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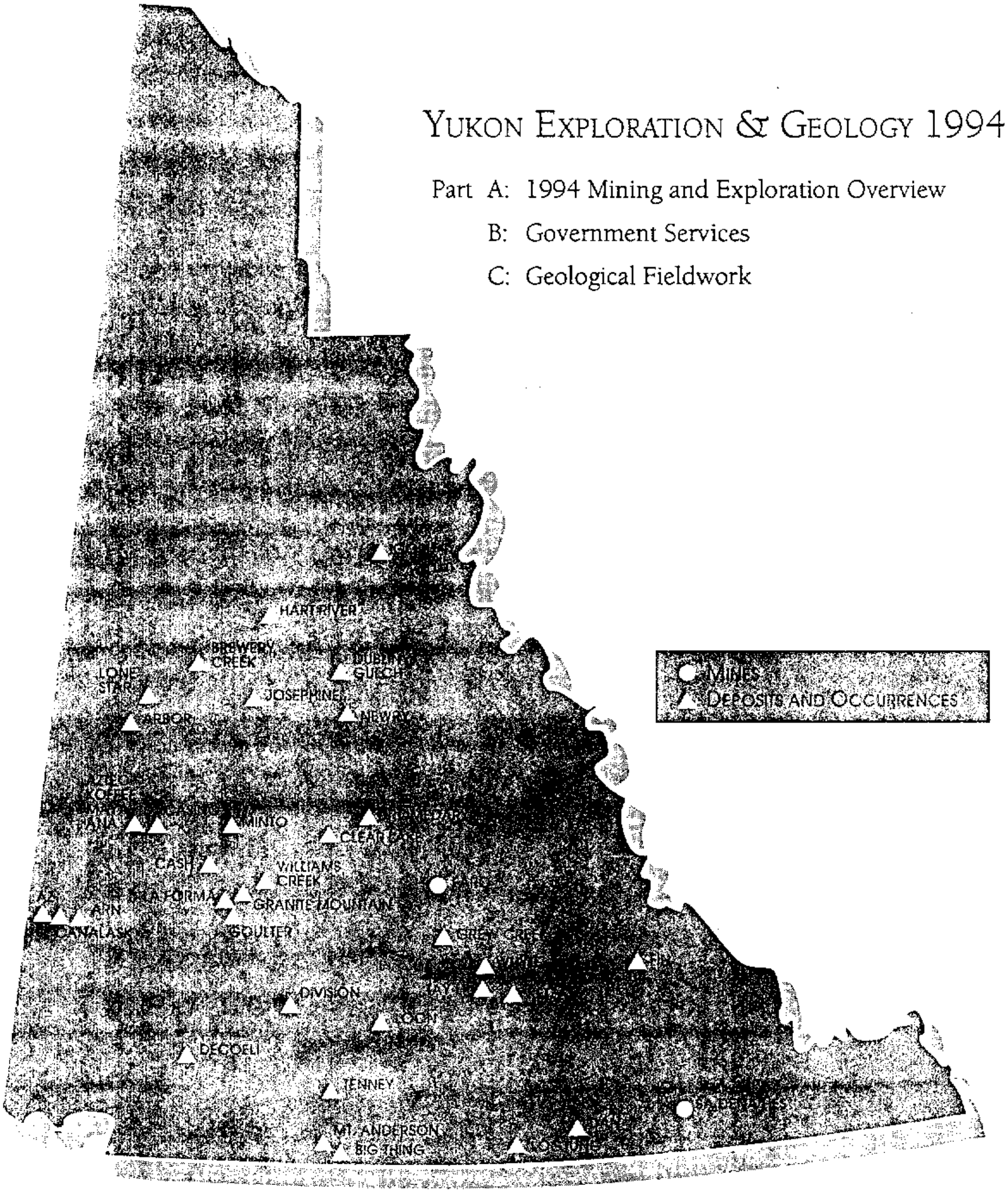
Indian and Northern Affairs Canada Affaires indiennes et du Nord Canada

EXPLORATION AND GEOLOGICAL SERVICES DIVISION, YUKON REGION

YUKON EXPLORATION & GEOLOGY 1994

Part A: 1994 Mining and Exploration Overview
B: Government Services
C: Geological Fieldwork



Canada

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To strengthen and diversify the Yukon economy

Yukon
Economic Development

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YUKON EXPLORATION AND GEOLOGY
1994

PART A:
1994 MINING AND EXPLORATION
OVERVIEW

PART B:
GOVERNMENT SERVICES

PART C:
GEOLOGICAL FIELDWORK

PREFACE

Yukon Exploration and Geology 1994 consists of three parts: Part A is a comprehensive overview of mining and exploration activity in the Yukon; Part B summarizes the activities of Government agencies which provide technical and financial assistance to the Yukon mining and exploration industries; and Part C consists primarily of geological reports by Canada/Yukon Geoscience Office geologists. Two outside reports are also included.

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.

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Yukon Region

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PART A

1994 YUKON MINING AND EXPLORATION OVERVIEW

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BURKE, M.R. and ABBOTT, J.G., 1995. 1994 Yukon Mining and Exploration Overview. In: Yukon Geology and Exploration 1994; Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada.

INTRODUCTION

In 1994, for the second year in a row, no hard rock metal mines were operational in Yukon, while placer production remained steady. The future, however, looks much brighter as production decisions have recently been announced on two lode projects. Positive feasibility studies have been received on three projects and are expected soon on three others. Exploration expenditures rose to $24.7 million by October 1994. Mining and exploration expenditures should reach $36 million by year end, up from the $20 million spent in 1993 (Fig. 1). This includes about $11 million that will be spent by Anvil Range Mining Corporation on stripping the Grum orebody at the Faro Mine. This marks the third consecutive year that expenditures have risen in Yukon.

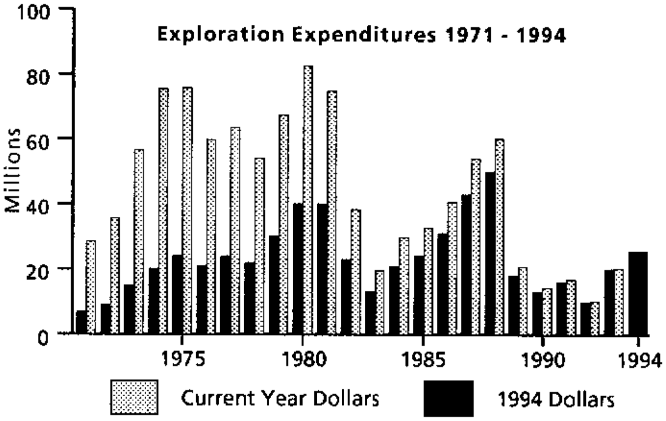

Figure 1: Exploration Expenditures: 1971 - 1994

The number of quartz claims staked to November 30, 1994 was 10,238, doubling the 5000 claims staked in 1993 (Fig. 2). Quartz claims in good standing have increased in Yukon for the first time in six years to 46,870 as of November 30, 1994 (Fig. 3). The number of placer claims staked during 1994 to November 30 was 1,350, a slight increase over 1993 (Fig. 4). The amount of placer ground held in good standing in the Yukon has increased slightly to 17,706, but has generally remained steady for the last couple of years (Fig. 5), as claim owners have continued to hold ground in historic mining areas. However, the low number of placer leases staked in recent years (Fig. 6) suggests that exploration for new deposits has been minimal, and that production could soon decline.

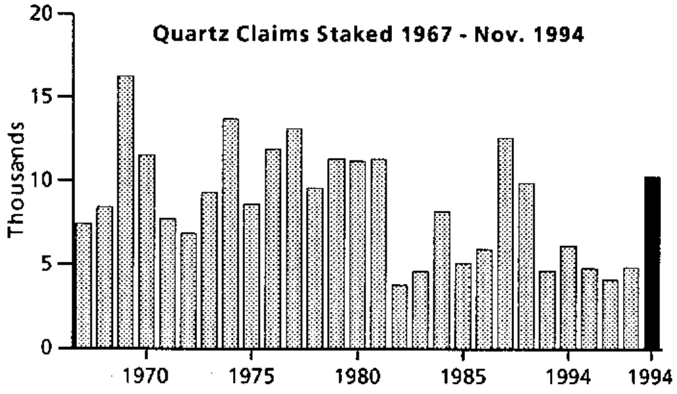

Figure 2: Quartz claims staked: 1967 - November 30, 1994

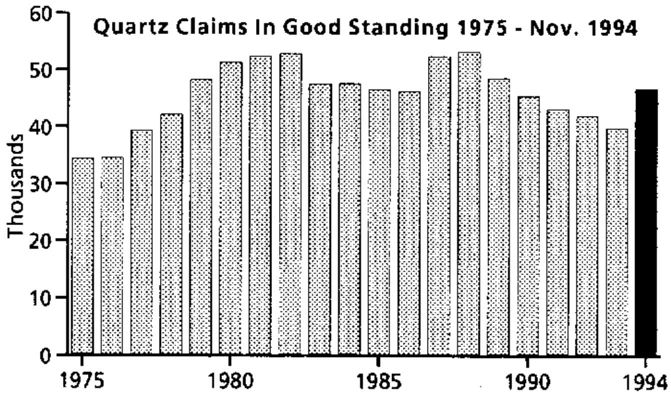

Figure 3: Quartz Claims in good standing: 1975 - November 30, 1994

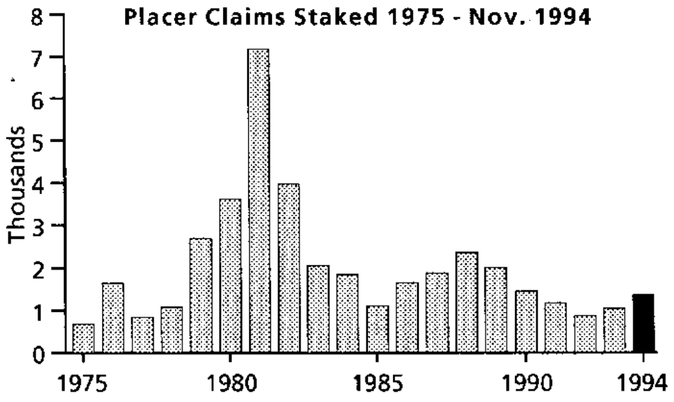

Figure 4: Placer claims staked: 1975 - November 30, 1994

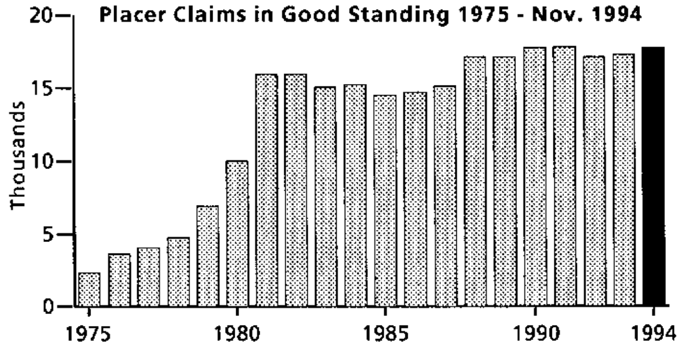

Figure 5: Placer claims in good standing: 1980 - November 30, 1994

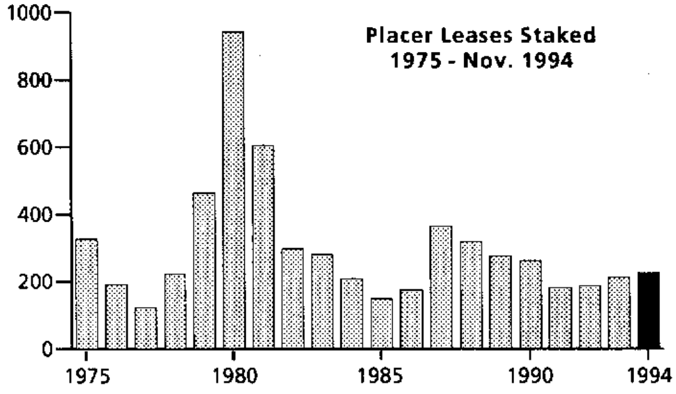

Figure 6: Placer leases staked: 1975 - November 30, 1994

More than 40 different properties were explored in 1994 (Fig. 7, Appendix 1), but 7 projects accounted for most of the money. These include Casino, Brewery Creek, Division Mountain Coal, United Keno Hill Mines, Kudz Ze Kayah and the Fairchild Project. The highlight of the exploration season was the discovery by Cominco of a large polymetallic volcanic hosted massive sulphide deposit on the Kudz Ze Kayah property in southeastern Yukon 115 kilometres southeast of Ross River. Not only is the discovery is the largest and most significant in Yukon in over a decade, but it significantly changes our perception of the mineral potential of the Yukon-Tanana terrane which underlies much of central Yukon. The project is being fast tracked and may support a one million tonne per year mine.

PLACER MINING

Placer gold mining continues to be a major industry in the Yukon, as it has been since the Klondike Gold Rush of 1898. For the last five years, placer production (Fig. 8) has averaged 125,000 crude ounces per year and included a modern-day production record of 169,345 crude ounces in 1989, a value not seen since 1917. Since 1989 production has generally declined, with only 108,950 crude ounces produced in 1993. In 1994, 107,392 crude ounces worth more that C$45 million were mined to the end of October; a 5% increase over the same period in 1993. An estimated 700 persons were directly employed at 226 mining operations in 1994, somewhat higher than the 182 active in 1993.

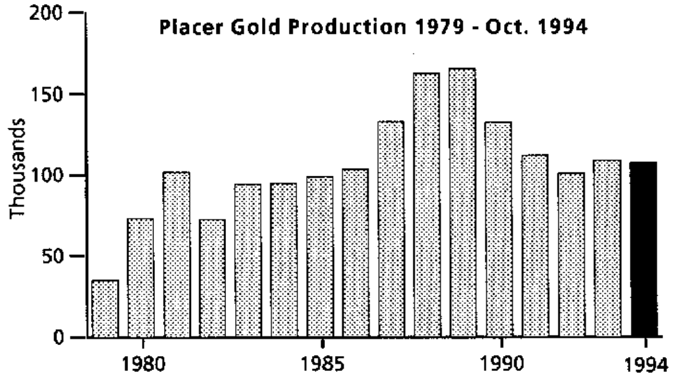

Figure 8: Placer gold production in crude ounces: 1979 - October 31, 1994

LODE MINING

Anvil Range Mining Corporation successfully acquired the Faro Mine assets (Minfile #'s 105K-46,55,56,61) from bankrupt Curragh Resources in November, and immediately began stripping overburden from the sedimentary-exhalative **Grum** deposit. Mining and concentrating of ore is planned for August 1995 following completion of stripping. The Grum deposit contains open pit diluted reserves of 16.9 million tonnes of 4.9% Zn, 3.0% Pb, 47 g/T Ag and 0.82 g/T Au, enough to sustain production for 6 years. Other reserves on the property include: 790,000 tonnes (proven) grading 4.19% Zn, 3.35% Pb, 42.4 g/T Ag and 0.68 g/T Au in the **Vangorda** deposit, which was in production when the mine closed; 20.3 million tonnes (probable and possible) grading 7% Zn, 5.7% Pb, 82 g/T Ag and 0.87 g/T Au in the **Dy** deposit; and 5 million tonnes (possible) grading 4.4% Zn, 3.5% Pb, 47 g/T Ag and 0.65 g/T Au in the **Swim** deposit. The Faro concentrator, which has been idle since April, 1993, will be upgraded in 1995.

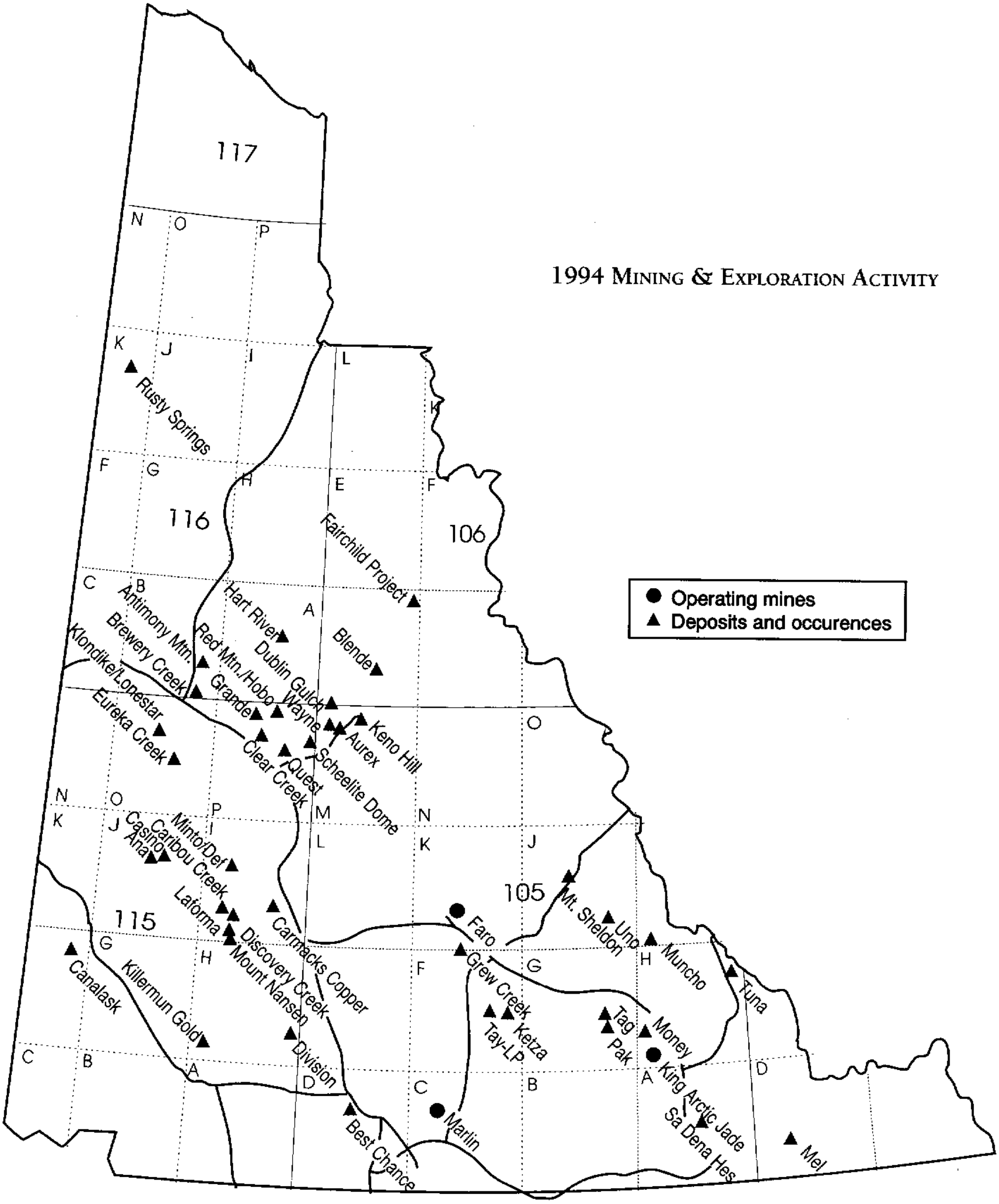
1994 Mining & Exploration Activity

Figure 7: 1994 mining and exploration activity.

The **King Arctic Jade** (Minfile #105H 014) property continued to produce nephrite jade for southern and overseas markets. Nephrite (twisted-fibre tremolite) occurs as talus blocks up to 90 tonnes in size and forms lenses up to 15 m long and 5 m thick in the footwall of several southwest-dipping thrust faults.

Approximately 20 tonnes of rhodonite was mined from the **Marlin** (Minfile #105C 017) occurrence.

ADVANCED DEVELOPMENT AND EXPLORATION

The **Brewery Creek** deposit (Minfile #116B-160), wholly owned by Loki Gold Corporation, received a positive feasibility study in June and is slated for production in August, 1995. The oxide gold deposit is hosted mainly by sill-like intrusive bodies but significant mineralization has recently been outlined in sedimentary and volcanic rocks (Fig. 9). The deposit is oxidized to a depth of 50 m. Eight near-surface zones host total mineable oxide reserves of 17,172,000 tonnes grading 1.44 g/T Au with a 0.5 g/T cutoff and a stripping ratio of approximately 1.2-to-1. The eight bodies form a 6 km segment of a linear east-trending mineralized belt 12 km long. Other ore grade intersections have been located in trenches and drill holes on several zones in the belt east and north of the main reserves, and outside the belt, south of the main reserves along a large southeast-trending geochemical anomaly. The sulphide potential of the property is yet to be fully explored. Open-pit mining will be seasonal and last from April to October, but conventional cyanide heap leaching will continue year-round (Fig. 10). Recoveries are expected to be 80%, and mining costs about US$178/ounce. The mine has reserves to last 7.5 years, at a rate of 83,000 ounces/year. Loki has submitted an Initial Environmental Evaluation Report (IEE) to the Federal Government and is currently being screened under the Environmental Assessment Review Process (EARP). The company has also applied to the Yukon Water Board for a water use license.

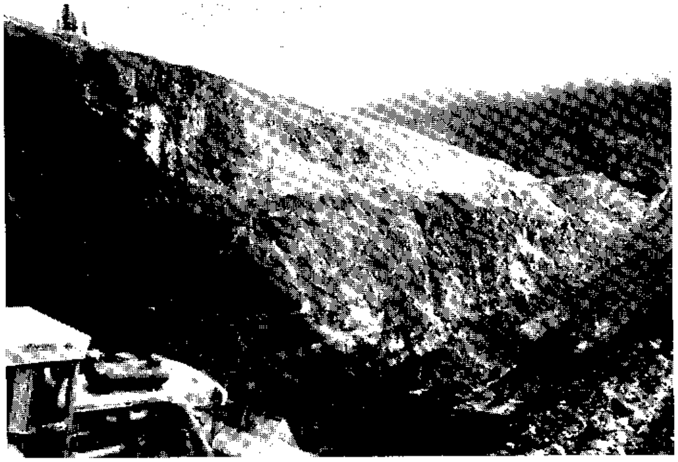

Figure 9: Bulk sample trench on the Kokanee zone at Loki Gold Corporation's Brewery Creek property. Barren Devono-Mississippian Earn Group shale is in fault contact with altered and mineralized quartz-monzonite of the Tombstone Suite.

Figure 10: Rick Diment, Project Geologist at Brewery Creek, explains the deposit to a group of visiting Russians. Leach pads will be located in the stripped area seen in the background.

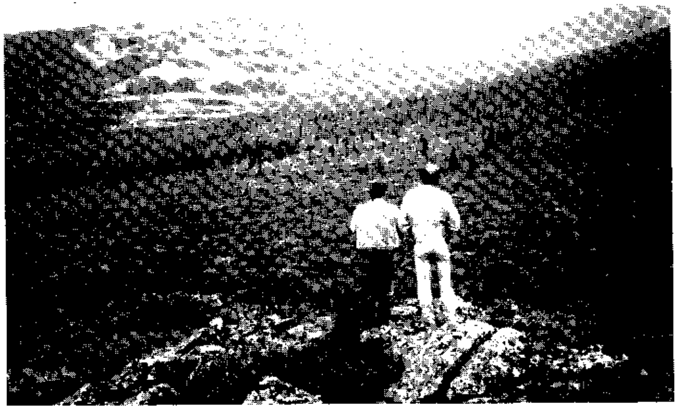

Figure 11: In 1994 Pacific Sentinel conducted an 83 hole 16,800 m drilling program of in-fill holes for open pit mine planning and step-out holes for determining the overall size of the deposit.

Pacific Sentinel Gold Corporation drilled 83 large diameter diamond drill holes totaling 16,800 m on the **Casino** (Minfile #115I-028) Cu-Au-Mo porphyry deposit (Fig. 11). The deposit is located in the Dawson Range, northwest of Carmacks, 60 km from the end of the Mt. Freegold road. Reserves are estimated at 531 million tonnes grading 0.26% Cu, 0.025 Mo, and 0.27 g/T Au. The deposit is hosted by the Casino Complex, a subvolcanic suite of breccias, dykes and porphyritic phases dated at about 70 Ma. These intrude granodiorite of the mid-Cretaceous Klotassin Batholith. The deposit is unglaciated and includes a well developed leached cap, supergene zone, and hypogene zone. An initial open pit containing reserves of 119.3 million tonnes grading 0.27% Cu and 0.48 g/T Au at a stripping ratio of 0.9-to-1 has been designed. The pit encompasses the oxide gold zone (36.5 mT @ 0.6 g/T), the supergene zone (58.6 mT @ 0.43% Cu, 0.44 g/T Au) and a small portion of the hypogene zone (24.3 mT @ 0.31% Cu, 0.41 g/T Au). Pacific Sentinel is working on a detailed prefeasibility study including testing for different methods of metal extraction. These include: cyanide leaching of Au from the oxide gold zone, acid leach of copper with SX/EW for Cu followed by cyanide heap leach for Au, conventional milling, and bioleaching. Casino was the largest exploration project in the Yukon this year with 16,800 m of diamond drilling in 83 holes. A total of over 67,000 m in 220 large diameter drill holes have now been drilled on the property.

Western Copper Holdings and Thermal Exploration received a positive feasibility study in October for the **Carmacks Copper** deposit (Minfile #115I-008). The property is located 40 km by road northwest of Carmacks. The feasibility study is based on diluted open pit oxide reserves of 14.2 million tonnes grading 1.01% Cu and 0.51 g/T Au. Copper recovery is estimated at 80%. Mining would be conducted on a seasonal basis at a rate of 1.6 million tonnes of ore per year. The copper will be recovered through heap leaching and SX/EW on a year round basis. A successful pilot leach, SX/EW project was conducted from September 1993 to February 1994 in the town of Carmacks. Temperatures as low as -50 C were encountered. The proposed mine will produce 41 tonnes of cathode copper per day at an estimated cost of $0.69 per pound. Capital costs are estimated at $57 million. Based on existing reserves the mine will have an 8.5 year life. Carmacks Copper is one of three metamorphosed copper deposits located in Jurassic granodiorite along the boundary between the Yukon-Tanana and Northern Stikine terranes. The others are **Stu** (Minfile #115I 011) and **Def-Minto** (#115I 021,022). Petrographic studies by Western Copper Holdings suggest that the Williams Creek host gneiss was originally volcanic (andesitic or basaltic tuff and breccia), possibly the Triassic Lewes River Group. However, based on work on the Minto property in 1994, other researchers have suggested that the deposits represent metamorphosed porphyry-style mineralization which was emplaced in shear zones during intrusion of the host Jurassic batholith.

BYG Natural Resources Inc. announced a positive feasibility study for the **Mt. Nansen** property (Minfile #115I-64,65). Geotechnical and engineering work was also performed. An existing mill on site is to be upgraded to 300 tonnes per day. Production will commence with open pit mining of the Brown-McDade zone (Fig.12) which contains oxide reserves of 200,000 tonnes with an approximate grade of 7 g/T Au and 70 g/T Ag. The Brown-McDade zone is in a strong northwest-trending, steeply west-dipping vein fault which cuts Cretaceous granodiorite and feldspar porphyry of the Mount Nansen Group. The shear contains lenses up to 30 m wide of grey quartz with pyrite and arsenopyrite and minor chalcopyrite, galena, tetrahedrite, sphalerite and stibnite. The sulphides are oxidized to a depth of about 30 m. The Flex, Heustis North, and Brown-McDade sulphide zones, which also contain reserves on the Mt. Nansen property, were tested with 12 diamond drill holes totalling 1000 m in 1994. Total reserves in all categories from all zones on the property were calculated in 1989 to be 953,000 tonnes grading 9.4 g/T Au and 189.6 g/T Ag.

Figure 12: Production from BYG Resources Mt. Nansen property will commence with open pit mining of 200,000 tonnes of oxide reserves in the Brown-McDade zone, the stripped area pictured above.

BYG can also acquire a 51% interest in Omni Resources by spending $2.7 million on engineering and metallurgical work on Omni properties in the next three years. These properties include the **Mt. Skukum** mine (Minfile #105D-158) a former producer with estimated reserves of 99,000 tonnes grading 14.7 g/T Au, and the **Skukum Creek** property (Minfile #105D-022) which hosts diluted mineable reserves of 465,400 tonnes grading 7.6 g/T Au and 274.3 g/T Ag.

YGC Resources explored the **Grew Creek** deposit (Minfile #105K-009) with a 12 hole diamond drill program totalling 1350 m. In 1995, YGC is planning to truck Grew Creek ore 92 km to its 450 tonne per day mill at Ketza River. Projected production is 30,000 oz (930,000 g) Au per year for 3 years, with a 93% recovery. Grew Creek is an epithermal gold deposit in Eocene volcanic and sedimentary rocks that were deposited in a pull-apart basin within the Tintina strike-slip fault zone. In the Main zone, gold occurs as very fine grained electrum in chalcedonic and fine- to medium-grained quartz which forms a vein stockwork, and cements hydrothermal breccias in hydrothermally altered rhyolitic crystal-lithic lapilli tuffs. Open pit mineable reserves in the Main Zone at Grew Creek are 170,000 tonnes at 12.0 g/T Au. In 1994, intersections into the Main Zone included 47.9 m grading 3.45 g/T Au and 5.9 g/T Ag and 29.25 m grading 4.96 g/T Au and 5.9 g/T Ag.

EXPLORATION

Coal

Cash Resources has outlined a coal measure with over 50 km of strike potential at **Division Mountain** (Minfile #115H-013), 90 km north of Whitehorse and 18 km from the Klondike Highway and a major electrical transmission line. In 1994, Cash completed an extensive trenching program and drilled 4054 m in 26 diamond drill holes. Open pitable, drill-indicated reserves are now 15.8 million tonnes of low sulphur, high volatile bituminous coal ideal for

Figure 13: Red Ridge (in the centre of the photo) north of the Division Mountain coal deposit of Cash Resources was trenched to expose three seams of coal with an aggregate thickness of 11.4 m. Trenching and drilling in 1994 was conducted approximately five km south of this location.

electrical power generation. Coal has been demonstrated to be continuous over a 10 km strike length (Fig. 13) and reserve potential is excellent near the nose of a syncline.

Base metals

In late 1993, Cominco discovered mineralized float from the ABM deposit (Minfile #105G-117) on the **Kudz Ze Kayah** property while following up stream sediment anomalies from a government regional geochemical survey. Since then, an intense exploration program has outlined an "Inferred Resource" of 13 million tonnes grading 5.5% Zn, 1.0% Cu, 1.3 Pb, 125 g/T Ag and 1.2 g/T Au in 1994. A total of 8500 m in 52 diamond drill holes were completed in 1994 in a helicopter supported, low impact exploration program. Cominco has stated that they will "fast track" the deposit to a 1 million tonne per year operation. Preliminary mine planning indicates that more than half of the deposit can be mined by open pit methods. The polymetallic volcanic hosted massive sulphide deposit is hosted in Devono-Mississippian felsic volcanic rocks of the Yukon-Tanana Terrane. This VMS discovery is the first with immediate economic potential in the Yukon-Tanana Terrane, and it greatly enhances the mineral potential of a large part of central Yukon. Cominco flew 15,000 km of airborne geophysics and subsequently staked more than 3700 claims over targets that will be explored in 1995.

The Pamicon Developments-Equity Engineering-Westmin Resources-Newmont Exploration joint venture spent $2.7 million on the **Fairchild Lake** project in the Bonnet Plume Area. Since 1928, exploration in the area has continued for various commodities including coal, oil & gas, iron, uranium, cobalt, copper, lead, zinc, silver and gold. Recent exploration has focused mainly on Cu-Au-Ag-Co mineralization in "Wernecke breccias" cutting Middle Proterozoic Wernecke Supergroup. In 1994, the **Slab** (Minfile #106D-70), **Olympic** (Minfile #106C-91) (Fig. 14) and **Hoover** (Minfile #106E-2) properties were explored with a low impact helicopter-supported diamond drill program of 21 holes totalling 4808 m. Other properties in the area were explored with geology, geochemistry and geophysics. An airstrip was constructed to improve access.

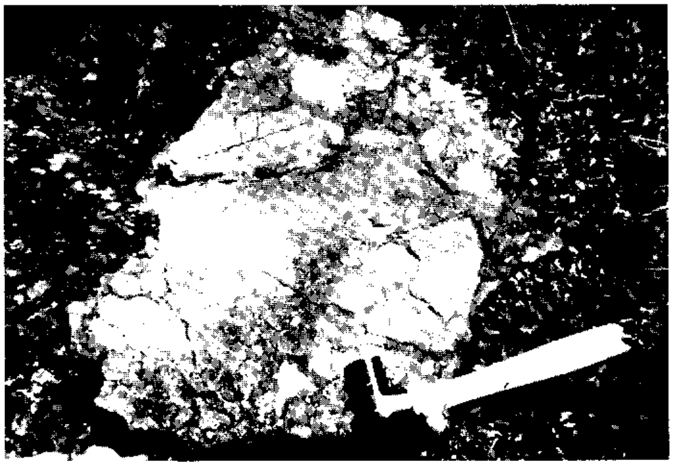

Figure 14: Potassic altered heterolithic breccia from the Olympic property in the Wernecke Mountains. The breccia contains Gillespie Group dolostone clasts and fewer Quartet Group mudstone clasts in a matrix of pink K-feldspar, hematite and sericite.

Figure 15: Minto Explorations drilled targets defined by 1993 geophysics outside the main reserve on the Minto/DEF property.

Minto Explorations continued work on the **Minto/DEF** deposit (Minfile #115I-021,022). Exploration to the end of 1992 outlined proven and probable reserves of 6.56 million tonnes grading 1.87% Cu, 0.5 g/T Au and 8.2 g/T Ag, and possible reserves of 5.0 million tonnes grading 0.74% Cu, 0.31 g/T Au and 4.5 g/T Ag. In 1994, targets outside the existing reserves were tested with 16 diamond drill holes totalling 2084 m (Fig. 15). Nine holes spaced 70 m apart intersected a new zone which averages 6.77 m thick and grades approximately 2.17% Cu and 1.13 g/T Au. One hole (#94-17), in the existing deposit close to the edge, intersected 12.62 m grading 6.26% Cu, 1.68 g/T Au and 22.97 g/T Ag. A mineral inventory and ore reserve review based on 1993 and 1994 drill results is currently underway. Minto also performed engineering and geotechnical studies including overburden and waste characterization, tests on tailings solids and tailings effluent, and standard acid-base accounting. The studies indicate that the deposit is not acid-generating and that the tailings solids are low in heavy metals and are strongly acid-consuming. A feasibility study expected by late 1994 will be based on a production rate of 477,000 tonnes of ore per year. The deposit would be mined by open pit followed by underground operations.

United Keno Hill Mines contracted Watts, Griffis & McOuat (WGM) to conduct an exploration program consisting of over 5700 m of percussion, 4000 m of diamond, and 2700 m of reverse circulation drilling on the **Silver King** (Fig. 16), **Husky Southwest** and **Bellekeno** Mines (Minfile #105M-001). The mined silver veins of the Keno Hill Camp occur in an area 26 km long and 1 to 6.4 km wide. All but the Sadie-Ladue vein are confined to the Mississippian Keno Hill Quartzite. Since 1921 the district has produced nearly 200 million ounces of silver from approximately 65 veins, with over 50% of production coming from 6 veins. Low silver prices forced the mines to close in January 1989. WGM began the program by compiling a massive amount of historical data and constructing a multi-dimensional computerized model of the geology and existing workings. Measured and indicated reserves are 112,590 tonnes grading 1337 g/T Ag and inferred reserves are 63,270 tonnes grading 1306 g/T Ag; enough to support a mine life of 1.5 years. The goal of the project is to increase reserves to support an initial 5 year mine life at a historic average grade of approximately 1300 g/T Ag.

Figure 16: Over 4000 m of diamond drilling was conducted on the Silver King vein in the Keno Hill camp.

International Barytex Resources tested the **Mel** deposit (Minfile #95D-005) with six deep diamond drill holes. All intersected mineralization. The widest intersection contained 10 m grading 5.98% Zn, 0.67% Pb and 77% $BaSO_4$. The Mel deposit consists of a concordant, folded lens of barite and coarse, recrystallized galena and sphalerite, at the contact between Cambro-Ordovician limestone and calcareous slate and phyllite. Drill-indicated reserves have increased to 6.8 million tonnes grading 7.1% Zn, 2.3% Pb and 54.7% $BaSO_4$. Barytex intends continue the drilling program in 1995.

At the **Rusty Springs** project (Minfile #116K-003) Eagle Plains Resources Ltd. discovered two new zones of high grade copper-lead-zinc-silver mineralization called the Mike Hill and Big Onion zones. Brecciated dolomite and shale of the Lower and Middle Devonian Ogilvie Formation contain sulphides in vugs, quartz-calcite veinlets, widespread narrow lenses and, most commonly, in veins. The Mike Hill zone was defined by a multi-element geochemical anomaly over 700 m long and was uncovered by trenching in 1994. The showing is a vein trending at 040° and is exposed in trenches for a strike length of 300 m. Mineralization consists of quartz-carbonate with galena, stibnite, pyromorphite, malachite and azurite (Fig. 17). Selected samples assayed up to 630 g/T Ag, 13.9% Cu, 4.4% Pb, 2.6% Zn, 9.1% Sb and 0.45 g/T Au. The Big Onion zone is located 1.3 km south of Mike Hill. Mineralization resembles the Mike Hill zone. Specimens assayed up to 2300 g/T Ag, 2.03% Cu, 17.8% Pb, and 0.2 g/T Au. A multi-element soil anomaly indicates that the Big

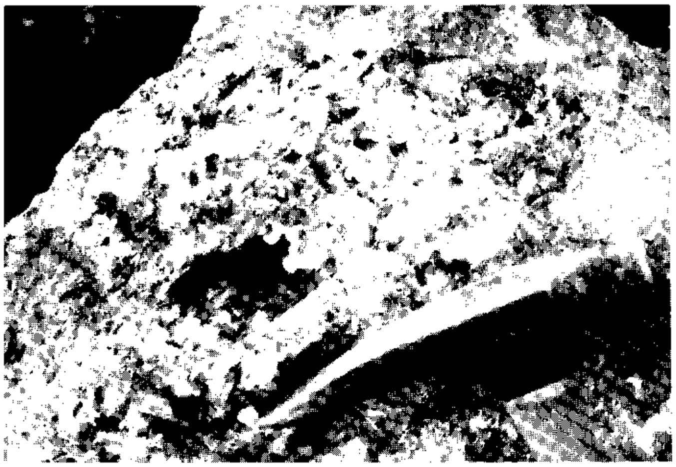

Figure 17: Vuggy quartz (white) with azurite and malachite (grey shades) and minor galena from Mike Hill on the Rusty Springs property.

Onion trends at 170°. Current exploration is directed at defining the high grade veins on the property and to then drill using on the model of the Prairie Creek deposit in the Northwest Territories where similar high grade veins in carbonates are associated with much larger replacement deposits.

Expatriate Resources and Cachet Enterprises explored the **Canalask** property (Minfile #115F-045) with 940 m of diamond drilling in 6 holes. Drilling was directed at confirming reserves reported in 1967 as 454,545 tonnes grading 1.5% Ni. The deposit consists of massive sulphide lenses in Permo-Pennsylvanian tuffs of the Station Creek Formation. Disseminated sulphides are present throughout the volcanic unit. The main sulphide zone lies approximately 122 m beneath the footwall of a peridotite sill. A program planned for 1995 will be based on the Noril'sk-Talnakh model in Russia. At Noril'sk, a large portion of the PGE-rich, copper-nickel sulphide ores consist of large, wavy, conformable layers, veins, and streaks in wall rock beneath the intrusions as well as in the lower portions of the intrusions.

NDU Resources explored the **Blende** Deposit (Minfile #106 D-064) with 7 diamond drill holes totalling 596 m. Drilling was to the immediate west of the area where previous drilling indicated an open pitable geological resource of 19.5 million tonnes grading 3.04% Zn, 2.81% Pb and 55.9 g/T Ag. Six holes intersected significant mineralization, with the best intersection assaying 9.71% Pb, 5.48% Zn, 0.78% Cu and 228.4 g/T Ag across 14.9 m. The mineralization remains open to the west.

Inco Exploration explored the **Hart River** volcanogenic massive sulphide deposit (Minfile #116A-009) with 6 diamond drill holes totalling 1653 m. The drilling tested the projected strike length of the favorable horizon. The horizon was intersected but metal values were low. The deposit is in black shale beneath a local lens of mafic volcanic rocks in the Middle Proterozoic Gillespie Lake Group. Published reserves are 523,454 tonnes (proved) grading 3.6% Zn, 1.45% Cu, 0.9% Pb, 49.7 g/t Ag and 1.4 g/t Au plus 544,320 tonnes (probable) of similar grade. The deposit exhibits proximal exhalative features and is synsedimentary. Mafic sills which appear to be feeders to the volcanics have yielded a uranium/lead date of 1380 Ma (Abbott, 1993). The age of the deposit is probably similar.

YGC Resources compiled the geology of its **Money** claims (Minfile #105H-078) where massive sulphide mineralization occurs in a northeast-dipping sequence of green and maroon andesitic pillow lava, breccia and tuff intercalated with argillaceous and cherty tuff of the Slide Mountain Terrane. Two showings, approximately 2000 m apart, consist of float boulders and 1.5 m thick beds of massive pyrite with minor chalcopyrite. The showings are associated with several gossanous zones containing disseminated and stockwork pyrite with minor chalcopyrite and sphalerite. Specimens resemble those from Besshi-type volcanogenic deposits. Massive sulphide float collected in 1990 contained up to 2.06% Cu with 2.1 g/T Au.

Atna Resources Ltd. worked on the **Pak** property (Minfile #105H-032) located approximately 10 km south of Cominco's Kudz Ze Kayah discovery. The property is hosted in Devono-Mississippian interlayered felsic and mafic metavolcanic rocks similar to those which contain the Cominco discovery. The Pak showing is a gently dipping massive sulphide body between 0.4 to 1.0 m wide, with an exposed strike length of 300 m. Assays are up to 5% Cu, 11.1% Zn, 1.1% Pb, 62 ppm Ag and 340 ppb Au. Extensive soil geochemical anomalies and magnetometer-VLF anomalies suggest that the Pak showing is much larger. The anomalies led to the discovery in 1994 of the East Cirque Zone located 800 m along strike from the original showing. The East Cirque zone contains values up to 1.5% Cu, 0.4% Pb, 1.6% Zn and 24.4 g/T Ag.

Atna also performed geochemical surveys on the **Foot** (Minfile #105G-072) and **Toe** properties near the Cominco discovery. Anomalous base metal values in stream sediments were reported from the Foot property. Based upon Cominco's success and the encouraging results on the Pak in 1994, Atna is planning an aggressive program including drilling on the Pak, Toe and Foot properties in 1995.

Gold

YGC Resources explored the **Ketza River** Mine property (Minfile #105F-019) with a 25 hole diamond drilling program totalling 2180 m. Proved, probable and possible oxide reserves of 16,400 tonnes remained when Canamax Resources Inc. closed the mine in September, 1990. YGC drilled near the Break-Nu pit to explore for extensions of two parallel east-striking, steeply dipping zones (Fig. 18). The Nu zone was originally intersected by Canamax 10 m into an exploration adit that was being driven to the Break zone. Former production from the Break-Nu zone was approximately 68,000 tonnes grading 13.0 g/t Au. In 1994, YGC

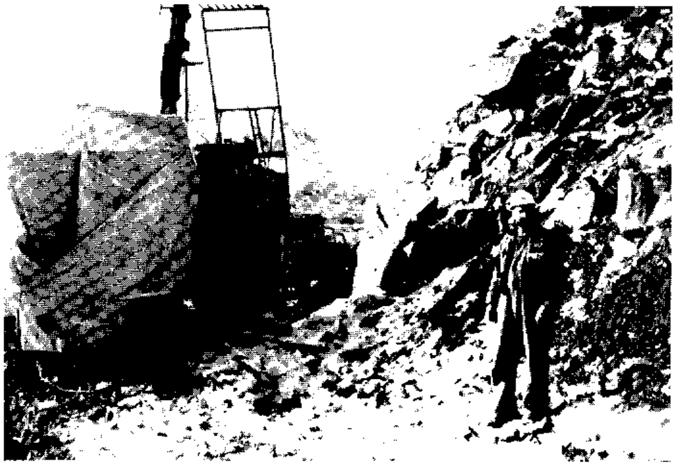

Figure 18: YGC Resources explored for new reserves with a 25 hole, 2180 m diamond drilling program on the Ketza River Mine property, formerly operated by Canamax Resources Inc. When the mine closed in September, 1990, 16,400 tonnes of proved, probable and possible oxide reserves remained.

reported intersections of oxide material including 3.1 m grading 13.9 g/T Au in Hole KR94-494 and 7.0 m grading 5.0 g/T Au in Hole KR94-489. Further drilling in 1995 will be required to define the extent of these intersections.

Redell Mining Corporation completed trenching and 2000 m of diamond drilling in 23 holes on the G-3 Zone of the **Laforma** Gold Mine project (Minfile# 115I-054), located 45 km west of Carmacks (Fig. 19). The G-3 Zone is a shear zone containing lenses of broken vein quartz, occasionally with finely disseminated pyrite and arsenopyrite. Seams of crushed pyrite and occasional arsenopyrite, chalcopyrite, sphalerite and galena are also present. Gold occurs mainly as free-milling, fine disseminations in the quartz. Granitic rock in the shear zone is almost completely altered to clay and sericite and the wallrocks exhibit similar alteration. A detailed study by Redell indicates the mineralized shear system may reach a width of 12 m or more, and mining the entire shear would result in a higher tonnage and lower grade than the reserve calculated in 1984 of 181,000 tonnes at 11.3 g/T diluted to a 1.5 m mining width. Samples from the shear in existing underground workings returned an average grade of 7.2 g/T Au over a 6 m width and for 112 m along strike. Highlights of 1994 drilling include an intersection of 10.5 m assaying 47.65 g/T Au. Trenching over 100 m west of the G-3 zone produced an assay of 40 g/T Au over a 0.9 m width.

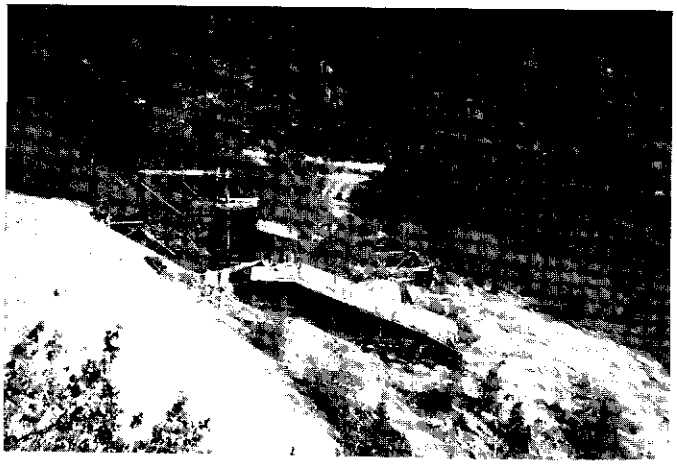

Figure 19: This 9 tonne mill at the Laforma Gold Mine was used in 1939–40 to produce 1286 tonnes of ore grading over 34 g/T Au from the No. 2 level of the G-3 vein.

Redell has also optioned the contiguous **Antoniuk** (Minfile #115I-111), **Ant** (115I-111) and **Goldstar** (115I-053) properties to bring their holdings to over 3000 hectares.

The **Aurex (Newry)** property of Yukon Revenue Mines (Minfile #105M-060) adjoins the United Keno Hill Mines property. The claims were explored with 200 percussion drillholes totalling 6000 m followed by 4 diamond drill holes totalling 600 m. Intersections from the percussion holes included 3 m grading 4.1 g/T Au in hole 94-50 and 5.5 g/T Au over 3 m in hole 94-193. On the property, metasedimentary and volcanic rocks of the Lower Cambrian Hyland Group contain three types of vein mineralization: quartz-massive arsenopyrite, foliaform bull quartz, and siderite-quartz-chlorite. Layers of rusty, extremely fine grained actinolite-pyrrhotite skarn in quartz-sericite schist assayed up to 5.4 g/T Au. Results of the diamond drilling were pending at the end of 1994.

