minerals, that dips moderately northeast. This rock type extends down the flanks into talus at the base of slope, where a buried contact is suspected because carbonaceous silty argillite (Earn Group) is exposed at the heads of streams draining north and south from the hills. Topographically the grey-green phyllite overlaps the Earn Group. Ten kilometres westward these two units are in direct contact, as described for Locality 2 (next section).

In summary the four belts of grey-green phyllite are lithologically similar, although contact relations are insuffícent to determine stratigraphic relations. If it is as young as Permian (Mount Christie Formation) which it most resembles, the absence of Keno Hill quartzite from all but the southern belt is puzzling. Alternatively the unit may represent volcanic-derived sediment distal to the discontinuous metavolcanic units of Upper Devonian (unit DMv of Gordey, 1990b) or Mississippian (unit DMvs of Turner and Abbott, 1990) age. No grains or coarse grained sedimentary layers were seen despite a thorough search. Volcanic parentage cannot be proven. Nevertheless the lateral extent, common alteration and iron sulphide content of the unit, along structural trend from the Marg volcanogenic massive sulphide deposit, requires further investigation.

LOCALITIES OF INTEREST

Locality 1

is a prominent orange weathering rock cliff facing southwest into "Rainbow Creek" (local name) which drains northwest into the Stewart River east of '1815 m mountain'. Located at 63°37'N 133°40'W, this locality is protected by steep, dense forest and a lack of nearby helicopter landing sites. The covered surface trace of the Robert Service Thrust trends northwest, roughly parallel to the creek on its south side of the valley. The footwall Earn Group, consisting of black mudstone laced with white quartz and lesser brown phyllite which results in iron-stained seeps, is exposed in the floor of the steep-walled creek. The northeast side is brush-covered talus surmounted by 200 m high vertical cliffs. Rusty weathering green, grey and brown interlaminated siltstone and fine sandstone, commonly silicified, occurs at the west end and atop the cliffs. This rock, considered part of the southern belt of the grey-green phyllite described above, has a map width of 2 km to a possible stratigraphic contact with Keno Hill quartzite In at least several places the siltstone is deeply oxidized and clay-altered. The cliff, when viewed from a vantage point across "Rainbow Creek", reveals a reticulate pattern of granitic dykes, up to 30 m wide, vertically and horizontally on the face. Talus blocks consist of medium grained, leucocratic, muscovite granite, and contain up to 1% interstitial sulphide blebs (probably pyrrhotite). This granite has not been described or shown on earlier maps. Because the exposure is steep, the plan view of this intrusion is minute, yet it is probably 1300 m long.

No indication of previous exploration or economic mineralization was encountered during a rapid traverse of the area in 1996. The reconnaissance stream sediment geochemical survey (Friske et al., 1991; sites 3351 and 3349) sampled "Rainbow Creek" 3 km downstream from the cliff. Site 3351 is highly anomalous in As, Ba, Sb, Rb and most REE; Cu, Ag, Hg and Cr are above background values. All metallic elements show large increases when compared to another site (3349) on the same creek 2 km above locality 1. The newly-discovered intrusion, prospective stratigraphic units and abundant red alteration are worthy of follow-up.

Locality 2,

a small rock island and adjacent shoreline of the Stewart River 2 km southwest of the mouth of the Beaver River, exposes a contact which may be critical to understanding the regional structure. The locality (63°57'N 133°54.5W) is on southeastward extrapolation of the Tombstone Thrust (Abbott, 1990a,b). Carbonaceous shale and siltstone (probably Earn Group) containing abundant iron sulphide nodules are exposed northeast and southwest of the locality. In these outcrops cleavage is subordinate to generally northeast dipping bedding, although isolated exposures reveal southeast, and northwest dips, suggesting regional open folds with east-trending axes. At the locality north of the island, a steep (75° N) dipping succession of similar black shale with 2 cm thick grey siltstone interbeds (Earn Group), is structurally overlain by grey-green phyllitic mudstone(Fig. 5). At the contact, exposed along 15 m of shoreline at low water levels, is a 5 cm thick, grey silicified and tectonized layer. This rock appears to represent recrystallized fault gouge, dips about 35° northeast, and contains streaky white quartz which defines a stretching lineation gently plunging toward 100° azimuth.

The rock above the tectonized layer is exposed on both sides of the river for about 500 m as well as on the small island. Most common is a papery-cleaved, locally slaty or crumbly, phyllitic grey mudstone, although 5 cm thick brown sandstone interbeds on the island exhibit poorly preserved ripples which could be interpreted as inverted. About 100 m upstream from the island a brightly coloured (alteration with iron reduction fronts) outcrop contains bedding dipping gently northeast, coplanar with cleavage and the underlying tectonized layer.