Kennecott Canada worked on its **Klondike** group of properties (Minfile #115O-072, etc.) in the Dawson area. The claims are optioned from the Arbor Group of companies. Existing workings on the Lonestar property were mapped and surveyed, and two holes were drilled on the Buckland zone to confirm earlier results. One hole intersected 4.7 m grading 4.6 g/T. An airborne magnetic survey suggested the presence of a caldera collapse feature in the 80 Pup area. Detailed geophysics (61 line kilometre E-Scan survey) defined targets that were tested with 5 diamond drill holes. Abundant hydrothermal alteration was encountered but gold values were low.

Kennecott was also active in the Mayo district where they explored for a Fort Knox-type deposit on the **Scheelite Dome** property (Minfile #115P-033) with geological mapping, soil geochemistry and trenching. Kennecott also staked and explored the Antimony Mountain (Minfile #116B-001) area.

Cash Resources was active on a number of properties in Yukon. The **Killermun Lake Gold** property (Minfile #115H-047), located 48 km northeast of Haines Junction was explored with prospecting, geological mapping, soil geochemistry and minor trenching. Gold is associated with disseminated arsenopyrite in quartz veins and in wallrock of graphitic quartz-biotite schist. The quartz veins also contain native gold grains up to 1 mm across. The average grade of 63 samples from surface float, outcrops and hand trenches was 16.32 g/T Au. Most of the samples were taken from within two Au-As soil geochemical anomalies. The anomalies are located 3 km apart. One is 4 km long and 300 m wide and the other is 2.5 km long and 800 m wide. A chip sample from a hand trench returned a value of 9.22 g/T Au over 7.4 m.

Cash also conducted geochemical surveys on the **Grande** (Minfile #115P-032) and **Quest** (Minfile #115P-057)properties located north of Mayo, and the **Mucho** (Minfile #105I-004) and **Uno** (Minfile #105J-030) properties located east of Ross River. Multi-element anomalies were defined on all of the properties and will be followed up in 1995.

Pacific Mariner Explorations Ltd. and Wealth Resources trenched gold soil anomalies on the **Eureka Creek** property (Minfile #115O-057) located approximately 60 km south of Dawson. Six of seven trenches intersected significant fault gouge. Assays included 1670 ppb Au over 1.8 m and 462 ppb Au over 6.6 m from the fault gouge. The property is underlain by Paleozoic Nasina quartzite with interbeds of chloritic muscovite schist.

Regent Ventures explored the **Hobo/Red Mountain** (Minfile #115P-006) property 55 km northwest of Mayo with six diamond drill holes totalling 243 m. The main target was the 50/50 zone, which derives its name from its strike of 050° and dip of 50° NW. The 50/50 zone is interpreted to be stratabound in metasedimentary rocks adjacent to a small Early Cretaceous quartz monzonite stock belonging to the Tombstone Plutonic Suite. An assay of 16.8 g/T Au over 3.35 m was reported from hole 94-02. The property is also being explored for its potential to host a Fort Knox-type vein system.

Pacific Comox Resources Ltd. completed a reverse circulation drill and trenching program on the **Tay-LP** property (Minfile #105 F-121) in July. The property is located 50 km south of Ross River and 15 km west of the Ketza River Mine. The drilling was designed to test airborne electromagnetic anomalies from 1991 work. Trenching on a well defined geophysical anomaly over 900 m long uncovered a quartz-pyrrhotite vein that assayed 6.2 g/T Au over 4.4 m. The drill program of 27 holes totalling 426 m returned values up to 6.7 g/T on the same vein. Additional work is planned for 1995.

Bernie Kreft excavated a bulk sample from his **Wayne** Property (Minfile #105M-029) west of the Keno Hill Camp. Seventeen tonnes were excavated from a skarn/replacement body consisting of vuggy quartz with coarse scheelite and no visible sulphides in quartz-sericite schist of the Late Proterozoic-Early Cambrian Hyland Group. The sample was processed at Westmin Resources Premier Mill in northern B.C. where 22.1 ounces of gold were recovered for an average grade of 44.6 g/T at an estimated recovery of 98%. Core assays from 1981 returned up to 33.3 g/t Au and 2.07% W03 over widths ranging from 46 cm to 3.17 m.

Appendix 1: 1994 Exploration Projects

Property	Company	Mining District	Minfile #	Work Type	Commodity
Ana	Eastfield Res.	Whitehorse	115I-101	G,GC	Cu
Antimony Mountain	Kennecott Canada	Dawson	116B-001	GC,G	Au
Aurex	Yukon Revenue	Mayo	105M-060	DD,PD,G	Au
Best Chance	Best Chance	Whitehorse	105D-053	GP	Cu
Blende	NDU Resources	Mayo	106D-064	DD,G	Pb,Zn,Ag
Brewery Ck.	Loki Gold Corporation	Dawson	116B-160	PD,T,G,GC,F,D	Au
Canalask	Expatriate Res. Cachet Enterprises	Whitehorse	115F-045	DD, G	Ni,Cu
Caribou Ck.	Ormsby M L	Whitehorse	115I-049	BS	Au
Carmacks Copper	Western Copper Holdings Thermal Expl.	Whitehorse	115I-008	F,G,GC,GP	Cu,Au
Casino	Pacific Sentinel Resources	Whitehorse	115I-028	DD,G,PF	Cu,Mo,Au
Clear Creek	Starmin Res.	Dawson	115P-011	G,GC	Au
Discovery Ck.	Aurchem Expl.	Whitehorse	115I-093	PD,G	Au,Ag,Cu,Mo,Pb,Zn
Division Mtn.	Cash Res. Ltd.	Whitehorse	115H-013	DD,T,G,GP	Coal
Dublin Gulch	Starmin	Mayo	106D-21-29	G,GC	Au
Eureka Ck.	Wealth Res.	Dawson	115O-057	T,G,GC,GP	Au
Fairchild Project	Westmin Res. Newmont Expl.	Mayo	106C,D,E	DD,G,GC,R	Cu,Au,Ag,Co
Faro (Grum)	Anvil Range Mining Corp.	Whitehorse	105K-46,55, 56,61	D	Pb,Zn,Ag,Au
Grew Ck.	YGC Res.	Whitehorse	105K-009	DD,G	Au
Grande	Cash Res.	Watson Lake	105I-007	G,GC	Ag,Mo,Zn,Cu

Appendix 1: 1994 Exploration Projects - continued

Property	Company	Mining District	Minfile #	Work Type	Commodity
Hart River	Inco Expl.	Mayo	116A-009	DD,G	Cu,Zn,Pb,Au,Ag
Hobo/Red Mtn.	Regent Ventures	Mayo	115P-006	DD,GC,T,G	Au
Keno Hill	United Keno Hill Mines	Mayo	105M-001	C,DD,PD,G	Pb,Zn,Ag
Ketza	YGC Res.	Watson Lake	105F-019	DD,G	Au
Killermun Lake Gold	Cash Res. Ltd.	Whitehorse	115H-047	G,GP,T	Au
King Arctic Jade	Max Rosequist	Watson Lake	105H-014	T,BS	Jade
Kudz Ze Kayah (Tag)	Cominco Ltd.	Watson Lake	105G-117	G,GC,GP	Cu,Zn,Pb,Ag,Au
Laforma	Redell Mining Corp.	Whitehorse	115I-054	DD,T,G	Au
Lonestar/ Klondike Au	Kennecott Canada	Dawson	115O-072	GC,GP,G,DD	
Marlin	Anooraq Resources	Whitehorse	105C-017	T,BS	Rhodonite
Mel	International Barytex es.	Watson Lake	95D-005	DD,G	Zn,Pb,Ba
Minto/DEF	Minto Expl.	Whitehorse	115I-21, 22	DD,G,F	Cu,Au,Ag
Money	YGC Resources	Watson Lake	105H-078	G,GC	Cu,Zn,Ag,Au
Mt Nansen	BYG Natural Res.	Whitehorse	115I-64, 65	DD,G,F	Au,Ag
Mt Sheldon	Consolidated Ramrod	Whitehorse	105J-008	G,GC	Au
Mucho	Cash Res.	Watson Lake	105I-004	GC,G	Ag,Pb,Zn,Cu,Au
Pak/Foot/Toe	Atna Res.	Watson Lake	105G-032	G,GC	Ag,Cu,Zn,Pb
Quest	Cash Res. Ltd.	Dawson	115P-057	GC,G	Ag
Red Mtn.	Consolidated Ramrod	Mayo	115P-006	G,GC	Au
Rusty Springs	Eagle Plains Res.	Dawson	116K-003	G,GC,GP,T	Ag,Cu,Zn,Pb
Sa Dena Hes	Cominco/Teck	Watson Lake	105A-12, 13	Compilation	Pb,Zn,Ag
Scheelite Dome	Kennecott Canada	Mayo	115P-033	G,GC,T	Au
Tay-LP	Pacific Comox	Watson Lake	105F-121	PD,G	Au
Tuna	Consolidated Ramrod	Watson Lake	105H-082	G,GC	Au
Uno	Cash Res. Ltd.	Watson Lake	105J-030	GCG	Pb,Zn,Cu
Various	Westmin Res.	Watson Lake	SE Yukon	R	
Various	Inco Expl.	Whitehorse	SE Yukon	R	
Wayne	B. Kreft	Mayo	105M-029	BS	Au

BS-Bulk Sample; D-Development; DD-Diamond Drilling; F-Feasibility;G-Geology; GC-Geochemistry; GP-Geophysics; PD-Percussion Drilling; PF-Prefeasibility; R-Reconnaissance; T-Trenching

Appendix 2: 1994 Drilling Statistics

Property	**Company**	**Diamond Drilling Metres**	**Diamond Drilling # Holes**	**Percussion Drilling Metres**	**Percussion Drilling # Holes**
Aurex	Yukon Revenue	600	4	6,000	200
Laforma	Redell Mining	2,000	21		
Grew Ck	YGC Resources	1,350	12		
Hart River	Inco	1,653	6		
Ketza	YGC Resources	2,180	25		
Red Mtn/Hobo	Regent Ventures	243	6		
Casino	Pacific Sentinel	16,800	83		
Minto	Minto Explorations	2,246	19	183	17
Canalask	Patriate Resources Cachet Enterprises	940	6		
Division	Cash Resources	4,054	26		
Mel	International Barytex Resources	3,123	6		
Blende	NDU Resources	596	7		
Lonestar/Klondike	Kennecott	1,554	7		
Kudz Ze Kayah	Cominco	8,500	52		
Keno Hill	United Keno	4,000		8,400	
Brewery Ck	Loki Gold			11,043	242
Discovery Ck	Aurchem			3,855	27
Fairchild Project	Westmin-Newmont	4,800	21		
Mt Nansen	BYG Resources	990	12	46	3
Tay-LP	Pacific Comox			426	27
Totals		**55,629**	**308**	**29,953**	**516**

PART B

GOVERNMENT SERVICES

INTRODUCTION

In the Yukon Territory, government technical and financial assistance to the exploration and mining industry is administered through three programs. These are: Northern Affairs Program, Indian and Northern Affairs Canada; Department of Economic Development, Government of Yukon; and the Canada/Yukon Mineral Development Agreement. Each organization provides complementary services which together aim to provide a comprehensive geoscience data base, and technical and financial support. Further assistance and information on mining and exploration in the Yukon can be obtained at the following addresses.

1. **Mineral Resources Directorate, Northern Affairs Program**
   #345 - 300 Main Street
   Whitehorse, Yukon Y1A 2B5
   a) **Exploration and Geological Services Division**
      (403) 667-3203 (T.J. Bremner, Acting Chief Geologist)
      (403) 667-3204 (Geoscience Information and Sales)
      (403) 667-3198 (FAX)
   b) **Mineral Development Division**
      (403) 667-3153 (A. Waroway, Regional Manager)
      (403) 667-3139) (FAX)
   c) **Mineral Rights Division**
      (403) 667-3260 (R. Ronagan, Regional Manager)
      (403) 667-3193 (FAX)

2. **Department of Economic Development**
   Mailing Address:
   Department of Economic Development
   Government of Yukon
   P.O. Box 2703,
   Whitehorse, Yukon Y1A 2C6
   Street Address: #400 - 211 Main Street
   a) **Mining Facilitator:**
      (403) 667-3422 (J. Duke)
      (403) 667-8601(FAX)
   b) **Mineral Resources Program**
      (403) 667-5884 (R. Hill Manager)
      (403) 667-8601(FAX)
   b) **Canada/Yukon Geoscience Office**
      Street Address: 2099 Second Avenue,
      (403) 667-8510 (J. Kowalchuk, MDA Coordinator)
      (403) 667-8516 (D. Murphy, Senior Project Geologist)
      (403) 667-7074 (FAX)

EXPLORATION AND GEOLOGICAL SERVICES DIVISION (EGSD), GOVERNMENT OF CANADA

Exploration and Geological Services Division (EGSD) is part of the Mineral Resources Directorate, Northern Affairs Program, Indian and Northern Affairs Canada. The Mineral Resources Directorate is responsible for administration of mineral rights through the Yukon Quartz Mining and Placer Mining Acts. The primary role of EGSD is to accumulate and disseminate geological information, and provide related services that assist the exploration, development, and management of mineral resources in Yukon. Functions include detailed studies of mineral deposits and their geological setting, monitoring and reporting industry activities, and approval of technical reports for assessment credit. EGSD also maintains a core library and a Geoscience Information and Map Sales Outlet. Indian and Northern Affairs Canada maintains a library with a collection of geological texts and journals which is open to the public.

Staff activities

Staff presently includes Trevor Bremner (Acting Chief Geologist), Grant Abbott (Senior Geologist), Diane Emond (Environmental Geologist), Bill LeBarge and Mike Burke (Staff Geologists), Rob Deklerk (Manager, Geoscience Information and Sales) and Ali Wagner (Office Manager). Trevor Bremner, in addition to carrying out the functions of Chief Geologist, undertook 1:50 000 scale mapping at the Brewery Creek deposit east of Dawson. Grant Abbott is currently located at the MDA Geoscience office on secondment as scientific advisor. Mike Burke is responsible for approving quartz assessment reports, visiting active mining properties in Yukon, and compiling the annual Yukon Mining and Exploration Overview. He is also responsible for the H.S. Bostock Core Library. Bill Lebarge is responsible for visiting placer mining properties and approving placer assessment reports in Yukon. Bill completed the 1994 YUKON MINFILE update. Robert Deklerk manages the Geoscience Information and Sales outlet.

Publications

EGSD publishes its own technical reports and those produced by the Canada/Yukon Mineral Development Agreement. The two main products of EGSD are this volume, and YUKON MINFILE, a database containing information on mineral occurrences in the Yukon. Yukon Exploration and Geology is published annually in late January or early February. YUKON MINFILE is updated annually and released in late spring. From time to time EGSD also publishes bulletins on geological studies undertaken by staff and colleagues. A complete publication list is available on request.

YUKON MINFILE is currently available in hard copy or on diskette as a set of word processor text files. Occurrence locations are recorded on 38 maps which cover all of Yukon, mostly at a scale of 1:250 000. A second version of YUKON MINFILE, currently in progress, consists of a Dbase file with UTM coordinates for each location and several major search fields. This version allows mineral occurrence locations to be plotted by CAD and GIS programs. A third version, modeled on B.C.'s Minfile system, is being improved and is scheduled for release on diskette in 1995. In the meantime, please contact Mike Burke (403-667-3202) for searches or for further information.

Geoscience Information and Map Sales

EGSD also manages the Yukon outlet of the Canada Map Office and sells topographic, geological (surficial and bedrock), aeromagnetic, aeronautical and land use maps. Geological and other relevant publications by EGSD, Canada/Yukon Mineral Development Agreement, Geological Survey of Canada, and Geological Association of Canada are also available.

Library

Northern Affairs Library Services maintains a collection of geological texts and journals along with material for other departments in Indian and Northern Affairs Canada. The public is welcome to use these facilities.

H.S. Bostock Core Library

The H.S. Bostock Core Library houses approximately 120,000 metres of diamond drill core from 179 Yukon properties. The facility is located across the street from the former Northern Affairs building at 200 Range Road. The core is stored in its original boxes, with no sample reduction. Confidentiality is maintained on the same basis as mineral claim assessment reports; a letter of release from the company owning the property must accompany a request to view confidential core. Status of specific core can be checked and arrangements to view or submit new core can be made by contacting the core librarian at 667-3202. Diamond saws, a core splitter and microscopes are available for use in heated examination rooms. Renovations to improve the core logging, sampling and the viewing area as well as the laboratory facilities will be completed by the spring of 1995.

DEPARTMENT OF ECONOMIC DEVELOPMENT, GOVERNMENT OF YUKON

The Mining Facilitator is a senior management-level position designed to be the primary point of contact between exploration and mining companies and the Yukon Government. Jesse Duke assists companies with all aspects of the regulatory regime and with all Yukon Government programs and services.

The Mineral Resources Program is part of the Energy & Mines Branch, whose primary objective is to encourage the development of Yukon's mineral and energy resources. Services are provided in three main areas: Mining Programs, Mineral Policy, and the Canada/Yukon Mineral Development Agreement (MDA). The Yukon Mining Incentive Program (YMIP) provides contributions for prospecting and mineral exploration in Yukon. The Energy Infrastructure Loans for Resource Development Program (EILRDP) provides loans for the development of energy infrastructure required by resource development projects. The staff strive to increase public knowledge of the mining industry, and are available to advise companies and individuals on the relevant legislation and support programs for the industry.

Rod Hill manages the Mineral Resources unit and the Canada/Yukon Geoscience Office, prepares briefings, and undertakes special projects at the request of the Minister or Deputy Minister. Shirley Abercrombie conducts mineral policy research projects relating to federal and territorial legislation and policies, and conducts economic and financial reviews of mining projects. Karen Pelletier administers the YMIP program and provides advice to individuals and companies on relevant legislation and other government programs.

Yukon Mining Incentives Program

The Yukon Mining Incentives Program (YMIP) is designed to promote and enhance mineral prospecting, exploration and development activities in the Yukon. The program's function is to provide a portion of the risk capital required to locate and explore mineral deposits. Grassroots programs (Prospecting and Grubstake categories) are conducted on open ground (crown land) and Target Evaluation programs are conducted on newly-discovered prospects and targets covered by mineral claims, placer prospecting leases and claims, and coal licenses and leases. Technical assistance is offered to prospectors upon request.

Program funding for 1994/95 was $720,000. Equal numbers of grants were approved in each category - 29 in the Grassroots programs and 29 in the Target Evaluation Program. Approximately 60% of the total funding was allocated to placer gold exploration projects.

Energy Infrastructure Loans for Resource Development Program

This program assists the resource development sector in Yukon by helping to defer the capital cost of building energy infrastructure. The program provides loans to companies to help them create electrical infrastructure to meet their energy needs. So far in 94/95 no projects have been approved under this program.

CANADA/YUKON MINERAL DEVELOPMENT AGREEMENT

The Mineral Development Agreement (MDA) is funded (70% Federal; 30% Territorial) under the 1991-1996 Canada/Yukon Economic Development Agreement (EDA). The agreement includes three elements; 1)Geoscience, 2)Mining Technology, and 3)Information. The Energy and Mines Branch, Department of Economic Development, Government of Yukon administers the agreement, and Northern Affairs Program has scientific authority. The Agreement is managed by a committee which includes representatives of Indian and Northern Affairs Canada, the Mining Sector of Natural Resources Canada, Government of Yukon, the Council for Yukon Indians, and the Yukon Chamber of Mines. Independent project proposals are considered under all elements. Inquiries should be directed to the MDA Coordinator, c/o the Canada/Yukon Geoscience Office.

1. Geoscience Element

The long term objective of the Geoscience Element is to promote active and successful hardrock and placer exploration industries by accelerating the development of a comprehensive, modern geoscience information base. The main components of the program are geological mapping at 1:50,000 scale in more economically significant areas of the Yukon, and regional geophysical and geochemical surveys.

Canada/Yukon Geoscience Office

The Canada/Yukon Geoscience office has been established in order to develop locally-based expertise in the regional geological setting of Yukon mineral deposits. The project manager is Rod Hill and the scientific authority is Grant Abbott. Geoscience Office staff include Don Murphy (Senior Geologist), Ted Fuller (Placer Geologist), Craig Hart (Project Geologist), Steven Johnston (Project Geologist), Derek Thorkelson Project Geologist), John Kowalchuk (MDA Coordinator), Will VanRanden (Draftsperson), and Diane Carruthers (Administrative Assistant). Charlie Roots from the Geological Survey of Canada, and Grant Abbott from Exploration and Geological Services Division, Northern Affairs Program are being supported by the Geoscience Program. Seasonal geological assistance was provided by Diane Brent, Danièle Héon, Julie Hunt, Carol Wallace, Jay Timmerman, and Larry Thorogood.

Ongoing mapping programs are shown on Figure 1 and in 1994, included the following:

a) C. Hart and J. Hunt in the Whitehorse Trough near Whitehorse (105D/16).
b) S. Johnston in the Dawson Range northwest of Carmacks; with the aid of data from an airborne spectrometric survey flown in 1993, Steve is compiling and reinterpreting the geology of three sheets (115J/9,10 and 115I/12) at 1:100,000 scale.
c) D. Murphy and D. Héon in western Selwyn Basin in the Seattle Creek area (115P/16).
d) D. Thorkelson and C. Wallace in the Wernecke Supergroup and PinguiculaGroup in the Wernecke Mountains (106/C/14).
e) E. Fuller and D. Brent in unglaciated surficial deposits, primarily high level terraces along the Yukon and Sixtymile River valleys(115O/5,12; 115N/9).
f) C. Roots with the aid of G. Abbott of DIAND, and S. Gordey and M. Cecile of the GSC mapped the east half of Lansing map area (105N).

The results of the 1994 field season appear in Part C of this volume. This marks the last full year of mapping under the current Mineral Development Agreement. The remaining time until the agreement expires in March 1996 will be spent in producing final maps and reports, with a small amount of fieldwork to revise existing maps in 1995.

Regional Surveys

Regional geochemical and geophysical surveys (Fig. 2) are conducted by the Geological Survey of Canada. A combined radiometric, aeromagnetic and VLF Survey was flown in the Dawson Range (115I/3,5,6) covering several areas with high mineral potential. Results for the survey will be released during the summer of 1995. In March 1994, the Yukon Prospectors Association supervised an airborne EM and magnetometer survey near Jakes Corner 50 km southeast of Whitehorse. Results are now available. The project was intended to identify favourable structures for mesothermal gold veins.

Other Geoscience Programs

A limited number of independent research proposals are also funded under the Geoscience Element. Two projects nearing completion are: (1) A Pilot Project to Test Light Auger Drilling for Placer Prospecting in the Klondike District - administered by Diane Brent of the Canada/Yukon Geoscience Office, and (2)A Pegmatite Study - submitted and administered by Dr. Lee Groat of University of British Columbia.

2. Technology Element

The objective of the Technology Element is to increase the efficiency of Yukon placer and hardrock mining operations, and to reduce or mitigate environmental impacts by encouraging innovative exploration, mining and processing technology. A technical report suitable for publication completes each project. Ongoing projects are:

1) Testing the Gold Recovery of Placer Drills Using Radiotracers submitted and administered by New Era Engineering;
2) Evaluation of the Use of Excavator and Floater Dredging in Permafrost Terrain, submitted and administered by Forty Mile Placers; and
3) The Beneficiation of Barite Ores submitted and administered by Jim Coyne of H. Coyne and Sons.

3. Information Element

The objective of the Information Element is to communicate information about the mining industry to Yukon residents and to encourage businesses to take advantage of economic opportunities in the industry. Programs approved and operated under the information element include:

1) Curriculum Development - submitted and administered by the Yukon Chamber of Mines and directed by the Department of Education, CYI and the Yukon Teacher's Association;
2) Yukon Gold Legacy Exhibit - Submitted and administered by McBride Museum); and
3) Alteration and Petrology for Prospectors - Short Course - submitted and operated by the Yukon Chamber of Mines.

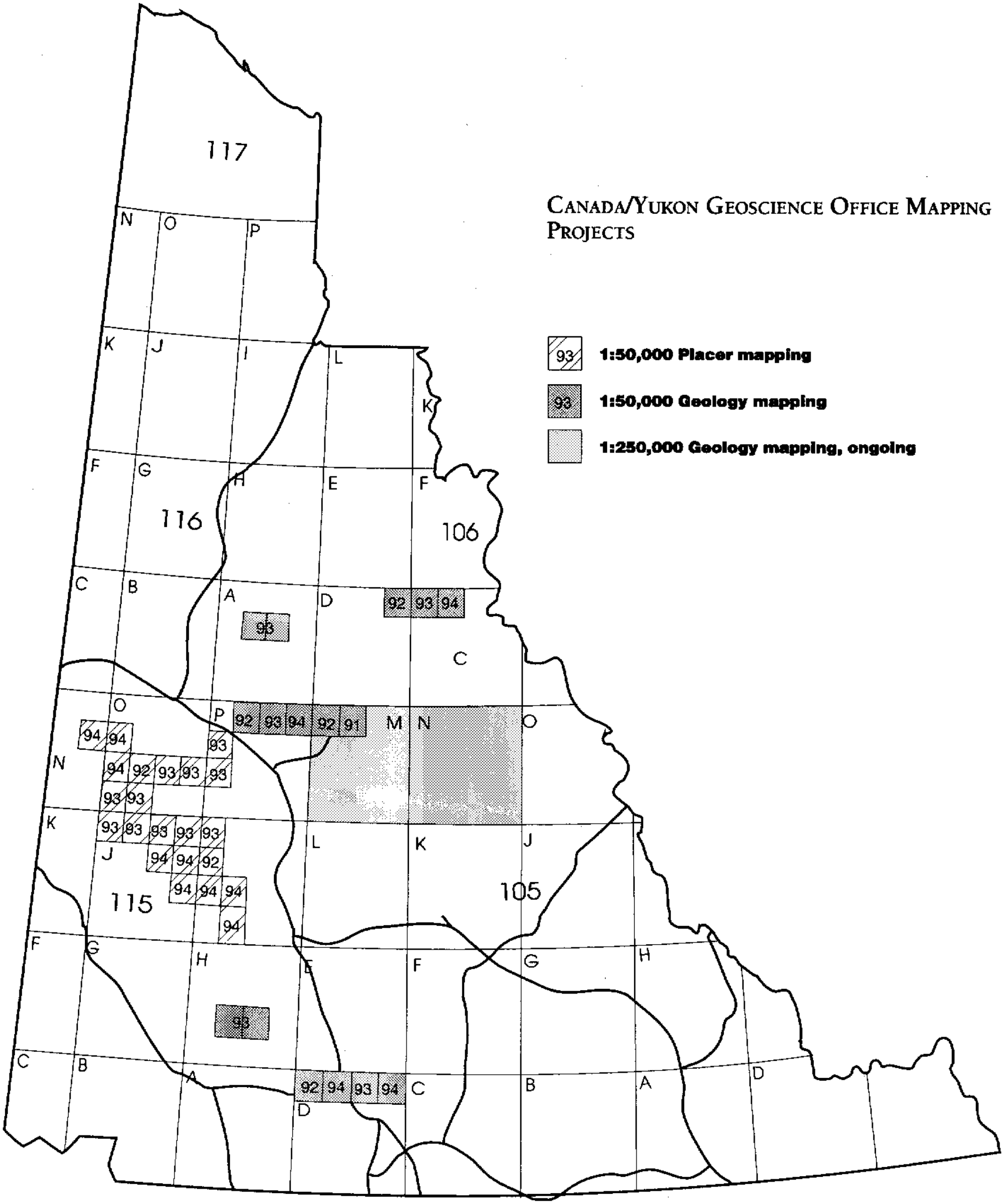

Figure 1: Canada/Yukon Geoscience Office Mapping Projects

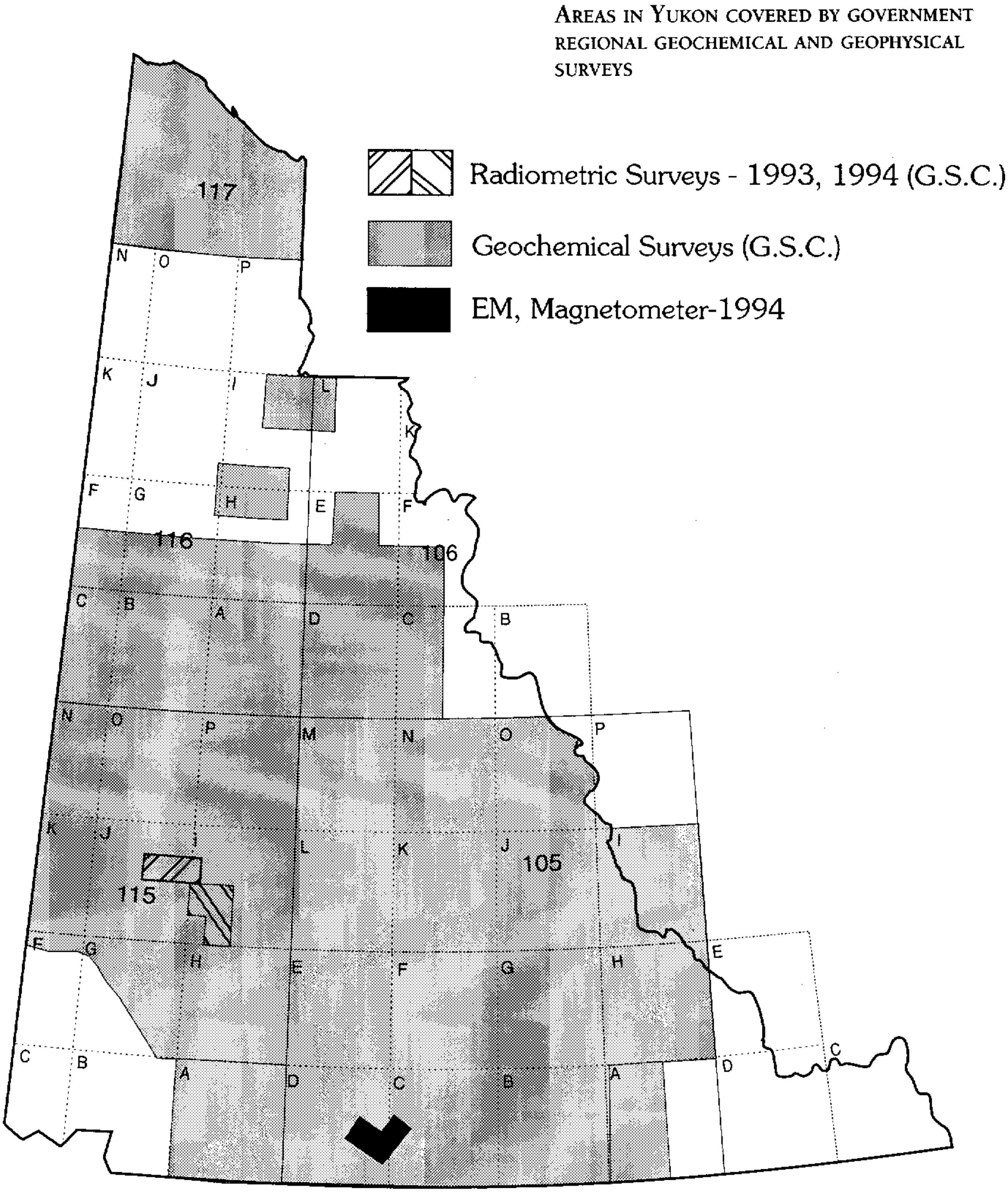

Figure 2: Areas in Yukon covered by government regional geochemical and geophysical surveys.

PART C

GEOLOGICAL FIELDWORK

GEOLOGY AND MINERAL OCCURRENCES OF THE "DOLORES CREEK" MAP AREA (106C/14), WERNECKE MOUNTAINS, NORTHEASTERN YUKON

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THORKELSON, D.J. and WALLACE, C.A., 1995. Geology and mineral occurrences of the "Dolores Creek" map area (106C/14), Wernecke Mountains, northeastern Yukon. In: Yukon Exploration and Geology, 1994. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 19–30.

Abstract

The study area is underlain by four stratigraphic successions ranging in age from Middle Proterozoic to Early Paleozoic. From oldest to youngest, they are: Middle Proterozoic Wernecke Supergroup; Middle to Upper Proterozoic Pinguicula Group; Upper Proterozoic Windermere Supergroup; and Uppermost Proterozoic to Lower Paleozoic sandstone and carbonate. Together, they represent about a billion years of intermittent sedimentation punctuated by processes such as deformation, uplift, erosion, magmatism, and mineralization.

Rocks in the study area record eight phases of contractional and extensional deformation, some of which may be related to strike-slip faulting. Two phases of southwest-verging folds and thrust faults may be related to dextral transpression on the Snake River Fault. Mineral enrichments occur in two general forms: breccia-related (Middle Proterozoic), and veins (Mesozoic to Tertiary). The breccia-related occurrences have enrichments of Cu +/- U, Co, Au, and Ag, as disseminations and veinlets in and near intrusive breccia zones (Wernecke breccia). The vein occurrences comprise Zn-Pb-Ag +/- Cu and Au, in veins and related lenses and irregular replacements of carbonate.

INTRODUCTION

Geological mapping and research were carried out in the summer of 1994 in the eastern Wernecke Mountains, map area 106C/14, herein called the study area (Fig. 1). Because of its remoteness, neither the study area nor most of its geographical features are named. A large creek known to geologists and explorers as "Dolores Creek" is present in the centre of the area, and serves as an unofficial name for the map sheet (Fig. 2).

This report and a companion geological map (Thorkelson and Wallace, 1995) represent the third study in an ongoing project on the geology and mineral occurrences in the Wernecke Mountains. The relative locations of the map areas studied to date are shown in Figure 3. Work began in 1992 in map area 106D/16 (Thorkelson and Wallace, 1993a,b) and progressed eastward through map area 106C/13 (Thorkelson and Wallace 1994a,b) and into the present study area near the Yukon-Northwest Territories border.

The Wernecke Mountains (Fig. 1) have been a principal region of exploration and claim staking in Yukon since the late 1960's. Exploration for U, Co, Cu, Pb, Zn and coal reached a peak in the late 1970's and early 1980's when about thirty prospects were explored by drilling. Although a few of these occurrences were defined by grade and tonnage, most have not been comprehensively evaluated. Little exploration was undertaken between the early 1980's and about 1992. Since then, the region has been the focus of renewed activity involving claim staking, detailed mapping, systematic geochemical sampling, airborne and ground-based geophysical surveys, and drilling.

STRATIGRAPHY

Four principal stratigraphic units, bounded by unconformities, occur in the study area (Figs. 2, 4). From oldest to youngest, they are: Middle Proterozoic Wernecke Supergroup; Middle to Upper Proterozoic Pinguicula Group; Upper Proterozoic Windermere Supergroup; and Upper Proterozoic to Lower Paleozoic carbonate and sandstone. Together, these successions record about 1 Ga of intermittent migeoclinal to platformal sedimentation interrupted by periods of uplift and erosion, and in some cases, deformation, magmatism, and mineralization.

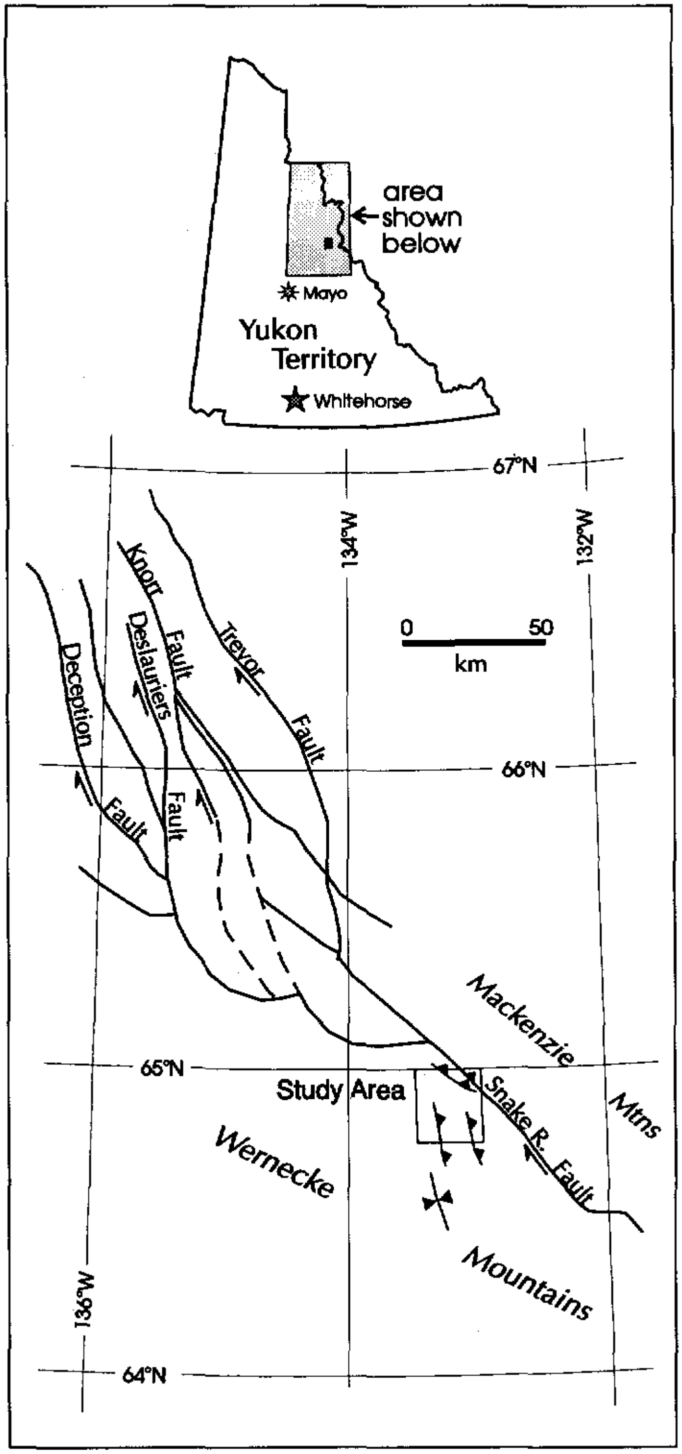

Figure 1: Location of study area, showing southwest-verging thrust faults and syncline in vicinity of study area, in context of Snake River fault and Richardson fault array (modified from Norris, 1984).

Wernecke Supergroup

The Wernecke Supergroup, as defined by Delaney (1981) and used in our investigations, consists of three groups. The lowest unit, the Fairchild Lake Group, consists mainly of siltstone with minor carbonate interbeds. It is overlain by the Quartet Group, comprising mainly siltstone and shale, which is overlain by the Gillespie Lake Group, comprising mainly dolostone. Stratigraphic contacts within the Supergroup are conformable and gradational. Stratigraphic details are provided in Delaney (1981) and Thorkelson and Wallace (1993a). The Wernecke Supergroup is considered to have been deposited on crystalline basement of Early Proterozoic age, perhaps about 1.7 Ga (Delaney, 1981; Norris and Dyke, in press). The only isotopic date from Wernecke Supergroup was provided by Abbott (1993) who obtained preliminary U-Pb zircon ages of about 1.38 Ga from sills related to the Hart River volcanics, 150 km west-southwest of the study area. The volcanics lie within the Gillespie Lake Group, near the top of the Wernecke Supergroup. A minimum age for the Wernecke Supergroup was provided by Parrish and Bell (1987) who obtained a U-Pb monazite age of 1.27 +/- 0.04 Ga from a crosscutting breccia (part of Wernecke breccia, discussed later) in the Richardson Mountains, 150 km north-northwest of the study area.

Pinguicula Group

The Pinguicula Group is a carbonate and siliciclastic succession deposited with angular unconformity on the Wernecke Supergroup (Eisbacher, 1978). As originally defined by Eisbacher (1981), the Group consists of six stratigraphic successions, named units A to F, of miogeoclinal to platformal affinity. In this publication, we adopt Eisbacher's divisions for units A, B and C, but consider unit D to include unit E as a lithofacies. Although unit F does not crop out in the study area, it was examined about 7 km south-southwest of Mt. Profeit, and is herein also regarded as part of unit D. The Pinguicula Group nonconformably overlies and is younger than Wernecke breccia (ca. 1270 Ma), and older than the Windermere Supergroup, whose deposition began at about 780 Ma (Ross, 1991). The maximum age of the Pinguicula Group may be further constrained by correlations with the Mackenzie Mountains Supergroup (Yeo et al., 1978), and the Fifteenmile group in the Ogilvie Mountains (Thompson and Roots, 1982; Abbott et al., 1994), both of which have yielded detrital zircons with ages as young as about 1050 Ma (R.H. Rainbird, V.J. McNicoll, and J.G. Abbott, pers. comm., 1994). Maximum thickness of the Pinguicula Group in the study area is about 3800 m.

Unit A of the Pinguicula Group is characterized by maroon, green and black weathering shale and siltstone (100–600 m thick), underlain by a thin (0–10 m) basal succession of conglomerate and greenish grey to rusty weathering, locally pyritic sandstone. The shale and siltstone are generally planar bedded and laminated. The conglomerate is dominated by clasts of siltstone probably derived from the Wernecke Supergroup. The clasts are subrounded to

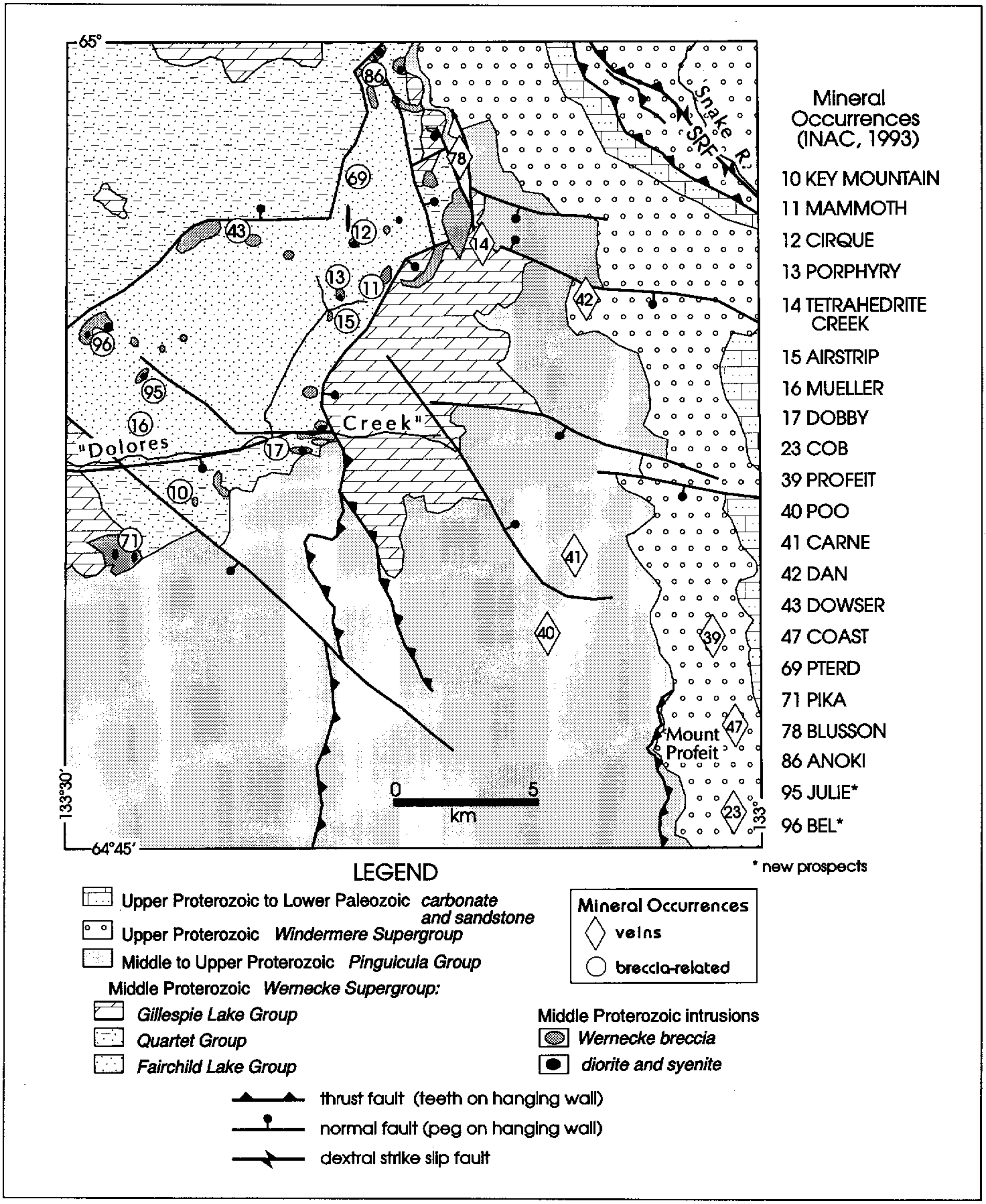

Figure 2: Geology and mineral occurrences in the study area (106C/14), simplified from Thorkelson and Wallace (1995). SRF=Snake River Fault.

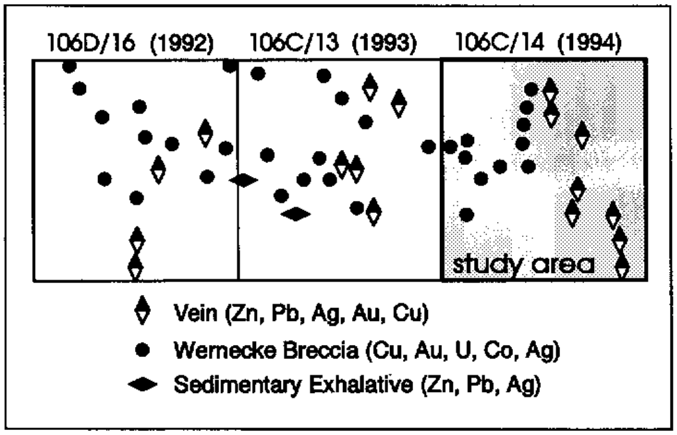

Figure 3: Distribution of mineral occurrences in the present and previous study areas of the Wernecke Mountains project (modified from INAC, 1993).

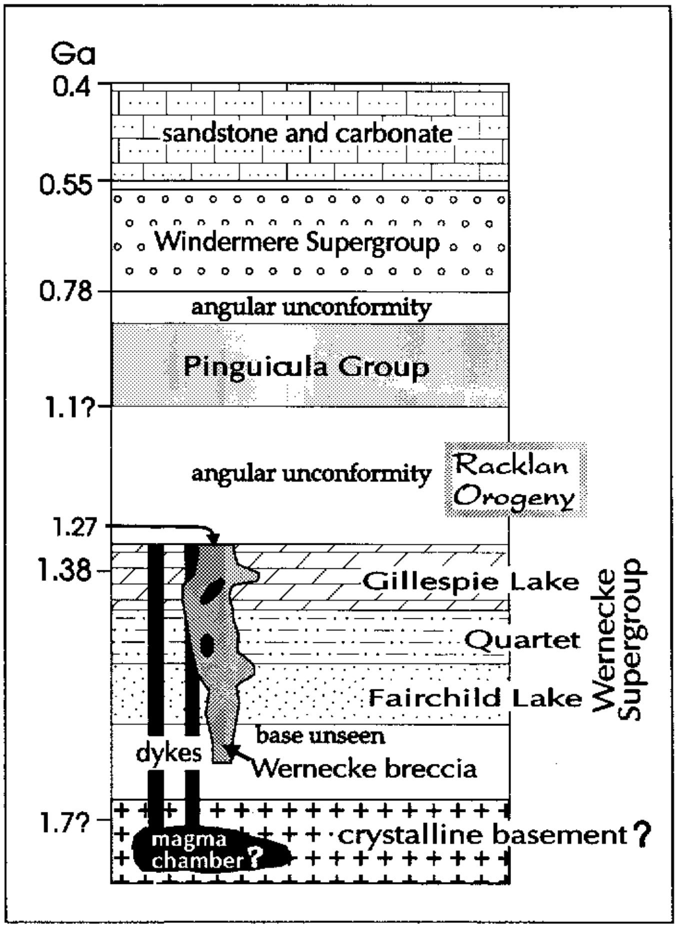

Figure 4: Simplified time-stratigraphic column for the study area, (modified from Thorkelson and Wallace, 1994a).

rounded, from 1 to 30 cm long, and are supported by a sandy matrix. South of the PIKA occurrence, the conglomerate contains clasts of Wernecke breccia. Unit A thickens to the south where it changes to mainly black to rusty weathering shale and siltstone. It reaches a thickness of about 1400 m in the southwestern part of map area 106C/11.

Eisbacher (1981) reported volcanic rocks in unit A which he named the "Kohse Creek volcanics." Despite numerous inspections, no volcanics were found in unit A or in any of the Pinguicula strata in either the study area or farther south near Kohse Creek (106C/11). On the mountains directly north and south of Kohse Creek, dioritic dykes and sills crosscut Pinguicula Group and Wernecke Supergroup strata (Blusson, 1974). We suspect that these intrusive rocks were misidentified by Eisbacher as volcanic rocks, and that the Kohse Creek volcanics do not exist, a possibility accepted by Eisbacher (pers. comm., 1994).

Unit B consists of medium bedded, orange weathering, laminated dolostone and limestone up to 320 m thick. It conformably and abruptly to gradationally overlies unit A. A few beds of maroon siltstone are scattered throughout the unit, suggesting depositional continuity with unit A. Beds up to 60 cm thick hosting rounded intraclasts of grey weathering limestone are common near the base of the unit. Crossbeds are present locally. Thin beds of grey carbonate are common near the top of unit B.

Unit C is up to 1800 m thick and consists of thin to very thick bedded or massive, grey to yellowish grey weathering micritic limestone and dolostone. It abruptly to gradationally overlies unit B. Original sedimentary textures are commonly overprinted by narrow (1–15 mm wide) en-echelon bands of white sparry dolostone, known as zebra texture (Wallace et al., 1994). Local intraformational conglomerates or "storm beds" within unit C contain intraclasts of both grey micrite and zebra dolostone (Fig. 5). The discovery of zebra dolostone as rip-up clasts infers that the zebra texture in unit C developed at or near the sediment surface, shortly after micrite deposition and prior to lithification. Pods and lenses up to 50 m wide of pinkish grey weathering, very coarse dolomite spar locally crosscut both bedding and zebra textures. These sparry zones may have developed from recrystallization, or dissolution and open space filling in a karst environment. Locally, beds of black weathering shale are intercalated with the dolostone near the top of unit C.

Unit D is a diverse succession of carbonate and clastic rocks up to 1050 m thick which conformably and locally gradationally overlies unit C. At the base, it commonly consists of up to 100 m of black weathering shale intercalated with orange weathering stromatolitic dolostone. Overlying the basal strata is thin to very thick bedded, buff, grey and orange weathering dolostone, intercalated with various lithotypes including: black weathering shale; thin to medium bedded, black, maroon and buff weathering, locally muscovite-bearing siltstone; finely laminated grey to maroon weathering nodular limestone; and thick bedded, locally cross bedded, grey weathering quartz arenite (Fig. 6). The dolostone beds, which constitute about 50% of the succession, commonly contain small (0.5–5 cm) dolostone rip-up clasts, nodules and thin replacement beds of black weathering chert, and orange to white weathering nodules of sparry calcite, quartz, and jasper. Clusters of small (5–15 cm wide), closely spaced, orange weathering stromatolites are uncommon, but scattered throughout the succession. Siltstone commonly displays mudcracks (or possibly syneresis cracks) and ripple marks. Generally, the siliciclastic component coarsens upsection; quartz arenite occurs as subordinate, thin tongues in the lower parts of unit D, and thick (up to 200 m) successions toward the top, where it commonly predominates.

Eisbacher (1981) distinguished the quartz arenite-dominated part of the Pinguicula Group as unit E, "Corn Creek quartzite." However, in our mapping we were unable to reliably separate units D and E because quartz arenite interbeds occur throughout, and dolostone and siltstone occur above even the thickest quartz arenite successions. We therefore regard the quartz arenite component as the Corn Creek lithofacies of unit D. Eisbacher (1981) also identified a finely laminated nodular limestone as unit F. It overlies maroon siltstone and Corn Creek sandstone in the core of a syncline about 7 km south-southwest of Mount Profeit. The siltstone and limestone may be correlative with similar rocks in the region, particularly maroon siltstone and stromatolitic to massive dolostone which lie between thick tongues of quartz arenite located 1 km south of the study area at longitude 133°20'W (Fig. 7).

Windermere Supergroup

In the study area, the Windermere Supergroup rests with angular unconformity on the Pinguicula Group (Eisbacher, 1978). In contrast to the miogeoclinal to platformal Pinguicula Group, the oldest Windermere sediments were deposited in more dynamic environments involving rifting and glaciation (Ross, 1991; Aitken, 1991; Narbonne and Aitken, in press). Upper Windermere strata indicate a return to more stable conditions. Eisbacher (1981) recognized five formations of the Windermere Supergroup in the Wernecke and Mackenzie mountains. All five are present in the study area, where total thickness is at least 2500 m.

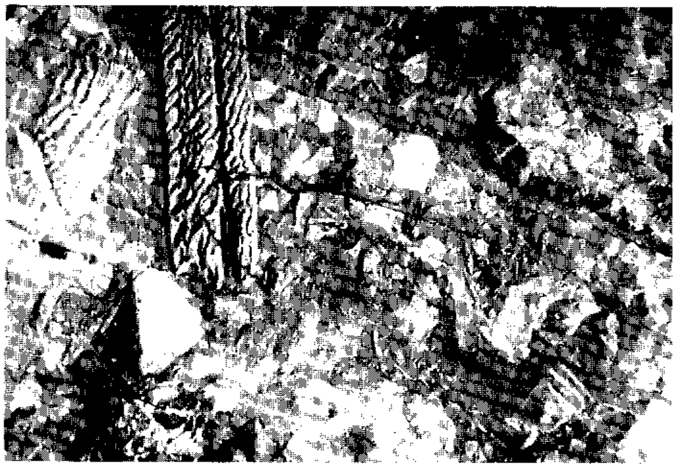

Figure 5: Two clasts of zebra dolostone (upper left) and micritic carbonate in intraclast conglomerate of Pinguicula Group unit C. Length of photograph is about 25 cm.

The lowest unit, the Sayunei Formation, is a poorly stratified succession of orange, brown and grey weathering, matrix to clast supported conglomerate and friable sandstone (Fig. 8). The conglomerate contains clasts of subangular to rounded pebbles, cobbles and boulders of mainly quartz arenite, carbonate, siltstone, and micaceous siltstone, all of which may have been derived from the Pinguicula Group. The unit is discontinuous, and varies in thickness from 0–210 m.

The Shezal Formation comprises unstratified, green to rusty brown weathering, matrix-rich diamictite containing pebbles and cobbles of dolostone, quartz arenite, and (?)greenstone. Eisbacher (1981) identified striated clasts in the diamictite, and considered it to be of glacial origin. The Shezal is inferred to sit between the Sayunei

Figure 6: Thinly bedded dolostone and shale in unit D of Pinguicula Group.

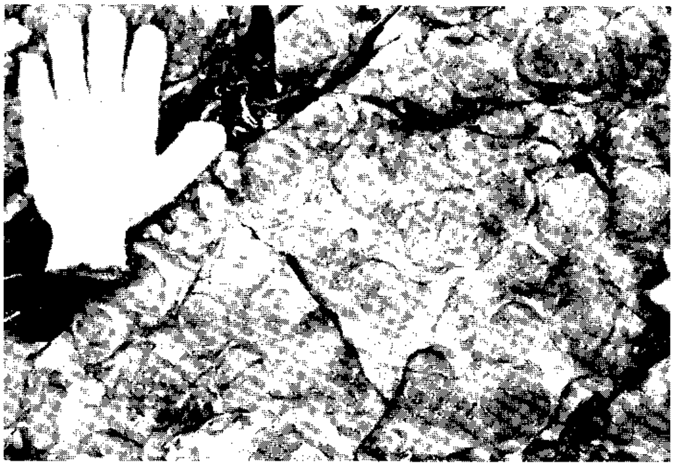

Figure 7: Small stromatolites in dolostone beds near top of unit D.

and Twitya formations on the basis of stratigraphic relations elsewhere in the Wernecke and Mackenzie mountains. In the study area, the diamictite is massive, cleaved, and separated from other units by a thrust fault. The absence of internal stratigraphy in the diamictite hinders estimates of thickness; we suggest a minimum thickness of 300 m, well below maximum thicknesses of 500–800 m reported by Eisbacher (1981) and Narbonne and Aitken (in press).

The Twitya Formation consists of mainly siltstone and dolostone, with minor sandstone and "grit" (granule to pebble conglomerate). It conformably overlies Sayunei conglomerate (Fig. 9), or where the Sayunei is absent, it unconformably overlies the Pinguicula Group. The siltstone is brown, dun, and locally maroon weathering, thin bedded and laminated, locally calcareous, and commonly cleaved. It hosts several discontinuous intervals of sandstone and grit up to 10 m thick. The sandstone and grit are commonly crossbedded and fill local scours in the host siltstone. The grit beds occur with increasing abundance toward the top of the formation, and contain rounded pebbles of siltstone, sandstone, and carbonate. Both the sandstone and the grit contain angular rip-up clasts of black or green siltstone, orange dolostone, and shale. The dolostone, named Profeit dolostone by Eisbacher (1981), forms interlayers of variable thickness. It is massive to medium bedded, light grey weathering, and commonly fetid. Oolites, intraclasts, oncolites, stromatolites, algal filaments and vugs, are common, indicative of shallow water deposition. At Mount Profeit, the dolostone is about 1200 m thick and represents the entire Twitya Formation. It grades northward into Twitya siltstone and grit, dividing into several tongues ranging from 0–45 m thick.

Above the Twitya Formation is a thin, discontinuous succession (0-15 m thick) of laminated, thin bedded to massive, light orange to cream weathering micritic dolostone, known informally as the Teepee dolostone (Eisbacher, 1981; Aitken, 1991). Massive, light brown weathering diamictite locally underlies the dolostone. The diamictite was observed only at about latitude 64°58'N where it is 15 m thick and contains clasts of grey weathering carbonate, light grey weathering quartz sandstone, and black weathering siltstone or (?)chert. Both the diamictite and the dolostone were considered parts of the Keele Formation by Eisbacher (1981), and that usage is followed in this report and by Thorkelson and Wallace (1995). The diamictite may correlate with the glaciogenic Ice Brook Formation in the Mackenzie Mountains (Aitken, 1991).

The Sheepbed Formation overlies the Keele Formation. It is about 500 m thick and includes recessive black, dark brown, and locally rusty weathering shale, siltstone, and local calcareous siltstone. Toward the top of the succession are a few thin (<5m) interbeds of buff to grey weathering silty limestone. Flutes and cross beds are present locally in the siltstone.

Upper Proterozoic to Lower Paleozoic Strata

A little-studied succession of quartz arenite, dolostone, siltstone and conglomerate overlies the Windermere Supergroup (Narbonne et al., 1985). It may correlate with the Backbone Ranges and Vampire formations, and unit 11 of Fritz et al. (1983). Quartz arenite forms the base of the succession in the northeastern part of the map area, and pinches out to the south-southeast. It is typically trough cross bedded to plane bedded, grey to rusty weathering, with very well rounded grains cemented with either silica or brown weathering carbonate. It is interbedded with pinkish-orange weathering carbonate. East of Mount Profeit, the lowest units consist of dark grey to buff weathering carbonate and minor sandstone, overlain by conglomerate, dolostone and siltstone.

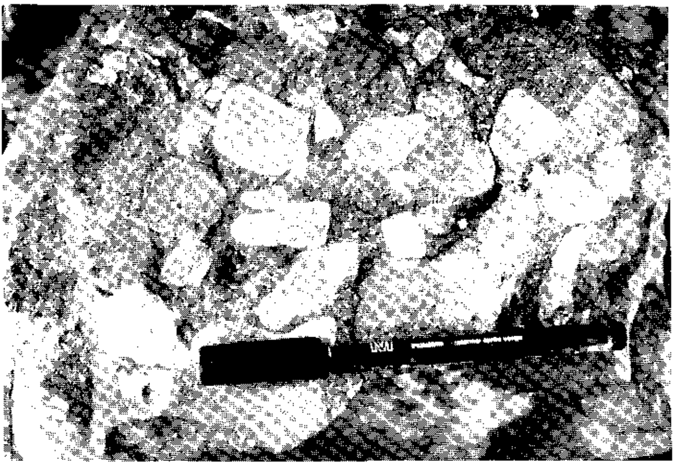

Figure 8: Subrounded clasts of siltstone and dolostone in Sayunei Formation (basal conglomerate of Windermere Supergroup).

Figure 9: Lower Windermere Supergroup: 200 m thick basal conglomerate of the Sayunei Formation overlain by Profeit dolostone, 7 km south of Mt. Profeit.

INTRUSIVE ROCKS

Numerous small bodies of breccia and igneous rock intrude the Wernecke Supergroup. The igneous bodies are all considered older than the breccias and form small stocks and dykes less than 0.1 km^2 in area, many of which have been dismembered and altered during subsequent breccia emplacment. The igneous rock is principally fine to medium grained, greenish grey weathering, equigranular plagioclase-pyroxene diorite, and its variably altered equivalents. Local coarse-grained pegmatitic segregations occur in a diorite dyke along the south wall of the CIRQUE occurrence. The only non-dioritic igneous body, a fine grained quartz albite syenite stock, occurs at the PORPHYRY occurrence. Although Laznicka and Edwards (1979) considered this body to be a zone of sodically metasomatized sedimentary rock, its igneous origin is revealed by typical igneous textures such as interlocking plagioclase and interstitial quartz, and locally distinct chilled margins. However, a sample of this stock which was chemically analyzed contains an unusually low concentration of K_2O (0.1%), a low concentration of CaO (4.9%), and a high concentration of Na_2O (5.8%), supporting the contention of sodic metasomatism. Apparently, hydrothermal fluids related to emplacement of an adjacent breccia body altered the stock from its original composition (granodiorite?) to its present composition dominated by albite.

The breccia bodies belong to a set of clastic intrusions known collectively as Wernecke breccia (Bell, 1986a,b; Lane, 1990; Thorkelson and Wallace, 1994a). The breccias are widely distributed in the Wernecke and Ogilvie mountains and are characterized by disseminated hematite and variably altered clasts of sedimentary country rock. They commonly crosscut or engulf igneous dykes and stocks, and locally contain abundant igneous clasts (Fig. 10). Hydrothermal activity related to breccia development has typically produced a large metasomatic aureole in the country rocks. In the study area, an unusually large proportion of the country rock between the PORPHYRY and ANOKI occurrences has been variably fractured, metasomatised, and locally enriched in Cu, U, and Co. An igneous source for the fluids is suspected (Thorkelson and Wallace, 1994a). Unconformable relations between breccia-metasomatic zones and the Pinguicula Group indicate that brecciation and related mineralization preceded Pinguicula deposition.

STRUCTURE

The structural style in the study area is dominated by normal faults, thrust faults and open to tight folds. Slaty cleavage is present locally. Eight phases of deformation occurred during the interval Middle Proterozoic to Paleozoic or younger. The first phase was contractional, producing folds and cleavage in the Wernecke Supergroup. The style and orientation of these structures in the study area is not certain, but to the west, correlative structures comprise inclined to overturned folds verging mainly to the south or southeast (Thorkelson and Wallace, 1993a; 1994a). Northwest-dipping cleavage near the CIRQUE occurrence may be related to this deformation. The second phase, also contractional, produced kinkbands in phase one cleavage. These contractional events are considered manifestations of the Racklan orogeny (Gabrielse, 1967; Thorkelson and Wallace, 1994a; Cook, 1992). The third phase involved fracturing, brecciation, and probably faulting during development and emplacement of Wernecke breccia. These structures may have been produced by crustal extension and underground explosions of fluids. Crustal dilation along these structures may have localized brecciation. Randomly oriented clasts of kinked slate of the Fairchild Lake Group in Wernecke breccia at the JULIE occurrence indicates that contractional deformation of phases one and two preceeds the brecciation. This relationship was established previously at the SLAB occurrence (Thorkelson and Wallace, 1993a). Large-offset normal faults within the Wernecke Supergroup near the ANOKI, PTERD, MAMMOTH, CIRQUE, PORPHYRY, and BEL breccia occurrences may have been active during breccia genesis. In the fourth phase, a foliation consisting of anastomosing fractures developed in Wernecke breccia and Gillespie Lake Group at the PIKA occurrence (Thorkelson and Wallace, 1994a). This fabric postdates breccia emplacement, but is truncated by the unconformity with the overlying Pinguicula Group. The fifth and sixth phases occurred after deposition of the Pinguicula Group, but before deposition of the Windermere Supergroup. The fifth phase was contractional, producing westerly to southwesterly verging thrust faults and folds in the Pinguicula Group. A thrust fault and related folds of this phase are truncated by basal Windermere strata on the western flank of Mount Profeit (Fig. 11). A few kilometres southwest of Mount Profeit, other folds and thrust faults deform Pinguicula strata, but not the overlying Windermere Group. The sixth phase was extensional, producing mainly west to northwesterly trending normal faults. The clearest example of this phase is located southwest of Mount Profeit, south of the study area, where a normal fault offsets Pinguicula strata, but is truncated by the

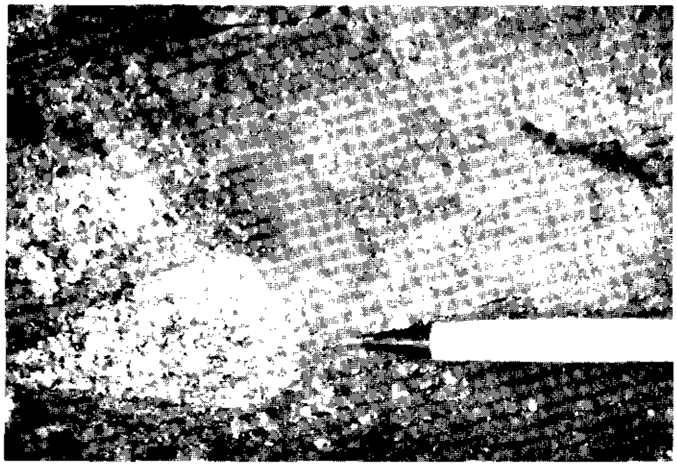

Figure 10: Clasts of quartz albite syenite (light grey, left of pencil) in Wernecke breccia at the PORPHYRY occurrence.

overlying Windermere Supergroup. This deformation occurred either before or during deposition of the basal (Sayunei) conglomerate. Syndepositional faulting is suggested by the abrupt thickening of the conglomerate on the southern side of the fault.

The seventh and eighth phases occurred after deposition of the Windermere Supergroup, and Upper Proterozoic to Lower Paleozoic strata. Although the relative timing between these phases is uncertain, the contractional phase is considered to be the earlier phase (seven). Southwest-verging thrust faults of phase seven place the Twitya and Shezal formations onto uppermost Proterozoic strata, in the northeastern corner of the study area. A few kilometres to the southeast, beyond the study area, rocks as young as Lower Paleozoic appear to be involved in the thrusting. The eighth phase produced normal faults such as those in the east-central part of the study area, which cut Windermere and younger strata.

Many structures in the study area cannot be assigned with confidence to a particular phase. For example, the two thrust faults in the southwestern part of the study area involve the Wernecke Supergroup and Pinguicula Group, and therefore belong to either phase five or phase seven. Rocks of the Windermere Supergroup or younger strata are absent in this area, so a more precise distinction cannot be made. For similar reasons, few normal faults can be assigned to a particular phase.

Some faults have been reactivated. The most prominent example is the fault which forms the western margin of the Gillepsie Lake Group near the centre of the study area. Along the northern part of the structure, the Gillespie Lake Group is downdropped against the Fairchild Lake Group. To the south, the fault displays the opposite sense of displacement where the Gillepsie Lake Group is thrust over the Pinguicula Group. This relationship appears to have developed from two stages of deformation, beginning with large-displacement normal faulting of phase three, which cut out the entire Quartet Group and juxtaposed the Gillespie Lake and Fairchild Lake groups against Fairchild Lake strata. After deposition of the Pinguicula Group, the fault was reactivated and the eastern side of the fault was thrust upward, placing the Gillespie Lake Group over Pinguicula strata during phase five or seven deformation. Because the amount of reverse displacement was minor compared to the earlier normal offset, the net displacement between the Gillespie Lake and Fairchild Lake groups remains east-side-down.

Southwest-verging folds and faults in and near the study area were mapped by Eisbacher (1981). Our identification of additional Southwest-verging structures corroborates his findings and demonstrates that: (1) the affected region extends through most of the study area and for at least 25 km to the south; and (2) deformation occurred at two different times: (i) after deposition of the Pinguicula Group but prior to deposition of the Windermere Supergroup; and (ii) after deposition of uppermost Proterozoic or Lower Paleozoic rocks. The vergence of these structures contrasts with the northeast vergence common to most of the contractional structures affecting rocks younger than the Wernecke Supergroup in the Wernecke and Mackenzie mountains. The northeast-verging structures are considered to represent craton-directed thin-skinned orogenesis of Mesozoic to Paleocene age common to the eastern North American Cordillera.

Some of the deformation in the study area may be related to strike-slip faulting. In particular, the Snake River fault, in the northeastern corner of the study area, has been identified as a dextral strike-slip fault by Norris (1975). To the north, the Snake River Fault connects with the Richardson fault array, including the Knorr, Deslauriers, and Deception strands which also have been identified as post-Paleozoic dextral strike-slip faults (Fig. 1) (Norris and Hopkins, 1977; Norris, 1984). Where the Snake River fault and the Richardson fault array meet, the strands of the Richardson fault array have a pronounced curvature, changing from north-northwest-trending to west-trending. If dextral translation on the Snake River fault was concurrent with that on the Richardson fault array, then the region of fault curvature would constitute a major restraining bend, resulting in significant transpression. The bend is so large, and at such a high angle to the main strike of the faults, that folds and thrust faults would probably develop even from small amounts (a few kilometres) of transcurrence. Cecile (1984) suggested that dextral translation on the Snake and Richardson fault system could be 10–20 km. Southwest of the strike-slip system, contractional structures would tend to be northwest-trending, and possibly southwesterly directed (cf. Sylvester, 1988).

The Southwest-verging contraction in the study area may be related to transpression along the Snake-Richardson fault system, or to a combination of transpression and back-thrusting. Southwest-directed back-thrusting may have occurred during the Mesozoic to Paleocene as part of the general regime of northeasterly directed contraction in Mesozoic to Paleocene time. For phase-seven deformation, which may have occurred during this interval, back-thrusting may be an appropriate model. Fifth-phase contraction,

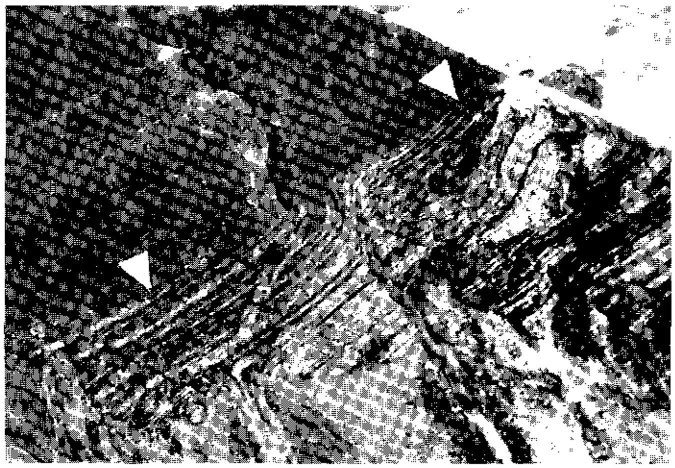

Figure 11: Angular unconformity (at tips of arrows) between folded unit D of the Pinguicula Group and overlying Sayunei conglomerate of the Windermere Supergroup, on western flank of Mount Profeit.

however, occurred much earlier and must be explained by compression or transpression in the Middle to Late Proterozoic.

MINERAL OCCURRENCES

Enrichments of metals in the study area occur in two general forms: (1) veins, and related pods in carbonate rock; and (2) disseminations and fracture fillings in Wernecke breccia and related metasomatites. The Wernecke breccia occurrences are characterized by local concentrations of Cu, U, Co, Ag and Au. Breccia-related mineralization occurred in Middle Proterozoic time, prior to deposition of the Pinguicula Group. In contrast, the vein occurrences are characterized by Zn, Pb, Ag, and in one case, Cu, Sb and Au. The veins postdate deposition of the Windermere Supergroup and may belong to an array of veins of probable Mesozoic or Tertiary age which extends southward to the Keno Hill mining district (Abbott et al., 1994).

Twelve Wernecke-breccia related mineral occurrences are known in the study area. The PORPHYRY occurrence was most intensively explored, receiving 7 drill holes totalling 600 m in 1969 (INAC, 1993). Mineralization is concentrated in a small, sodic- and iron-altered stock of intermediate composition. It hosts disseminations of chalcopyrite yielding enrichments of Cu averaging about 0.7% The mineralization may be related to emplacement of the stock, to development of an adjacent breccia zone, or to both. The concentration of Cu in the stock rather than the country rock is consistent with Cu distributions at some other igneous-breccia-related occurrences in the region (Thorkelson and Wallace, 1994a).

At the PIKA occurrence, enrichments of Cu (chalcopyrite) and Au occur in breccia and country rock. The enrichments are concentrated along contacts between breccia and metasomatized diorite. Minor supergene enrichment of Cu and Ag occurs beneath the overlying Pinguicula Group (Thorkelson and Wallace, 1994a). At the MAMMOTH, DOWSER, KEY MOUNTAIN and AIRSTRIP occurrences, chalcopyrite occurs as veinlets and disseminations in and around zones of Wernecke breccia (INAC, 1993). Similar mineralization at the MUELLER occurrence is over 1 km south of the nearest identified breccia zone. At the CIRQUE occurrence, chalcopyrite and cobaltite occur as disseminations and stringers in siderite-quartz bearing fractures. Chip samples reported from exploration in 1981 averaged 0.2% Cu and 0.02% Co (INAC, 1993).

Uranium occurs along with Cu in the ANOKI, TETRAHEDRITE CREEK, DOBBY, and PTERD Breccia-related occurrences. At the ANOKI occurrence, fracture zones related to faults contain uraninite, brannerite and chalcopyrite (Yeager and Ikona, 1979; 1980). Concentrations of 0.6% U_3O_8 and 1% Cu were reported over a 1 m interval (Stammers and Ikona, 1977). At the PTERD occurrence, fracture fillings in altered sedimentary rock contain pitchblende and chalcopyrite. At the TETRAHEDRITE CREEK occurrence, a breccia body and adjacent 'skarn' in metasomatized siltstone host veinlets and disseminations of chalcopyrite, tetrahedrite and brannerite. Nearby vein mineralization is also included in this occurrence.

Eight vein occurrences crosscut Wernecke Supergroup, Pinguicula Group and Windermere Supergroup strata. They form a linear belt extending northward from the COB occurrence near Mount Profeit to the BLUSSON occurrence. Six of these occurrences have a common Zn-Pb-Ag metallogenic signature. The PROFEIT occurrence is the best known and was explored by five drill holes totalling 200 m. It includes several showings in a 1200 m long zone. Galena, sphalerite, tetrahedrite, pyrite, marcasite and minor chalcopyrite form massive pods, vug fillings, and veinlets. Replacement and open space filling appear to have been important controls on mineralization. The largest pod of massive sulphides, 9 m long and 8 m wide, assayed 17% Zn, 47% Pb, and 580 g/tonne Ag (INAC, 1993). At the nearby COB occurrence, Zn/Pb ratios are higher, and a sulphide-rich vein assayed 42% Zn, 20% Pb, and 600 g/T Ag (INAC, 1993). The COAST, POO, DAN and CARNE occurrences have similar metal signatures but lower grades. A newly discovered lens of sphalerite about 700 m east of the DAN, is considered part of that Minfile occurrence. An assay from the lens returned 47% Zn, 255 g/T Ag, 0.25% Cu, >0.2% Sb, and 0.17% Pb.

Metal signatures in the TETRAHEDRITE CREEK and BLUSSON occurrences are different from those at the other vein occurrences. In the TETRAHEDRITE CREEK occurrence, native Au occurs with tetrahedrite, galena, and sphalerite in quartz-carbonate veins. Selected samples assayed up to 410 g/T Au, 82 g/T Ag, 6% Cu, 5.5% Zn, and 21% Pb (INAC, 1993). The BLUSSON consists of scattered, thin veinlets of chalcopyrite or malachite in unit A of the Pinguicula Group. The higher Cu +/- Au concentrations in these occurrences, relative to the other vein occurrences, may be a result of remobilization of nearby Wernecke breccia-type mineralization during introduction of mainly Zn, Pb, and Ag bearing fluids.

New Prospects

Two new Wernecke Breccia-related mineral occurrences will appear in forthcoming editions of Yukon Minfile. The BEL is a group of chalcopyrite-malachite showings in fractured and brecciated siltstone of the Fairchild Lake Group, and veined, metasomatized diorite. It was previously identified but not described by Bell (1986a). The showings occur over a 1 x 0.5 km area. The diorite crops out along the banks of two small creeks in exposures up to 0.1 km^2, and appears to form the roof of a stock. The diorite hosts veinlets and disseminations of secondary specularite, potassium feldspar, and locally, chalcopyrite. The best assay result, 0.8% Cu, was from a selected hand specimen from a showing in brecciated siltstone located at 4490 feet above sea level, at UTM E 572500, N 7199200.

The JULIE occurrence consists of quartz-dolomite-pyrite-chalcopyrite veins associated with nearby zones of Wernecke breccia. Two zones of veining about 5 m wide within the Fairchild Lake Group occur near the base of a cirque headwall. Abundant vein float suggests that veins may also crop out higher on the cirque walls. The two best assays from vein material were 1.8% Cu, 0.42 g/T Au; and 0.02% Cu, 0.23 g/T Au.

CONCLUSIONS

- The study area is underlain by four main stratigraphic successions ranging in age from Middle Proterozoic to Lower Paleozoic. Sedimentation was punctuated by events such as deformation, uplift, erosion, magmatism, brecciation and mineralization.
- Two of the eight phases of structural deformation in the study area have resulted in southwest-verging folds and thrusts. These contractional events may be related to dextral transpression along the Snake River Fault.
- Two styles of mineralization occurred in the study area. In Middle Proterozoic time, enrichments of Cu, U, Co, Au, and Ag occurred in association with mafic to intermediate intrusions and emplacment of hematitic breccias. Enrichments of Zn, Pb, Ag, Cu and Au occurred after deposition of the Windermere Supergroup, possibly in Mesozoic or Tertiary time, as veins, open space fillings and replacements.
- The geological history of the area is summarized:
  a) deposition of the Wernecke Supergroup;
  b) folding, cleavage and kink banding related to Racklan orogeny; uplift and emergence;
  c) emplacement of dioritic to granodioritic intrusions; possible Cu, U, Co, Au and Ag mineralization;
  d) subterranean volatile explosions and emplacement of Wernecke breccia; Cu, U, Co, Au and Ag mineralization; probable normal faulting;
  e) faulting of uncertain style, and local development of shear fabrics;
  f) uplift, weathering, erosion, and local, minor supergene enrichment of breccia-related mineralization;
  g) marine transgression; deposition of the Pinguicula Group in a southward-deepening basin;
  h) southwesterly directed folding and thrust faulting; possible dextral strike-slip along the Snake River Fault, followed by normal faulting, uplift and erosion;
  i) rifting, glaciation and marine transgression; deposition of the Windermere Supergroup and strata as young as Lower Paleozoic;
  j) southwesterly directed folding and thrust faulting; possible dextral strike-slip along the Snake River Fault; normal faulting;
  k) mineralization of Zn, Pb, Ag, Cu, and Au in veins and pods.

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HIGH LEVEL TERRACES ALONG PARTS OF YUKON RIVER AND SIXTYMILE RIVER (115N/9 EAST HALF, 115O/5, AND 115O/12)

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ABSTRACT

High level terraces representing former valley bottom deposits exist along Yukon River and several of its tributaries. The terraces contain fluvial gravel deposits which are veneered by loess. Soil development in the gravel suggest they predate the oldest Pleistocene glaciation in central Yukon.

These high terraces are given a Neogene age (Miocene-Pliocene) based on their relative heights and the ages of bedrock that they occur on. They may be the same age as White Channel gravel in Klondike area.

Along Yukon River their elevation varies from 43 to 88 m (140 ft to 290 ft) above present river level rising to the north. Flow directions based on imbrication measurements in pits indicate flow generally followed that of the modern Yukon River. The paleo-Yukon River flowed to the north when these gravels were laid down.

The reason why terrace elevations rise in elevation northward, opposite to the present drainage is presumed to be from tectonic warping. The area around Dawson was uplifted more than that near the mouth of Stewart River.

Placer gold was recovered in small quantities from test pits at several sites along the Yukon River and Sixtymile River valley. The gold is typically flat, fine grained and far-traveled; suggestive of deposition in a bar environment. The number of gold particles in gravel samples (each sample 23 litre volume) ranged from 0 to 1 in Sixtymile River valley and 0 to 12 in Yukon River valley terraces. Downcutting of Yukon River and its tributaries led to placer accumulations in the modern creeks. Highly anomalous arsenic in sediment soils from Ten Mile Creek drainage with coincident anomalous gold suggest gold-arsenopyrite veins as sources for placer gold in that creek.

INTRODUCTION

A series of high level terraces are present along the Yukon River and Sixtymile River valleys and some of their tributaries. These terraces represent deposits from a paleo-Yukon River and its tributaries which followed the same valleys as the present Yukon drainage. These large scale ribbon-like features may contain placer deposits or provide sources of detrital gold which may supply tributaries entrenched within these high terraces.

Although these terraces have not been mapped previously, surficial geology and pedologic studies have been done on other high level terraces in central Yukon (Foscolos et al., 1977; Tarnocai et al., 1985; Smith et al., 1986; Tarnocai and Smith, 1989). Detailed work has also been carried out on auriferous high level terraces such as: the White Channel gravel (Morison and Hein, 1987; Morison, 1985a; Dufresne and Morison, 1984), upper Sixtymile River terraces (Hughes, 1986), Clear Creek terraces (Morison, 1985b), and fluvial and kame terraces in the Mount Nansen area (Lebarge, 1993; Jackson, 1993).

No government surficial geology mapping has been done on the lower Sixtymile River or this reach of Yukon River. This is a preliminary report based on mapping activities carried out over the last two field seasons. This work builds on that of Fuller (1994a, b, c) which concerned high terraces along Stewart River valley.

Physiography

Klondike plateau is the physiographic feature covering the project area. It is a subdivision of Yukon Plateau and is characterized by deep narrow valleys entrenched in a surface with smooth ridges of uniform elevation which represent an old erosion surface (Bostock 1948; Mathews 1986). This low relief surface in which Yukon and Sixtymile River valleys lie may be Late Miocene (Tempelman-Kluit 1980). The Yukon River is bordered by bedrock terraces below Stewart River and the Sixtymile River has terrace remnants along much of its length. Yukon Plateau has been tectonically upwarped based on bedrock terrace elevations and presence of thrust structures carrying Eocene and older rocks into White Channel gravel (Hughes, 1970).

Yukon River drainage evolution possibly dates to the deposition of Carmacks Group volcanics. These rocks are considered to be laid down in Late Cretaceous time (Johnston and Timmerman, 1994). The distribution of Carmacks Group volcanic rocks in Wolverine Creek map area (115I/12) suggest that the topography resembled the present (S.T. Johnston pers comm, 1994). Tempelman-Kluit (1980) recognized a low-relief stage in the evolution of physiography in central Yukon with Pliocene? White Channel gravel deposited along the lower Stewart River and adjacent parts of Yukon River. These gravel deposits were mapped but their precise age remains undetermined.

Glaciation

The area mapped is beyond the all time limit of Cordilleran Ice Sheet glaciation based on information from Bostock (1966) and Hughes et al. (1969). Cordilleran Ice Sheet glaciations in central Yukon occurred repeatedly during Pleistocene time and have been termed McConnell, Reid, Klaza, and Nansen, in order of age from youngest to oldest (Bostock, 1966). The Nansen and Klaza glaciations are difficult to differentiate outside of the area mapped by Bostock and are generally referred to as pre-Reid (Hughes, 1987; Jackson, 1993).

Pre-Reid glaciations in Stewart River valley did however, contribute outwash to the Yukon River from the mouth of Stewart River and through to Indian River. The White River has and continues to contribute sediment to Yukon River from glaciers in the St. Elias Mountains. The lack of glaciation in this reach of the Yukon River and its tributaries is beneficial for placer formation.

Placer mining

Both currently operating and abandoned placer mines occur in the project area. The early history of placer mining includes "good prospects" found by Arthur Harper and Leroy McQuesten on bars of the lower Sixtymile River in 1876 or 1877 (Gilbert, 1981; Coutts, 1980). Rich placer gold was found on tributaries of the Sixtymile in 1891 (Coutts, 1980). Mr. Bob Porsild placer mined about six miles from the mouth of Sixtymile River in 1937 and there is evidence of earlier mining on the south side of the river (Bostock, 1979). Placer leases were in good standing on Ten Mile Creek and Rosebute Creek, in the late '30s early '40s (Debicki, 1983). In 1956, 1957, and 1958, Mr. J. Sestak mined on Ten Mile Creek (Debicki, 1983).

Placer gold is reported on a few of the creeks entering Sixtymile River in this lower reach and terraces associated with those creeks may be auriferous (Ten Mile Creek, Matson Creek - Placer Mining Section, 1993, Thirteen Mile Creek - Olsson, 1988). Placer gold mining was carried out on Ten Mile Creek by Frazer Resources Limited 1981 and 1982, N.B. Cook Corporation 1978-82, and by RMP Mining in 1980-1981 on a bench deposit near Ten Mile Creek mouth. Sestak Creek was mined by Bill Trerice and Midas Rex (Placer Mining Section, 1993).

During 1994, there was placer mining on Ten Mile Creek by Mr. Jon Ganter. In addition, a high level terrace on Ten Mile Creek was being mined by Jardin Gold. The valley bottom deposits are described as 10 to 12 feet deep with muck over gravel (page 72, Placer Mining Section, 1993). A high level terrace on Thirteen Mile Creek was also tested by Jardin Gold. No other terraces along the Sixtymile River below Matson Creek or Yukon River were being mined in 1994. Mineral exploration was being carried out on Ten Mile Creek and Donovan Creek by a prospector, Mr. Dan Hermanutz, during part of 1994.

Creek names are inconsistent on published government topographic maps. For example, the 1:250 000 scale topographic map (edition 2, 1988) has Five Mile, Ten Mile, Thirteen Mile, and Twenty Mile creeks shown while the GSC geology map (Tempelman-Kluit, 1974) labels Twenty Mile Creek as Ten Mile Creek in accordance with the 1:50 000 topographic map (1970). This report uses the 1988 map names when referring to these tributaries. Smaller creek names are from placer claim maps published by Indian and Northern Affairs Canada.

PROJECT OBJECTIVES AND RATIONALE

This project is a continuation of one started in 1993 (Fuller and Andersen, 1993; Fuller, 1994a) which tackled mapping of high level terraces along lower Stewart River valley and Yukon River valley from Selwyn River to Dawson City and terraces along Black Hills Creek and its mouth. This project addresses the Yukon River and Sixtymile River valley terraces from about Henderson Creek to Indian River. The maps produced cover Excelsior Creek (115O/5), Ogilvie (115O/12), and Matson Creek - East half (115N/9) (Fuller, 1995). They show the distribution of alluvial plain, alluvial terrace, abandoned channels, landslide deposits, and pingos.

Comparisons can be drawn between the project area and adjacent parts of Alaska. Placer gold is found on high level terraces 50 to 180 m above valley bottoms, in the Alaskan Fortymile River area (Fig. 1) (Yeend, 1990). The Alaskan Fortymile mining district has produced over 16,272 kg (523,154 oz) of placer gold since discovery in 1886 to 1991 (Swainbank et al., 1993). Other high level alluvial deposits adjacent to Yukon River in the northern corner of the Circle quadrangle have also yielded small flakes of gold (Yeend, 1991). A high bench level of Nolan Creek in the Koyukuk-Nolan district of Alaska is being mined (Bundtzen et al., 1994) and nuggets up to 5 troy ounces have been obtained (Giancola, 1993). Gravels in the present Yukon River bed have been drilled and were found to contain gold near Dawson (Lebarge and Morison, 1990, p. 67).

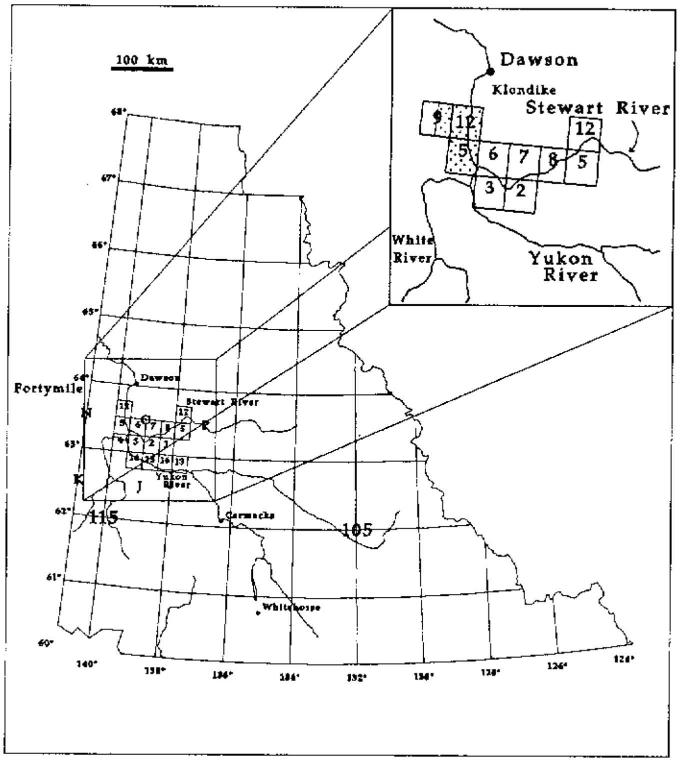

Figure 1: Location map of areas being studied for high level terraces. Blowup shows shaded areas pertaining to this report and unshaded areas that were published previously (Fuller, 1993, 1994b,c).

These terraces represent stages in drainage evolution in central Yukon and associated placer mineral concentrations. Their position adjacent to Yukon River makes them accessible by barge for seasonal transportation, which increases their mining potential. The present program of mapping high level terraces of the lower Sixtymile River valley and the Yukon River valley was prompted by the lack of stratigraphic and sedimentological information and the potential for discovery of new placer gold reserves.

As terraces are reservoirs of fluvial material, examination of main terraces on Sixtymile River and the Yukon River may help identify which tributary terraces hold potential gold reserves. Reworking of terrace gravels by tributary streams may concentrate heavy minerals into younger stream gravels.

The objective was to map terraces along Sixtymile and Yukon Rivers by airphoto interpretation, detailed mapping of exposed cuts, detailed mapping of soil pits, measuring terrace and bedrock elevation, and sample gathering for gold grain counts, geochemistry, grain size analysis, and pebble provenance.

FIELD WORK

During 1994 field work, the lower reaches of the Sixtymile River, below Matson Creek were mapped and sampled (see Appendix 1 for station locations) as well as continued mapping along Yukon River from Henderson Creek to Indian River (Fig. 2) (Fuller, 1995).

Field Methods

The 1988 and 1989 black and white aerial photography was interpreted prior to going into the field. Field mapping was done by measuring terrace heights relative to the river based on the airphoto interpretation. Digital and analog altimeters were used (accuracy estimated at ±15 feet) for elevation measurements relative to river level. Because of the regional nature of our mapping not all terraces were measured and sampled.

Level areas of the terrace top were chosen for soil pit excavations where possible. Unfrozen dry sites forested in aspen or mixed aspen and spruce were preferred. Hand dug pits were employed on Sixtymile River valley and both hand dug and Kubota excavator dug pits to bedrock or a maximum depth of 3 m along Yukon River (Fig 3). The soil pit was mapped and data collected for grain size, soil development, flow direction, pebble lithology, and periglacial features. Gravel samples (23 litre volume) were collected for heavy mineral concentration from different depths. They averaged about 38 kg (85 lb).

The bulk samples were panned or put through a sluice box. A count of gold particles in the heavy mineral concentrate followed. Gold particles counted include only those visible to the unaided eye although all gold was examined with a hand lens.

Samples were also collected for grain size (less than 50 mm size fraction) and geochemical analysis. These samples were submitted to an engineering firm for sieve analysis and to an assay and geochemical laboratory for chemical analysis.

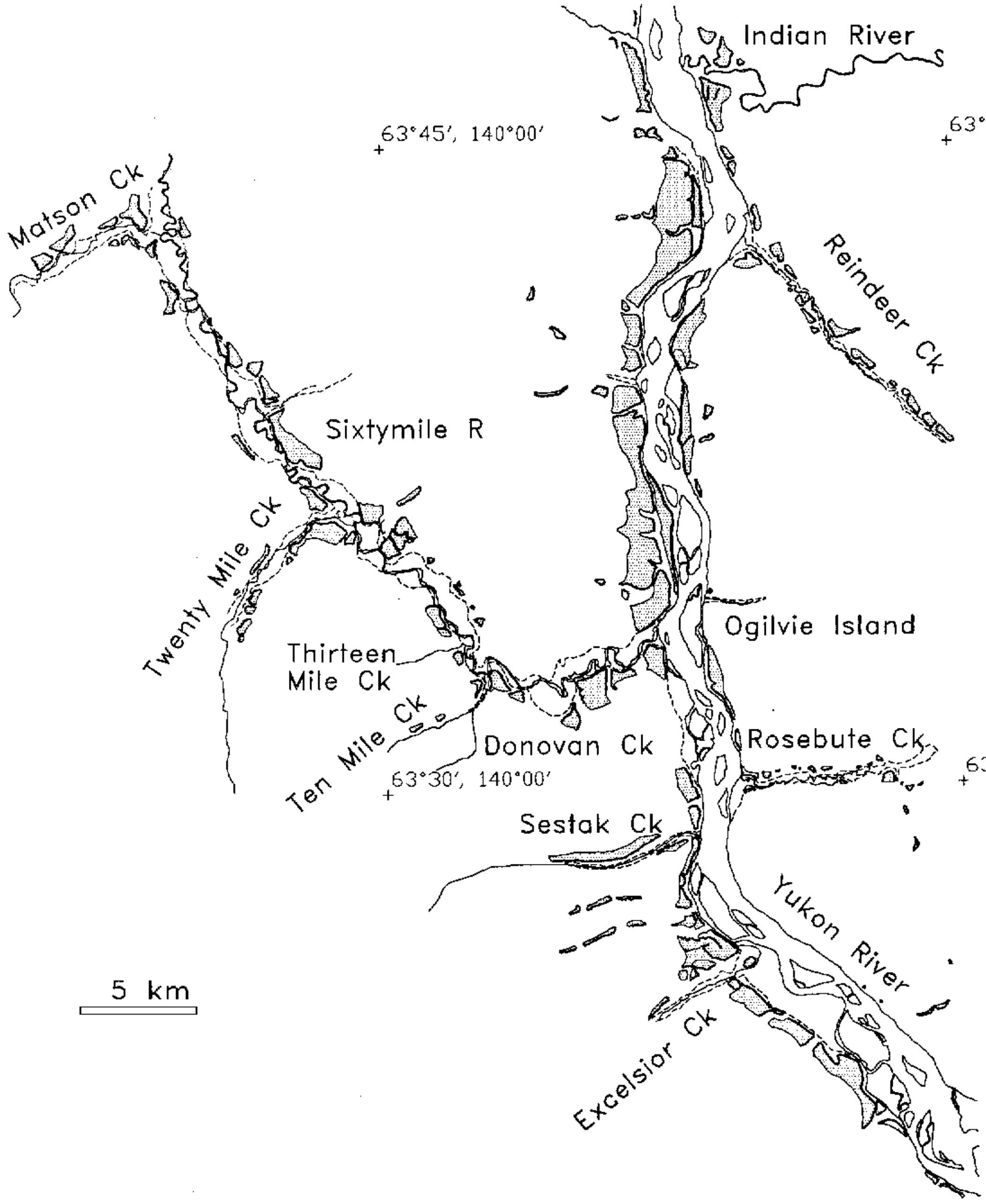

Figure 2: Sketch map of lower reach of Sixtymile River and part of Yukon River showing major tributaries and long profile section line. High level terraces are shaded and scarps are hatchured.