The significance of a fault contact between the two principal rock units of the area is unclear. The overlying rock unit exhibits more structural fabric and alteration than the underlying Earn Group. If

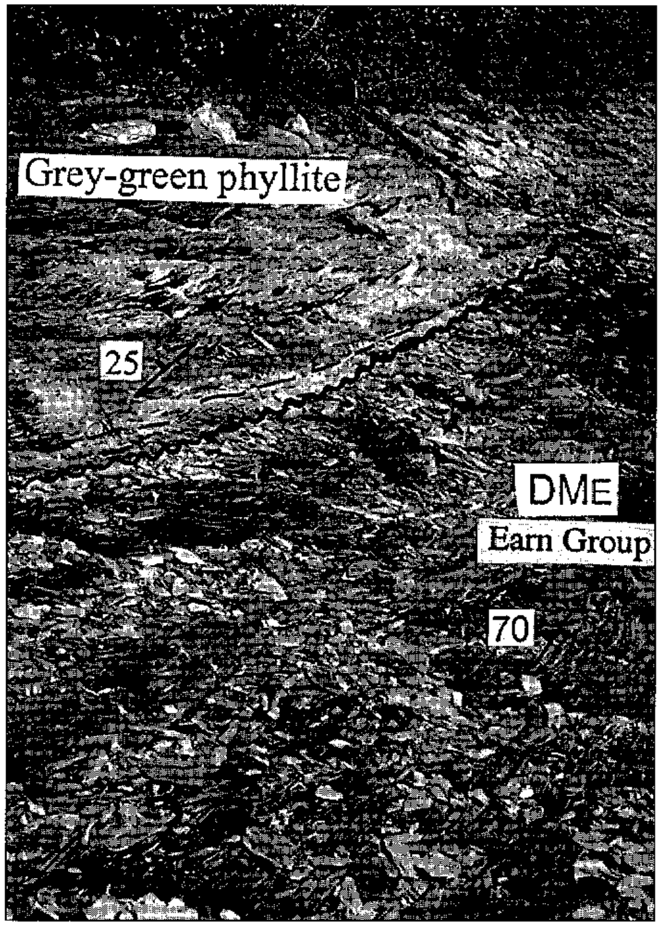


FIGURE 5: *North bank outcrop on the Stewart River 1.7 km southwest of the mouth of Beaver River (Locality 2, discussed in text). Dark grey, thin bedded siltstone (Earn Group) in lower half is separated from lighter, altered phyllite by a 5 cm thick, light grey tectonized layer. The contact may be a low-angle thrust.the same width as the standard text columnns*

correlated with the grey-green phyllite that caps the high hills directly east of the locality, it may be tectonically emplaced on low angle faults. The fault could be a splay of the Tombstone Thrust. Alternatively the contact at Locality 2 may be merely a competency contrast between black siltstone and grey shale with a tectonized boundary layer. This quite pleasant stretch of Stewart River shoreline deserves further examination by structural geologists.

ACKNOWLEDGMENTS

The stimulating field assistance of Diane Brent and Bruce Mitford, the gracious hospitality of Beth Hunt and family at the historic Lansing Post site, and capable flying of Ernie Onafreychuk and Pat Damian contributed to an excellent field season. Dr. A.E.H. Pedder of GSC Calgary identified the Upper Devonian corals. Don Murphy, Grant Abbott, Maurice Colpron and Dave Caulfield discussed field relationships with me, but flaws in the interpretation remain my own. The manuscript was improved by Dirk Tempelman-Kluit.

REFERENCES

Abbott, J.G., 1982. Structure and stratigraphy of the Macmillan Fold Belt: Evidence for Devonian faulting. In Yukon and Exploration and Geology, 1981, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 22-33.

Abbott, J.G., 1986. Geology of the Plata-Inca gold-silver veins, Yukon; In Yukon Geology, Vol. 1; Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 109-112.

Abbott, J.G., 1990a. Preliminary results of the stratigraphy and structure of the Mount Westman map area (106D/1), central Yukon. Current Research, Part E; Geological Survey of Canada, Paper 90-1E, p. 15-22.

Abbott, J.G., 1990b. Geological map of Mount Westman map area (106 D/1). Exploration and Geological Services Division, Mineral Resources Directorate, Whitehorse, Yukon, Indian and Northern Affairs Canada, Open File 1990-1 (scale 1:50 000).

Abbott, J.G. and Turner, R.J., 1990. Character and paleotectonic setting of Devonian stratiform sediment-hosted Zn, Pb, Ba deposits, Macmillan Fold Belt, Yukon. In J.G. Abbott and R.J.W. Turner (eds.), Fieldtrip Guidebook 14. 8th International Association on the Genesis of Ore Deposits symposium, 1990., Geological Survey of Canada, Open File 2169, p. 99-136.

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

Cecile, M.P., In press. Geology of the northeast Niddery Lake map area (NTS 105O/7, 8, 9, 10, 15, 16), Yukon, Geological Survey of Canada, Bulletin.

Cecile, M.P. and Abbott, J.G., 1992. Geology of Niddery Lake map area (105O). Yukon; Geological Survey of Canada, Open File 2465, Scale 1:125 000.

Friske, P.W.B., Hornbrook, E.H.W., Lynch, J.J., McCurdy, M.W. Gross, H., Galletta, A.C. and Durham, C.C., 1991. National Geochemical Reconnaissance stream sediment and water data, east central Yukon, (NTS 105N), Geological Survey of Canada, Open File 2363.