Figure 3: Pre-Reid (Wounded Moose Paleosol) developed in clast-supported, matrix filled pebble gravel (52 cm) overlying clast-supported cobble gravel (72 cm thick) above cobbly pebble gravel. The soil pit at this station (94-26) was dug to 280 cm on a terrace 1.3 km northwest of Matson Creek mouth.

Soil Descriptions

Soils colours (Munsell Soil Color Chart, 1990), texture, presence of silt and clay skins, weathering, secondary carbonate, and thickness were determined. The aim was to differentiate terrace material age based on soils using the criteria for pre-Reid and Reid soils as defined by Foscolos et al. (1977) and Tarnocai and Smith (1989).

Analytical methods

Laboratory investigations

Grain size analysis was carried out by EBA Engineering Consultants Limited (less than 50 mm size fraction) of gravel and sand samples. Samples were air dried, cone split, and weighed on an analytical balance and processed through nested sieves (32, 16, 8, 4, 2, 1, 0.500, 0.250, 0.125, 0.062, mm respectively).

Geochemistry samples were derived from the grain size rejects (69 samples) as well as four rock samples collected specifically for chemical analysis. Sample splits were assayed by fire assay of 30 g and atomic absorption and multi-element induced coupled plasma (ICP) analysis at Bondar-Clegg Laboratories, North Vancouver, British Columbia.

TERRACE LEVEL DESCRIPTIONS

High level terraces

High level terraces are arbitrarily defined here to occur 20 m (60 ft) above river level. They have elevated bedrock straths and are covered by variable thicknesses of silt, sand, gravel and diamicton (unsorted unconsolidated detritus).

Vegetation on the terraces varies with exposure direction; south facing terraces are commonly aspen covered while north facing ones are spruce covered. Moss is present on most areas of the terraces. Permafrost is present where the spruce vegetation and moss are thick. Areas underlain by aspen are commonly unfrozen.

Terraces were plotted on a long profile down the axis of the stream (Fig. 4). Data was extracted from topographic maps and terrace elevations measured in the field relative to river level. The terrace levels varied from 43 m (140 ft) to 88 m (290 ft) above Yukon River in the reach between Henderson Creek and Indian River and from 20 m (65 ft) to 95 m (310 ft) on the Sixtymile upstream to Matson Creek.

The age of terraces is bracketed by the youngest bedrock and the youngest surficial material. In the Sixtymile River valley, and Yukon River, the youngest bedrock is probably basalt, with conglomerate, sandstone, and shale being older. While the volcanic rocks may be Tertiary or Quaternary in age the sedimentary rocks may be Eocene and as young as Miocene (Tempelman-Kluit, 1974). An outcrop of sandstone with plant fragments (*Equistum sp.?*) is present at 8.2 kilometers along the mining road from Sixtymile River mouth to Ten Mile Creek. No age determinations were done on the basalt or fossil plants during this project.

The age and stratigraphic position of tephra deposits may help in correlating terrace gravels. One possible tephra was observed on the high bench on Ten Mile Creek about 4 km from its mouth. It is light gray, well sorted, compact, varies in thickness from 2 to 6 cm and occurs within a gravel unit which has been channeled. It occurs in the 1994 mining cut and has not been correlated at this time with any particular dated tephra in Yukon. Terrace gravel in Ten Mile Creek was bouldery (Fig. 5) while at Twenty Mile Creek and Sixtymile River terraces it was cobbly (Fig. 6).

Bedrock terraces

Bedrock terraces are those whose base level is recorded as the height of bedrock/gravel contact above the valley bottom. These terraces occur along both Yukon River and Sixtymile River valleys as broad elevated valley features (Fig. 4). Their margins closest to the valley wall are commonly covered with slope deposits (colluvium). The surface morphology of the bedrock strath is most commonly horizontal or subhorizontal where seen in cuts but excavations show a variable surface generally rising away from the axis of the Yukon River valley. Along Sixtymile River valley, a 20 m (65 ft) terrace remnant occurs on basalt (Fig. 7) marking the lowest rock cut high level terrace.

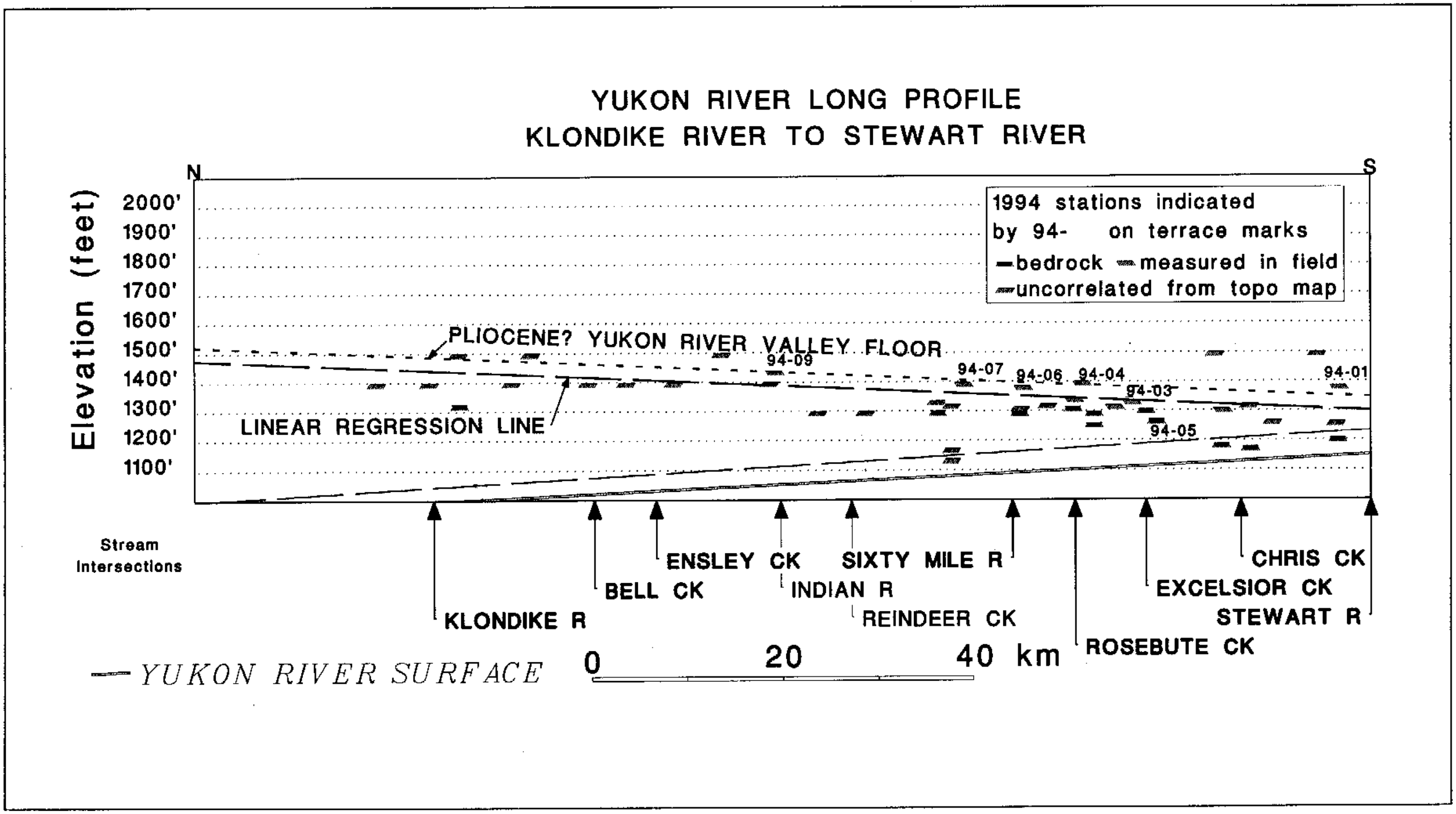

Figure 4: Long profile of Yukon River reach with terrace levels derived from field measurement and topographic maps. A linear regression line through terrace spot elevations shows a feature sloping from the Klondike River toward Stewart River. A dashed line, parallel to the present-day Yukon River surface, indicates a lower alluvial terrace.

Figure 5: Section exposed in bulldozed trench at station 94-018 on a high level bench on Ten Mile Creek. A channel is cut into older gravel and filled with bouldery gravel. The gravel is subangular.

Figure 6: Section exposed in bulldozed trench at station 94-016 on a terrace 250 ft above the Sixtymile River on an east tributary called Thirteen Mile Creek. A 57 cm thick layer of pebbly compact light brown sand overlies clast supported, well sorted fine gravel (53 cm thick) which in turn overlies 35 cm of medium to coarse washed sand with heavy mineral laminations. Imbricated coarser gravel 65 cm thick lies on fractured bedrock (dark gray). The pick handle is 82 cm long.

PALEOSOL DESCRIPTIONS

Correlation of terraces was accomplished by plotting long profiles of terrace remnants, identifying their geomorphology and comparing their soil development (Fig. 4). The surface material with soil development was mostly gravel and sand with a loess veneer, but colluvium and diamicton (poorly sorted, unstratified clastic sediment) were encountered.

Foscolos et al. (1977) determined soil development and correlation based on detailed studies of soil mineralogy and characteristics for central Yukon. In this way, broad features can be crudely related. In addition, the soils are correlated with Wounded Moose paleosols (pre-Reid), Diversion Creek paleosols (Reid), and the Stewart soils (McConnell) (Tarnocai and Smith 1989; Tarnocai 1987; Smith et al. 1986). The soil characteristics for Wounded Moose and Diversion Creek paleosols have been summarized before (Table 2 of Fuller, 1994a).

Figure 7: Top of bedrock terrace 65 feet above Sixtymile River valley floor and 800 m southeast of Twenty Mile Creek (station 94-22). Basalt is overlain by a thin layer of cobbles at edge of terrace. Ten feet away, a 210 cm soil pit was dug to permafrost in pebble and cobble gravel.

Pre-Reid soils (Wounded Moose paleosols)

The thickest soils were found along the Yukon River at station 94-09 and the Sixtymile River at station 94-16, in gravel deposits, where the deepest level of clay skins was 228 cm and 125 cm respectively. Each of these soils had distinctive characteristics of clay skins on pebbles, strong brown or red colour in their upper part, and intense weathering of pebbles. Ventifacts and sand wedges were present locally. These are considered to have formed during a pre-Illinoian interglacial on material of about 1.2 million year age (Hughes 1987; Tarnocai and Smith 1989). Another example of pre-Reid soil is found at station 94-07 on a 240 foot high terrace at about 1320 feet elevation, five kilometers north of the mouth of Sixtymile River on map 115O/12 (Fig. 2 and 4). The paleosol has a red colour (2.5YR 5/8) and extends to 50 cm. Tops of soil profiles were likely deflated during intense cold glacial events.

RESULTS OF ANALYSES

Grain Size Analysis

The size distribution of selected gravel samples taken from cuts and soil pits is plotted in Figure 8. Most of the samples fall in the sandy gravel (sG) and gravel (G) category. One diamicton matrix is muddy sand (mS). The gravel samples are quite clean of mud on the terraces and active creek deposits.

NUMBER	LTR	PAILS	GOLD	ASSAY
94-001	c	1 bucket	0	6
94-002	pit 1	3 pans	0	0
94-002	pit 2	1 pan	0	0
94-003	a	1 bucket	0	36
94-003	b	1 bucket	0	18
94-003	c	1 bucket	0	0
94-003	d	1 bucket	0	0
94-005	a	1 bucket	0	0
94-006	a	1 bucket	2	339
94-006	b	1 bucket	0	0
94-006	c	1 bucket	0	0
94-006	d	1 bucket	3	18
94-007	a	1 bucket	12	12
94-007	b	1 bucket	5	17
94-007	c	1 bucket	3	0
94-009	a	1 bucket	4	18
94-009	b	1 bucket	6	11
94-011	a	1 bucket	0	0
94-011	b	1 bucket	1	0
94-011	c	1 bucket	0	11
94-011	d	1 bucket	0	17
94-012	a	1 bucket	0	23
94-013	a	1 bucket	0	0
94-013	b	1 bucket	0	6
94-015	a	1 bucket	0	17
94-016	a	1 bucket	0	23
94-016	b	1 bucket	1	9
94-016	c	1 bucket	0	8
94-017	a	1 bucket	0	18
94-017	b	1 bucket	0	0
94-017	c	1 bucket	5	47
94-017	d	1 bucket	8	10
94-018	a	5 pans	0	16
94-018	b	1 bucket	1	331
94-018	c	1 bucket	5	9
94-018	d	1 bucket	1	6
94-018	e	1 bucket	5	12
94-018	f	1 bucket	1	18
94-018	g	1 bucket	4	6
94-018	h	1 bucket	8	18
94-019	a	1 bucket	6	12
94-019	b	1 bucket	10	7430
94-019	c	1 bucket	22	358
94-019	d	1 bucket	38	160
94-020	a	1 bucket	11	9
94-020	b	1 bucket	10	24
94-020	c	1 bucket	18	24
94-020	d	1 bucket	36	168
94-021	a	1 bucket	1	6
94-021	b	1 bucket	1	6
94-022	a	1 bucket	0	0
94-022	b	1 bucket	0	0
94-023	a	1 bucket	0	6
94-023	b	1 bucket	1	0
94-024	a	1 bucket	0	6
94-024	b	1 bucket	0	11
94-025	a	1 bucket	1	11
94-025	b	1 bucket	1	0
94-026	a	1 bucket	0	9
94-026	b	1 bucket	0	6
94-027	a	1 bucket	0	23
94-028	a	1 bucket	0	0

Table 1: Gold grain counts from sluiced and panned samples and gold assays.

Gold particle counts

The distribution of gold particles for panned and sluiced samples is shown in Table 1. Gold grain counts varied from 0 to 38 in the study area. The highest concentrations are from Ten Mile Creek valley bottom (6-38 gold particles). The maximum gold count of 12 was found on a high level terrace five kilometers downstream from the mouth of Sixtymile River (shown in Figure 2). Placer gold was found in various gravel facies including clast-supported pebble gravel, clast supported cobble gravel, and matrix-supported gravel. It is associated with black sand (magnetite) and red garnets.

Geochemistry

Forty eight of the 69 gravel samples analyzed contain detectable gold with values up to 7430 ppb (Appendix 2). The gold assay values were plotted against the gold grain counts from sluicing 5 gallon buckets of gravel (Fig. 9). The inference made from this plot is that visible free gold is present in 25 of the duplicate samples and only four samples where gold occurred (1-3 particles) did not return detectable gold in the -80 mesh fraction assayed. The ICP analysis provides an indication of coincident arsenic-gold geochemical anomalies which may be explained by the possible source of gold in quartz veins. The anomaly extends over 5.5 km length of the present Ten Mile Creek drainage as well as the high level terrace 4 km upstream of the mouth. Arsenic ranges from 43 to 482 ppm and gold from 6 to 7430 ppb (Appendix 2).

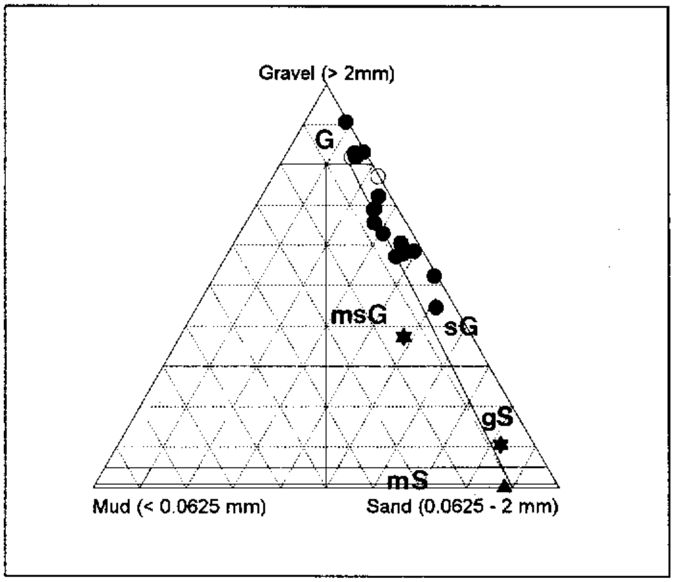

Figure 8: Ternary plot of grain size analyses for selected gravel samples. Filled circles represent terrace gravels, open circles represent creek gravel, stars represent weathered bedrock, and triangles represent diamicton.

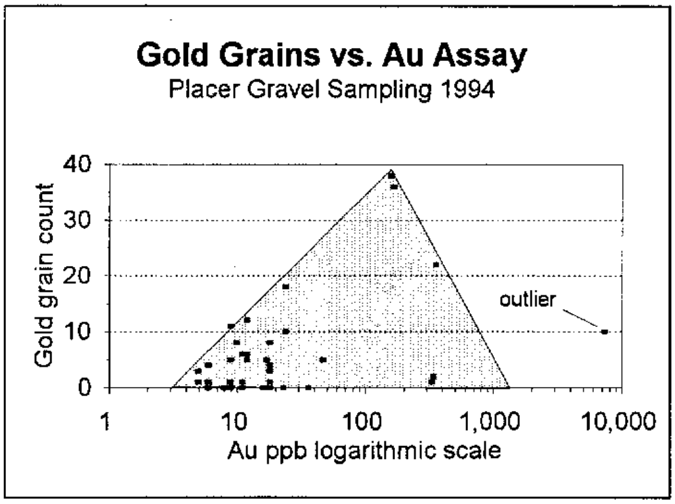

Figure 9: Scatterplot of gold grain counts against geochemical assay results above the 5 ppb detection limit. The raw data is included in Table 1.

A 20 cm long cobble of white quartz shot through with black paper thin fractures of finely divided sulphides, probably pyrite and arsenopyrite, (rock sample 94-18G) collected at bedrock on this terrace returned 2291 ppm As and 66 ppb Au. A pyrite-pyrrhotite bearing rock sample of ultramafic rock (dark green amphibole-chlorite-actinolite ±epidote) collected from the most upstream site returned 216 ppm Cu, 137 ppm Ni, and 126 ppm Cr but no detectable gold. Reconnaissance geochemical survey (Geological Survey of Canada, 1986) shows low gold values generally but there are anomalies on Ten Mile Creek.

DISCUSSION

Terraces

This discussion is based on the Yukon River and Sixtymile River reaches of the study. There are only broad correlations of terraces which relate to uplift at this time for lower Sixtymile River valley and Yukon River. The highest fluvial terraces mapped range from 64 to 76 m (210 to 250 ft) above present river level. They record a period of tectonic stability and uniform base level presumed to be Tertiary in age. Their incision and downcutting is thought to result from differential tectonic uplift of Yukon Plateau possibly related to Tintina fault activity (Hughes, 1970). This tectonic warping causing tilting is evident by the relative rise in terrace elevation northward with respect to present Yukon River floodplain elevation.

A terrace of Bonanza Creek, in the Klondike, contains Mosquito Gulch Tephra with a fission-track date of 1.22 Ma (Naeser et al., 1982). This terrace formed after incision of the high level terraces above the White Channel Gravel so provides a minimum date of entrenchment in Dawson area (Hughes, 1987).

The terrace remnants follow the west side of the Yukon River valley from Chris Creek to Indian River. The style of deposition based on pit profiles suggests that the streams depositing these sediments had variable flow rates. Both matrix- and clast-supported gravel occurs with openwork fine gravel and granule beds. Flat pebble imbrication and cobble armoring of the channel deposits is locally present. The maximum clast size varies between 15 and 40 cm and probably reflects the limited depth where our samples were obtained.

Lower terraces slope parallel to the present grade of Yukon River and may reflect a Pleistocene aggradation. south sloping high level terraces were presumed to represent south flowing drainage by Tempelman-Kluit (1980) but may represent differential uplift in the Klondike. High level terraces on Sixtymile River upstream of its confluence with Yukon River appear to grade to about 1300 ft which is close to the level of terraces in Yukon River valley from Stewart River to Sixty Mile River. The terraces along Reindeer Creek and Rosebute Creek were not examined but vary in elevation to 2000 feet.

The Yukon River occurs in an antecedent transverse valley where the river existed before uplift occurred and downcut during ascent. Its incision in stages has left series of terraces along the valley. Tectonically warped terraces are known (Mangelsdorf et al., 1990) where plotting of terrace remnants shows a bowed geometry.

Placer deposits

Placer gold found in surface samples and above bedrock in Sixtymile River and Yukon River valley high level benches is typically fine grained, flat, far traveled and in low concentrations. Placer gold is present as single grains in 5 gallon test samples at five sites on Sixtymile River high level terraces and up to 8 particles from Ten Mile Creek terrace samples. The low amount of gold recovered may indicate that our 23 litre bucket samples are too small in volume.

There is still potential at the gravel/bedrock interface which was only sampled at a few sites. Tributary high level benches offer other targets for placer exploration.

Placer gold in a paleo-Yukon River drainage may exist as found in drilling the Yukon River at Dawson City where high gold values were erratically distributed throughout the sediments and not concentrated on bedrock (Lebarge and Morison, 1990). Higher gold values may exist downstream from gold placer tributary streams. This appears to be the case with the Sixtymile River mouth where there is placer gold in gravels at the mouth and downstream on Yukon River terraces but not on upstream Yukon River terraces.

The source for the placer gold was not directly determined. However, a vein of brown drusy quartz is reported about 10 km upstream from the mouth of Sixtymile River (McConnell, 1900; in Bostock, 1957) from which a specimen assayed 0.117 ounces/ton. The vein was not seen during 1994 field work but placer gold was found on benches along both sides of the river near this point. A rock sample submitted for assay from Ten Mile Creek drainage yield anomalous gold (66 ppb in a cobble). The coincidence of arsenic and gold anomalies in soil samples collected during the 1994 field work suggest a vein source for Ten Mile Creek bench and valley bottom deposits.

SUMMARY

High level terraces in the lower Sixtymile River valley and Yukon River valley have been mapped and sampled at 1:50 000 scale. Part of the terrace chronology can be fitted to Tertiary fluvial systems as high level terraces with elevated bedrock benches. Previous to any Pleistocene glaciation, a low relief upland had developed broad flat bottomed valleys in Sixtymile River and Yukon River valleys. A period of stability (stillstand) resulted in deposition of high level gravel unrelated to glaciation. Subsequent uplift and downcutting produced elevated bedrock terraces which constrained lateral migration of these major streams. The modern streams were entrenched into bedrock.

The fluvial environment was dominated by north flowing streams in the paleo-Yukon River valley. The paleo-Sixtymile River graded with this elevated base level as did those of Reindeer Creek and Rosebud Creek for example. The Sixtymile River also flowed in the same direction as present. Pebble gravel was deposited in presumed braided system channels and bars based on the distribution of gravel types seen in shallow pits. Boulder and cobble gravel were deposited in paleochannels in the upper reaches of Ten Mile Creek on high level benches and in the creek valley bottom.

Regional uplift and tilting occurred following a long period of stability, leading to entrenchment of the Yukon River and its tributaries into their former valley floors. The timing of uplift is presumably during the Neogene (Miocene-Pliocene). The style of deposition varied from the trunk stream which has probably been multichannel and low sinuosity for this entire period to modern meandering stream systems in tributaries as the present streams adjust to the new gradients.

Prior to the Pleistocene glaciations and during the Late Tertiary, a more humid climate prevailed in central Yukon and caused the development of Luvisols (Foscolos et al., 1977; Tarnocai et al., 1985; Smith et al., 1986). These soils are characterized by clay accumulation and strong chemical weathering. Cordilleran glaciations beginning with the pre-Reid advance, resulted in a change to harsh climatic conditions which affected sediments beyond the pre-Reid ice limits. This led to vegetation-free sand and gravel bars of meltwater derived braided rivers supplied fine-grained sediment which was deposited as a nearly continuous veneer of loess on terrace surfaces. Periglacial features such as sand wedges, ventifacts, and frost shattered pebbles were superposed on terrace surface sediments. Deflation of part or all previously formed soil horizons likely occurred during this time, resulting in the truncation of pre-Reid solums on terrace surfaces. This cycle of soil formation and subsequent truncation was repeated during the Reid and McConnell glaciations.

Since Pleistocene glaciations in central Yukon have been more extensive through time, fluvial deposits associated with the (oldest) pre-Reid glaciation are the most extensive and lie at the highest elevations. Placer gold found on the high level terraces appears to be far traveled and may have been reworked through several fluvial episodes. Its occurrence in the near surface (within the top three metres) may be a function of heavy mineral accumulation in a bar setting similar to the present Sixtymile and Yukon Rivers. Gold may have been supplied by distal sources in tributary streams.

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Appendix 1

Station	NTS	Easting	Northing	Grid	Air photo line	Air photo no.	Location	Elev.
94-004	115O/12	564680	7043616	7			Yukon River terrace u/s 60mile River east side	1270
94-005	115O/12	562121	7047279	7			Yukon River terrace S side 60mile River	1370
94-006	115O/12	561149	7054691	7			downstream of 60mile R W bank high terrace	1295
94-043	115O/05	573108	7024830	7	A27325	093	side of gully 120' above YR. 115O/5	1280
94-045	115O/05	570013	7029329	7	A12066	366	180' high Y.R. terrace 3 km d/s of Chris Ck	1305
94-047	115O/12	565168	7042349	7	A27326	144	N side Rosebute Ck mouth 265' above Y.R.	1380
94-001	115O/06	579650	7024950	7	A27325	093	left limit Henderson Creek NW trend knob	1275
94-002	115O/12	571477	7032278	7	A27325	025	half way btn Chris & Excelsior Cks E side	1640
94-003	115O/5	562994	7036203	7	A27326	143	half way btn Sestak & Excelsior Creeks	1335
94-004	115O/5	565276	6941596	7	A27326	143	left limit Rosebute Ck 1 km from mouth	1400
94-005	115O/5	565180	7033937	7	A27326	143	left level of Excelsior Ck 1 km SSE of Ck mouth	1210
94-006	115O/12	561680	7047094	7	A27482	028	1 mile S of 60mile mouth on W side YR	1385
94-007	115O/12	561216	7053671	7	A27482	112	4 km N of 60mile 3rd tributary	1400
94-009	115O/13	563600	6974200	7	A12066	270	higher main terrace W of Indian River	1440
94-010	115O/12	555801	7049825	7	A27482	026	3.5 km NW of 10 Mile Ck mouth	2025
94-011	115O/12	553709	7048940	7	A27482	025	flat terrace at edge of W-trending ridge	1525
94-012	115O/12	555156	7049347	7	A27482	026	3 km NE of mouth of 5 Mile Ck near road	1725
94-013	115O/12	561150	7050611	7	A27482	027	terrace on Ck 2 km N of 60mile R mouth	1345
94-014	115O/12	563305	7057398	7	A27482	113	8 k SW of Reindeer Ck mouth E side Y.R.	1305
94-016	115O/12	552485	7048384	7	A27482	024	about 0.5 km NW of mouth of 13 Mile Ck	1330
94-018	115O/12	550800	7044272	7	A27481	265	high level terrace mine cut	1700
94-019	115O/12	554043	7046215	7	A27482	026	lower 10 Mile Ck by old airstrip terrace	1210
94-020	115O/12	553964	7046085	7	A27481	265	below former 10 Mile Ck 10' below stream	1220
94-021	115N/9	548774	7053345	7	A27482	108	1 km ESE of mouth 20 Mile Ck on terrace	1465
94-022	115N/9	548236	7053216	7	A27482	108	800 m SE mouth of 20 Mile Ck 60 Mile terrace	1365
94-023	115N/9	544882	7057472	7	A27482	107	on cat road 1 km SE of Ck mouth	1505
94-024	115N/9	544431	7058564	7	A27482	107	right limit of creek draining SE side	1450
94-025	115N/9	539633	7065336	7	A27520	160	400 m W of Matson Ck mouth on terrace	1520
94-026	115N/9	538814	7066330	7	A27520	160	1.3 km NW mouth of Matson Ck on high	1575
94-027	115O/12	553712	7046273	7	A27481	264	left limit terrace 10 Mile Ck	1425
94-028	115O/12	554851	7046151	7	A27481	265	right limit terrace 60mile below Ten Mile Ck	1300

YR - Yukon River; u/s - upstream; d/s - downstream; btn - between.

Appendix 2

Sample ID	Au30 ppb	Cu ppm	Pb ppm	Zn ppm	Mo ppm	As ppm	Ba ppm
94-01C-174-250	6	16	9	30	2	8	60
94-2-PIT1	-5	121	18	84	3	-5	767
94-2-PIT3	-5	113	9	96	3	-5	526
94-03-148-175	36	49	23	128	2	12	142
94-03-175-200	18	58	25	136	4	10	180
94-03-225-240	-5	52	18	107	3	12	134
94-03-240-270	-5	47	19	101	2	8	100
94-05-A	-5	28	8	68	2	6	189
94-06A-80-126	339	15	9	52	2	-5	92
94-06B-126-147	-5	14	9	47	-1	-5	82
94-06C-147-183	-5	14	11	48	1	-5	78
94-06D-183-260	18	14	9	58	-1	-5	86
94-07A-30-80	12	45	8	42	3	12	232
94-07B-80-180	17	38	10	54	3	10	299
94-07C-180-280	-5	29	10	51	2	-5	169
94-09-A	18	20	8	42	2	6	566
94-09-B	11	30	10	63	2	14	154
94-09-C	-5	32	9	44	3	24	144
94-09-108-128	9	25	8	47	1	8	168
94-09-128-193	-5	16	7	26	2	11	102
94-09-195-260	-5	21	8	32	2	14	112
94-09-74-108	-5	25	8	44	1	7	136
94-09A-30-88	6	21	9	34	2	14	106
94-09B-88-100	6	26	13	44	3	31	166
94-11-A	-5	23	11	54	3	17	132
94-11-B	-5	24	9	56	3	8	155
94-11-C	11	21	10	61	2	8	327
94-11-D	17	35	14	80	5	19	432
94-12-A	23	64	20	130	3	9	229
94-13-A	-5	35	6	73	3	9	273
94-13-B	6	88	6	108	5	-5	529
94-15	17	20	7	47	2	6	109
94-16	23	45	12	64	4	12	448
94-16-B	9	16	6	39	1	5	128
94-16-C	8	33	4	52	2	-5	274
94-17	18	22	17	78	2	95	170
94-17-B	-5	22	17	69	2	89	161
94-17-C	47	32	24	82	4	221	321
94-17-D	10	29	16	83	3	123	256
94-18-A	16	32	22	67	3	46	344
94-18-B	331	34	30	83	3	67	441
94-18-C	9	29	22	75	2	69	170
94-18-D	6	34	21	70	2	43	227
94-18-E	12	73	17	114	3	111	232
94-18-F	18	57	47	113	6	482	571
94-18-G	6	46	32	104	4	182	241

Continues on next page.

Appendix 2 - continued

Sample ID	Au30 ppb	Cu ppm	Pb ppm	Zn ppm	Mo ppm	As ppm	Ba ppm
94-18-H	18	36	23	95	3	118	196
94-19-A	12	24	12	73	2	57	255
94-19-B	7430	23	14	73	2	61	242
94-19-C	358	29	15	107	3	68	251
94-19-D	160	34	20	100	3	105	277
94-20-A	9	37	13	132	3	65	225
94-20-B	24	59	25	98	13	107	1767
94-20-C	24	62	21	93	9	106	1426
94-20-D	168	47	16	80	4	79	334
94-21-300-315	6	25	12	67	3	9	146
94-21-180-210	6	27	7	65	3	-5	174
94-22-170-210	-5	17	9	52	3	-5	139
94-22-95-136	-5	21	6	81	3	-5	213
94-23-200-290	-5	31	21	84	3	-5	158
94-23-152-200	6	28	16	79	3	-5	140
94-24-136-236	11	19	9	70	3	-5	120
94-24-74-120	6	20	9	70	4	5	184
94-25-220-250	-5	50	12	85	7	6	220
94-25-108-183	11	22	7	65	3	6	180
94-26-270-280	6	22	8	67	3	-5	136
94-26-177-270	9	13	9	49	2	-5	102
94-27	23	28	51	91	5	176	186
94-28	-5	31	7	67	7	61	39

GEOLOGICAL MAPPING IN THE CAMPBELL RANGE, SOUTHEASTERN YUKON (PARTS OF 105 G/8, G/9 AND 105 H/5, H/12)

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PLINT, H.E., 1995. Geological mapping in the Campbell Range, southeastern Yukon. In: Yukon Exploration and Geology, 1994, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs, Canada, p. 47–58.

Abstract

The Finlayson Lake fault zone forms the boundary between autochthonous North American rocks and rocks of the innermost accreted Slide Mountain and Yukon-Tanana terranes in southeastern Yukon. Geological mapping at 1:50 000 scale in a well exposed area of the Campbell Range, southeastern Yukon, was undertaken to examine the kinematics of the Finlayson Lake fault zone and rock types of the Slide Mountain terrane.

Five units were identified: (1) chloritic schist and phyllite, (2) laminated metachert and carbonaceous black slate, (3) tan weathering metachert and maroon siliceous and argillaceous metasiltstone, (4) greenstone and associated breccia, gabbro, metagreywacke, metachert and maroon metasiltstone and (5) serpentinite. Unit 2 is structurally interleaved with submap-scale bodies or layers of serpentinite, hornblende-plagioclase porphyry, plagioclase-potassium feldspar porphyry, quartz-eye muscovite-chlorite phyllite or schist, chloritic schist and minor grey, calcareous metacarbonate. Serpentinite is also exposed in unit 4 and as small slivers along the thrust contact between units 3 and 4.

Lithologically, units 4 and 5 are similar to the upper division of the Slide Mountain terrane in east-central and north-central British Columbia. Unit 2 has similarities with the lowest division of the Sylvester allochthon and is tentatively correlated with the Slide Mountain terrane. Maroon metasiltstone in unit 3 is indistinguishable lithologically from metasiltstone in the overlying greenstone unit suggesting that the eastern thrust fault juxtaposes parts of the same depositional sequence, i.e. the Slide Mountain terrane. Regional correlation of unit 1 is unclear.

Unit 2 is inferred to be bounded to the east and west by northwest-striking faults and to the south, by a east-striking, steeply dipping, normal (north-side down) fault. The northern boundary of unit 2 is unconstrained. Greenstone (unit 4) is thrust towards the southwest over unit 1 in the western part of the map area along a northwest-striking, gently northeast-dipping thrust fault. In the eastern part of the map area, greenstone is thrust towards the northeast over unit 3 along a northwest-striking, moderately southwest-dipping thrust fault. Outcrop data and topographic patterns suggest that the eastern thrust fault is truncated by a northwest-striking, steeply dipping fault and that the normal fault truncates the westernmost northwest-striking fault. The northwest-striking faults are poorly exposed and their kinematics have yet to be determined. However, if they are steep faults, they are likely dextral strike-slip faults.

Field data indicate that the Finlayson Lake fault zone consists of diverging thrust faults and subparallel strike-slip(?) faults. These structures are consistent with the interpretation of the Finlayson Lake fault zone as a transpressive fault zone. More constraints on the relative timing of faulting and the kinematics of the steep faults are required to test this hypothesis.

INTRODUCTION

In the northern Cordillera, Late Devonian to Late Triassic, massive greenstone, mafic to ultramafic plutonic rocks and associated sedimentary rocks of the Slide Mountain terrane crop out between autochonous North American strata and the innermost accreted, Yukon-Tanana and Slide Mountain terranes. In southeastern Yukon, the boundary between the North American rocks and accreted rocks is the Finlayson Lake fault zone (Fig. 1). The fault zone is interpreted to be the displaced northern extension of the dextral transpressive Teslin suture zone of south-central Yukon, that has been offset 450 km to the southeast along the mid-Cretaceous to Tertiary, dextral strike-slip Tintina fault (e.g. Tempelman-Kluit, 1979; Hansen, 1989).

The Finlayson Lake fault zone incorporates and deforms rocks of the Slide Mountain and Yukon-Tanana terranes and locally contains eclogitic rocks. The timing and nature of motion along the fault zone is poorly understood. At its northern end, it is marked by anastomosing vertical to steeply dipping faults with mainly strike-slip displacement (Mortensen, 1992a). Farther south, in the northern Campbell Range, the fault zone is apparently structurally overlain by a synform of stacked thrust sheets of Slide Mountain terrane rocks although the structure of the fault zone itself is unknown (Mortensen and Jilson, 1985).

Complex internal thrust imbrication, lack of fossil and isotopic ages and lack of detailed field mapping has hindered regional correlation of the Slide Mountain terrane and tectonic reconstructions in southeastern Yukon (Mortensen, 1992a). Geological mapping in the Campbell Range was initiated to examine the Finlayson Lake fault zone and the Slide Mountain terrane in a well exposed area northeast of Wolverine Lake, southeastern Yukon (Fig. 2 to 5) to aid regional correlations, tectonic reconstructions and interpretation of LITHOPROBE SNORCLE transects 2 and 3.

LOCATION AND ACCESS

The study area is located 150 km north of Watson Lake, Yukon between the Robert Campbell Highway to the east and Wolverine Lake to the west (Fig. 3). It covers parts of NTS maps: 105G/8, 105G/9, 105H/5, 105H/12. The area is accessible by helicopter from the towns of Watson Lake and Ross River and on foot from the highway in the northeastern part of the map area. Outcrop is excellent to sporadic above treeline (about 1600 m elevation), moderate on mountain slopes below treeline and locally present along creeks.

Mapping at 1:50 000 scale was carried out for 6 weeks during the 1994 field season from two-person helicopter-supported fly camps. Fieldwork was terminated prematurely due to a forest fire in the Campbell Range.

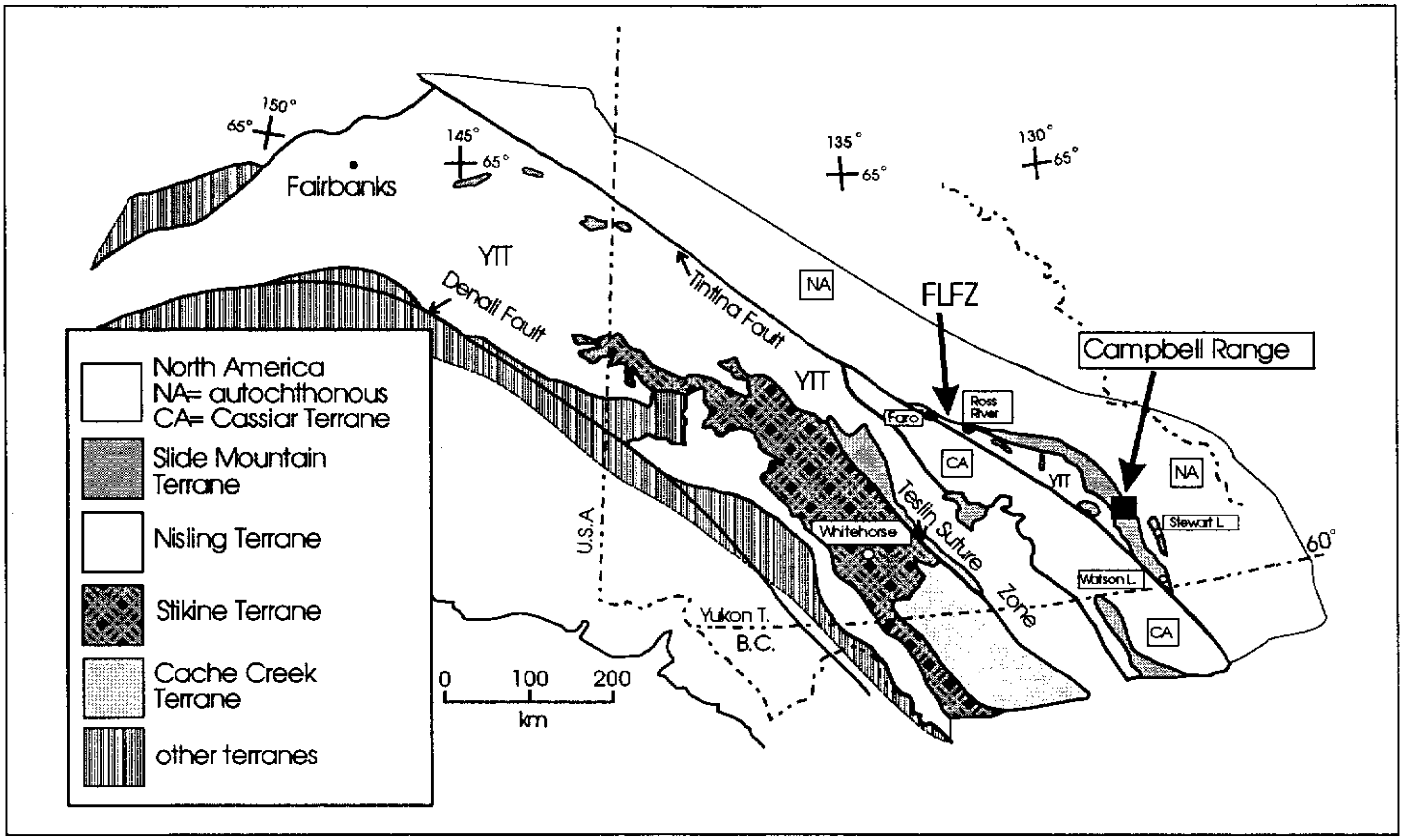
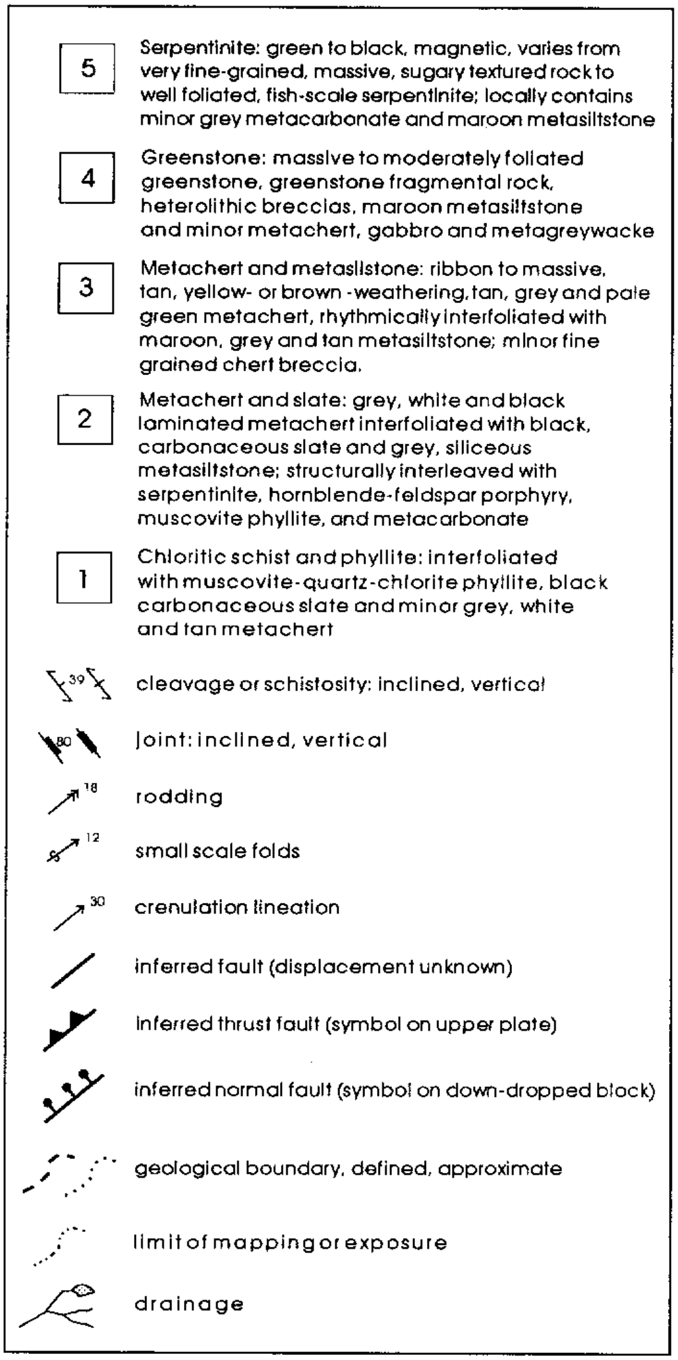


Figure 1: Terranes of the Northern Cordillera. NA is autochthonous North American strata. CA is allochthonous North American strata (= Cassiar Terrane); YTT is Yukon-Tanana Terrane. FLFZ is the Finlayson Lake fault zone. Modified from Mortensen (1992b).



5 Serpentinite: green to black, magnetic, varies from very fine-grained, massive, sugary textured rock to well foliated, fish-scale serpentinite; locally contains minor grey metacarbonate and maroon metasiltstone

4 Greenstone: massive to moderately foliated greenstone, greenstone fragmental rock, heterolithic breccias, maroon metasiltstone and minor metachert, gabbro and metagreywacke

3 Metachert and metasiltstone: ribbon to massive, tan, yellow- or brown-weathering, tan, grey and pale green metachert, rhythmically interfoliated with maroon, grey and tan metasiltstone; minor fine grained chert breccia.

2 Metachert and slate: grey, white and black laminated metachert interfoliated with black, carbonaceous slate and grey, siliceous metasiltstone; structurally interleaved with serpentinite, hornblende-feldspar porphyry, muscovite phyllite, and metacarbonate

1 Chloritic schist and phyllite: interfoliated with muscovite-quartz-chlorite phyllite, black carbonaceous slate and minor grey, white and tan metachert

cleavage or schistosity: inclined, vertical

joint: inclined, vertical

rodding

small scale folds

crenulation lineation

inferred fault (displacement unknown)

inferred thrust fault (symbol on upper plate)

inferred normal fault (symbol on down-dropped block)

geological boundary, defined, approximate

limit of mapping or exposure

drainage

Figure 2: Legend for Figures 3 through 5 inclusive. Formation age of units is unknown, although on the basis of isotopic and fossil age data elsewhere in southeastern Yukon (Mortensen, 1992a,b) units 1 and 4 are middle Paleozoic to early Mesozoic.

TECTONIC SETTING AND PREVIOUS WORK

The rocks underlying the map area have been assigned to the Slide Mountain and Yukon-Tanana terranes (e.g. Mortensen, 1992a,b; Wheeler and McFeely, 1991). The Slide Mountain terrane in southeastern Yukon consists of greenstone, ultramafic and mafic plutonic rocks, red, green and grey ribbon chert and minor marble (Mortensen, 1992a). The Yukon-Tanana terrane is a pericratonic terrane of polydeformed and metamorphosed rocks derived from pre-Devonian to Upper Triassic sedimentary, volcanic and plutonic protoliths (e.g. Hansen, 1989, 1990). The Slide Mountain terrane (Anvil allochthon of Tempelman-Kluit, 1979) is interpreted to be the remnants of oceanic crust that separated the Yukon-Tanana terrane from North America (e.g. Hansen, 1988, 1990; Nelson, 1993). The Yukon-Tanana terrane may be a distal equivalent of North America or an unrelated allochthonous terrane (e.g. Hansen, 1990; Hansen et al., 1991).

Early geological maps for the Campbell Range (Wheeler et al., 1960; Roots et al., 1966) show the study area underlain predominantly by greenstone, metadiorite, minor serpentinite and minor amphibolite. A thin unit of shale, chert, quartzite, greywacke and chert-pebble conglomerate is reported along the eastern edge of the map area.

Regional mapping in the study area by Mortensen and Jilson (1985) defined the "Campbell Range belt" as consisting of a unit of greenstone, serpentinite, chert, minor diabase and minor gabbro structurally overlying a massive carbonate unit and a dominantly grey chert and metachert unit. The latter is structurally interleaved with minor mafic and felsic metavolcanic rocks, greenstone and serpentinite. Mortensen and Jilson (1985) interpreted the greenstone unit as a synformal klippe thrust over the carbonate and chert/metachert units and correlated it with the Slide Mountain terrane. Fossil and isotopic age determinations indicate that these rocks range from latest Devonian to Early Permian age (Mortensen and Jilson, 1985; Mortensen, 1992a)

In the study area (Fig. 3) the Finlayson Lake fault zone is interpreted to be developed in the chert/metachert unit and is truncated by a thrust fault at the base of the greenstone unit (Mortensen and Jilson, 1985, p. 807). Regional correlation of the chert/metachert unit is unclear. Correlations with Devonian-Mississippian North American stratigraphy, mid-Paleozoic units of the Yukon-Tanana terrane (e.g. Mortensen, 1992a) and cherts in the Late Devonian to Late Triassic Slide Mountain terrane have been suggested (Mortensen, pers. comm., 1994).

MAP UNITS

Five main map units are identified and named on the basis of the dominant rock type in each unit (Fig. 2):

1) chloritic phyllite and schist
2) metachert and slate
3) tan to yellow weathering metachert and maroon siliceous and argillaceous metasiltstone
4) greenstone
5) serpentinite

Unit 4 structurally overlies units 1 and 3 in thrust contact. Steep faults, one of which is interpreted to be a normal fault, are inferred to bound unit 2. Serpentinite is exposed as small slivers in unit 4, along the faulted contact between units 3 and 4 and is structurally interleaved with rocks in unit 2. Due to its varied mode of occurrence, it is described separately below although it rarely forms bodies large enough to be considered a unit at the scale of mapping.

Chloritic phyllite and schist (Unit 1)

This unit is composed of chloritic phyllite and schist interfoliated with muscovite-quartz-chlorite phyllite, black carbonaceous slate and minor grey, white and tan metachert. This unit is equivalent to the Yukon-Tanana terrane of Mortensen (1992a) and to the middle unit of the "layered metamorphic suite" of Mortensen and Jilson (1985).

Green chloritic phyllite to schist is well foliated, very fine- to fine-grained, weathers rusty brown, tan or brownish green. Foliation is defined by chlorite and locally by actinolite or flattened, 1-2 mm long quartz grains and calcite blebs (amygdules). The protolith for the chloritic phyllite and schist is interpreted to be a mafic metavolcanic rock.

Tan, orange-pink and pale green weathering muscovite-quartz-chlorite phyllite is very fine- to fine-grained and fissile. Foliation is defined by muscovite and chlorite. The protolith for the phyllite is probably a felsic metavolcanic rock.

Carbonaceous, grey to black slate is exposed locally, interfoliated on the metre-scale with chloritic phyllite and schist. The slate is blue-grey to grey weathering, fissile and pyrite-bearing. In the southern part of the map area, it is interfoliated on the scale of metres with minor, fine grained, quartz-feldspar-biotite semipelitic schist. In the northwestern part of the map area, it forms a sequence at least 700 metres thick, structurally underlying chloritic schist.

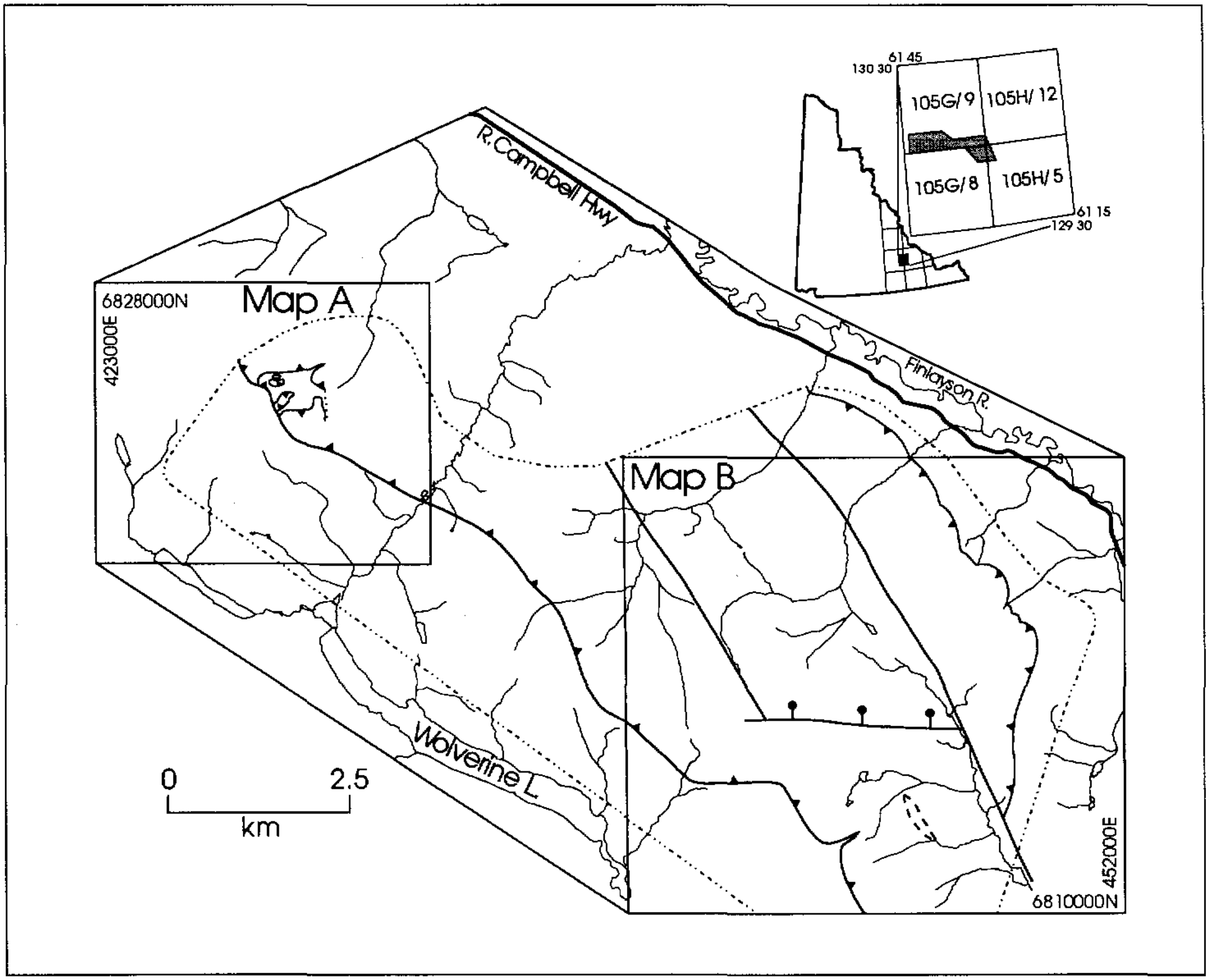


Figure 3: Location map showing area of the Campbell Range mapped in this study (maps A and B). The regional faults are modified from Mortensen and Jilson (1985).

Primary laminations and thin beds are preserved locally but show evidence of foliation-parallel transposition such as isoclinal intrafolial folds. Quartz veins and veinlets commonly cut the slatey cleavage.

Metachert is very fine grained, grey, greenish grey, white and tan coloured on fresh and weathered surfaces. Millimetre-scale colour banding parallel to the foliation is common. Foliation surfaces have thin carbonaceous or micaceous coatings. At one outcrop, thinly bedded, grey metachert is rhythmically interbedded with muscovite-chlorite phyllitic schist. Grey, siliceous, very fine grained metasiltstone is typically interfoliated at centimetre-scale with carbonaceous slate and metachert.

Metachert and Slate (Unit 2)

This unit consists predominantly of grey, white and black laminated metachert, grey siliceous metasiltstone and rusty brown to grey weathering, grey to black carbonaceous slate, all interlayered on the centimetre- to metre-scale. Foliation is parallel to compositional layering. These rocks are structurally interleaved with serpentinite, hornblende-plagioclase and plagioclase-potassium feldspar porphyry, quartz-eye muscovite-chlorite phyllitic schist, chloritic schist and minor grey, calcareous metacarbonate. This unit was included as part of the chert/metachert unit of the Campbell Range belt by Mortensen and Jilson (1985).

Metachert is a very fine grained, rusty brown, blackish grey, light grey and white weathering, massive to fissile, well-jointed rock, commonly cut by quartz veins. White, grey and black millimetre-scale laminations, varying from lenticular to planar are common and give the metachert a "ribboned" appearance. Metachert, rhythmically interbedded on the centimetre-scale with metasiltstone, was observed at one outcrop. Foliation surfaces have a graphitic sheen and graphitic argillaceous partings are parallel to the foliation surfaces.

Grey to black, carbonaceous slate and siliceous metasiltstone are interfoliated on the centimetre- to metre-scale with metachert. Quartz veins, veinlets and lenses are parallel to and cut the slatey cleavage. Overall, slate and metachert are present in equal proportions and make up about 95% of the unit.

Quartz-eye muscovite-chlorite phyllitic schist, chloritic schist, calcareous metacarbonate, serpentinite, hornblende-plagioclase porphyry and plagioclase-potassium feldspar porphyry are minor components in unit 2 accounting for about 5 % of the unit. Calcareous metacarbonate, observed at two outcrops, is grey to tan weathering, fine grained and locally contains 1 to 2 cm thick lenses of fine grained, serpentine-rich rock. Primary structures are not preserved. Quartz-eye phyllitic schist is well foliated, contains moderately well sorted, elliptical, 2 to 5 mm long, bluish grey quartz grains and minor plagioclase grains. The protolith for the phyllitic schist is interpreted to be a felsic metavolcanic rock. Chloritic schist is fine grained, grey-green and well foliated. Fuchsite porphyroblasts were observed at one outcrop. The protolith for the schist is interpreted to be a mafic volcanic flow or tuff.

Massive hornblende-plagioclase and plagioclase-potassium feldspar porphyry is juxtaposed against carbonaceous slate or quartz-muscovite phyllite by faults that are parallel or sub-parallel to foliation. An intrusive contact between porphyry and metachert was observed at one location. The porphyries contain euhedral to subhedral hornblende, plagioclase and K-feldspar phenocrysts set in a very fine grained matrix of quartz and feldspar.

Tan to yellow weathering metachert and maroon siliceous and argillaceous metasiltstone (Unit 3)

This unit is exposed along the eastern edge of the study area and was included as part of the chert/metachert unit of the Campbell Range belt by Mortensen and Jilson (1985). It is structurally overlain in thrust contact by greenstone of unit 4. The thrust fault is locally marked by green to black, fish-scale serpentinite (Unit 5).

Unit 3 is composed of rusty brown, yellow, tan and maroon weathering, tan, grey, pale green and maroon, ribbon metachert rhythmically interbedded on centimetre- to metre-scale with grey, tan and maroon metasiltstone. Metachert layers, 1 to 10 cm thick, vary from planar to lenticular and are parallel or subparallel to the foliation in the metasiltstone. Minor, grey to tan weathering, fine grained, sandy, chert breccia is exposed in isolated outcrops.

Greenstone (Unit 4)

This unit comprises massive to moderately foliated greenstone, greenstone fragmental rock, heterolithic breccias, maroon metasiltstone and minor metachert, gabbro and metagreywacke. Generally, contacts are not exposed.

The tan, rusty brown or green weathering, massive to moderately foliated, well jointed greenstone is aphanitic to very fine grained and typically aphyric, although augite and plagioclase microphenocrysts and amygdules occur in some samples. Quartz,

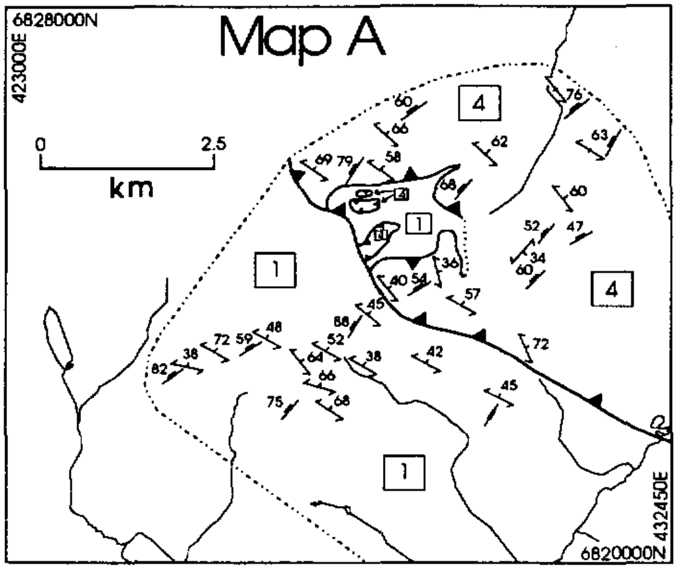


Figure 4: Geology of map area A.

quartz-calcite, quartz-epidote and epidote veins and veinlets in greenstone are common. Locally, joints are filled by quartz crystals oriented normal to the joint walls.

The greenstone fragmental rock consists of coarse sand- to boulder-sized, rounded to angular fragments of greenstone set in a well-foliated, chlorite-rich matrix that wraps around, or is truncated by, the fragments. Amygdules and cuspate shards of altered volcanic glass are common in the matrix and pillow fragments with selvages are observed locally, indicating that the rock had a pyroclastic origin (Fig. 6).

Hematitic, heterolithic breccia is exposed in the eastern part of the map area. Poorly sorted angular clasts, 1 mm to 6 cm long, of greenstone, green or maroon metachert and maroon metasiltstone are set in a matrix of greenstone or maroon metasiltstone. The breccia is cut by irregular hematite-rich or epidote-rich veins which themselves are brecciated. Metasiltstone clasts are irregularly shaped and plastically deformed around other clasts suggesting soft sediment deformation. Planar fabrics are absent in this rock type. The patchy occurrence of the breccia, its gradation into massive

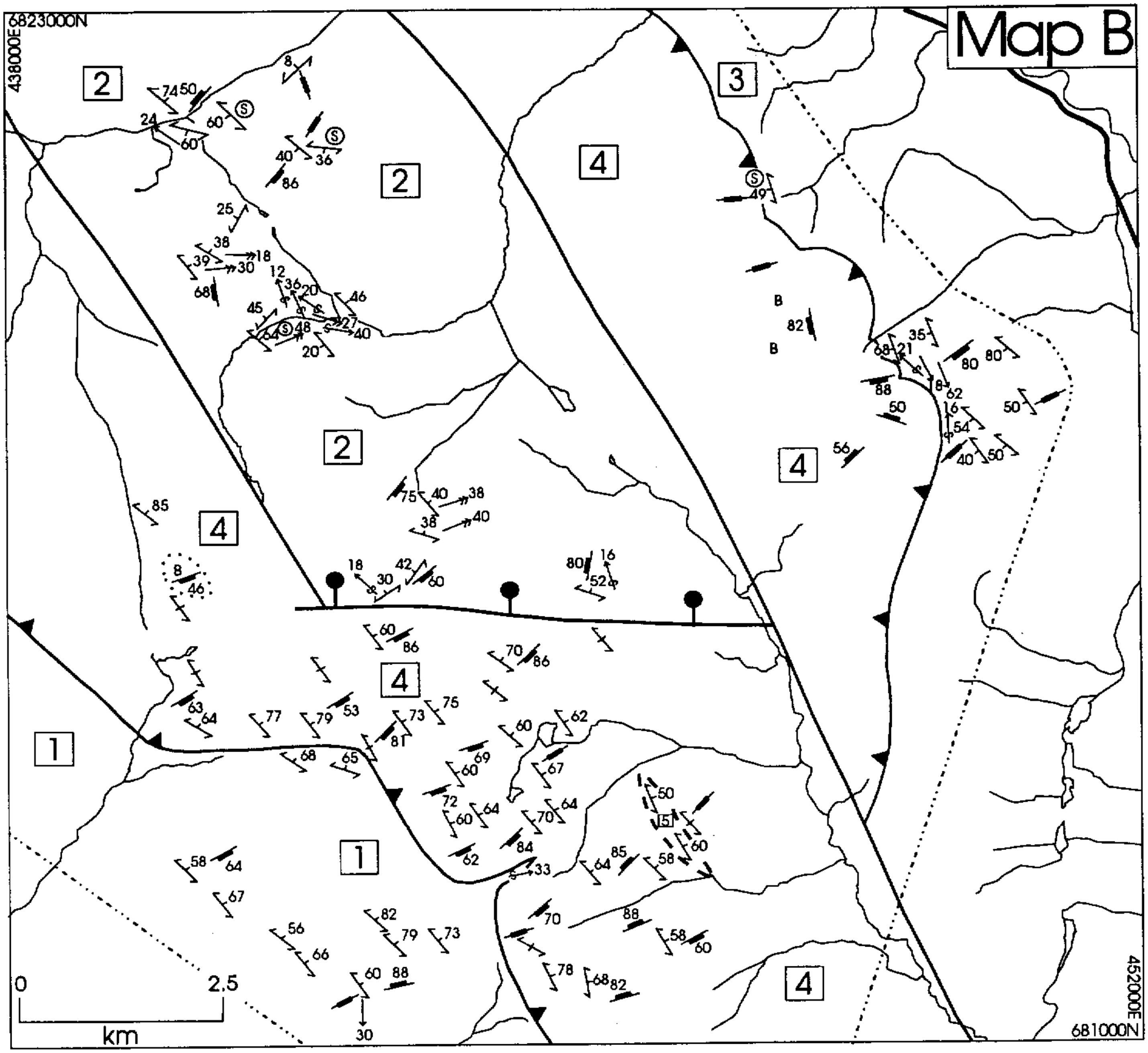


Figure 5: Geology of map area B. Circled "S" denotes areas where submap-scale bodies of serpentinite are exposed. "B" denotes exposures of heterolithic and metavolcanic-plutonic breccia in the greenstone unit.

greenstone and the lack of a spatial association with known faults suggests that the breccia is of depositional rather than tectonic origin.

In the western part of the map area, blocky weathering, metavolcanic-plutonic breccia is exposed on an isolated mountain over an area of approximately 0.5 km^2. The breccia is composed of 1 mm to 3 cm, angular clasts of grey-green metabasalt and minor, rounded to subrounded metagabbro and metadiorite set in a matrix of epidote-plagioclase-hematite-rich rock and smaller metabasalt clasts (Fig. 7).

Metagreywacke, maroon metasiltstone, metachert and metagabbro are exposed locally in the greenstone unit. Fine- to coarse-grained metagreywacke contains angular, coarse silt- to coarse sand-sized clasts of grey chert, quartz, feldspar, black slate and rare fine grained basaltic rock. The metagreywacke is interfoliated on the scale of a metre to several tens of metres with greenstone and with minor, <1 m thick layers of black carbonaceous slate.

Maroon metasiltstone occurs locally as angular clasts in greenstone, greenstone fragmental rock and heterolithic breccia. Lithologically, the maroon metasiltstone is indistinguishable from that in unit 3. In the eastern part of the map area, it forms minor rubbly isolated outcrops or is rhythmically interbedded with maroon metachert. At one outcrop, maroon metachert contains recrystallized radiolaria. Very fine grained, white, grey, green and tan, massive or finely laminated metachert is commonly found in talus and locally as outcrop. Medium grained, clinopyroxene-bearing, metagabbro forms small intrusive bodies in the greenstone unit and a 2 m thick sill in metagreywacke. Exposed contacts are uncommon.

Figure 6a: Greenstone fragmental rock of unit 4 viewed on a horizontal weathered surface. Massive greenstone fragments weather up relative to the well foliated matrix. Foliation is sub-vertical and dips into the plane of the photograph.

Figure 6b: Relict pillows in the greenstone fragmental rock. Note well-developed selvage (arrows). Coarse graduations on scale bare are 1 cm.

Serpentinite (Unit 5)

Green to black, magnetic, lizardite-rich serpentinite varies from very fine grained, massive, sugary textured rock to well foliated, fish-scale serpentinite. Locally it contains minor lenses of grey, calcareous metacarbonate rock and maroon metasiltstone. Late, cross-fibre serpentine veins cut the foliation. In thin section, serpentine exhibits mesh and bladed-mat textures (cf. Maltman, 1978) with minor relict pyroxene and olivine. Magnetite porphyroblasts overprint serpentine and relict minerals.

STRUCTURAL GEOLOGY

Mesoscopic, planar, penetrative fabric elements consist of bedding, cleavage and joints. Thin, planar or lenticular beds are observed mainly in metachert interbedded with metasiltstone in units 3 and 4. The metasiltstone beds exhibit a well developed cleavage that is parallel or subparallel to bedding. Transposed sandy laminations and thin beds are preserved in slate in the southern part of the map area.

Planar cleavage and schistosity is well-developed in phyllite and schist of unit 1. Foliation is defined mainly by chlorite and muscovite and locally by biotite, actinolite or flattened quartz grains and amygdules. Cleavage is sporadically developed in greenstone. It is evident as a planar parting emphasized locally by epidote- and quartz-rich veins. Clasts in greenstone fragmental rock are typically flattened in the plane of the foliation.

Planar to subplanar, steeply dipping to vertical, generally northeast-striking joints are common in greenstone and metacherts. Quartz- and epidote-rich veins intrude along joint surfaces.

Figure 7: Heterolithic breccia exposed in western part of study area (Map B). Angular fragments consist of metabasalt and minor metagabbro set in a matrix of smaller fragments which in turn, are set in a matrix rich in epidote, feldspar and hematite. Scale bar is 8.5 cm long.

Figure 8: Looking southeast at northwest-striking, moderate northeast-dipping shear bands deflect northwest-striking, steeply northeast-dipping cleavage in chloritic schist of unit 1 in a dextral (top-to-the-southwest) shear sense.

Macroscopic structures consist of (a) thrust faults at the base of the greenstone unit, (b) inferred steeply dipping, northwest- and east-striking faults that bound the metachert and slate unit (unit 2) and (c) north-northwest-trending, northerly plunging folds in unit 2. The north-northwest-trending folds and most outcrop-scale faults are observed only in unit 2. The relative timing of the thrust and steep faults is unknown. However, mapped trends of the eastern thrust fault and topography suggest that the thrust fault is truncated by the eastern, northwest-striking, steep fault and that the normal fault along the southern boundary of unit 2 truncates the western, northwest-striking fault (Fig. 3, 5).

Thrust Faults

A thrust fault is interpreted to separate the chloritic phyllite and schist unit from greenstone along the western margin of the map area. The fault is not exposed, but it is inferred on the basis of outcrop patterns, which are best accounted for by a gently northeast-dipping thrust fault. Outcrop patterns in map area A suggest that more than one thrust sheet of greenstone overlies unit 1 (Fig. 4). Outcrop-scale, northeast-dipping thrust faults and shear bands which deflect cleavage in a sinistral (top-to-the-southwest) shear sense in chloritic schist and greenstone, support the interpretation that unit 4 is thrust towards the southwest over unit 1 (Fig. 8).

Along the western margin of the map area, greenstone is thrust towards the east-northeast, over tan weathering metachert and maroon metasiltstone (unit 3) along a west-southwest-dipping thrust fault. The fault is well constrained by outcrop although it is not exposed. Several kinematic indicators in unit 3 support the thrust fault interpretation: Down-dip rodding on west-dipping foliation surfaces in siliceous metasiltstone overprints an earlier, strike-parallel crenulation lineation. In vertical sections that have strikes parallel to the rodding, lensitic metachert beds exhibit asymmetry or

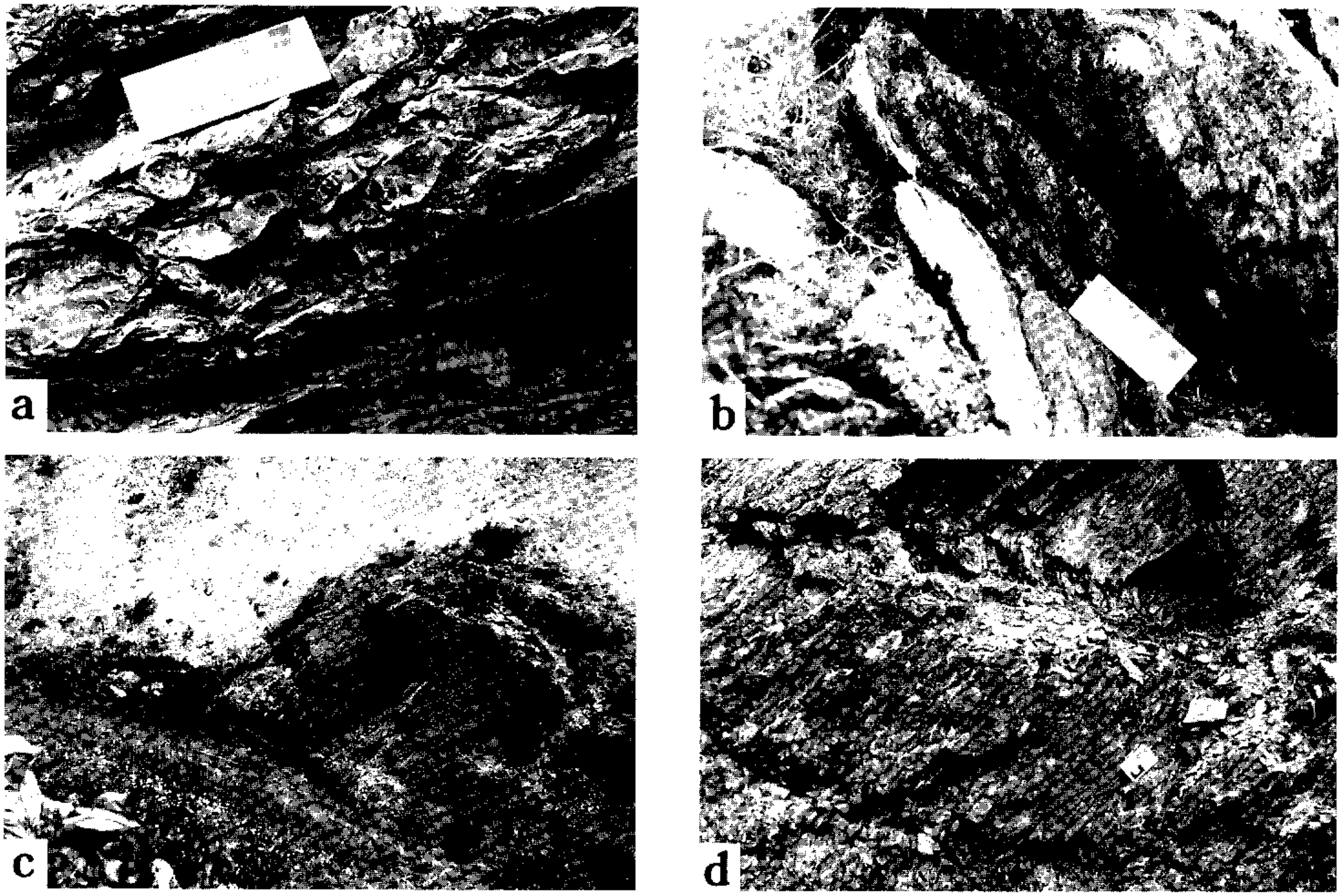


Figure 9: (a) Lensitic beds in tan-weathering metachert of unit 3 viewed along a steep, northeast-striking surface indicate a dextral (top-to-the-northeast) shear sense. Outcrop is approximately 250 m (perpendicular to the foliation) below the regional, easternmost thrust fault. (b) Moderately southwest-dipping shear bands deflect the more steeply dipping foliation in serpentinite exposed along the regional, eastern thrust fault (see Fig. 5). The shear bands record dextral (top-to-the-northeast) shear sense. View looking southeast at true dip of the foliation. Coarse graduations on scale bar are 1 cm. (c) Overview looking north at mesoscopic, low-angle, northwest-striking, northeast-dipping thrust faults in unit 3 approximately 260 metres (perpendicular to foliation) below the regional thrust fault. d) Close-up showing that foliation (parallel or subparallel bedding) is folded and offset across the faults recording top-to-the-southwest displacement. These faults are interpreted as back thrusts associated with the regional, top-to-the-northeast thrust fault. Field book is 18 cm long.

imbrication that records dextral (top-to-the-northeast) sense of shear (Fig. 9a). Mesoscopic, east-northeast-verging, gently north-plunging folds are developed in the foliation in the metachert. Exposures of fold hinges is uncommon. Rather, folds are recorded by local angular relationships between bedding and cleavage. Dextral shear bands are developed in serpentinite exposed along the trace of the fault (Fig. 9b).

Minor, outcrop-scale, moderately east-dipping thrust faults, fold and offset the foliation in unit 3 in a sinistral (top-to-the-west) shear sense. These are interpreted to be back thrusts associated with the regional, top-to-the-east-northeast thrust fault (Fig. 9c, d).

Steep faults

Northwest-striking faults are inferred to bound the unit 2. The east-striking fault that forms the southern contact is interpreted to be a normal fault because normal faults of similar orientation are common in the region (e.g. Tempelman-Kluit, 1979; Mortensen, 1992a) and because small scale normal faults and shear bands with similar orientations are exposed locally in unit 2. The kinematics of the inferred northwest-striking faults are unknown. The western fault is interpreted to be a steep fault because a narrow, steep valley is developed along its northern trace. The trace of the eastern fault coincides with a broad, swamp-filled valley. Its dip is unknown.

Regional north-northwest-trending folds and other structures

Moderately east-southeast-plunging, upright, gentle folds to tight crenulations deform the cleavage in slate in unit 2. Quartz rodding in metachert and in foliation-parallel quartz veins in slate have a similar orientation and may have developed synchronously with the east-southeast-plunging folds.

Foliation parallel or sub-parallel, northwest-striking, northeast-dipping faults truncate the east-southeast-plunging folds and juxtapose massive hornblende-plagioclase porphyry, serpentinite, slate and metachert. At one outcrop, massive serpentinite becomes strongly foliated towards the unexposed contact with slate suggesting a faulted contact. Kinematic indicators are lacking for these faults.

North-northwest-trending, shallowly to moderately northerly plunging, commonly upright to steeply inclined folds, deform the foliation on the outcrop and regional scale. The timing of folding about north-northwest-trending axes relative to faults and east-southeast-trending folds is unclear. Steeply northeast-dipping, small scale normal faults and normal shear bands locally offset the foliation (north side down) in unit 2.

METAMORPHISM

Preliminary petrography indicates that metamorphic grade increases from prehnite-pumpellyite facies in the east to greenschist facies in the west. Porphyroblasts of epidote and actinolite are widespread in greenschist facies rocks. Stilpnomelane porphyroblasts are developed locally. Preliminary pressure and temperature estimates, based on mineral assemblages, are 350 to 400°C and 4 to 5 kbar for greenschist facies rocks.

DISCUSSION

The presence of serpentinite, minor pillow fragments and metachert in the greenstone unit indicate a submarine depositional environment. Terrigenous metagreywacke and slate layers in greenstone, some containing volcanic clasts, suggest contemporaneous sedimentation and volcanism (cf. Nelson, 1993). The greenstone unit is lithologically similar to the upper division of the Slide Mountain terrane in east-central British Columbia, where massive to pillowed basalt, volcanic breccia, and minor argillite, chert and gabbro are reported (Ferri and Melville, 1988). The greenstone unit is similar also to Division II of the Sylvester Allochthon in the Slide Mountain terrane, north-central British Columbia. Division II consists of structurally interleaved aphyric basalt, serpentinite, gabbro, breccia and siliclastic and argillaceous sedimentary rocks (Nelson, 1993; Nelson and Bradford, 1988). Accordingly, units 4 and 5 are correlated with the Slide Mountain terrane.

Lithologically, unit 2 is similar to Division I of the Sylvester Allochthon in that it consists predominately of black carbonaceous slate, siliceous metasiltstone and metachert with argillaceous partings. However, calc-arenite and radiolarian-bearing metachert have not been observed in unit 2 (cf. Nelson, 1993). A preliminary correlation of unit 2 with the Slide Mountain terrane is proposed here. More field data are required to test the validity of this correlation. Unit 1 has broad lithologic similarities with the Yukon-Tanana terrane, although metaplutonic rocks have not been observed (cf. Mortensen, 1992b, p. 838) and no correlation is made here.

Greenstone is thrust towards the southwest over unit 1 in the western part of the map area along a northwest-striking, gently northeast-dipping thrust fault. Outcrop patterns suggest that more than one thrust sheet of greenstone is present. In the eastern part of the map area, greenstone is thrust towards the northeast over unit 3 along a northwest-striking, moderately southwest-dipping thrust fault. Maroon metasiltstone, metachert and heterolithic breccia are most abundant in the greenstone unit towards the eastern part of the map area. Field data do not support the grouping of units 2 and 3 into the same unit as proposed by Mortensen and Jilson (1985). The maroon metasiltstone in unit 3 is lithologically indistinguishable from that in the overlying greenstone unit suggesting that the eastern thrust fault juxtaposes parts of the same depositional sequence. Therefore, unit 3 is interpreted to be a sedimentary facies of the greenstone unit. It may be correlative with the upper stratigraphy of the Slide Mountain terrane which is reported to be dominated by siliceous argillite and chert in the Sylvester allochthon (Nelson 1993).

Unit 2 is inferred to be bounded to the east and west by northwest-striking, steeply dipping faults and to the south, by a east-striking normal (north-side down) fault. The northern boundary of unit 2 is unconstrained. The northwest-striking faults are poorly exposed and their kinematics have yet to be determined. However if they are steeply dipping, their northwest-trends suggest that they are probably strike-slip faults.

Field data indicate that the Finlayson Lake fault zone is composed of northwest-striking thrust faults with hanging wall displacements to the southwest and northeast and of poorly exposed, northwest-striking, strike-slip(?) faults. The kinematics of the thrust faults do not support their interpretation as a single, synformally folded thrust fault (cf. Mortensen and Jilson, 1985). The structures in the Finlayson Lake fault zone are consistent with that documented in transpressive zones, i.e. diverging thrust faults and parallel or subparallel strike-slip faults (e.g. Gates, 1987; Sylvester and Smith, 1976). However, thrust and strike-slip faults are largely synchronous in transpressive zones. Excluding map and topographical patterns which suggest that the eastern thrust fault is truncated by the eastern steep fault in the Campbell Range, the relative timing of fault development in the Finlayson Lake fault zone is unknown.

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GEOLOGY AND MINERAL OCCURRENCES OF SEATTLE CREEK MAP AREA (115P/16), WESTERN SELWYN BASIN, YUKON

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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 Division, Yukon, Indian and Northern Affairs Canada, p. 59–71.

Abstract

New mapping in Seattle Creek map area in the northeastern corner of McQuesten map area completes an east-west transect of regional geological coverage from Clear Creek to Keno Hill. Seattle Creek map area is underlain by clastic metasedimentary rocks of the Late Proterozoic to Cambrian Hyland Group and structurally underlying Keno Hill quartzite (Mississippian). Volumetrically minor marble and deformed intermediate to mafic dykes of unknown age occur throughout the Hyland Group, deformed mafic rocks of possible mid-Triassic age intrude Keno Hill quartzite, and undeformed Cretaceous felsic stocks intrude Hyland Group rocks in the south-central part of the map area.

Hyland Group rocks in the northern third of the area lie on the southwest-overturned limb of the Lost Horses syncline, comprising relatively weakly strained argillite, metasandstone, metaconglomerate, and marble of the Yusezyu Formation and maroon and green argillite, marble, and metasandstone of the Narchilla Formation. In contrast, highly strained gritty phyllitic psammite and phyllite of the Yusezyu Formation in the southern half of the map area is part of a broad belt here termed the Tombstone Strain Zone. In this area the gently northerly dipping northern (upper) boundary of the Tombstone Strain Zone is a narrow strain transition which coincides with a trend of aeromagnetic highs. The Tombstone Strain Zone is the exposed deeper part of the hanging wall of the Tombstone Thrust, and includes the footwall and much of the hanging wall of the older, structurally overlying Robert Service Thrust.

A variety of types of mineral occurrences is found in the area including skarns, veins, breccias and alteration zones spatially associated with felsic stocks and Keno Hill-type vein-faults. Notable new results include the recognition of gold mineralization on the OLIVER occurrence in southeastern Sprague Creek map area, the discovery of an area of gold-bearing quartz-arsenopyrite veins between Highet and Bennett creeks in the southeastern part of Seattle Creek map area, documentation of gold- and arsenic-mineralized quartz veins in a satellite of the Scheelite Dome stock, and the identification of an area of hornfels and tourmaline alteration along the north boundary of the map area associated with a previously undocumented intrusion in southern Larsen Creek map area.

INTRODUCTION

Seattle Creek map area is the easternmost of three contiguous 1:50 000 scale map areas in western Selwyn Basin selected for investigation during the term of the 1991-1996 Canada/Yukon Economic Development Agreement (Fig. 1). Clear Creek area (115P/14) was mapped during 1992 (Murphy et al., 1993a, b); Sprague Creek (115P/15) was mapped during 1993 (Murphy and Héon, 1994a,b). This report describes the geology of the Seattle Creek area mapped during 1994 and accompanies Murphy and Héon (1995), a 1:50 000 scale open-file map. The new geological coverage of Seattle Creek map area completes an east-west transect of 1:50 000 scale mapping from Clear Creek to Keno Hill in northern Mayo map area (Murphy and Roots, 1992; Roots and Murphy, 1992a; Hunt et al., 1993; Murphy et al., 1993a,b; Murphy and Héon, 1994a,b).

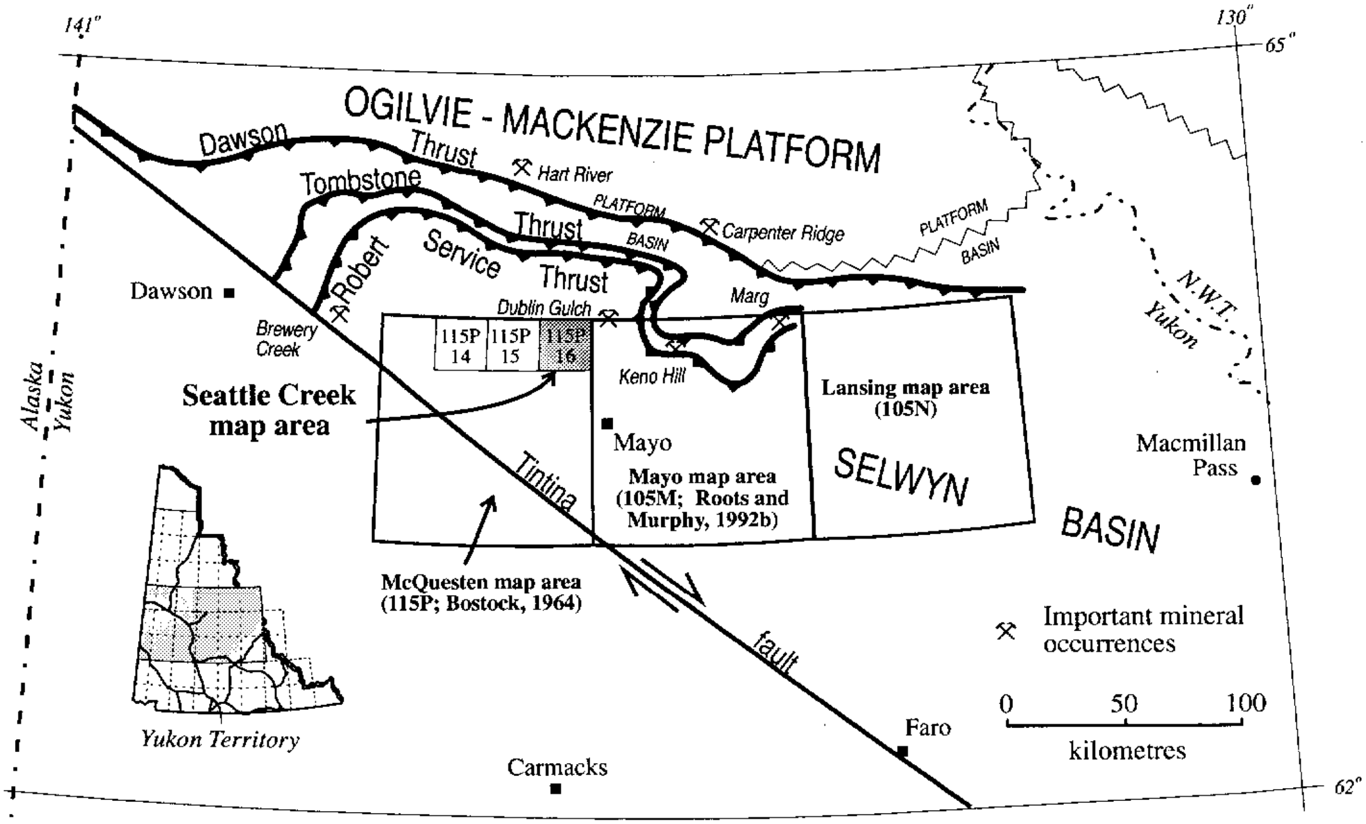

Figure 1: Location of Seattle Creek map area with respect to regional geographic and geological features and important mineral occurrences.

Seattle Creek map area is located about 30 km west of Elsa and 35 km north-northwest of Mayo (Fig. 1). Much of the area is accessible by a network of placer mining roads. Access from the south is via the Highet Creek placer road with branches leading into Morrison, Sabbath and Johnson creeks. The South McQuesten River valley, Goodman, Rodin, and Red creeks are accessible from the Haggart Creek placer mining road. Areas remote from roads were reached by helicopter based in Mayo (about a 0.4 hr flight).

Physiographically, the area lies within the Stewart Plateau (Matthews, 1986) which is generally characterized by elevations ranging from under 2000' (610 m) to under 6000' (1830 m), moderate local relief, and few areas above treeline. Most of Seattle Creek map area is under 4000' (1220 m) in elevation and bedrock is generally poorly exposed. Rock exposure is best in the southern part of the area around Scheelite Dome (Fig. 2) and in the northernmost part of the area north of Red Creek. Elsewhere outcrops are few and discontinuous except along some ridgetops. Felsenmeer is common on ridgetops above treeline.

Mineral exploration and development has occurred in the area since the 1800s. Placer gold has been mined in Highet and Johnson creeks since the late 1800s. The area has been actively explored for lode occurrences, including Keno Hill-type silver-lead mineralization since the 1920s and tin and tungsten mineralization in the 1970's and 1980's. Most recently, many of the granitic intrusions have been the focus of exploration for low-grade, bulk tonnage gold deposits like Fort Knox near Fairbanks, Alaska (e.g. Hollister, 1991).

Previous Work

Seattle Creek area was first examined by Bostock (1964) during systematic reconnaissance mapping of the McQuesten map area (1:250 000-scale; Fig. 1) in the late 1940's. Early re-interpretations of the geology of this area are presented in Tempelman-Kluit (1970) and Green (1971). A more recent interpretation is shown by Wheeler and McFeely (1991). Topical studies of parts of the area include Steffler (1980) and Kuran et al. (1982) on the geology and geochronometry of the Scheelite Dome mineral occurrences; Emond (1985, 1986), Potter (1987), and Emond and Lynch (1992) on various aspects of vein, breccia, and skarn occurrences in the McQuesten River region; and Emond (1992) on the igneous geochemistry and petrography of felsic intrusions in McQuesten River map area and the relationship of igneous geochemistry to mineralization. Many mineral assessment reports include geological observations, some of which are summarized in Yukon Minfile (INAC, 1993) and Yukon Exploration (e.g. INAC, 1989; 115P), periodically updated publications by Exploration and Geological Services, Yukon, Indian and Northern Affairs Canada.

Regional Geological Framework

Rocks of Seattle Creek map area are part of the Selwyn Basin tectonic element (Fig. 1), a locus of Late Proterozoic to Middle Paleozoic basinal clastic sedimentation which lay between coeval inner miogeoclinal sedimentary rocks of the Mackenzie - Ogilvie Platform to the north and east, and the Cassiar Platform to the south and west (Abbott et al., 1991 and references therein). Selwyn Basin and associated sub-basins (Misty Creek and Meilleur River embayments and Kechika Trough) are thought to have been formed by intermittent attenuation and rifting of transitional continental crust at or near the western margin of North America (Abbott et al., 1991 and references therein).

Selwyn Basin rocks are imbricated by the Jura-Cretaceous Dawson, Tombstone, and Robert Service thrusts (Tempelman-Kluit, 1970; Abbott, 1990 and references therein; Mortensen and Thompson, 1990; Fig. 1). Underlying and defining one of the largest thrust sheets in the Canadian Cordillera, the Robert Service Thrust extends eastward from the southern Ogilvie Mountains east of Dawson to the Keno Hill mining camp and beyond into Lansing map area. The Robert Service Thrust typically places Upper Proterozoic Hyland Group over Mississippian Keno Hill quartzite and carries the bulk of Selwyn Basin rocks in its hanging wall, including those of Seattle Creek map area. The underlying Tombstone thrust sheet comprises Upper Devonian Earn Group, Mississippian Keno Hill quartzite, mafic intrusions, some of which are known to be Triassic (Mortensen and Thompson, 1990), and, locally, Upper Paleozoic and Mesozoic clastic rocks (Abbott, 1990 and references therein). These rocks are juxtaposed across the Tombstone Thrust against an immediate footwall ranging in age from Devonian(?) to Late Jurassic (Poulton and Tempelman-Kluit, 1982; Abbott, 1990 and references therein). An intense strain zone, herein referred as the Tombstone Strain Zone, affects much of the Tombstone thrust sheet, extending upward well into the Robert Service thrust sheet, including rocks in the structurally deeper parts of Seattle Creek map area.

GEOLOGY OF SEATTLE CREEK MAP AREA

Seattle Creek map area (Fig. 2) is underlain primarily by variably deformed and metamorphosed low-grade metasedimentary rocks of the Upper Proterozoic Hyland Group and Mississippian Keno Hill quartzite. Volumetrically minor intermediate to mafic bodies intruded Hyland Group and Keno Hill quartzite before regional deformation. The age of pre-kinematic intrusions into Hyland Group is not known; mafic intrusions into Keno Hill quartzite are correlated with mid-Triassic intrusions described by Mortensen and Thompson (1990). All of the regionally deformed and metamorphosed rocks in the area are intruded and hornfelsed by unfoliated felsic rocks that range in composition from granite to granodiorite to quartz monzonite (Bostock, 1964; Emond, 1992).

Hyland Group

Most of Seattle Creek map area is underlain by rocks of the Upper Proterozoic to Lower Cambrian Hyland Group (Fig. 2). Where defined in Nahanni map area (Gordey and Anderson, 1993), the Hyland Group consists of the older Yusezyu Formation (predominantly sandstone, pebbly sandstone and shale) and the younger Narchilla Formation (includes maroon and green argillite). Approximately 80% of Seattle Creek map area is underlain by Yusezyu Formation at various degrees of deformation; the Narchilla Formation underlies a small region in the northwestern part of the area.

Hyland Group rocks in Seattle Creek map area are in the lower greenschist facies of regional metamorphism, generally containing fine grained muscovite and chlorite. Near felsic intrusions, Hyland Group pelitic rocks may contain porphyroblasts of biotite, andalusite, sillimanite, cordierite, staurolite and chloritoid and are locally converted to cherty grey to maroon hornfels. Rocks of calc-silicate composition are contact metamorphosed to massive or banded quartz-actinolite-epidote-diopside (±garnet, axinite) calc-silicate hornfels or skarn.