Gordey, S.P., 1990a. Geology and mineral potential, Tiny Island Lake map area, Yukon. Current Research, Part E, Geological Survey of Canada, Paper 90-1E, p. 23-29.

Gordey, S.P. 1990b. Geology of Tiny Island Lake map area (105M/16). Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, Open File 1990-2, Scale 1:50 000.

Gordey, S.P., In prep. Evolution of the Selwyn Basin area, Sheldon Lake (105J) and Tay River (105K) map areas, central Yukon Territory (working title). Geological Survey of Canada, Bulletin.

Gordey, S.P. and Anderson, R.G., 1993. Evolution of the northern Cordilleran miogeocline, Nahanni map area (105I), Yukon Territory and District of Mackenzie. Geological Survey of Canada, Memoir 428.

Gordey, S.P., Abbott, J.G., Tempelman-Kluit, D.J. and Gabrielse, H., 1987. "Antler" clastics in the Canadian Cordillera. Geology, v. 15, p. 103-107.

Gordey, S.P. and Thompson, R.I., 1991. Selwyn Basin, ancestral North America. In H. Gabrielse (comp), Structural Styles. In H. Gabrielse and C.J. Yorath (eds.), Geology of the Cordilleran Orogen in Canada, Chapter 17. Geological Survey of Canada, Geology of Canada, no. 4, p. 571-676 (also Geological Society of America, The Geology of North America, v. G-2)

Hulbert, L.J., Gregoire, D., Paktunc, D. and Carne, R.C., 1992. Sedimentary nickel, zinc and platinum group element mineralization in Devonian black shale at the Nick property, Yukon, Canada: a new deposit type. Exploration Mining Geology, v. 1, no. 1. p. 39-62.

Mortensen, J.K. and Thompson, R.I., 1990. A U-Pb zircon-baddeleyite age for a differentiated mafic sill in the Ogilvie Mountains, west-central Yukon Territory. In: Radiogenic Age and Isotopic Studies: Report 3, Geological Survey of Canada, Paper 89-2, p. 23-28.

Murphy, D.C. 1997. Geology of the McQuesten River region, northern Mayo and McQuesten map areas (105 M/13, 14 and 115P/14, 15, 16) Yukon Territory. Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, Bulletin 6. (includes coloured 1:50 000 maps of above areas)

Murphy, D.C. and Héon D., 1995. Geology and Mineral Occurrences of Seattle Creek map area (115P/16), western Selwyn Basin, Yukon; in Yukon Exploration and Geology 1994: Exploration and Geological Services, Indian and Northern Affairs Canada, p. 58-72.

Roots, C.F., Abbott,, J.G., Cecile, M.P., Gordey, S.P. and Orchard, M.J., 1995a. New stratigraphy and structures in eastern Lansing map area, central Yukon Territory. Current Research 1995-A, Geological Survey of Canada, p. 141-147.

Roots, C.F., Abbott,, J.G., Cecile, M.P., Gordey, S.P. and Orchard, M.J., 1995b. Bedrock geology of Lansing map area (105N) east half, Hess Mountains, Yukon. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs, Open File 1995-7 and Geological Survey of Canada, Open File 3171, Scale 1:125 000.

Roots, C.F. and Brent, D., 1994a. Geological framework of West Lake map area (NTS 105N/9), Hess Mountains, east-central Yukon, In Yukon Exploration and Geology, 1993. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, P. 111-121.

Roots, C.F. and Brent, D., 1994b. Geological map of West Lake map area (105N/9), Hess Mountains, east-central Yukon. Exploration and Geological Services Division, Indian and Northern Affairs Canada, Open File 1994-5 (G), Scale 1:50 000.

Roots, C.F. and Brent, D., 1994c. Preliminary stratigraphy from Lansing map area, central Yukon Territory. Current Research 1994-A, Geological Survey of Canada, p. 1-9.

Roots, C.F. and Murphy, D.C., 1992. New developments in the geology of Mayo map area, Yukon Territory. Current Research, Part A. Geological Survey of Canada, Paper 92-1A, p. 163-171.

Tempelman-Kluit, D.J., 1979. Transported cataclasite, ophiolite and granodiorite in Yukon: Evidence of arc-continent collision. Geological Survey of Canada, Paper 79-14, 27 p.

Teskey, D., 1995. Residual Total Field Magnetic Map of the Yukon Territory; Geological Survey of Canada, scale 1:1 000 000.

Turner, R.J.W. and Abbott, J.G., 1990. Regional setting, structure and zonation of the Marg volcanogenic massive sulphide deposit, Yukon; In Current Research, Part E, Geological Survey of Canada, Paper 90-1E, p. 31-41, 1990.

Wheeler, J.O. and McFeely, P. (comp.), 1991. Tectonic assemblage map of the Canadian Cordillera and adjacent parts of the United States of America. Geological Survey of Canada, Map 1712A. scale 1:2 000 000

Yukon Minfile, 1996. Northern Cordilleran Mineral Inventory. Compiled by Indian and Northern Affairs Canada, Exploration and Geological Services, 300 Main Street, Whitehorse, Yukon.