The degree of strain of Hyland Group rocks varies throughout Seattle Creek map area. Rocks in the northern part of the map area lie above and outside the Tombstone Strain Zone (Figs. 2 and 3, see below); at this structural level original bedding is well preserved, bearing only the relatively weak axial-surface foliation associated with regional-scale southwest-overturned folds. In the southern two-thirds of the area, south of the upper transitional boundary of the Tombstone Strain Zone, rocks of the Yusezyu Formation are strained to the extent that original rectilinear bedding is deformed into intensely foliated, lineated and folded shear-bounded sigmoidal compositional domains.

Yusezyu Formation

In the northern part of the map area, outside the Tombstone Strain Zone, the Yusezyu Formation comprises green-grey to grey phyllite and metasiltstone, medium- to coarse-grained metasandstone and pebbly metasandstone, metaconglomerate, and sandy marble. Abundant graded bedding and channel scours indicate that the section is overturned to the southwest. The top of the Yusezyu Formation in Seattle Creek map area is marked by relatively continuous grey sandy marble units on the order of a few metres thick. In its type locality in Nahanni map area, the top of the Yusezyu Formation is also marked by a prominent limestone member (Gordey and Anderson, 1993).

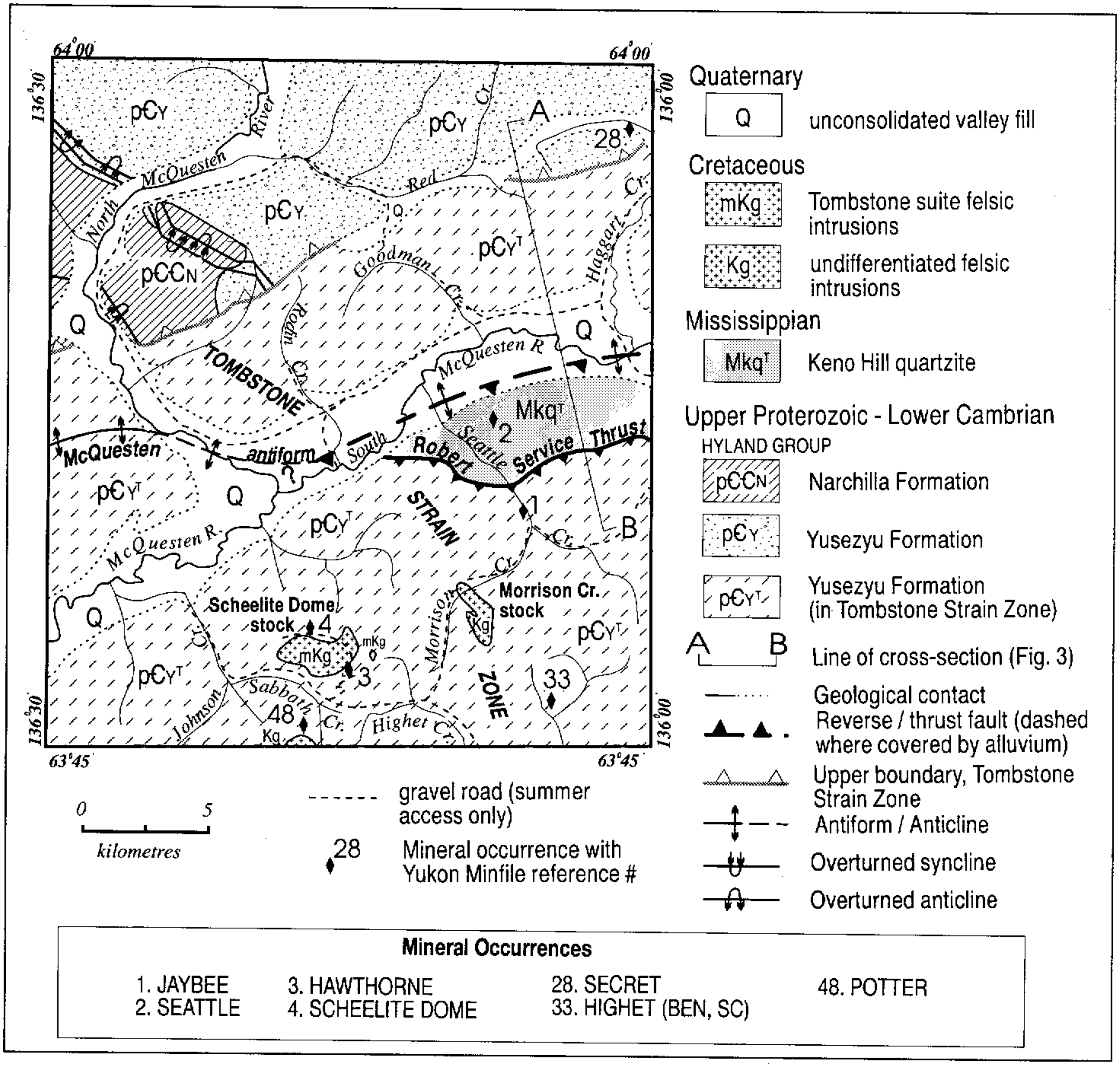

Figure 2: Geological map of Seattle Creek map area. Unit designation symbols with a superscripted 'T' are used to designate rock units that have been deformed in the Tombstone Strain Zone. All rocks in Seattle Creek map area south of the light grey line ornamented with open triangles lie within the Tombstone Strain Zone.

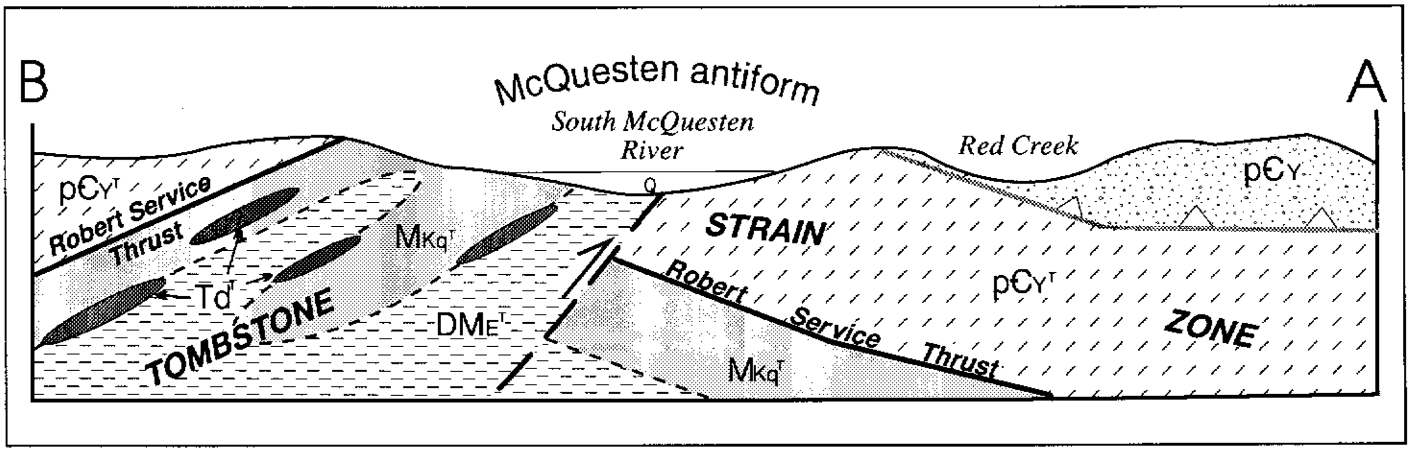

Figure 3: Diagrammatic cross-section of eastern part of Seattle Creek map area, along line of section shown in Figure 2. All of the rocks south of and beneath the light grey line ornamented with open triangles are within the Tombstone Strain Zone; the Tombstone Thrust is inferred to underlie the Earn Group at some unknown depth. The fault in the South McQuesten River valley is inferred to be a late splay off the Tombstone Thrust that juxtaposes deeper levels of the Tombstone Strain Zone (south of the fault) with shallower levels.

In the southern part of the area within the Tombstone Strain Zone, the Yusezyu Formation comprises prominently foliated and lineated quartzofeldspathic and micaceous psammite (metamorphosed sandstone) and muscovite-chlorite (-biotite) phyllite. Less common but locally important are gritty or pebbly psammite (metamorphosed coarse grained or pebbly sandstone), metamorphosed pebble conglomerate, foliated phyllitic or sandy marble, and calc-silicate rocks. Sedimentary structures are rarely preserved in the strain zone in Seattle Creek map area. The amounts of psammite, phyllite, and rocks of carbonate or calc-silicate composition vary throughout the strain zone but the Yusezyu Formation is not subdivided at this scale of mapping. Nevertheless, carbonate rocks are more common in the Yusezyu Formation in the structurally (and stratigraphically(?)) deeper southern part of the map area than further north. This carbonate-rich belt within the Yusezyu Formation continues westward into Sprague Creek and Clear Creek map areas (Murphy et al., 1993b; Murphy and Héon, 1994b).

Narchilla Formation

The Narchilla Formation in Seattle Creek map area consists of medium- to thick-bedded quartzofeldspathic sandstone, green phyllite, maroon phyllite (green where in contact with common centimetre-scale tan siltstone interbeds), and sandy white-, grey-, and tan-weathering marble. The Narchilla Formation is distinguished from the Yusezyu Formation by the occurrence of varicoloured phyllite and a larger proportion of marble. Metre-scale bands of marble occur throughout the Narchilla Formation. A limestone member several tens of metres thick was mapped in Sprague Creek map area to the west; this unit was not observed in Seattle Creek map area but it likely underlies the valley of the North McQuesten River.

Keno Hill quartzite

The Mississippian Keno Hill quartzite occurs south of the South McQuesten River in the east-central part of the map area. The exposures of Keno Hill quartzite in Seattle Creek map area form the western end of the belt of Keno Hill quartzite that extends eastward across Mt. Haldane map area into and beyond the Keno Hill mining camp. The unit is truncated at its western end by the fault in the valley of the South McQuesten River (see below).

The Keno Hill quartzite includes massive to well foliated and lineated, medium to dark grey quartzite and phyllitic quartzite and medium to dark grey, locally carbonaceous phyllite. Folded and planar white quartz veins and pods commonly cut the quartzite giving it a mottled appearance. Light grey to green phyllite reminiscent of Upper Devonian felsic metavolcanic rocks known around the Keno Hill district about 30 km to the east occurs within the Keno Hill quartzite in the Seattle Creek map area; it is not known whether these occurrences are infolds of the underlying Upper Devonian rocks or beds within the Keno Hill quartzite.

Igneous Rocks

Two types of deformed intermediate to mafic igneous rocks occur in Seattle Creek map area, one type intrusive into the Hyland Group and one type into Keno Hill quartzite. Undeformed felsic intrusions occur primarily in the southern part of the map area.

Foliated Intermediate to Mafic Rocks Intrusive into Hyland Group

Rare foliated and folded, intermediate to mafic sills and dykes occur in the Hyland Group. Within the Tombstone Strain Zone, these intrusions become foliation-conformable bodies of foliated and lineated plagioclase-actinolite-biotite-chlorite rock. The age of these bodies is not known.

Triassic Mafic Meta-Igneous Rocks

Lenses of foliated and lineated mafic meta-igneous rocks are abundant within the Keno Hill quartzite. These pods are thought to be pulled apart remnants of once-continuous mid-Triassic mafic sills as exposed in the southern Ogilvie Mountains (Tempelman-Kluit, 1970; Mortensen and Thompson, 1990).

Cretaceous Granitic Rocks

Felsic stocks intrude highly strained Yusezyu Formation rocks in the southern part of Seattle Creek map area (Fig. 2). The largest is the Scheelite Dome stock, a hornblende-bearing quartz monzonite of mid-Cretaceous age (Steffler, 1980; Kuran et al., 1982; Emond, 1992) that has potential for tungsten and gold deposits. Others include a small stock east of the Scheelite Dome stock, a stock of unknown size whose northern end crops out along the southern boundary of the map area, and the Morrison Creek stock.

Two stocks on or near the OLIVER occurrence in the southwestern corner of Sprague Creek map area were visited this year. One, noted on Bostock (1964; and informally referred to as the Boss stock), is a biotite-quartz-feldspar porphyry; the other, noted in Emond (1985, 1992) and outcropping along the McQuesten River is a medium- to coarse-grained potassium feldspar-megacrystic, biotite-muscovite granite. The latter may be an extension of the Boulder Creek stock lying directly across the McQuesten River (Emond, 1985).

No large intrusions have been discovered in the northern part of Seattle Creek map area although the following evidence suggests their presence nearby. A prominent, locally gossanous hornfels and tourmaline alteration zone occurs in the north central part of the map area, extending into the southern part of Larsen Creek map area (see 'Black Hill' occurrence below). Reconnaissance in southern Larsen Creek map area north of the map boundary located the southern boundary of a previously unmapped stock. Small dykes and zones of tourmaline alteration were observed in the northwest corner of the map area, possibly indicating another unmapped stock. A feldspar porphyry dyke found along the northern boundary of the map area, in the northeast corner, is associated with anomalous base metal concentrations.

In general, felsic intrusions and surrounding hornfels zones of northern McQuesten map area (Lost Horses, Red Mountain, and Mahtin stocks, for example) are associated with prominent aeromagnetic anomalies and similar aeromagnetic features may coincide with unmapped intrusions. A belt of aeromagnetic anomalies which crosses the poorly exposed north-central part of Seattle Creek map area possibly indicates the presence of an unexposed intrusion or accompanying hornfels. However, nearby rocks are Hyland Group metasedimentary rocks and show no evidence of thermal metamorphism. The belt of anomalies is spatially coincident with the upper boundary of the Tombstone Strain Zone (see below).

Other than the Scheelite Dome stock (90 ± 3 Ma, K-Ar biotite, Scheffler, 1980; Kuran, 1982), felsic intrusions in Seattle Creek map area and the OLIVER intrusions are undated. The muscovite-bearing intrusion at OLIVER is likely to be Late Cretaceous, the age of other muscovite-bearing intrusions in the region (J. Mortensen, unpublished data). U-Pb dating of intrusions within Seattle Creek map area is in progress.

Structure

The distribution and structural fabrics of rocks in Seattle Creek map area result from pre-Late Cambrian normal faulting, SW-vergent regional deformation of unknown but probable Mesozoic age, and Jura-Cretaceous thrusting and regional deformation. Although Devonian deformation is known from other parts of Selwyn Basin (Abbott et al. 1991 and references therein), it is not known if deformation of this age occurred in Seattle Creek map area.

Pre-Late Cambrian Normal Faulting

Pre-Late Cambrian normal faulting cannot be documented on the basis of observations solely within Seattle Creek map area; however, the Sprague Creek fault, a pre-Late Cambrian normal fault inferred in the adjacent Sprague Creek map area (Murphy and Héon, 1994a,b) is thought to extend into Seattle Creek map area. The Sprague Creek fault is overprinted by the Tombstone Strain Zone (Fig. 2, see below) at the western boundary of the map area and is therefore not visible in Seattle Creek map area as a distinct feature. It may be inferred, however, by the continuation of the Narchilla Formation into Seattle Creek map area from Sprague Creek map area where it is thought to be preserved in the downdropped footwall of the Sprague Creek fault.

Mesozoic Deformation

Structures in Seattle Creek map area thought to be Mesozoic in age are: 1) folds and foliations associated with the Lost Horses syncline, 2) the Robert Service Thrust, 3) the Tombstone Strain Zone and associated structures, 4) warps of foliations associated with the Tombstone Strain Zone including the faulted McQuesten antiform, and 5) brittle shear zones that may be coeval with intrusion of Scheelite Dome stock.

Lost Horses Syncline

The northern part of Seattle Creek map area is underlain by inverted Hyland Group rocks on the northeastern limb of the Lost Horses syncline. The axial surface trace of syncline has been traced west-northwestwardly across the northern part of the McQuesten map area (Murphy et al., 1993a,b; Murphy and Héon, 1994a,b). The syncline plunges to the west-northwest and is overturned and verges to the south-southwest. The axial surface trace of the syncline is overprinted by the younger Tombstone Strain Zone (see below) in Sprague Creek map area to the west. The axial surface traces of second-order folds on the inverted limb of the syncline are cross-cut by the Tombstone Strain Zone in the western part of Seattle Creek map area (Fig. 2). Neither the age of the Lost Horses syncline nor its relationship (if any) to other regional structural features such as the Robert Service or Tombstone thrusts are known. The syncline is post-Devonian, the age of the youngest folded rocks in Clear Creek and Sprague Creek map areas, and older than the cross-cutting Jura-Cretaceous Tombstone Strain Zone. Similar regional-scale features elsewhere in the Canadian Cordillera are thought to be Early Middle Jurassic (Murphy et al., in press).

Robert Service Thrust

The contact between the Hyland Group and Keno Hill quartzite in the east-central part of the map area is the Robert Service Thrust, a regional thrust fault that was first recognized in the southern Ogilvie Mountains east of Dawson where Upper Proterozoic Hyland Group rocks are thrust over Paleozoic and Mesozoic rocks (Tempelman-Kluit, 1970). The thrust has been traced eastward to the northern part of Mayo map area (Tempelman-Kluit, 1970; Green, 1972; Roots and Murphy, 1992a,b). At its western extent, Hyland Group rocks are overthrust onto units as young as Late Jurassic; the thrust itself is cut by granitic intrusions as old as about 94 Ma (J.K. Mortensen and D.C. Murphy, unpublished data), therefore proving a Jura-Cretaceous age. Neither the displacement direction nor its relationship (if any) to other regional structures such as the Lost Horses syncline are known.

Tombstone Strain Zone

The Tombstone Strain Zone is a several kilometre thick shear zone in the hanging wall of the Tombstone thrust, a regional thrust fault that was originally recognized in the southern Ogilvie Mountains where the Mississippian Keno Hill quartzite overlies Upper Jurassic shale and sandstone, and traced eastward to northern Mayo map area (Mortensen and Thompson, 1990; Abbott, 1990; Roots and Murphy, 1992a,b). In northern Mayo and McQuesten map areas, the hanging wall strain zone extends upwards from the base of the thrust sheet (Abbott, 1990), through the overlying Robert Service Thrust into the Robert Service thrust sheet (Roots and Murphy, 1992a) to a narrowly transitional upper boundary (Murphy and Héon 1994b). At this upper boundary, bedding and earlier structures and fabrics are thoroughly overprinted by a suite of foliations, lineations, and folds that suggest a complex strain history although generally indicating top-to-the-west-northwest shear (Roots and Murphy, 1992a; Murphy et al., 1993a; Murphy and Héon 1994a). The north-dipping upper boundary of the strain zone has been traced eastward across the central part of Clear Creek and Sprague Creek map areas and across the northern part of Seattle Creek map area. In Seattle Creek map area, Tombstone Strain Zone structures are the dominant fabric elements in Hyland Group rocks from the strain zone boundary southwards to the southern edge of the map area.

Warps of Tombstone Strain Zone Structures

Foliations and lineations in the Tombstone Strain Zone are folded by low amplitude, long wavelength folds with east-northeast- and north-trending hinges. The regional change in dip of foliations from northerly to southerly that occurs across northern McQuesten and Mayo map areas is generally known as the McQuesten anticline or antiform (Figs. 2 and 3). Its axial surface trace lies in the valley of the McQuesten River from the foot of the Davidson Range at the southern edge of Nash Creek map area southwestward to the confluence of the North and South McQuesten rivers in Seattle Creek map area. To this point the axial surface trace coincides with a south-side-up (reverse?) fault that juxtaposes different levels of the structural sequence. Southwest from this point, the axial surface trace continues westward, diverging from the southwest trend of the McQuesten valley. The fault that lies along the axial surface trace in the South McQuesten River valley probably dies in the valley as it has not been observed westward along the trace of the antiform.

Brittle Shear Zones

Hyland Group rocks south and east of Scheelite Dome in the southeast corner of the map area are cut by an array of veins, veinlets, and breccias locally containing quartz-arsenopyrite mineralization (see section on Mineralization below) and are commonly rusty, punky and gossanous. Mineralized veins occur in a variety of orientations: the HAWTHORNE vein on the southeast flank of Scheelite Dome trends steeply northwestwardly; smaller veins and veinlets on the SC claim between Bennett and Highet creeks strike southwest and dip to the northwest. Although not mapped in detail, the boundary of the brittle shear zone containing these veins appears to trend approximately east-northeast / west-southwest. The age of fracturing and mineralization has not been determined but the vein geochemistry is similar to the geochemistry of mineral occurrences associated with the Scheelite Dome stock suggesting a possible relationship (see below).

Breccias of unknown age have also been observed peripheral to the Morrison Creek stock, in the hornfels and tourmaline alteration zone around the 'Black Hill', on the narrow ridge north of the McQuesten River and west of the North McQuesten River, in float in Seattle Creek (JAYBEE occurrence), and in the northwest corner of the map area west of the North McQuesten River (see section on Mineralization below). Breccia outcrops are spatially associated with north- to northwest-trending structures. A belt of north- to northwest-trending airphoto lineaments comes into the southwest corner of Seattle Creek map area. These lineaments were found to be associated with gossanous, locally mineralized breccias in Sprague Creek map area (Murphy and Héon, 1994a,b).

Mineralization

The discovery of gold in the bars of the Stewart River in 1883 brought miners to the area. Placer mining dominated until 1914 when mining began on the Silver King deposit near Elsa. Today, placer mining remains the main industry in Seattle Creek map area, while several exploration programs targeting gold and silver mineralization in bedrock are under way.

Coarse gold was discovered in Haggart Creek in 1885 and Highet Creek, located 20 km to the south, was staked around 1903 after coarse gold was found on a rock bench opposite the mouth of Rudolph Gulch. Highet and Haggart creeks are still being mined. Other creeks with past and present placer mining are Secret, Goodman, Rodin, Johnson, Sabbath, Morrison and Seattle creeks (Fig. 2). In addition to gold, other heavy minerals appearing in placer concentrates from the area are hematite, magnetite and scheelite, and those from Morrison and Johnson creeks also contain galena. Native bismuth, wolframite, stibnite and jaspilite have been documented in Highet Creek.

Past hard rock mineral exploration [see Table 1 for mineral occurrences summarized in Yukon Minfile (INAC, 1993)] focused on potential for Keno Hill - type veins in the Keno Hill quartzite (JAYBEE, SEATTLE), as well as the skarn and intrusive-hosted porphyry gold and tungsten (tin) potential of the Scheelite Dome pluton (SCHEELITE DOME) and adjacent veining (HAWTHORNE). Foliaform base metal mineralization on the south side of Highet Creek, upstream from its confluence with Rudolph Gulch was informally reported to the authors. The POTTER occurrence is the alleged location of a gold-bearing vein and consists of an axinite tin skarn (INAC 1993). These two latter mineral occurrences were not examined during the 1994 field season.

The SECRET and HIGHET Minfile occurrences are located on Au, Ag, Sn, W soil and stream sediment anomalies. No follow up work was done on the SECRET property. Although early prospecting on the HIGHET occurrence (Ben claims) located isolated mineralized float samples grading up to 5 g/T Au, the property was dropped. Newly discovered mineralized zones in this area (hereafter referred to as the "SC" in accordance with the present name of the claim block) would explain the presence of those anomalies. The OLIVER (EPD, NHL claims) occurrence, located on the adjacent Sprague Creek map area, was not visited in 1993 when the rest of that sheet was mapped and will be included in this present discussion. Trenching and drilling were focused on defining skarn-hosted tin and silver mineralization.

Mineralization documented in 1994 can be divided into three broad categories: 1) skarn, 2) intrusion-hosted, and 3) wall rock-hosted. Intrusion-hosted occurrences may be further subdivided into vein and breccia occurrences. Wall rock-hosted occurrences include vein, breccia, and disseminations in alteration or hornfels zones. Table 2 lists pertinent locations, descriptions and significant results of our 1994 sampling.

Skarn Occurrences

Skarn mineralization occurs on the north side of the Scheelite Dome pluton and at the Oliver occurrence. At SCHEELITE DOME, two bands of carbonate in the Hyland group are cut by a Cretaceous quartz monzonite. Mineralization consists of disseminated pyrrhotite, scheelite and chalcopyrite in prograde wollastonite skarn, and scheelite in retrograde actinolite skarn. Samples have assayed up to 8.3% WO_3 in float and 8.2 g/T Au/1.5 m in trench (INAC, 1993; 115P/004). A gossanous banded exoskarn was sampled in 1994

Occurrence	Minfile 115P	Metals	Minfile Description	Best assays (Minfile)	New data (see Table 2 for results)
JAYBEE	1	Pb, Ag	galena-bearing float	1% Pb, 34 g/T Ag	94DM-45a: 1.63% Pb, 60.7 g/T Ag, anom. Zn and Bi in ox, vuggy+veined calc-pelite, qtz boxwork
SEATTLE	2	Pb, Ag	galena-bearing float	40.3% Pb, 1556 g/T Ag	
HAWTHORNE	3	Au,Ag,Sb	quartz-stibnite-asp vein	63 g/T Au, 674 g/T Ag, 39% Sb	
SCHEELITE DOME	4	Au, W	skarn intrusion-hosted vein	skarn: up to 8% WO3, 8.2 g/T Au qtz vein in intrusion: up to 24 g/T Au	94DM-6b: 486 ppb Au, anom As, W smoky qtz veins in small plug E of main stock
SECRET	28		W,Sn,Ag,Au soil anomalies		
HIGHET (BEN, SC)	33	Au	anom heavy min concentrate pyrrhotite vein in rusty qtzite	5.5 g/T Au, 0.03% Cu	94DH-100a, 104a to d, 94DM-268, 269 a,b: up to 5.6g/T Au, anom As, Bi, Sb, W in discordant and foliaform qtz-asp veins
POTTER	48	Sn	axinite skarn	1036 ppm Sn	
OLIVER	30	Sn,Ag	skarn, tourm-chl breccia	up to: 2.5% Sn, 12 g/T Ag	94DH-160: 1.6 g/T Au, anom Ag, Cu, Zn, Co, Bi, As, W

Table 1: Mineral occurrences in Seattle Creek map area as recorded in Yukon Minfile (INAC, 1993) and selected assay results on samples from occurrences visited during the 1994 mapping program.

where one rock sample (taken parallel to a previous chip sample) containing foliaform pyrrhotite bands oriented parallel to the dominant foliation graded 2.9 g/T Au and contained anomalous concentrations of Cu, Bi, As and W (# 94DH-17, Table 2). Skarn alteration is found up to about 700 m away from the intrusion. Scheelite was also found in apparently unhornfelsed calcareous metasedimentary rocks two kilometers south of the Scheelite Dome pluton.

At the OLIVER occurrence, tin and silver mineralization are hosted in actinolite-chlorite (-calcite-diopside-quartz-epidote) skarn, tourmaline breccia and quartz veins. Ore minerals include cassiterite, sphalerite, pyrrhotite, pyrite and scheelite (INAC, 1993; 115P/030). Core log descriptions indicate a correlation between high tin and silver content and "chloritic breccias". Previous exploration efforts were targeted towards tin and silver and therefore the samples were never assayed for gold. One sample of actinolite skarn(?) taken from a trench during a property visit in 1994 contained a two centimetre wide band of arsenopyrite that grades 1.6 g/T Au, 34.9 g/T Ag and 366 ppm Bi (# 94DH-160). This newly detected coincident gold/bismuth anomaly on what was known as a tin/silver prospect indicates potential for gold mineralization on this property.

A weak skarn/hornfels is observed at the mouth of Sunshine Creek, just west of the 115P/16 map area, where actinolite, pyrite and rusty quartz veins occur in oxidized calcareous and pelitic Hyland Group metasedimentary rocks and altered intrusive rocks (endoskarn) of unknown extent. The relationship of alteration to the nearby Sunshine Creek stock is not known. Sampling failed to detect any anomalous concentrations of metals.

Intrusion-Hosted Mineralization

Quartz (-scheelite-muscovite-tourmaline) veins in the Scheelite Dome pluton have been explored for Fort Knox-type (Hollister, 1991) mineralization (INAC, 1992, 115P/004). Pyrrhotite and trace bismuthinite mineralization is reported to occur in the selvages of veins. Although our work did not outline any new economic mineralization in the main body, a satellite stock located 500 m to the east of the main stock contains thin smoky quartz veins that grade 486 ppb Au, 575 ppm As, 68 ppm Bi and 226 ppm W (# 94DM-6b).

An altered feldspar porphyry dyke(?) was located along the northern border of the map area, in the northeast corner, where it had been exposed by trenching. A sample of brecciated, vuggy and rusty intrusive/wall rock contact returned anomalous values in Pb, Zn, As and Sb (# 94DH-148b).

The Morrison Creek pluton hosts quartz (-feldspar) and quartz-tourmaline veins and intrusive breccia. Veins and breccias also occur in the hornfels aureole. Rock samples taken in outcrop and in float in and near the intrusion did not yield economically significant mineralization. Hematite and chlorite alteration were observed but no pattern of zonation has been established. Some pyrite occurs in quartz veins, disseminated in the intrusive rock and in chloritized zones.

Wall Rock-Hosted Mineralization

Several gold-bearing veins and veinlets cut crenulated and locally rusty weathering psammite and phyllite in the area roughly bounded by Morrison, Bennett, and Highet creeks and Scheelite Dome. The HAWTHORNE occurrence consists of a series of northwest-striking quartz-arsenopyrite veins of varying thickness and grade (up to 2.5 m thick and up to 63.4g/T Au; INAC, 1993, 115P/003). Several other veins, containing anomalous values in gold, arsenic, bismuth, antimony and tungsten were located by our work in 1994. These veins might result from the same mineralizing event that produced the HAWTHORNE veins as they have similar mineralogy and geochemistry. New occurrences include:

- Several thin quartz-arsenopyrite veins on the west side of Rudolph Gulch in an area of blocky talus (#94 DH-155a,b,c). Vein density varied in the samples from one vein per 2 to15 cm. All three samples returned anomalous gold and arsenic values with the best assay grading 1.58 g/T Au.
- Quartz-arsenopyrite mineralization on the SC claims (HIGHET). Past exploration on this occurrence had outlined geochemical anomalies based on heavy mineral concentrates. The best showing discovered this summer is located in a steep west facing gully and consists of a discordant, 4 - 6 cm wide, quartz-massive arsenopyrite-scorodite vein that grades 5.6 g/T Au (# 94DH-104d). The vein has a westerly strike and moderate northerly dip, can be traced for approximately 15m and is cut by a small fault at the northwestern end of the exposure. High grade float has been located in the area, presumably originating from the same structure.
  Two other types of mineralization occur on the SC claims. Thin, discordant quartz-arsenopyrite veins yield anomalous gold, bismuth, arsenic and tungsten values (up to 1.3 g/T Au) (#94DH-104a, 165a,b, 94DM-269a). Foliaform quartz veins and boudins also locally contain sulphide mineralization and are anomalous in gold and arsenic (#94DM-269b). Locally, the discordant veins are sheared into parallelism with the dominant foliation, thus appearing as foliaform veins, suggesting a shearing event postdating the veining. Both discordant and foliaform mineralization have been observed in an area of at least 2 km^2, from the gully west of the main ridge on the SC property (#94DH-104) to the west fork of Bennett Creek (#94DH-165) and for about a kilometre along the ridge. The geochemical signature (Au, As, Bi, Sb, W) of the veins is similar to that of intrusive-hosted gold-bearing veins, thus suggesting an intrusive source to the wall rock-hosted mineralization. The Scheelite Dome pluton, located 6 km west of the main showing, may be a possible metal source.

Tourmaline (± quartz) veining at the northern end of the map area occurs in the hornfelsed aureole informally called the 'Black Hill'. Although only weakly anomalous in gold, these samples are also anomalous in Bi, As and Sb (#94DH-87a, 89b). Analyses of the

Sample #	Location	UTM E	UTM N	Description		Significant results									
		zone	8			Au	Ag	Cu	Pb	Zn	Co	Bi	As	Sb	W
						ppb	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
94DH-17	Scheelite Dome	438811	7074256	gossanous calcsil hfls w po rich pod // Sp	o/c	2930		457			38	68	6837		598
94DH-159f	OLIVER	425266	7071220	chlor-act skarn?	tr					2409					
94DH-160	OLIVER	425411	7071370	2 cm wide asp band in actinolite skarn	tr	1630	34.9	2685		739	303	366	>10 000		80
intrusion-hosted:															
94DM-6b	E of Scheelite Dome	439343	7073304	smoky quartz vein in intrusion		486							575		226
94DH-148b	trench west of Secret Ck	450353	7097082	lim vuggy feldspar porphyry/metased breccia	s/c				832	239			306	233	
wall rock-hosted:															
veins:															
94DH-87a	"Black Hill"	441376	7096970	altered sil psam w/ tourm veinlets and qtz vugs	s/c	6						32	4497	206	
94DH-89b	"Black Hill"	441676	7097282	0.5 cm wide qtz tourm (scor asp?) in dark psam	flt	170						31	5688	136	
94DH-104a	SC gully	444218	7071667	Thin steep quartz py vein	o/c								196		
94DH-104c	SC gully	444129	7071729	quartz and nodular arsenopyrite vein	flt	3715	6.2					48	>10 000	113	
94DH-104d	SC gully	444299	7071713	4-6 cm wide quartz-asp-scor vein	o/c	5618						82	>10 000	246	79
94DH-155a	W side of Rudolph Gulch	440081	7072582	thin qtz vein w/ sulph blebs, remob along Sc?	flt	1582							4657		
94DH-155b	W side of Rudolph Gulch	440081	7072582	asp blebs in qtz veinlets and in selv 1v/1-5cm	flt	30							486		
94DH-155c	W side of Rudolph Gulch	440081	7072582	sulph clots along fract and thin qtz vein	flt	82							1325		
94DH-165a	W fork of Bennett Ck	446041	7071201	1-2 cm wide qtz-asp vein w/ sulph blebs in selv	flt	175							700		
94DH-165b	W fork of Bennett Ck	446053	7071241	asp on fract/vein w/ qtz,act in bleach psam	flt	1340						20	>10 000		230
94DM-269a	SC ridge	444489	7071652	thin discordant qtz-asp vein	o/c								7650		
94DM-269b	SC ridge	444489	7071652	asp, py in clots in glassy qtz boudin	o/c	30							3350		
breccias:															
94DH-87-88	"Black Hill"	441439	7096856	gos qtz inj + brecciated grit w/ qtz-lined vugs	o/c	41			799			18	8399	149	
94DH-89a	"Black Hill"	441535	7097252	angular tourm breccia, psam-grit Fx	flt								144	61	
94DH-89c	"Black Hill"	441856	7097206	breccia ,yellow clay alt Fx, hem matrix	flt	7							1010	94	
94DH-91	"Black Hill"	442338	7097106	gosannous sil psam breccia	o/c							65	220	1096	
94DH-100a	SC claims	445082	7072022	brecc. qtz vein w/ ang qtz Fx + Mn-lim cement	o/c	10							391		
94DH-104b	SC gully	444128	7071730	phyll breccia + qtz. small fault	o/c	70							2553		
94DH-125a	test pit mouth of Sunsh. Ck	425497	7075569	vuggy grey sil breccia w/ qtz + clay alt Fx	flt	31	11.9					22	520		
94DH-133	W of North McQuesten river	427438	7078652	brecciated qtz/ps w euhedral qtz + lim in vugs	o/c		6.6			710			429	17	
94DH-140	Saddle N of map sheet	446259	7097463	limonitic breccia w/ lim-Mn coated vuggy qtz	flt	6			416					28	
94DH-149b	NE end of map	447598	7097040	vuggy limonitic breccia w/ Mn coating	flt				594	1141				14	
94DH-159e	OLIVER	425264	7071238	hematitic breccia	tr			423	663	3951					
94DM-45a	jctn Seattle/Morrison Cks	445865	7078977	rusty vuggy calc-pelite breccia w/ qtz boxwork	flt		60.7		1.63%	1249		62		11	
94DM-167	"Black Hill"	441231	7098119	rusty punky breccia	flt	28			329				2608	270	
94DM-168	"Black Hill"	441381	7090871	rusty Fe-cemented 3 m wide fault breccia		17							3925	793	
94DM-253	OLIVER	424576	7070866	brecciated phyllite w/ qtz cement		11							375		
alteration:															
94DH-101	SC claims	445724	7071646	bleached psam w/ Mn, lim fracture coating	o/c	33							87		
94DM-268	SC claims	444532	7071846	bleached rusty psammite		6							129		
94DM-192	S end of map sheet	436880	7069634	gossanous rusty phyllite		21							3568		

o/c: outcrop flt: float s/c: subcrop tr: trench Fx: fragments

Table 2: Significant assay results obtained from samples collected during the 1994 mapping program. Gold content was determined by the fire assay / AA finish method; analyses were mostly performed by Bondar-Clegg & Company Ltd., North Vancouver, B.C., with the following exceptions: analyses of samples 94DH-165a,b, -269a,b were performed by Chemex Labs Ltd., Vancouver, B.C. The silver and lead contents of sample 94DM-45a was determined by the fire assay and AAS low level assay methods, respectively, by Bondar-Clegg & Company Ltd. of North Vancouver, B.C. The contents of other metals were determined by the ICP method at Bondar-Clegg & Company Ltd. as above and Chemex Labs Ltd. as above.

breccias in the area display the same geochemical signature. Tourmaline veining and alteration is also found on the ridge northwest of the North McQuesten River but our sampling did not detect any anomalous concentration of metals.

Breccias of different types occur throughout the map area and are commonly, but not exclusively, spatially related to the presence of intrusions. Fragment types consist of angular to rounded quartz vein material and metasedimentary rocks which, where altered, are either hematized, clay altered, tourmalinized or coated with limonite and/or manganese. Matrix types include bull quartz, tourmaline, limonite and one distinctive type that is characterized by limonitic alteration and the lining of vugs with euhedral quartz crystals. Although only weakly anomalous in gold content, breccias do contain anomalous amounts of other metallic or pathfinder elements. The geochemical signature of most breccia samples allows division into two general populations that cross cut lithologic types: one containing As ± Au ± Bi ± Sb and the other containing Pb, Zn, Sb ± Bi ± Ag and containing no As.

The first category includes the breccias of the 'Black Hill' area (#94DH-87, -88,-89a,-89c,-91; 94DM-167,-168), one isolated breccia found at the southern edge of the map (#94DM-253) as well as those located on the SC claims (#94DH-100a,-104b). Two samples from the 'Black Hill' area also contain anomalous amounts of lead and a breccia sampled at the mouth of Sunshine Creek (#94DH-125a) also contains Ag. All of the different lithologic types of breccias described above are represented in this category.

Breccias belonging to the second geochemical population are vuggy, limonitic and are found in a saddle north of the map area (#94DH-140), in an unnamed creek at the northeastern end of the map area (#94DH-149b) as well as at the OLIVER (#94DH-159e) and JAYBEE (#94DM-45a) Minfile occurrences. Sample 94DM-45a is the only evidence of the reported JAYBEE occurrence and was found in float. It consists of brecciated gossanous phyllite containing silicic boxwork and grades 60.7g/T Ag.

A sample of quartz-limonite cemented breccia located on the long thin ridge west of the North McQuesten River (#94DH-133) has a geochemical signature overlapping the two previous populations and contains anomalous quantities of Cu, Zn, As, and Sb.

Several areas of alteration consisting of oxidation and tourmalinization were documented in the Seattle Creek map area. Oxidation of phyllite and psammite is prevalent in the area bounded by Morrison, Bennett and Highet creeks and Scheelite Dome. This rusty overprinting correlates with the presence of thin quartz-sulphide veins and is possibly related to the emplacement of the Scheelite Dome pluton. Three samples of oxidized metasediments returned anomalous values in Au and As (#94DH-101, 94DM-192,-268). Tourmaline alteration is widespread in the northern part of the map around the 'Black Hill' where hornfelsic dark grey weathering siliceous psammite, grit and minor phyllite are bleached, tourmalinized, locally clay altered and cut by quartz and tourmaline veins and breccias. Although an intrusive body has been located beyond the northern boundary of the map area, its complete outline and the full extent of the associated alteration and brecciation is not known. Tourmaline veining and alteration also occurs on a ridge northwest of the North McQuesten River.

Summary of Mineralization

Mineralization in the Seattle Creek map sheet is hosted in skarns, veins and breccias. Most of these occurrences are spatially related to intrusions. Significant new discoveries include:

- documention of gold mineralization at the OLIVER skarn and breccia occurrence;
- a satellite plug to the Scheelite Dome pluton hosts potential Fort Knox-type mineralization;
- gold values in quartz-arsenopyrite veinlets in Rudolph Gulch and on the SC claims between Morrison and Bennett creeks, indicating the potential for a low grade bulk-tonnage wall rock-hosted gold deposit; and
- a tourmaline and hornfels aureole at the northern end of the map area indicates an intrusion that has yet to be systematically prospected.

CONCLUSIONS

1. Sprague Creek map area is underlain by poly-deformed low-grade Upper Proterozoic to Lower Cambrian and Mississippian metasedimentary and meta-igneous rocks, Triassic mafic meta-igneous rocks, and Cretaceous felsic intrusions.
2. Metasedimentary rocks were deformed by at least three phases of regional deformation before Cretaceous intrusion.
3. Mineralization in Seattle Creek map area is hosted in skarns, veins, breccias and alteration zones. Most of these occurrences are related to the emplacement of plutons.

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BIOSTRATIGRAPHY OF THE LOWER TO MIDDLE JURASSIC LABERGE GROUP, WHITEHORSE MAP AREA (105D), SOUTHERN YUKON

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Abstract

New ammonite collections from fine-grained rocks of the Laberge Group in the Whitehorse area are assigned to nine ammonite zones or assemblages using the recently established North American regional zonations. Guide ammonites of these zones are illustrated. Supplemented by other published and critically revised data, the Laberge Group in the southern Yukon is shown to contain nearly all zones of the Upper Sinemurian to Lower Bajocian stages. The presence of the Hettangian and Lower Sinemurian is not adequately confirmed. In an Upper Pliensbachian section in the Miners Range, the occurrences of Fontanelliceras *cf.* fontanellense *and* Canavaria? *sp. extend the known range of these taxa in North America to the Carlottense Zone. The base of the Toarcian is marked by the first appearance of* Dactylioceras *ex gr.* simplex, *which may characterize the deepest faunal level within the Kanense Zone. Another section on Goat Mountain contains a Lower to Middle Toarcian succession.*

Deposition of the Laberge Group continued throughout Early and Middle Jurassic time. Conglomerates are confined to Upper Sinemurian to Upper Pliensbachian in the Takhini area and to Toarcian and older in the Fish Lake area. It is likely that Laberge Group conglomerate was not deposited in response to a single episode of relative sea level change, but to several such events during Early Jurassic time. Fine-grained clastics are Upper Sinemurian to lowermost Toarcian in the Takhini area whereas Lower Toarcian to Lower Bajocian in the Fish Lake area. Dacite tuff of the Nordenskiold formation is Late Pliensbachian in age.

INTRODUCTION

The Lower to Middle Jurassic Laberge Group is extensively exposed in the Whitehorse map area. Recent and ongoing 1:50 000 scale geological mapping yielded new fossil collections that led to a focussed field study of the biostratigraphy of selected key localities in 1994. Improved understanding of Laberge Group biostratigraphy is important in resolving the following problems:

1) The stratigraphy of the Laberge Group is characterized by dramatic facies changes manifested in lateral and vertical lithologic variability which commonly renders lithologic correlations unviable. The age of large influxes of coarse, polymict pebble conglomerate needs to be constrained in order to date episodes of uplift in the source areas.
2) Much of the Laberge Group is represented by successions of fine-grained clastic strata. Biostratigraphy may be the only method to determine offsets along faults that juxtapose similar lithologies.
3) Locally, the Laberge Group rests discomformably on the underlying Lewes River Group. Dating of the base of the Laberge Group at different localities is necessary to assess the duration and distribution of the hiatus.
4) Biostratigraphic age constraints of the interbedded Nordenskiold dacite are required to determine whether there

was one or more volcanic episodes coincident with the deposition of Laberge Group.

5) Improved age control is necessary to deduce whether depositional changes in the basin are related to global eustatic sea-level changes, local tectonic activity, or both.
6) The Whitehorse Trough is surrounded by rocks assigned to Quesnellia, Cache Creek, and Yukon-Tanana terranes. Locally, Laberge Group sedimentary rocks preserve a record of Stikinia's interaction with adjacent terranes. The timing of these interactions is crucial to the refinement of tectonic models.

Recent advances in ammonite biostratigraphic research led to the establishment of North American regional standard zonations for the Pliensbachian (Smith et al., 1988), Toarcian (Jakobs et al. 1994), Aalenian (Poulton and Tipper, 1991), and Lower Bajocian (Hall and Westermann, 1980) stages. Work is also in progress for the Hettangian (Tipper and Guex, in press) and Sinemurian (Pálfy et al., in press). Interpretation of new and older data in terms of this biostratigraphic framework provides much improved correlation potential.

In the present paper we document new biostratigraphic results, attempt an overview of the Jurassic biostratigraphy of the study area, and discuss the relevance of the emerging temporal framework to the geologic evolution of the Whitehorse Trough.

TECTONIC AND GEOLOGIC SETTING

The Canadian Cordillera consists of numerous tectonostratigraphic terranes that were accreted to the western margin of the North American craton during the Mesozoic (Monger et al., 1991). The northern segment of Stikinia is composed of rocks of the Late Triassic Lewes River arc and the adjacent Upper Triassic to Middle Jurassic Whitehorse Trough (Fig. 1). The Lewes River arc is a calc-alkaline island arc assemblage dominated by submarine to subaerial augite- and plagioclase-phyric basaltic andesite flows, autoclastic breccia, agglomerate and lahars. The arc sequence includes the volcanic components of the Lewes River (Povoas Formation) and Stuhini groups and forms the western margin of most of northern Stikinia.

Whitehorse Trough

The Whitehorse Trough is a 500 km long marine basin. Its lithologically diverse sedimentary strata record evidence of a tectonically active source region (Wheeler, 1961; Souther, 1971; Eisbacher, 1974; Dickie, 1989). Upper Triassic to Middle Jurassic strata of the Whitehorse Trough in the southern Yukon form four distinct assemblages: (1) a Carnian to Norian arc-related, coarse-fragmental volcanogenic succession of laharic flows, agglomerate, conglomerate, tuff and greywacke in depositional contact with volcanic rocks of the Lewes River arc; (2) Upper Norian (*sensu* Tozer, 1980) bioclastic limestone and calcareous fine-grained clastics; (3) Hettangian? to Bajocian shale, sandstone, and interbedded sandstone-mudstone rhythmites; and (4) Sinemurian to Bajocian marine, coarse-grained, clast-supported cobble and boulder conglomerate (Fig. 2). Assemblages 1 and 2 comprise the Aksala Formation of the Lewes River Group and are constrained by macrofossil and conodont ages (Tozer, 1958; Wheeler, 1961; Tempelman-Kluit, 1984; Hart and Radloff, 1990; M. Orchard written comm, 1990; Orchard, 1991). Assemblages 3 and 4 comprise the Laberge Group, the age of which is discussed in detail below.

The basin fill exceeds 6000 m in thickness of which the Laberge Group accounts for at least 2500 m (Cockfield and Bell, 1944; Wheeler, 1961; Dickie, 1989; Hart and Radloff, 1990). The Lewes River and Laberge groups are separated by an erosional unconformity along the western basin margin, yet they appear to be conformable near the basin axis (Wheeler, 1961; Dickie, 1989; Hart and Hunt, this volume). The disconformity reflects a sea-level lowstand in the basin. It corresponds to a major eustatic sea-level fall at the Triassic-Jurassic boundary (Haq et al., 1988) which may have been amplified by uplift of the basin margin (Dickie and Hein, 1992).

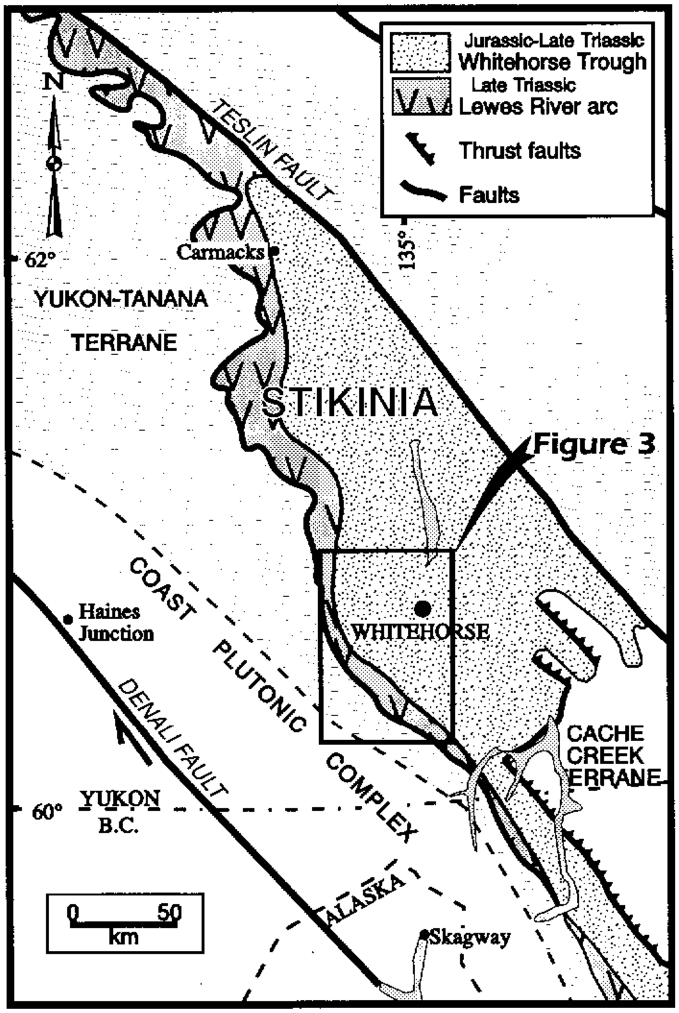


Figure 1: Tectonic setting of the Whitehorse Trough as part of Stikinia within the northern Canadian Cordillera.

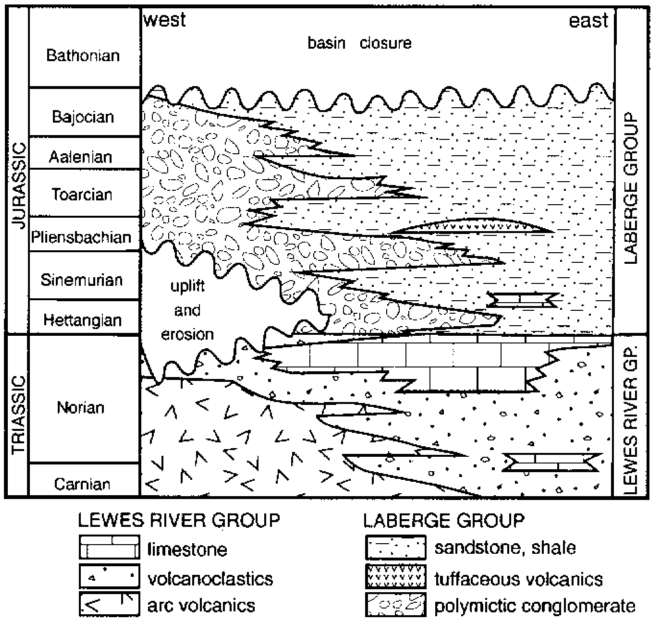


Figure 2: Generalized stratigraphy across Whitehorse Trough strata in the Whitehorse map area (modified from Hart and Radloff, 1990).

In the Whitehorse map area, the Laberge Group is composed of greywacke and arkosic sandstone, mudstone-sandstone couplets and thick successions of polymict cobble conglomerate. Large successions of conglomerate occur in the Fish Lake and Takhini Hotsprings areas where they were deposited as vast submarine fans from two separate point sources (Dickie, 1989). The conglomerates give easterly paleoflow directions and are mainly composed of Upper Triassic clasts (Hart et al., in press). The finer grained sediments were deposited as pro-deltaic sand and mud. Laberge Group strata have been deformed into northwest-trending folds. Successions dominated by mudstone or adjacent to underlying limestone form upright tight to isoclinal, low amplitude folds whereas successions dominated by conglomerate form broad open folds with wavelengths approximating 10 km.

The lower Mesozoic Whitehorse Trough strata are thought to have been deposited in a forearc basin above a southwest-dipping subduction zone, northeast of the Lewes River arc (Tempelman-Kluit, 1979). The lithological variation of sedimentary rocks in the basin records changes both in the depositional environment and in the source regions affected by tectonic perturbations.

PREVIOUS WORK

Biostratigraphic data from the Laberge Group in the Whitehorse map area have been limited. S.S. Buckman was the first to establish the age of the Laberge Group as Early to Middle Jurassic based on a handful of fossils collected by Cockfield and Bell (1926). Lees (1934) described additional Early Jurassic ammonites from the Laberge map area. In the Whitehorse map area, Laberge Group fossils were collected from 29 localities during geological mapping between 1946 and 1955. Identifications and age determinations of these collections provided by McLearn and Frebold were reported by Wheeler (1961). Several Pliensbachian and Toarcian ammonites from the Laberge Group, although mostly north of the Whitehorse map area, were described and illustrated by Frebold (1964, 1970). Much of these early data has been revised during the construction of regional standard zonations (Smith et al., 1988; Jakobs et al., 1994).

Recently H.W. Tipper identified Late Pliensbachian ammonites from shale units within a conglomerate-dominated succession reported by Dickie and Hein (1992). Earlier collections made during the Whitehorse Geological Mapping Project were also identified by Tipper (unpublished GSC fossil report J8-1994-HWT). His results served as a basis for the present study. Another recent report by Jakobs (1994) describes poorly fossiliferous sections from the east side of the Whitehorse Trough.

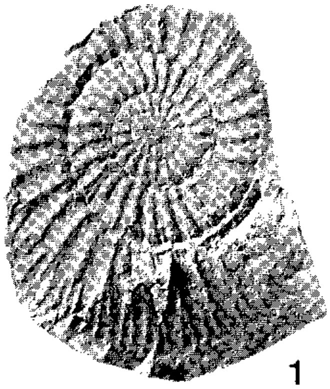
The Laberge Group in the Atlin Lake map area, in the southern part of the Whitehorse Trough, has been the subject of a recent biostratigraphic and sedimentologic study by Johannson (1993, 1994). This allows improved correlation between different parts of the basin which will benefit tectonic models of basin evolution.

BIOSTRATIGRAPHY OF THE STUDIED SECTIONS AND LOCALITIES

Fossils were collected at several localities in the course of a 1:50 000 scale geologic mapping project during 1993-94. The most significant localities were briefly revisited during 1994 for detailed biostratigraphic investigations (Fig. 3). Fossiliferous strata of the Laberge Group are typically recessive, fine-grained siliciclastic rocks. Continuous exposure is rare and is confined to steep slopes above treeline. Such sections were seen on Goat Mountain and between Fish Lake and Mount Granger. Where continuous sections were lacking, it was possible to reconstruct biostratigraphic successions from localities in proximity to each other with intervening covered intervals (Miners Range, Takhini microwave tower). The remaining localities are isolated outcrops with no clear biostratigraphic relationships.

The preservation of ammonites is poor to mediocre, introducing various degree of uncertainty in identification. Flattened internal and external moulds are the most commonly encountered modes of preservation. Taxonomic problems are discussed briefly only when they crucially affect the biostratigraphic age assignment.

PLATE 1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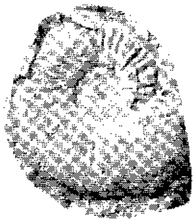
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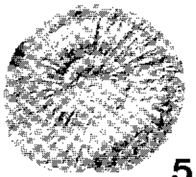
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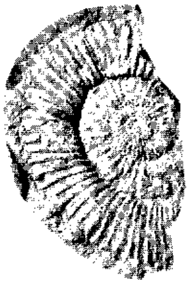
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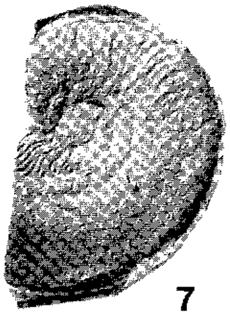
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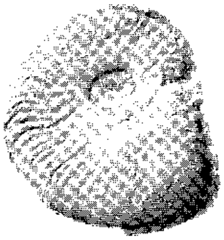
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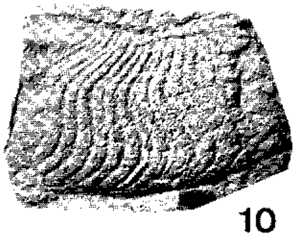
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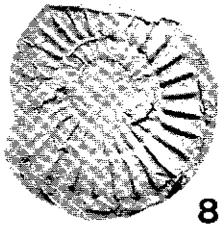
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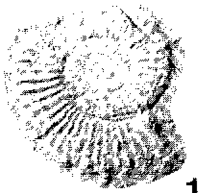
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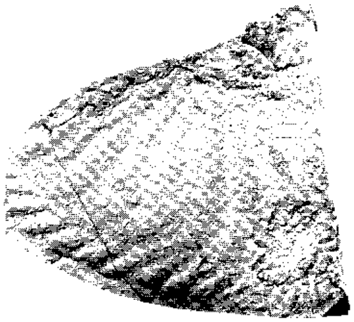
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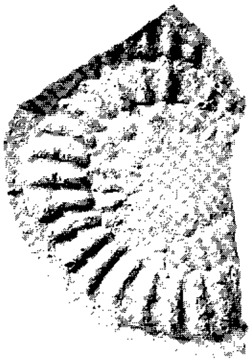
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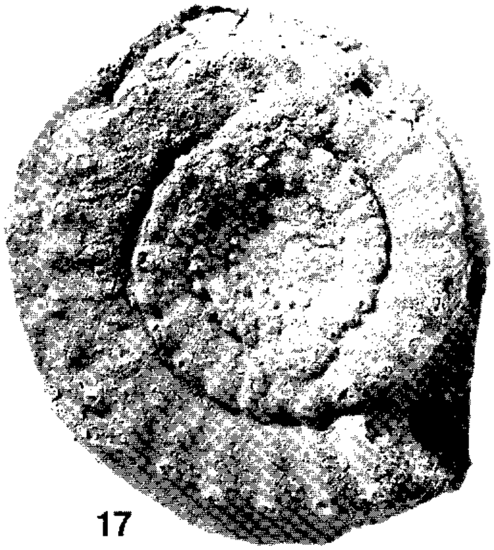
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Explanation of Plate 1 (facing page)

(All figures are natural size. Figured specimens are deposited in the type collection of the Geological Survey of Canada. For each specimen the GSC type number is followed by the locality name and locality code, the details of which are listed in the Appendix 1.)

Figure 1: Dactylioceras *ex gr.* simplex *Fucini; Kanense Zone, Lower Toarcian; GSC 108750; Miners Range; Locality M7.*

Figure 2: Peronoceras *cf.* verticosum *(Buckman); Planulata Zone, Middle Toarcian; GSC 108751; Goat Mountain; Locality G1.*

Figure 3: Sonninia? *sp.; Lower Bajocian; GSC 108752; Fish Lake-Mt. Granger; Locality F2.*

Figure 4: Euhoploceras? *sp.; Lower Bajocian; GSC 108753; Fish Lake-Mt. Granger; Locality F1.*

Figure 5: Dactylioceras *sp.; Kanense or Planulata Zone, Lower or Middle Toarcian; GSC 108754; Goat Mountain; Locality G1.*

Figure 6: Dactylioceras? *sp.; Kanense or Planulata Zone, Lower or Middle Toarcian; GSC 108755; Goat Mountain; Locality G1.*

Figure 7: Lioceratoides (Lioceratoides) propinquum *(Whiteaves); Carlottense Zone, Upper Pliensbachian; GSC 108756; Miners Range; Locality M5.*

Figure 8: Fontanelliceras *cf.* fontanellense *(Gemmellaro); Carlottense Zone, Upper Pliensbachian; GSC 108757; Miners Range; Locality M5.*

Figure 9: Lioceratoides (Lioceratoides) *cf.* allifordense *(McLearn); Carlottense Zone, Upper Pliensbachian; GSC 108758; Miners Range; Locality M5.*

Figure 10: Protogrammoceras *ex gr.* kurrianum *(Oppel); Carlottense Zone, Upper Pliensbachian; GSC 108759; Miners Range; Locality M4.*

Figure 11: Leptaleoceras *aff.* accuratum *(Fucini); Kunae or Carlottense Zone, Upper Pliensbachian; GSC 108760; Miners Range; Locality M2.*

Figure 12: Amaltheus *cf.* stokesi *(J. Sowerby); Kunae Zone, Upper Pliensbachian; GSC 108761; Takhini microwave tower; Locality T3.*

Figure 13: Canavaria? *sp.; Carlottense Zone, Upper Pliensbachian; GSC 108762; Miners Range; Locality M5.*

Figure 14: Gemmellaroceras *sp.; Whiteavesi or Freboldi Zone, Lower Pliensbachian; GSC 108763; Miners Range; Locality M1.*

Figure 15: Epophioceras? *sp.; Varians Assemblage, Upper Sinemurian; GSC 108764; Horse Creek, Locality H1.*

Figure 16: Epophioceras? *sp.; Varians Assemblage, Upper Sinemurian; GSC 108765; Horse Creek, Locality H1.*

Figure 17: Metaderoceras *aff.* mouterdei *Frebold; Whiteavesi or Freboldi Zone, Lower Pliensbachian; GSC 108766; Miners Range; Locality M1.*

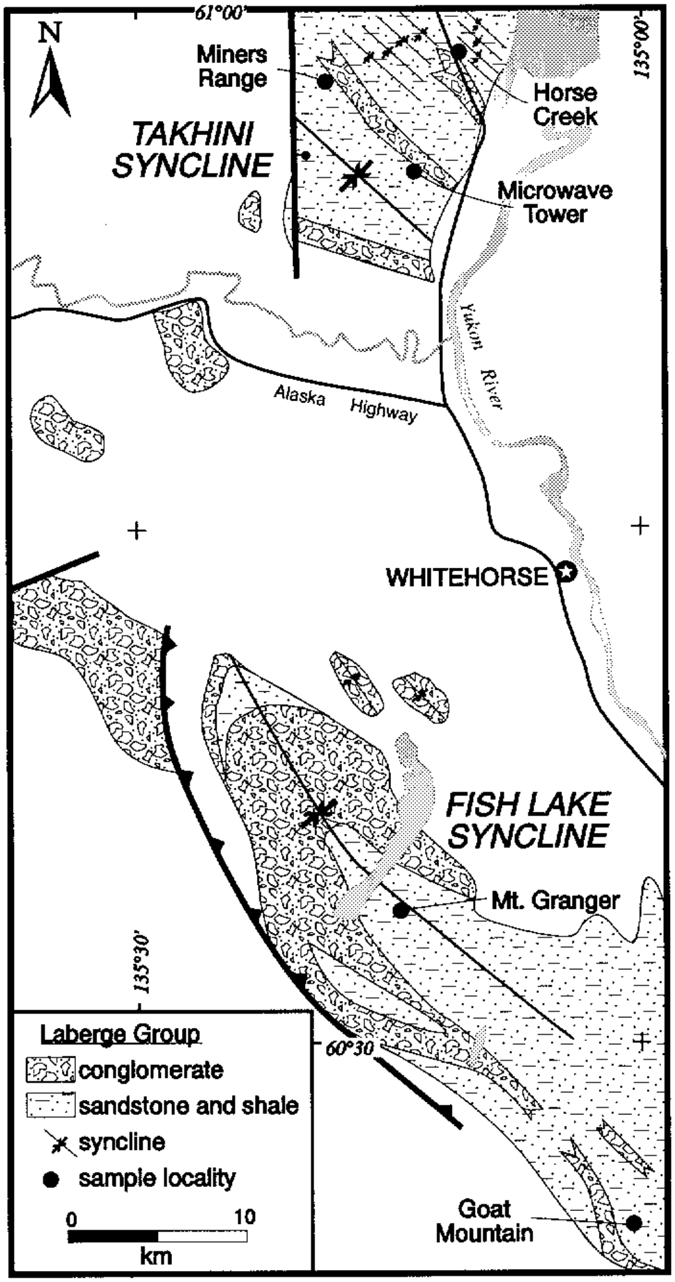

Figure 3: Location map showing the distribution of Jurassic Laberge Group conglomerate and finer-grained strata as well as the sample localities mentioned in the text. Geology is compiled from Hart and Radloff, 1990; and Wheeler, 1961.

Horse Creek

An isolated locality (Locality H1, see Appendix 1) near the intersection of the the Klondike Highway with Horse Creek exposes several metres of moderately resistant, dark, interbedded shale and siltstone. It yielded incomplete and crushed specimens of *Epophioceras*? sp. (Pl. 1, Figs. 15–16). The tentative identification is based on the very low expansion rate and the rounded profile of ribs. Lacking complete specimens with preserved venters, homeomorphic arietitids and echioceratids cannot be ruled out with certainty. *Epophioceras* is restricted to the lower part of the Upper Sinemurian (Varians Assemblage of Pálfy et al., in press).

Takhini Microwave Tower

A microwave communication tower located 8 km northeast of Takhini Hotsprings, accessible by a gravel road off the Klondike Highway, is used here to designate three fossil localities in its vicinity. The outcrops, stretching a distance of 400 m, cannot be proven to form parts of an uninterrupted sequence due to vegetation cover. Consistent bedding attitudes along with the biostratigraphic data presented below suggest that they do in fact represent pieces of a true stratigraphic succession.

The lowermost locality (Locality T1) is a small exposure of black bioclastic limestone with bivalve-rich, coquinoid crinoidal lenses. The ammonite fauna comprises small individuals of *Phylloceras* sp. and *Arieticeras*? sp. *Phylloceras* is a long-ranging genus of little stratigraphic value. Its abundance in a facies with reworked shallow marine benthic fossils is unusual considering its general rarity in the Canadian Cordillera and the widely held view about its oceanic or deeper water habitat. In Canada, *Arieticeras* is restricted to the Upper Pliensbachian with its greatest abundance in the Kunae Zone (Smith et al., 1988). Our specimens display smooth innermost whorls, gradually emerging, strong and simple ribbing, and carinate venter. Similar morphology exists in the Sinemurian *Arnioceras*, from which they are difficult to distinguish. Suture lines, which would provide a basis for distinction, are not preserved on our specimens. Somewhat flexuous and blunt ribbing of some individuals favours their tentative assignment to *Arieticeras*.

Stratigraphically a few metres upsection, above a covered interval, the hilltop is underlain by crystal-lithic dacite tuff of the Nordenskiold formation. Following another covered interval concealing a thickness of perhaps a few tens of metres, dark, thinly bedded shale, siltstone, and fine sandstone are exposed intermittently at the roadside. Locality T2 yielded *Arieticeras* sp. and the bivalve *Posidonotis semiplicata* Hyatt, whereas abundant *Amaltheus* cf. *stokesi* (J. Sowerby) (Pl. 1, Fig. 12) was recovered from a few metres upsection (Locality T3). The latter species unequivocally indicates the Kunae Zone of the Upper Pliensbacian. Therefore these three localities can be reasonably interpreted to represent a succession within the Kunae Zone.

Miners Range

Dominantly fine-grained Laberge Group strata of Pliensbachian age underlie a ridge in the Miners Range, southeast of Flat Mountain. Fossiliferous localities were found in intermittent outcrops exposing short sections along a distance of two kilometres. Generally consistent attitudes and the biostratigraphic data suggest that the area may only have been affected by block faulting causing minor offset. A composite stratigraphic column with ammonite distribution is presented in Figure 4.

The lowermost assemblage (Locality M1) is Early Pliensbachian in age. The co-occurrence of *Metaderoceras* aff. *mouterdei* Frebold (Pl. 1, Fig. 17) and *Gemmellaroceras* sp. (Pl. 1, Fig. 14) marks the upper part of Whiteavesi or lower part of Freboldi zones where their ranges overlap (Smith et al., 1988).

The middle part of the section (Localities M2ñM6) is Upper Pliensbachian. Its faunal succession indicates the Carlottense Zone, possibly also including the transition from the underlying Kunae Zone. *Lioceratoides* spp. (Pl. 1, Figs. 7, 9) and *Protogrammoceras* spp. (Pl. 1, Fig. 10) occur throughout, whereas *Leptaleoceras* aff. *accuratum* (Fucini) (Pl. 1, Fig. 11) and *Amaltheus* sp. were only found at the lower localities. The occurrence of *Posidonotis semiplicata* Hyatt in the Carlottense Zone (Locality M4) is the highest known record of this bivalve in western Canada. *Fontanelliceras* cf. *fontanellense* (Gemmellaro) (Pl. 1, Fig. 8) and *Canavaria*? sp. (Pl. 1, Fig. 13) were found higher in the Carlottense Zone.

In the upper part of the section (Localities M7 - M8), the first appearance of *Dactylioceras*, represented by *D.* ex gr. *simplex* Fucini (Pl. 1, Fig. 1), marks the base of the Toarcian. *Lioceratoides* spp. range up from the Upper Pliensbachian.

Goat Mountain

A spectacular section of recessive to moderately resistant, thin-bedded, fine-grained Laberge Group sedimentary rocks is exposed on the steep southeast slope of Goat Mtn. (Locality G1; Fig. 5). Reconnaissance collecting was carried out from approximately 100 m of dominantly argillaceous strata with no apparent stratigraphic breaks. The sequence is intruded by a 15 m thick feldspar-phyric andesite sill near the top. Although the base of the section was not seen, the lowermost collections yielded *Dactylioceras* spp. (Pl. 1, Fig. 5) of the lowest Toarcian Kanense Zone of Jakobs et al. (1994). It is followed upsection by an association of *Dactylioceras*? sp. (Pl. 1, Fig. 6), *Hildaites* sp., and *Harpoceras*? sp. juv., indicative of the upper part of Kanense Zone to possibly the lower part of Planulata Zone. A stratigraphically higher level yielded *Phymatoceras* sp., *Peronoceras* sp., and *Collina*? sp., suggesting the Middle Toarcian upper Planulata Zone ranging possibly up to the Crassicosta Zone. Additional specimens collected *ex situ* include *Partschiceras*? sp., *Peronoceras* cf. *verticosum* (Buckman) (Pl. 1, Fig. 2), *Pseudolioceras* ex gr. *lythense* (Young & Bird), *Polyplectus*? sp., and *Denckmannia* sp. These are all consistent with the Lower to Middle Toarcian stratigraphic range. The bivalve *Bositra buchii*? (Roemer) occurs in abundance, forming shell pavements in the higher part of the section. This section is recommended for future detailed collecting and measuring and has the potential to serve as an important reference section for the Lower and Middle Toarcian in northern Stikinia.

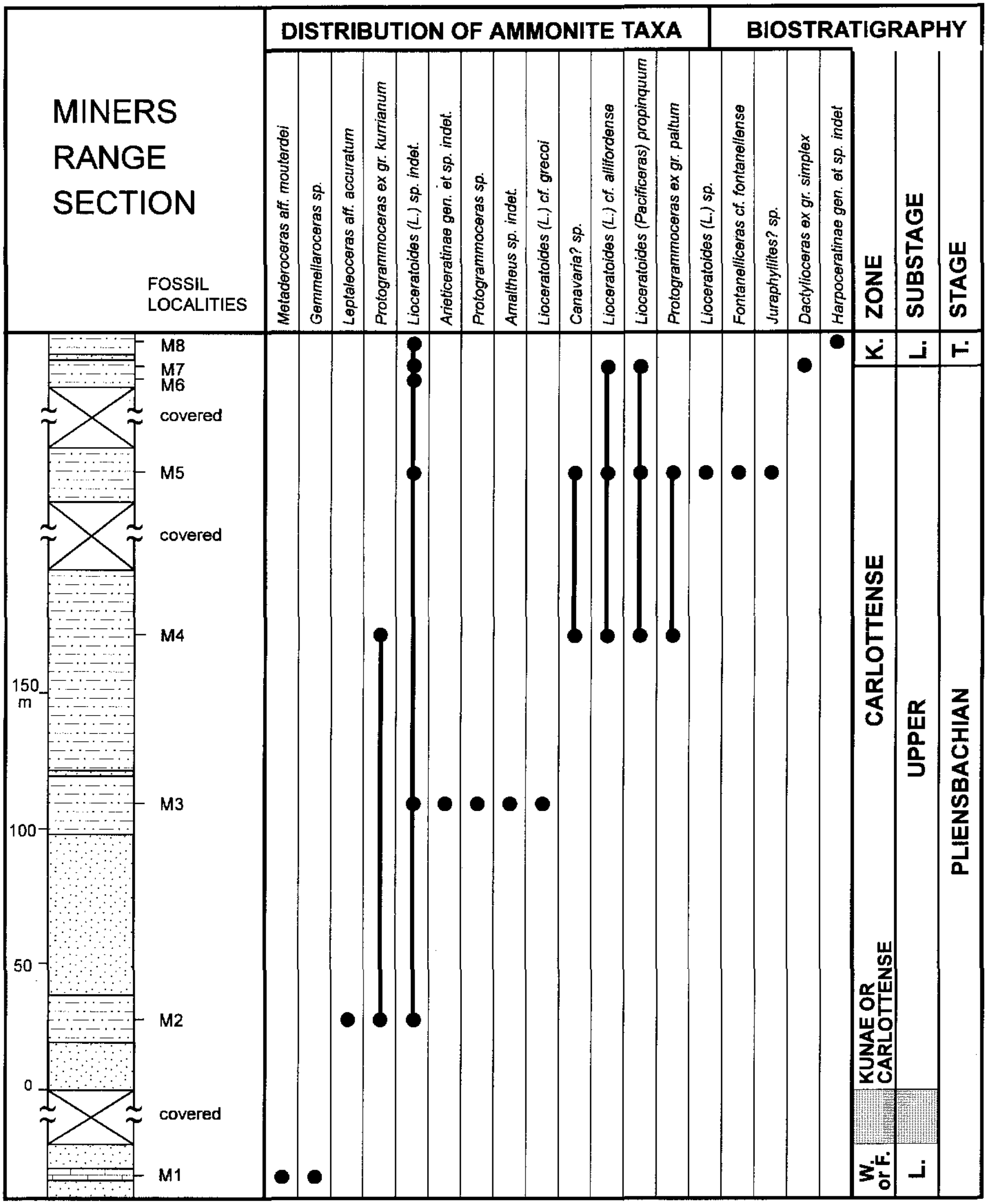

Figure 4: Composite stratigraphic column and biostratigraphy of the Miners Range section. (W. = Whiteavesi; F. = Freboldi; K. = Kanense; L. = Lower; T. = Toarcian.)

Fish Lake – Mount Granger

Another area providing excellent exposures of the Laberge Group is above the south end of Fish Lake west of Mt. Granger. There, the rocks are affected by hornfelsing related to the emplacement of the mid-Cretaceous Mt. Granger pluton and consequently the preservation of ammonites is generally poor. The site was chosen as *Stephanoceras*? sp., the youngest ammonite reported from the Laberge Group (McLearn in Wheeler, 1961) was collected here. Our reconnaissance collection at two localities (F1, F2) yielded *Sonninia*? spp. (Pl. 1, Fig. 3), *Euhoploceras*? sp. (Pl. 1, Fig. 4) and *Bradfordia*? sp. confirming the presence of Lower Bajocian strata.

OVERVIEW OF BIOSTRATIGRAPHY AND CORRELATION

Presented below is a discussion of the biostratigraphic units recognized from the new collections together with a compilation of previously published and recently revised faunal data. Information available from areas adjacent to the Whitehorse map area is also included. Where applicable, both taxonomic revisions and re-interpreted age assignments are discussed. Figure 6 summarizes the biostratigraphy of the Laberge Group in the southern Yukon.

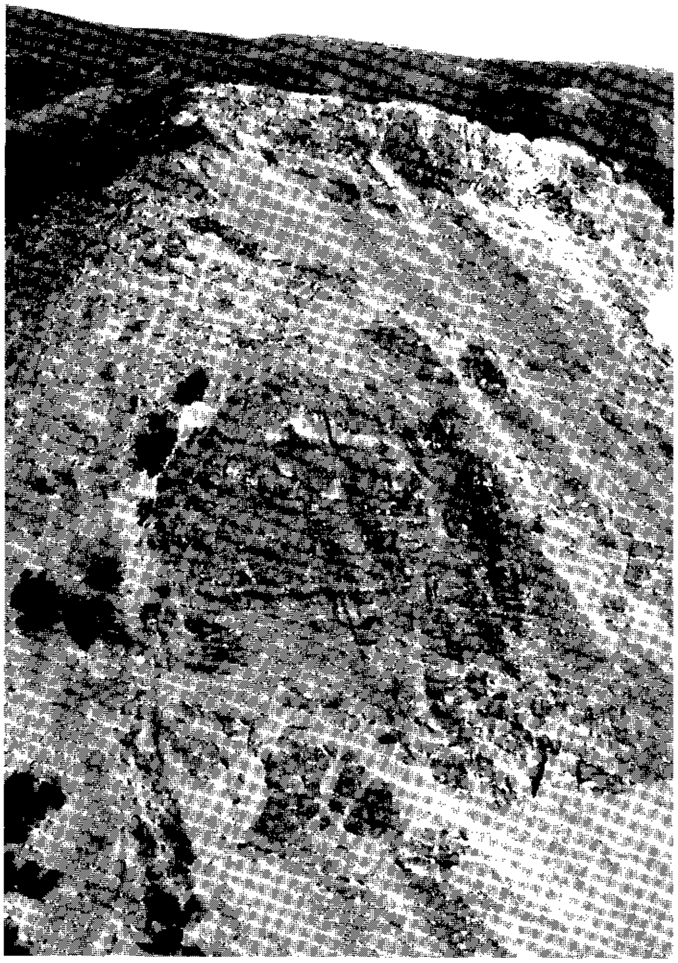

Figure 5: Exposure of fossiliferous Toarcian strata of the Laberge Group on the south slope of Goat Mountain. This view shows approximately 150 m of fine-grained sedimentary rocks capped by an andesitic sill.

Stages and ammonite zones recognized in the Whitehorse map area and adjacent parts of southern Yukon

Hettangian

No unequivocal record of the Hettangian stage exists from the Laberge Group and this study has also failed to provide biostratigraphic proof for oldest Jurassic strata. The identity of specimens described from the Laberge map area by Lees (1934, pl. 6, Figs. 1-4) as *Psiloceras* cf. *erugatus* (Bean) of early Hettangian age was called into question by Frebold (1964). Subsequently, Frebold and Poulton (1977) restudied the material and confirmed its assignment to *Psiloceras*. We speculate that these specimens may alternatively be referred to the Early Pliensbachian genus *Gemmellaroceras*. Representatives of this genus, morphologically similar to the specimens illustrated by Lees (1934), are reported herein from the Whitehorse map area.

Jakobs (1994) compared some poorly preserved ammonites to Hettangian or Sinemurian schlotheimiids but this interpretation remains doubtful due to the unsatisfactory preservation of the specimens.

Sinemurian

The oldest fauna reported in this study consists of *Epophioceras*? sp., indicative of the early Late Sinemurian Varians Assemblage of Pálfy et al. (in press). This assignment remains tentative; a more confident identification is precluded by the flattened preservation and lack of stratigraphic relationships or accompanying other taxa. Homeomorph forms exist among the earliest Sinemurian arietitids and latest Sinemurian echioceratids.

Paracoroniceras cf. *gmündense* (Oppel) described by Frebold (1964, pl. 1, Fig. 7) from the Wheaton River area is difficult to interpret in the lack of stratigraphic relationships or accompanying other forms. It shows greater similarity to *Paltechioceras* occurring in other localities of the Canadian Cordillera in the Upper Sinemurian Harbledownense Assemblage. Poorly preserved echioceratids? and *Juraphyllites* sp. indet. from the northwestern part of the Teslin map area (Jakobs, 1994) probably also indicate the upper part of Upper Sinemurian. "*Arnioceras* sp. near *humboldti* Hyatt" illustrated by Lees (1934, pl. 6, Figs. 5-8) from the Laberge map area is clearly an *Arnioceras*, although a revision of the species assignment has not been attempted. This genus indicates the Lower Sinemurian Arnouldi Assemblage or the Upper Sinemurian Varians Assemblage.

STAGE		NORTH AMERICAN AMMONITE ZONES OR ASSEMBLAGES	NEW DATA (THIS STUDY)	OTHER RECENT DATA	OTHER DATA (UN-REVISED)
BAJOCIAN	L	Oblatum Zone			▒
		Kirschneri Zone			▒
		Crassicostatus Zone	▒		▒
		Widebayense Zone	▒		▒
AALENIAN		Amplectens Zone			
		Howelli Zone		▓	
		Scissum Zone		?	
		Westermanni Zone			
TOARCIAN	U	Yakounensis Zone		▓	
		Hillebrandti Zone			
	M	Crassicosta Zone	▒		
		Planulata Zone	▓		
	L	Kanense Zone	▓		
PLIENS-BACHIAN	U	Carlottense Zone	▓		
		Kunae Zone	▓		
	L	Freboldi Zone	▓		
		Whiteavesi Zone	▓		
		Imlayi Zone			
		Tetraspidoceras Assembl.			
SINEMURIAN	U	*Harbledownense* Assembl.		▒	
		Varians Assemblage	▒		▒
	L	*Arnouldi* Assemblage			▒
		Coroniceras Assembl.			
		Canadensis Zone			
HETTANGIAN		*Doetzkirchneri* Assembl.			
		Franziceras Assembl.			
		Euphyllites Assembl.			
		Psiloceras Assemblage			

Figure 6: Zonal distribution of fossiliferous parts of the Laberge Group in the southern Yukon. Lighter shades indicate lower degree of confidence. Recent data sources: Poulton and Tipper, 1991; Jakobs, 1994; Jakobs and Smith, in press. Unrevised data (from Lees, 1934; and Wheeler, 1961) are shown only if indicative of zones undocumented from other sources.

Pliensbachian

The succession of Pliensbachian ammonites is nearly complete. With the exception of the basal Imlayi Zone, the other four North American zones of Smith et al. (1988) are documented. The Lower Pliensbachian Whiteavesi Zone was recognized from a locality not far from Takhini microvawe tower (H.W. Tipper, written comm., 1994). The lowermost locality in the Miners Range section yielded a fauna near the boundary of the Whiteavesi and Freboldi zones.

The Upper Pliensbachian is well represented in the Takhini - Miners Range area. There the Kunae Zone is characterized by *Amaltheus* cf. *stokesi* (J. Sowerby), *Arieticeras* spp. and *Leptaleoceras* sp. It is noted that certain beds are dominated by *Amaltheus* whereas others contain only abundant Arieticeratinae (in one case also *Phylloceras*), possibly recording alternating immigration events of Boreal and Tethyan ammonite populations. In the Miners Range *Leptaleoceras* aff. *accuratum* (Fucini) co-occurs with *Lioceratoides* sp. Elsewhere in North America *Leptaleoceras* is restricted to the Kunae Zone whereas *Lioceratoides* first appears in the Carlottense Zone (Smith et al., 1988). Resolving this correlation problem is difficult as *Fanninoceras*, which includes index species of both zones, has not been found in the Yukon. *Lioceratoides* and *Protogrammoceras*, both represented by several species, occur throughout the Carlottense Zone in the Whitehorse map area, whereas *Fontanelliceras* cf. *fontanellense* together with *Canavaria*? sp. were found in the upper part of the zone. In North America, they were previously thought to be restricted to the Kunae Zone (Smith et al., 1988; Smith and Tipper, in press). In the northwest Pacific (Japan and the Russian Far East), however, they were recorded from higher levels co-occurring with *Dactylioceras* (Repin, 1988; Sato and Westermann, 1991). An association of *Fontanelliceras fontanellense* and *Dactylioceras* spp. was reported from western Tethyan localities in Morocco, interpreted as earliest Toarcian in age (Guex, 1973). The worldwide stratigraphic distribution of *Fontanelliceras* and *Canavaria* thus also supports that these genera are not restricted to the early Late Pliensbachian.

Ammonites from several other Upper Pliensbachian localities were figured by Frebold (1964, 1970). A list of localities with revised zonal age assignments can be found in Smith et al. (1988: Table 2).

Toarcian

The Pliensbachian-Toarcian transition is contained within the Miners Range section. The base of the Toarcian is drawn at the first appearance of *Dactylioceras*, here represented by *D.* ex gr. *simplex* Fucini. The significance of this species and its occurrences was recently discussed in detail by Jakobs et al. (1994) who erected the Kanense Zone as the basal Toarcian standard zone in North America. *Dactylioceras kanense* McLearn was taken to indicate the lowest Toarcian faunal level known with certainty from measured sections. Jakobs et al. (1994) recognized that *D. simplex* may represent a horizon below *D. kanense* but did not include it in the range chart of North American Toarcian ammonites because of its poorly constrained record. *Lioceratoides*, known to range through the Pliensbachian-Toarcian boundary, is abundant in the Miners Range section which we propose as an important reference section for this stratigraphic interval. Further collecting is necessary to decide whether *D.* ex gr. *simplex* is in fact older than *D. kanense*, which was not found during this study.

Fossiliferous Lower and Middle Toarcian strata occur in the Goat Mountain section. The presence Kanense and Planulata zones is confirmed by a succession of moderately diverse ammonite assemblages, including *Dactylioceras* spp., *D.*? sp., and *Hildaites* sp. The Crassicosta Zone may also be present in the higher part of the section as indicated by the occurrence of *Phymatoceras*, *Peronoceras*, and *Denckmannia*?. Younger Toarcian faunas have not been indentified in our collections. Jakobs and Smith (in press) document the uppermost Toarcian Yakounensis Zone based on re-identification of specimens from the Whitehorse map area illustrated by Frebold (1964) and listed in Wheeler (1961) and additional specimens reported in unpublished GSC fossil reports. Jakobs and Smith (in press) list *Dumortieria*? sp. indet. from the Whitehorse map area and *Yakounia*? sp. indet. from the Laberge map area.

Aalenian

Aalenian ammonites are not yet known from the Whitehorse map area. Sparse occurrences (*Planammatoceras*? and *Tmetoceras*) in the Laberge map area suggest that Aalenian strata are present but probably not thick (Poulton and Tipper, 1991).

Bajocian

The youngest assemblage found in the course of this study is the Early Bajocian fauna from the Fish Lake - Mt. Granger area. Its zonal assignment remains uncertain. *Sonninia*? spp. are comparable with sonniniids reported from the Widebayense Zone in north-central British Columbia (Hall et al., 1991). The very poorly preserved specimen of *Bradfordia*? sp. bears resemblance to *Bradfordia costidensa* Imlay, known from the superjacent Crassicostatus Zone of Alaska (Imlay, 1964).

The presence of *Stephanoceras*? sp. (Wheeler, 1961) has not been confirmed. In North America, *Stephanoceras* and closely related genera range from the Lower Bajocian Widebayense Zone to the Oblatum Zone (Hall and Westermann, 1980).

There is no occurrence of Late Bajocian or younger ammonites known from the Laberge Group in the southern Yukon.

DISCUSSION AND CONCLUSIONS

Using ammonite biostratigraphy, the age of Laberge Group strata in the Whitehorse map area is constrained to Sinemurian to Bajocian, with good representation from most stages. In the Takhini area the lowermost progradational conglomeratic pulse directly overlies the Sinemurian siltstone sequence at Horse Creek. Finer-grained clastic rocks with Late Pliensbachian fauna in turn overlie a thick succession of conglomerate. Therefore the Takhini conglomeratic wedge is Late Sinemurian to Late Pliensbachian in age. Dacite tuff of the Nordenskiold formation is Late Pliensbachian in age.

Collections from the Fish Lake syncline (Mount Granger-Fish Lake and Goat Mountain localities) were obtained from fine-grained clastic strata stratigraphically above, or distal to the thick conglomeratic wedge. Rocks from the core of the syncline yielded Lower Bajocian faunal assemblages suggesting that the thick conglomeratic wedge was deposited prior to this time. The fine-grained section at Goat Mountain is Toarcian in age and suggests that this was either a time of fine-clastic deposition or that this section represents a distal fan facies coeval with conglomerate deposition. These constraints provide only an upper age limit for the timing of conglomerate deposition but indicate a late Early to Middle Jurassic age for strata in the Fish Lake syncline. Laberge Group strata in the Fish Lake syncline are disconformable upon Lewes River Group, but the age of the base of the Laberge Group here remains unconstrained.

Laberge Group conglomerate in the Takhini and Fish Lake areas represent two fans each deposited from its distinct point source (Dickie, 1989). The limited fossil evidence suggests that the two fans may have been deposited at different times in the Jurassic. Pending confirmation by further sampling, we propose that coarse-clastic deposition in Whitehorse Trough was not in response to a single sea-level change (eustatic or tectonic), but a result of several events during Early and Middle Jurassic time. No coarse clastic sediments are recognized to be younger than Toarcian.

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Appendix 1

Fossil Locality Register

For the localities mentioned in the text, the following information is listed: GSC locality number, NTS map sheet reference, UTM easting, UTM northing, geographic description, *in situ/ex situ*, interpreted age (zone/assemblage and stage).

F1: C-210916; 105D/11; 485450; 6712550; Slope of cirque 1.2 km NW of Mt. Granger; *ex situ*; Lower Bajocian.

F2: C-210917; 105D/11; 485600-485800; 6712250-6712450; Ridge 1.5 km NNW of Mt. Granger; *ex situ*; Lower Bajocian.

G1: C-210915; 105D/6; 498400-498550; 6698000-6698200; SSE trending spur 1.75 km ENE of Goat Mtn.; some *in situ*, others *ex situ*; Kanense to lower Crassicosta? zones, Lower to Middle Toarcian.

H1: C-108238, same as C-210901; 105D/14; 490670; 6760410; N of Horse Creek, 300m E of Hwy 2, small cliffs on N side of gravel road; *in situ*; Varians Assemblage?, Upper Sinemurian?

M1: C-108244, same as C-210913; 105D/14; 482540; 6758180; Miners Range, 4.6 km SE of Flat Mtn.; both *in situ* and *ex situ*; upper Whiteavesi to lower Freboldi Zone, Lower Pliensbachian.

M2: C-210914; 105D/14; 483380; 6757520; Miners Range, 5.4 km SE of Flat Mtn.; *in situ*; Carlottense Zone, Upper Pliensbachian.

M3: C-210912; 105D/14; 483300; 6757400; Miners Range, 5.5 km SE of Flat Mtn.; *in situ*; Carlottense Zone, Upper Pliensbachian.

M4: C-210911; 105D/14; 483270; 6757310; Miners Range, 5.5 km SE of Flat Mtn.; *in situ*; Carlottense Zone, Upper Pliensbachian.

M5: C-108249, same as C-210910; 105D/14; 483390; 6757000; Miners Range, 6.1 km SE of Flat Mtn.; *in situ*; Carlottense Zone, Upper Pliensbachian.

M6: C-210907; 105D/14; 483880; 6756890; Miners Range, 6.5 km SE of Flat Mtn.; *in situ*; upper Carlottense Zone, uppermost Pliensbachian.

M7: C-210908; 105D/14; 483885; 6756890; Miners Range, 6.5 km SE of Flat Mtn.; *in situ*; lower Kanense Zone, lowermost Toarcian.

M8: C-210909; 105D/14; 483890; 6756890; Miners Range, 6.5 km SE of Flat Mtn.; *in situ*; Kanense Zone, Lower Toarcian.

M9: C-210906; 105D/14; 483850; 6756800; Miners Range, 6.5 km SE of Flat Mtn.; *ex situ*; upper Carlottense Zone to lower Kanense Zone, uppermost Pliensbachian to lowermost Toarcian.

T1: C-203068, same as C-210904; 105D/14; 488020; 6753520; small outcrop on hillside 50 m N of Microwave Tower; *in situ*; Kunae Zone?, Upper Pliensbachian?

T2: C-203053, same as C-210902; 105D/14; 487700; 6753595; small outcrop on N side of road to Microwave Tower; *in situ*; Kunae Zone, Upper Pliensbachian.

T3: C-210903; 105D/14; 487620; 6753595; small outcrop on N side of road to Microwave Tower; *in situ*; Kunae Zone, Upper Pliensbachian.

GEOLOGY OF THE MOUNT M'CLINTOCK MAP AREA (105D/16), SOUTHERN YUKON TERRITORY

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HART, C.J.R., and HUNT, J.A., 1995. Geology of the Mount M'Clintock map area (105D/16), southern Yukon Territory. In: Yukon Exploration and Geology, 1994, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 87–104.

Abstract

The Mount M'Clintock map area, northeast of Whitehorse, is dominated by Middle Triassic to Jurassic sedimentary and volcanic strata of Stikinia with small portions of the Cache Creek and Yukon-Tanana Terranes. These assemblages were deformed prior to the mid-Cretaceous intrusion of three plutonic suites and the deposition of two suites of volcanic rocks.

Sedimentary rocks previously mapped as undifferentiated Lewes River and Laberge group strata are separated into their respective groups and further sub-divided into several members. Lewes River Group rocks form three units that are Carnian and older, Norian, and Upper Norian in age and are represented by siliceous siltstone and calcareous sandstone, conglomerate and limestone respectively. Laberge Group strata are divided according to lithology and dominated by siltstone-sandstone couplets and massive siltstone with lesser conglomerate and volcanogenic sandstone. Volcanic rocks previously mapped as Hutshi Group are divided into the dominantly mafic and submarine, Middle Triassic Joe Mountain volcanic complex (JMVC) and the dominantly felsic and sub-aerial Mount Byng volcanic complex (BCVC). The volcanic and sedimentary rocks generally increase in age from Middle Triassic to Jurassic from west to east across the map area

Plutons cutting these strata belong to the M'Clintock Lakes (120 Ma), the Whitehorse (115 Ma), and the Mount McIntyre (109 Ma) plutonic suites. The predominantly felsic fragmental rocks of the BCVC are genetically associated with the Byng Creek pluton of the Mount McIntyre plutonic suite. The BCVC is nested into the country rocks and its eastern margin and is preserved as the rim of a tilted cauldera.

Strata of the Laberge and Lewes River groups are folded throughout. Wavelengths are on the order of approximately 1-2 km, but are much tighter in black siltstone units and adjacent to northwest-trending faults. Faults are ubiquitous throughout the map area and form three sets. North-trending faults are the most common. They are spaced a few kilometres from each other and dictate the physiography and drainage of the region. Northwest-trending faults, in the northeastern corner of the map area control the Teslin River valley and juxtapose Yukon-Tanana rocks with Stikinia. Older faults are dominantly east-trending but are terminated or reactivated by younger faults.

Copper (gold-molybdenum-tungsten) skarns and gold-bearing quartz veins are the two mineral deposit types most likely to be discovered in the map area. The source of the placer gold in Sheldon Creek is unknown but may be related to gold veins in the JMVC, BCVC, Sheldon Creek volcanics or the surrounding sedimentary rocks. Hydrothermal activity in the JMVC is characterized by orange weathering alteration, breccias, and carbonate veins. Cache Creek rocks in the southern part of the map area are targets for listwaenite associated gold veins.

INTRODUCTION

The Mount M'Clintock map area (105D/16), in the northeastern corner of the Whitehorse map area (105D), was geologically mapped in 1994 as part of the second phase of the Whitehorse Geological Mapping Project (WGMP). Initiated in 1987, the WGMP encompasses 1:50 000 geological mapping of the south-central and northern parts of the Whitehorse map sheet (Fig. 1). The first phase of mapping covered regions with significant mineral potential in the Wheaton River, Carcross and Whitehorse areas. This second phase of the project provides maps of the northern portion of the Whitehorse map area (105D/13-16) which will: 1) identify geological settings potentially favourable for hosting mineral occurrences; and 2) provide a geological transect across the Stikinia geological province. The Thirty-seven Mile Creek map-sheet (105D/13) was geologically mapped during 1992 (Hart and Brent, 1993, Hart, 1993) and the sheet immediately west of the present map area, Joe Mountain (105D/15) was mapped in 1993 (Hart and Hunt 1994a, 1994b). Geological mapping of 105D/14 is currently ongoing. This report accompanies the geological map Open File 1995-4(G) (Hart and Hunt, 1995).

Mapping in the Mount M'Clintock map area by Wheeler (1961), identified the presence of three main rock units: 1) undifferentiated Upper Triassic to Jurassic Lewes River and Laberge Group sedimentary rocks (Whitehorse Trough); 2) Hutshi Group volcanic rocks; and 3) granitic rocks. Revision mapping advances the understanding of the geology of this region by: 1) separating out the Lewes River and Laberge groups and members within these groups; 2) separating middle Triassic and mid-Cretaceous volcanic complexes from the Hutshi Group; and 3) recognizing three plutonic suites among the granitic rocks.

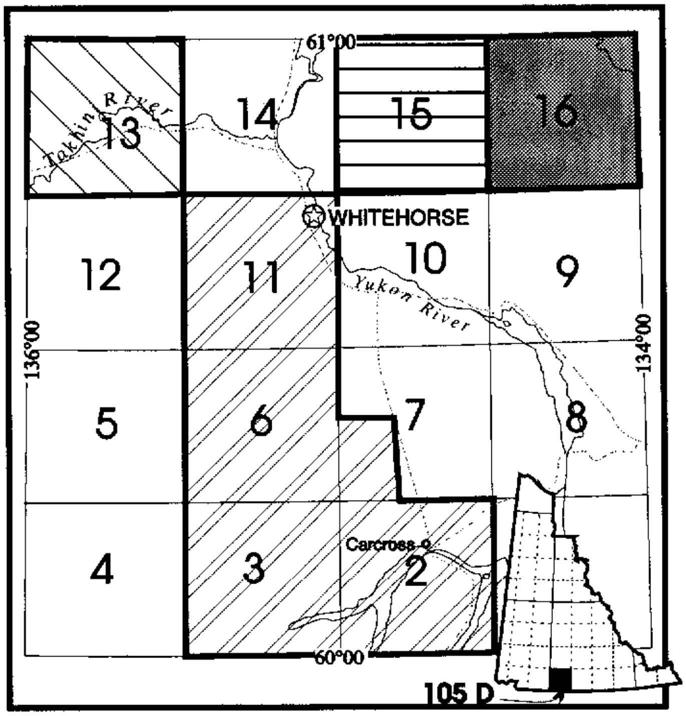

Figure 1: Within Whitehorse map area (105D) there are sixteen 1:50 000 scale map areas (numbered). Shaded areas denote previous mapping endeavors of the Whitehorse Geological Mapping Project with open file maps and reports as follows: 1) double diagonal lines (Hart and Radloff, 1990); 2) single diagonal lines. (Hart, 1993, Hart and Brent, 1993); 3) horizontal lines (Hart and Hunt, 1994a, b); and 4) dark shading, Mount M'Clintock map area (this report and Hart and Hunt, 1995).

Location references in the text are commonly made with respect to spot elevations listed for numerous mountain peaks on the 1:50 000 topographic map.

PREVIOUS WORK AND ACCESS

Reconnaissance-scale geological maps that include the Mount M'Clintock map area were produced by Cockfield and Bell (1926, 1944) and Wheeler (1961). More recent geological mapping of the adjacent Laberge (to the north) and Teslin (to the east) map-areas by Tempelman-Kluit (1984) and Gordey and Stevens (1994) respectively have advanced the understanding of the regional geology. Detailed investigations of rock units in the Mount M'Clintock area have been undertaken by Bremner (1991) and Schönicke and Weihe (1992).

Despite its close proximity to Whitehorse and the presence of placer gold, the Mount M'Clintock map area has seen little mineral exploration. Regional scale exploration programs and minor staking were undertaken by United Keno Hill Mines in 1975, Hudson Bay Mining and Smelting in 1979 and by Agip Resources Ltd. and Dupont Exploration in 1981. Regional geochemical silt sampling of 105D was undertaken by the Geological Survey of Canada (1985) and anomalies revealed by that program initiated a small amount of claim-staking in the Mount M'Clintock map area.

The Mount M'Clintock sheet is traversed by the northernmost extent of the M'Clintock (or Mitchie Lake) road. A branch of the road parallels the southern limit of the map area where it heads east through the valley just north of Augusta Mountain. Another branch trends north and follows Byng Creek to the top of its drainage where it continues into upper Sheldon Creek and down to the placer workings there. The quality of the road up Byng Creek has deteriorated and is locally badly rutted, muddy, washed out and overgrown. It is passable, with difficulty, using all-terrain, tracked or multi-wheeled vehicles. A trail shown on older maps leading from the Teslin River to Sheldon Creek is completely overgrown. Rapid, cost effective, helicopter access from Whitehorse, 60 km to the southwest, was best suited for this mapping project.

PHYSIOGRAPHY AND GLACIATION

Mount M'Clintock map area is in the northeast portion of the Teslin Plateau physiographic region (Mathews, 1986), is characterized by rolling mountains and upland plateaus dissected by steep-sided valleys. Two broad, linear, north-trending upland plateaus between 1600 and 1800 m elevation are separated by the

Byng Creek valley and flanked to the west and east by the M'Clintock Lakes/River and Teslin River and valleys, respectively. The northwestern portion of the map-sheet is dominated by jagged mountains characterized by cirques and arêtes. Approximately 1400 m in local relief separate the highest point in the map-area (Mount Byng at 2089 m) from the Teslin and M'Clintock River valleys at approximately 700 m. We noted a strong correlation between rock type and physiography. Volcanic rocks are typically high and craggy, plutonic rocks form reasonably high-standing (1500 m) plateaus and sedimentary rock units underlie long ridges with muted topographic expression.

The Mount M'Clintock map sheet has been extensively glaciated. Glacial straie indicate that ice sheets moved north up the M'Clintock Lakes valley and northwesterly out of the Teslin River valley and across the map area. Glacial deposits are extensive below 1400 m which is the approximate elevation of tree-line.

TECTONIC SETTING

Yukon Territory southwest of the Tintina Fault consists primarily of fault-bounded crustal fragments, or terranes, that accreted to the ancient North American margin during Mesozoic time. Rocks underlying the study area belong to a crustal fragment known as Stikinia as well as small portions of Cache Creek and Yukon-Tanana Terranes. Stikinia comprises a northwest-trending belt of Upper Triassic volcanic rocks and Upper Triassic and Jurassic sedimentary rocks (Fig. 2; Tempelman-Kluit, 1979). The volcanic rocks belong to the Lewes River Group and are interpreted to have formed as an island arc (the Lewes River arc). The sedimentary rocks of the Lewes River and Laberge groups constitute more than seven kilometres of arc-derived basin fill, which defines the Whitehorse Trough (Hart et al., in press; Dickie, 1989 and references therein). Geological investigations of Whitehorse Trough strata have shown it to be lithologically diverse, stratigraphically complex and dominated by abrupt facies changes (Tozer, 1958; Wheeler, 1961; Tempelman-Kluit, 1984; Reid and Tempelman-Kluit, 1987; Dickie, 1989; Dickie and Hein, 1988, 1992).

Cache Creek Terrane is composed of an Upper Paleozoic oceanic assemblage dominated by mafic volcanic rocks and overlying sedimentary rocks with minor, but important occurrences of ultramafite. Yukon-Tanana Terrane is composed of Paleozoic and older metasedimentary and metaigneous rocks that include an older member known as the Nisling assemblage.

Mesozoic tectonism resulted in folding and faulting of Stikinian volcanic and sedimentary packages against one another, and with other crustal fragments (Fig. 2). Stikinia is in fault contact with the accreted Cache Creek and Yukon-Tanana terranes that collectively compose the Intermontane Superterrane.

Magmatism during mid- and Late Cretaceous time resulted in the emplacement of numerous plutons and the deposition of extensive coeval volcanic successions within and above the deformed crustal fragments. Regional stresses during Late Cretaceous to Eocene time reactivated old faults and created new series of north and northwest-trending strike-slip faults.

REGIONAL GEOLOGY

Rocks in the map area are divisible into "Pre-Cretaceous" and "Cretaceous" constituents. Pre-Cretaceous rocks are those that define the terranes. Cretaceous rocks were deposited after terrane accretion and may overlap several terranes.

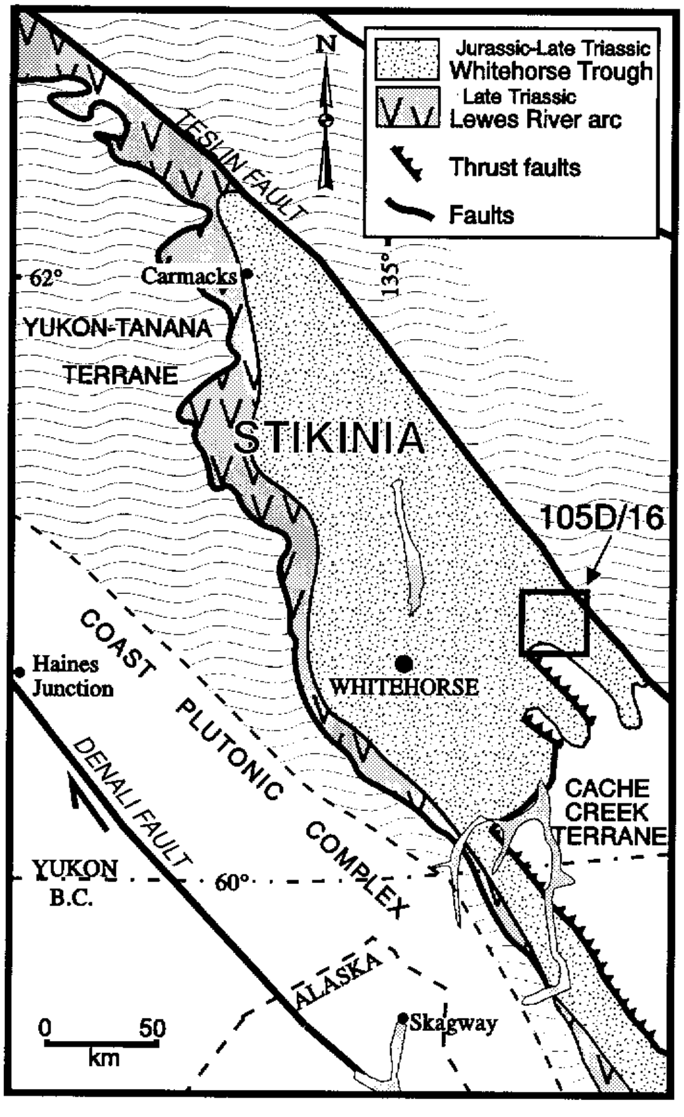

Figure 2: The regional tectonic setting of southern Yukon with the map area outlined. The map area is underlain primarily by the Whitehorse Trough rocks of Stikinia but also includes small portions of Cache Creek and Yukon-Tanana Terrane.

PRE-CRETACEOUS ROCKS OF MOUNT M'CLINTOCK MAP AREA

Portions of three terranes are represented in the Mount M'Clintock map area (Fig. 3). Yukon-Tanana and Cache Creek terranes are represented by rocks of the Nisling assemblage and Cache Creek Group receptively. Stikinia is represented by rocks of the Lewes River and Laberge Groups (Fig. 4). Rocks of the Joe Mountain volcanic complex have affinities to both Stikinia and Cache Creek and, in light of this discrepancy, are not affiliated.

Nisling Assemblage

A small region in the extreme northeastern part of the map area is underlain by steep southwesterly-dipping brown and pink quartzite, and quartz mica schist associated with the Nisling assemblage of the Yukon-Tanana Terrane (cf. Wheeler and McFeely, 1991). These rocks are separated from Laberge Group strata of Stikinia by a northwest-trending, strike-slip(?) fault. Age constraints for this rock package, from outside of the map area, suggest that they are pre-Devonian in age.

Cache Creek Group

The western part of the southernmost margin of the map area is underlain by rocks attributed to the Cache Creek Terrane. This package includes tectonized ultramafic rocks, diorite and altered basalt that are locally cut by dykes of younger granitic rocks. Massive, dark-green, very fine grained, non-magnetic diorite occurs on the slopes overlooking the southern M'Clintock Lakes. These rocks are strongly chloritized, contain epidote and are cut by numerous white veins whose composition is unknown. The south-central part of the map area contains poor exposures of massive, dark-green, variably altered, aphyric basalt with associated fine-grained gabbro are cut by numerous dacite dykes of the Byng Creek volcanic complex. The ultramafic rocks weather bright orange and are composed of serpentinized peridotite cut by numerous shears. These rocks are confidently correlated with similar rocks immediately south of the map area which likely belong to the Cache Creek Terrane. The basalt and diorite may belong to the Joe Mountain volcanic suite but their proximity to the ultramafic rocks and the lack of additional constraining data preclude a definitive correlation.

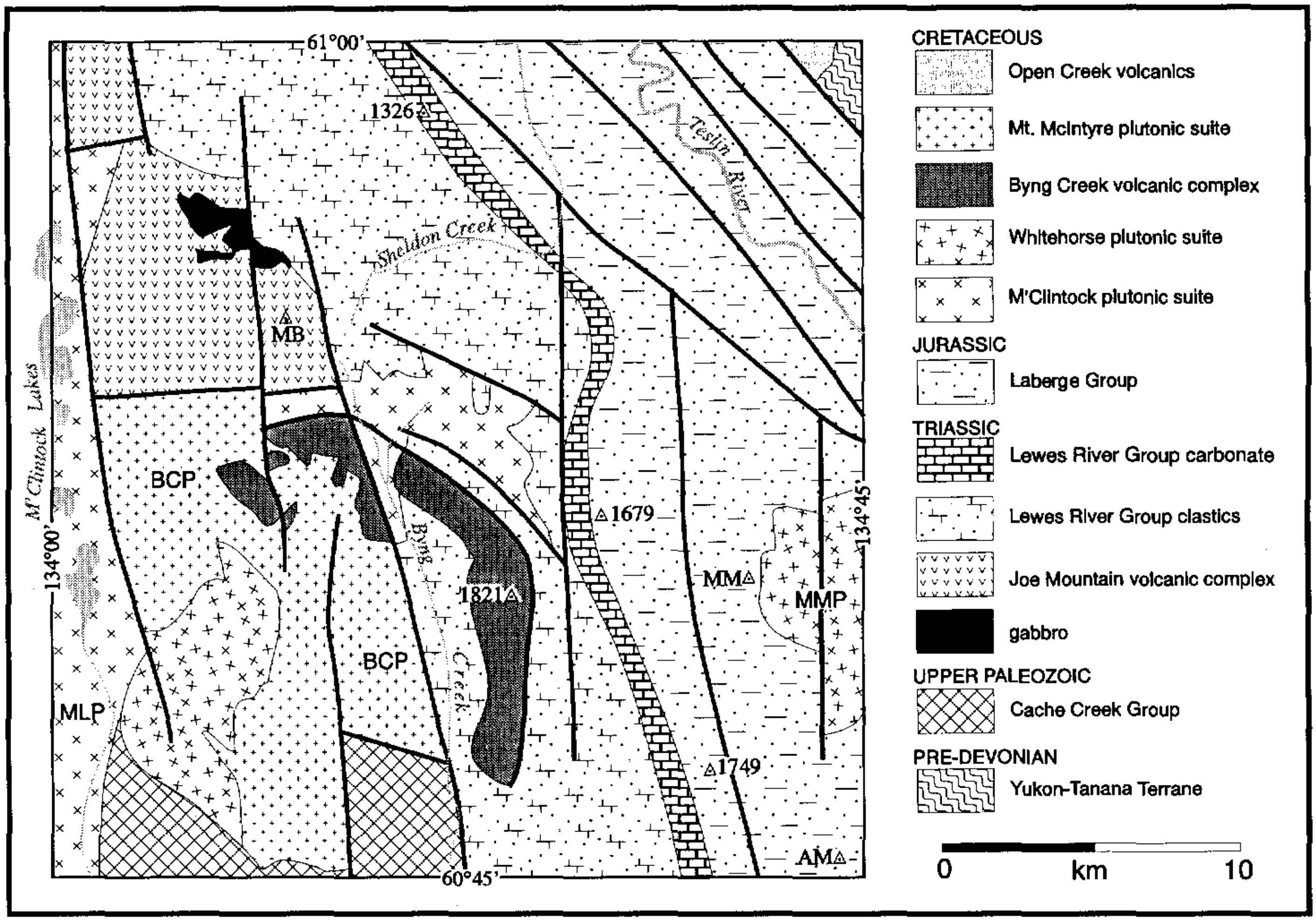

Figure 3: Generalized geological map of the Mount M'Clintock (105D/16) map area. MB=Mount Byng, MM=Mount M'Clintock, AM=Augusta Mountain, BCP=Byng Creek Pluton, MLP=M'Clintock Lakes Pluton, MMP=Mount M'Clintock Pluton.

Joe Mountain Volcanic Complex

The high-standing massif in the Mount Byng region is largely underlain by mafic volcanic rocks and intrusive equivalents of the Joe Mountain volcanic suite as defined by Hart and Hunt (1994a, 1994b). Together, these rocks from the Mount Byng and Joe Mountain areas comprise the Joe Mountain volcanic complex (JMVC). In the map area the Joe Mountain volcanics are generally in fault contact with adjacent units, however a few kilometres north of Mount Byng the volcanics are in apparent depositional contact on top of poorly exposed, recessive, clastic and calcareous sedimentary rocks. Rocks of the JMVC are intruded by the M'Clintock Lakes granite in the M'Clintock Lakes valley and near Mount Byng they are intruded by the Mount Byng felsite.

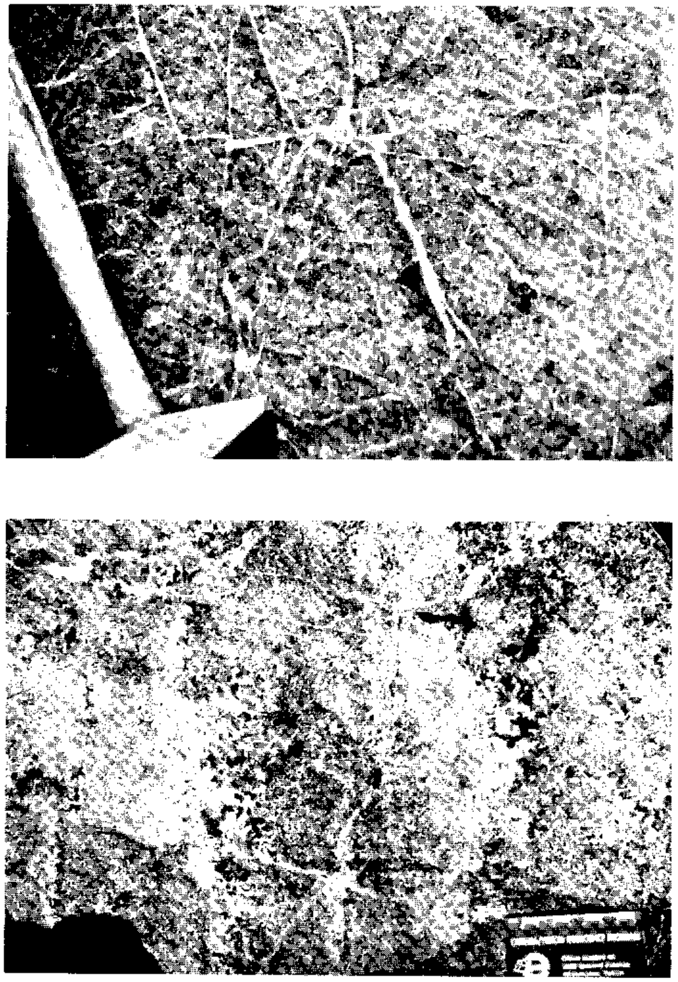

Figure 5: Typical rock types in the Joe Mountain volcanic complex from the Mount Byng area: a) (top) Microdiorite is characterized by a cross-cutting network of thin white veinlets (albite?). b) Variably textured, coarsely crystalline pyroxene gabbro intrudes the Joe Mountain microdiorite and is indicative of an unstable thermal environment associated with high-level intrusion.

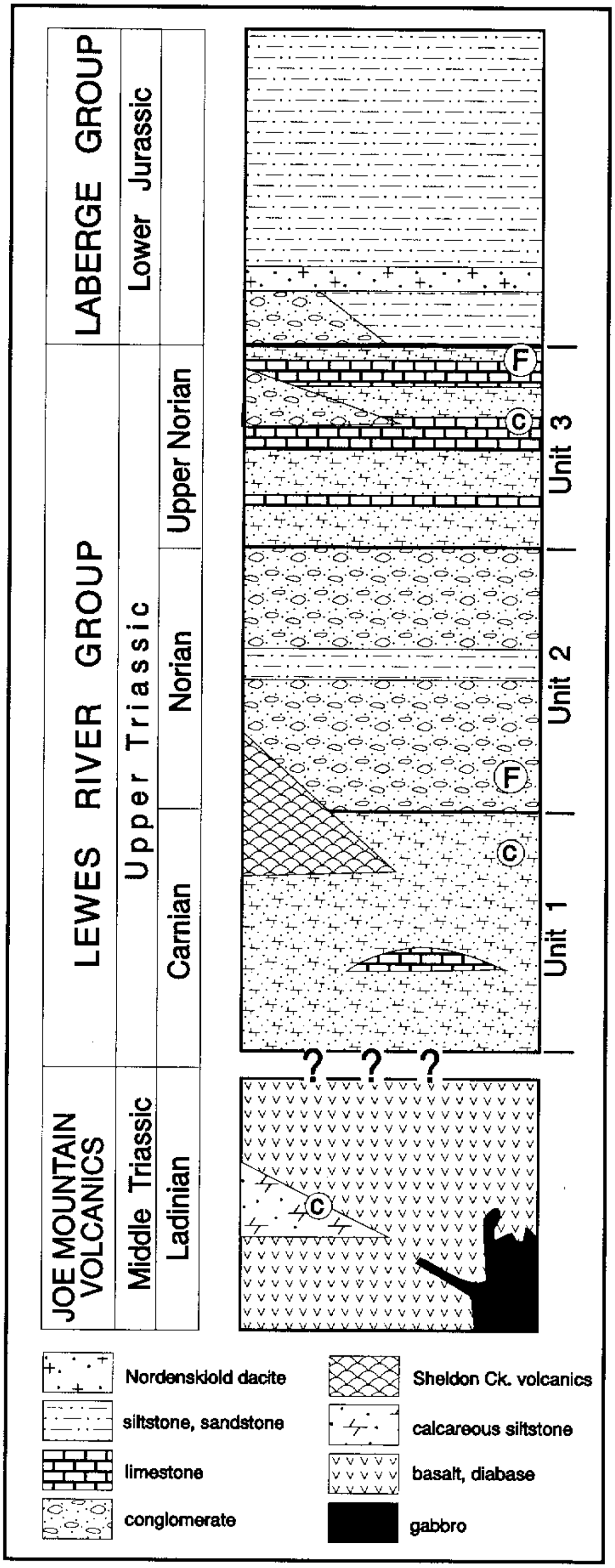

Figure 4: (Left) Generalized stratigraphic section of Stikinia in the map area. (c = conodont; F = macrofossil)

The JMVC is composed of extrusive volcanic flows and subvolcanic intrusions of microdiorite and gabbro. The volcanic ("Young Pillows" of Hart and Hunt, 1994a, 1994b) and sub-volcanic rocks are dominated by variably altered, locally pillowed andesitic and basaltic brecciated flows, massive microdiorite and diabase. The rocks are massive, dark weathering, generally non-magnetic, fine to medium grained, aphyric and locally feldspar-, or pyroxene-phyric (Fig. 5a). Subvolcanic phases are cut by networks of thin white veinlets of an unknown mineral (albite?). The thickness of the JMVC is unknown, but its distribution in the map area suggests a thickness in excess of 500 metres.

Coarse-grained and texturally variable pyroxene gabbro underlies and intrudes the microdiorite where it is exposed over much of the upland plateau north and west of Mount Byng (Fig. 5b). The gabbro is recognized by its leucocratic weathering and coarse-grained nature. Locally, coarse-grained anorthositic and pyroxenite bodies are associated with the gabbro.

Although common in the JMVC in the Joe Mountain map area (105D/15), pillows, associated extrusive textures and interbedded sedimentary rocks are rare in the Mount M'Clintock map area. This suggests that the volcanic succession in the Mount M'Clintock area is largely sub-volcanic or hypabyssal and may represent the roots or proximal source of the volcanics. The textural variation and intrusive relationship of the gabbro with the microdiorite indicates that the gabbro likely represents the hypabyssal portion of the magma chamber that fed the Joe Mountain volcanic suite. These relationships suggest that these rocks formed a volcanic complex — herein referred to as the Joe Mountain volcanic complex.

Several samples of calcareous sedimentary rocks interbedded with the Joe Mountain volcanics in the Joe Mountain map area yielded Middle Triassic conodonts (M. Orchard, written comm., 1994). A model whole-rock Rb-Sr date from andesite yielded an upper Permian age of 252±10 Ma (Bremner, 1991) but lack additional constraining points. K-Ar whole-rock analysis of the andesite and the gabbro gave ages of 143±5 and 168±6 respectively (Bremner, 1991) indicating that the rocks have been affected by younger thermal events. Nevertheless, the Middle Triassic age of this rock package is consistent with its stratigraphic position.

Rocks of the Joe Mountain volcanic suite are therefore dissimilar to, older than, and not in depositional contact with volcanic rocks of the Lewes River Group, and are therefore not included with the Lewes River Group. Their assignment as members of Stikinia is also in question since: 1) the rocks are along strike with volcanic rocks associated with Cache Creek Terrane rocks; and 2) the volcanic rocks have lithological similarities to Cache Creek rocks south of Carcross (described by Hart and Pelletier, 1989), but Middle Triassic volcanic rocks in Cache Creek Terrane are as yet, unknown.

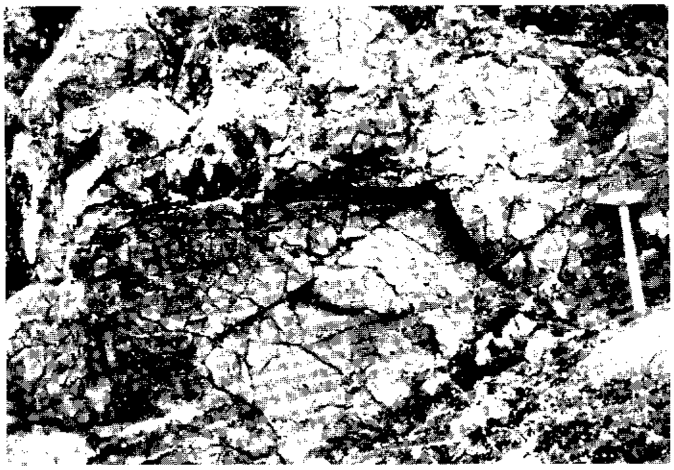

Figure 6: Pillowed and autobrecciated basalt with hyaloclasite, now bleached and silicified, of the Sheldon Creek volcanics.

Lewes River Group

The Lewes River Group in the map area is composed of the Sheldon Creek volcanic rocks and a thick assemblage of sedimentary rocks. The sedimentary portion of the Lewes River Group was termed the Aksala Formation by Tempelman-Kluit (1984). Within the map area, three units are defined as members of the Aksala Formation (Fig. 4).

Sheldon Creek Volcanic Rocks

Resistant exposures of volcanic flows and volcaniclastics underlie approximately 5 km^2, south of Sheldon Creek. The volcanic rocks underlie conglomerate attributed to the upper package of the Aksala Formation. The base of the volcanics was not observed. The volcanics are dominated by slightly rusty-orange weathering, massive and brecciated, locally pillowed, submarine flows of pale green basaltic andesite overlain by hyaloclastic breccia and tuff (Fig. 6). The rocks are unusually light in colour, locally have a conchoidal fracture, and ghosted fragmental textures were observed in apparently massive volcanics. These features suggest that these rocks have been intensively bleached and silicified.

The upright nature of the pillows confirm that the package is not overturned. The age of these rocks is not directly known, but they appear to underlie Upper Triassic Lewes River Group conglomerate. These volcanic rocks are unlike those of the Joe Mountain volcanic complex and Povoas Formation and are therefore uncorrelatable.

Aksala Formation

The dominantly sedimentary portion of the Lewes River Group has been called the Aksala Formation by Tempelman-Kluit (1984). These rocks outcrop along a north-northwesterly-trending belt that extends through the central part of the map area. The lower contact of the these rocks is not exposed, but they were likely deposited upon volcanic rocks of the Joe Mountain volcanic suite. The Aksala Formation is lithologically variable and divisible into three time-stratigraphic packages.

Figure 7: A >500m thick section of Unit 1 Lewes River Group strata is capped by well-bedded and resistant sandstone. The east-facing cliff, near Mount Byng, results from uplift in the north-trending fault in the valley in the foreground.

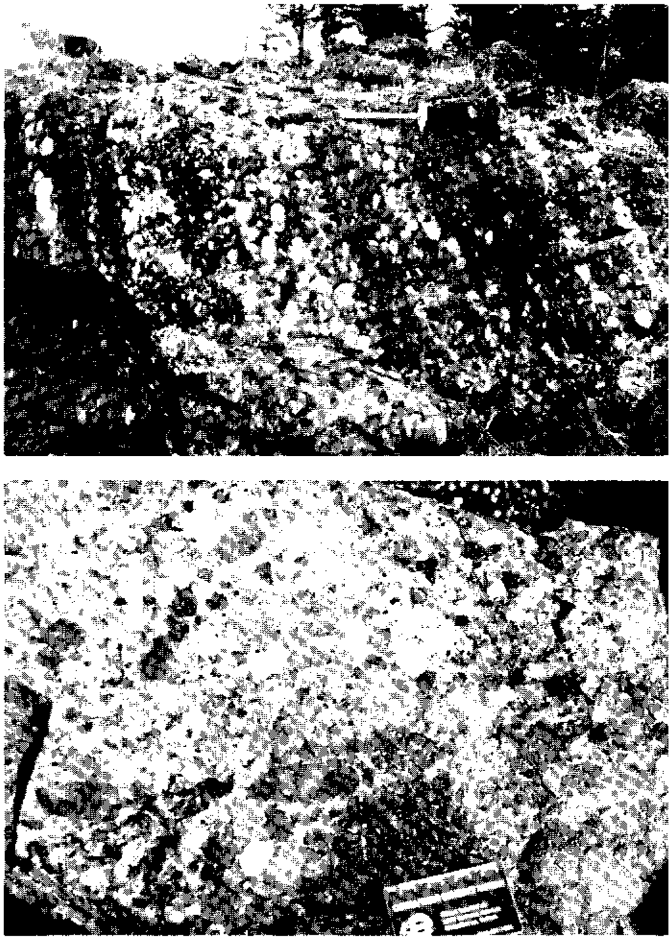

Figure 8: a) (top) Limestone-cobble conglomerate comprises a substantial proportion of Unit 2 strata in Lewes River Group but the clast source beneath this strata is unknown. b) This Unit 2 polymictic conglomerate resembles Laberge Group but is stratigraphically beneath the upper Norian (Unit 3) limestone unit.

Unit 1

The lowermost sedimentary unit in the Aksala Formation typically lacks the thick conglomerate or limestone units common in the other two units. This lower package is dominated by deep water, fine- and medium-grained clastic strata including a diagnostic black and white, wispy and finely laminated, bioturbated, siliceous siltstone unit, a succession of well-bedded, resistant gritty sands, and recessive, buff-brown weathering, gritty and limy sandstones (Fig. 7). This latter succession could also be characterized as extremely sandy limestone and includes several, thin (<5m), dark grey, fetid limestone beds and lenses with sparsely interbedded, light grey chert.

Unit 2

The middle package is dominated by coarse clastic strata including numerous and varied conglomerate units with lesser sandstone and limy siltstone (Fig. 8). Much of the conglomerate is similar to that of the Laberge Group described west of the Yukon River (Hart et al. in press; Dickie, 1989, Wheeler, 1961), but here is included in the Lewes River Group because it underlies the Unit 3 limestone. Conglomerate units are composed of generally sub- to well-rounded, pebble-, cobble- and boulder sized clasts of volcanic, intrusive and sedimentary origin. Although generally polymictic, individual beds may be dominated by a single clast type. Most of the well-bedded conglomerate is dominated by well-rounded, fist-sized limestone clasts in contrast to massive conglomerate which contains angular boulder-sized limestone clasts. Intrusive clasts light grey, feldspar-quartz-hornblende porphyry, are always well-rounded and up to 40 cm in diameter. Light grey and green chert comprises angular, pebble-sized clasts.

Unit 3

The uppermost package of the Lewes River Group is characterized by limestone (Fig. 9), but also contains limestone conglomerate (see Jakobs, 1994), bioturbated mudstone, sandstone-siltstone couplets, massive greywacke and thinly bedded light green chert. The limestone is generally composed of light grey weathering, resistant, slightly recrystallized, sparsely bioclastic, massive micrite with rare internal laminations. Locally, solitary corals, sponges and brachiopods are contained in the limestone but they are generally recrystallized and poorly preserved. This sequence also contains In the Laberge map area, the limestone unit is known as the Hancock Member (Tempelman-Kluit, 1984). In the central Mount M'Clintock map area this unit is up to 1500 metres thick and contains between two and six limestone beds or lenses that comprise up to one-third of the section.

The Aksala Formation contains reliable and well-exposed, unidirectional paleoflow indicators including imbricated pebbles in well-bedded conglomerate, and slump folds in muddy horizons in massive sandstone. When corrected to horizontal, the structures indicate that the general flow direction was from north to south, which was parallel to the axis of the Whitehorse Trough.

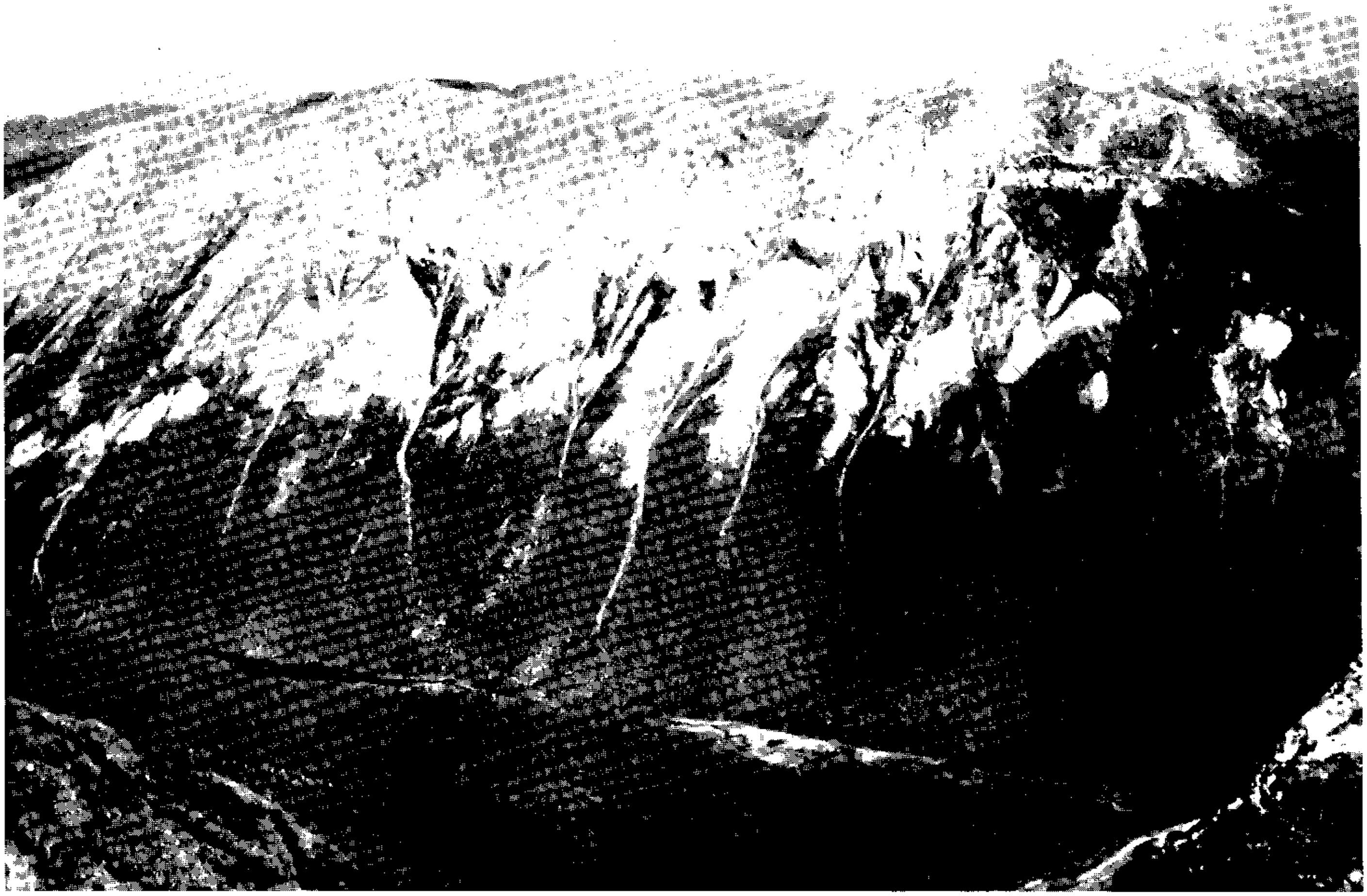

Figure 9: A well-exposed, west-facing section through the upper Norian limestone-dominated strata of Unit 3 in the Lewes River Group. The photo, of Peak 1679 in the central part of the map area, indicates that the section contains several, light weathering limestone beds that are offset along several small faults giving an apparent lensoidal appearance to the beds.

There are few constraints on the age of Lewes River Group sedimentary rocks within the map area. Unit 1 yielded a Carnian conodont collection (collected by O. Schönicke, submitted by S. Gordey and evaluated by M. Orchard) and is similar to rocks in the Joe Mountain map area which yielded mid-Triassic conodonts (M. Orchard, written comm. 1994) and is assigned a Carnian and older age range. A conodont collection from the uppermost, limestone-dominated, Unit 3 (collected by O. Schönicke, submitted by S. Gordey and evaluated by M. Orchard), gives an Upper Norian age for the succession. Unit 2 is assigned a Norian age. Macrofossil collections of *Halobia*? and *Monotis* within the map area give further evidence of an age range that includes the Norian.

Laberge Group

Laberge Group rocks underlie much of the eastern portion of the Mount M'Clintock map area, and for the most part are in apparent depositional contact with the uppermost package of the Lewes River Group. The Laberge Group in the Mount M'Clintock map area differs from strata described for other regions of the Whitehorse Trough. Here a thick, monotonous assemblage of pelagic sedimentary rocks lacking extensive arkosic sandstone and polymictic cobble conglomerate predominates. Thinly bedded brown-weathering, black siltstone and interbedded, well laminated, brown sandstone (also described by Jakobs, 1994) are typical. The siltstone and sandstone form couplets that are equivalent to CD(E) turbidites (Fig. 10). The couplets are locally limy and the black siltstone is generally heavily bioturbated by numerous worm burrows, particularly in the Mount M'Clintock area.

Conglomerate dominated by limestone clasts, locally forms numerous, 1-15 metre thick beds within the finer-grained strata (see Jakobs, 1994). These beds are common in the basal Laberge Group and sparse higher up in the section. Similar conglomerate occurs in much thicker (>50 m) beds east of the Teslin River.

Sedimentary rocks dominated by coarser clastic strata and a high percentage of fresh, crystals and lithic fragments occur in Sheldon Creek and at Peak 1749 (5 km northwest of Augusta

Mountain). In both localities, the conglomerate matrix and interbedded sandstones are composed of quartz and feldspar crystal-rich sand that appears to have a volcanogenic origin (Fig. 11). These strata have characteristics similar to Nordenskiold dacitic tuff described by Cairnes (1910) and Tempelman-Kluit (1984) and found throughout Whitehorse Trough.

At Sheldon Creek, the sedimentary rocks consist of at least 200 metres of brown to grey to green weathering, thick-bedded, medium to very coarse-grained sandstone, gritty sandstone and pebble conglomerate that overlies brown and black, well-bedded, tightly folded and cleaved siltstone. These rocks are composed of approximately 80% grey to grey-green matrix and 20% lithic clasts. The clasts are characterized by 40% angular (euhedral), white alkali feldspar grains (up to 2.5 cm), up to 25% glassy plutonic? quartz and coarse-grained polycrystalline quartz grains (2-4 cm), and brown-purple biotite grains. The conglomerate in particular also contains black siltstone "rip-up" clasts up to 20 cm across, hornblende granodiorite and rare angular limestone clasts (up to 10 cm). The matrix is crystal-rich, but is locally limy.

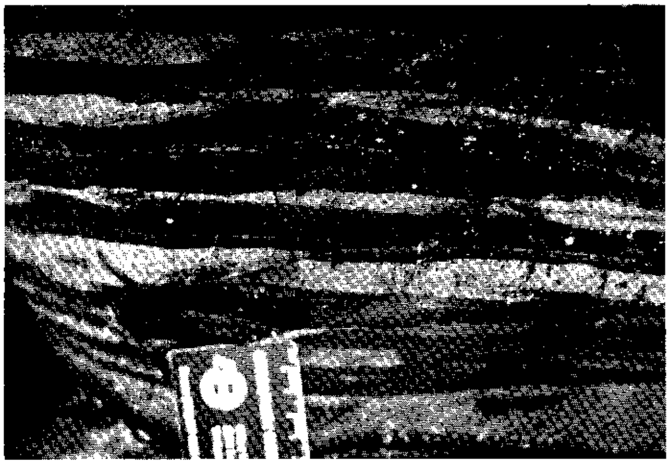

Figure 10: Sandstone-siltstone couplets comprise monotonous successions of the Laberge Group and probably represent accumulations of distal turbidites. This photo shows ripple cross-, and flaser laminations in the light weathering tan sandstone, and bioturbation of the black siltstone near Mount M'Clintock.

Rocks at Peak 1749 are dominated by equigranular, crystal-rich, feldspar-dominated sandstone. However unlike the Sheldon Creek locality, these rocks lack the characteristic conglomerate found there. They overlie several beds of well-rounded, clast-supported, polymictic granite-cobble conglomerate overlain by laminated and massive sandstone. This assemblage is typical of the Laberge Group in the western part of the Whitehorse Trough.

Despite recent advances in Laberge Group biostratigraphy (Pálfy and Hart, this volume; and references therein), there are few age constraints for Laberge Group rocks in the map area. However, much of the Laberge Group is in apparent depositional contact above the Late Norian Lewes River Group limestone, therefore suggesting a Lower Jurassic age. This is supported by a Hettangian to Sinemurian age determination from poorly preserved ammonites and indeterminate bivalves collected 3.5 km west of Mount M'Clintock (Jakobs, 1994). At Peak 1749, Laberge Group sandstone and conglomerate are apparently conformable above calcareous Lewes River Group strata containing Late Norian *Monotis*. Stratigraphically higher tuffaceous sandstone beds are likely equivalent to lithologically similar Nordenskiold dacite which has been determined elsewhere to be Upper Pliensbachian in age (Johannson, 1993; Pálfy and Hart, this volume). In summary, Laberge Group rocks in the map area are probably dominantly Hettangian and Sinemurian in age with some Pliensbachian localities.

CRETACEOUS ROCKS

Post-accretionary rocks in the map area are largely Cretaceous

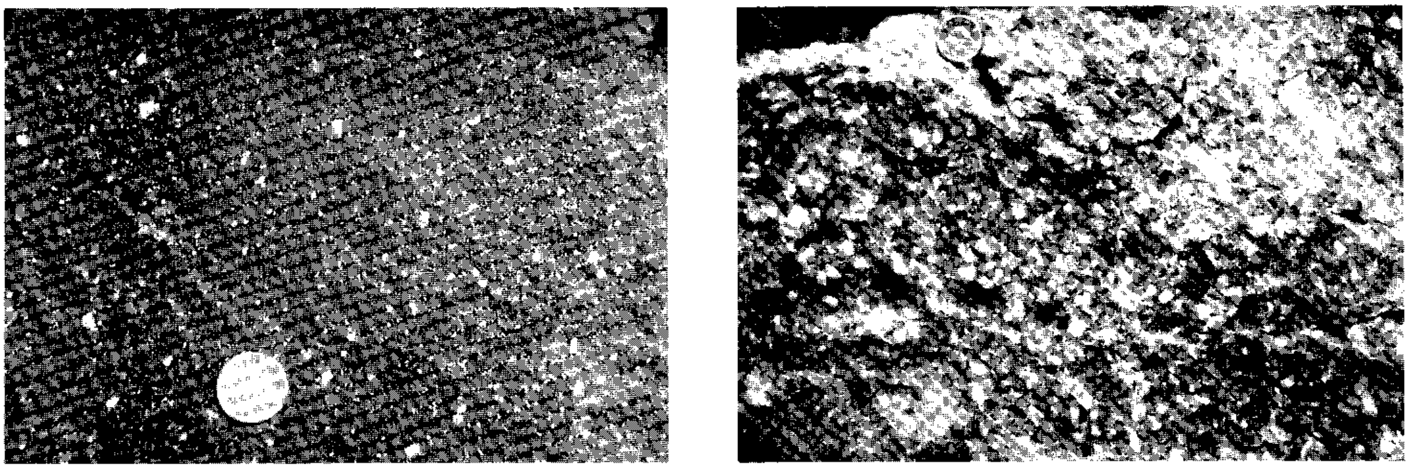

Figure 11: Distinctive Laberge Group strata of the lower Sheldon Creek includes a quartz and feldspar crystal-rich: (left) sandstone and (right) pebble conglomerate. Both rocks resemble Nordenskiold dacite tuff. The larger clasts in the conglomerate are composed of polycrystalline quartz, euhedral alkali feldspar, coarse-grained biotite, as well as granitic and siltstone lithic fragments.

in age and igneous in origin. They include the Byng Creek volcanic complex, several granitic plutons and the Open Creek volcanic rocks. These rocks either intrude, or were deposited unconformably upon deformed pre-Middle Jurassic rocks.

Volcanic Rocks

Byng Creek Volcanic Complex

Numerous exposures of lithologically diverse, sub-aerial, intermediate and felsic flow and pyroclastic rocks exposed near the headwaters of Byng Creek are collectively named the Byng Creek volcanic complex (BCVC). Four lithologic units have been identified: 1) andesite-dominated; 2) felsic pyroclastics, 3) dacite porphyry, and 4) rhyolite and associated hypabyssal intrusive rocks.

1) The **andesite-dominated** unit consist of dark weathering, massive, non-magnetic, aphyric and feldspar-phyric andesite flows, andesite flow breccias, feldspar-phyric andesite flows, and heterolithic breccia and tuff (Fig. 12a). The heterolithic breccia is composed of lapilli- to bomb-sized angular fragments of dominantly andesitic rocks and granodioritic country rock. A basal conglomerate, composed of well-rounded, pebble to cobble sized granitic and volcanic clasts, is locally present.

2) The **felsic pyroclastic** unit is composed of light orange weathering, massive and blocky, light grey, vitreous, felsic lapilli tuff, locally with bomb-sized clasts. The lapilli are dominated by angular fragments of flow-banded rhyolite and quartz-feldspar porphyry.

3) The **dacite porphyry** is composed of pale to dark grey weathering, black, grey, maroon and pink fine-grained and vitreous dacite with 15-40%, 0.4-1 mm, euhedral white feldspar phenocrysts (Fig. 12b). Sparse quartz and mafic (hornblende?) phenocrysts are also recognized. These rocks are dominantly intrusive, occur as sills and dykes with obvious chilled margins and are spatially associated with flow-banded rhyolite. Locally, they may be extrusive.

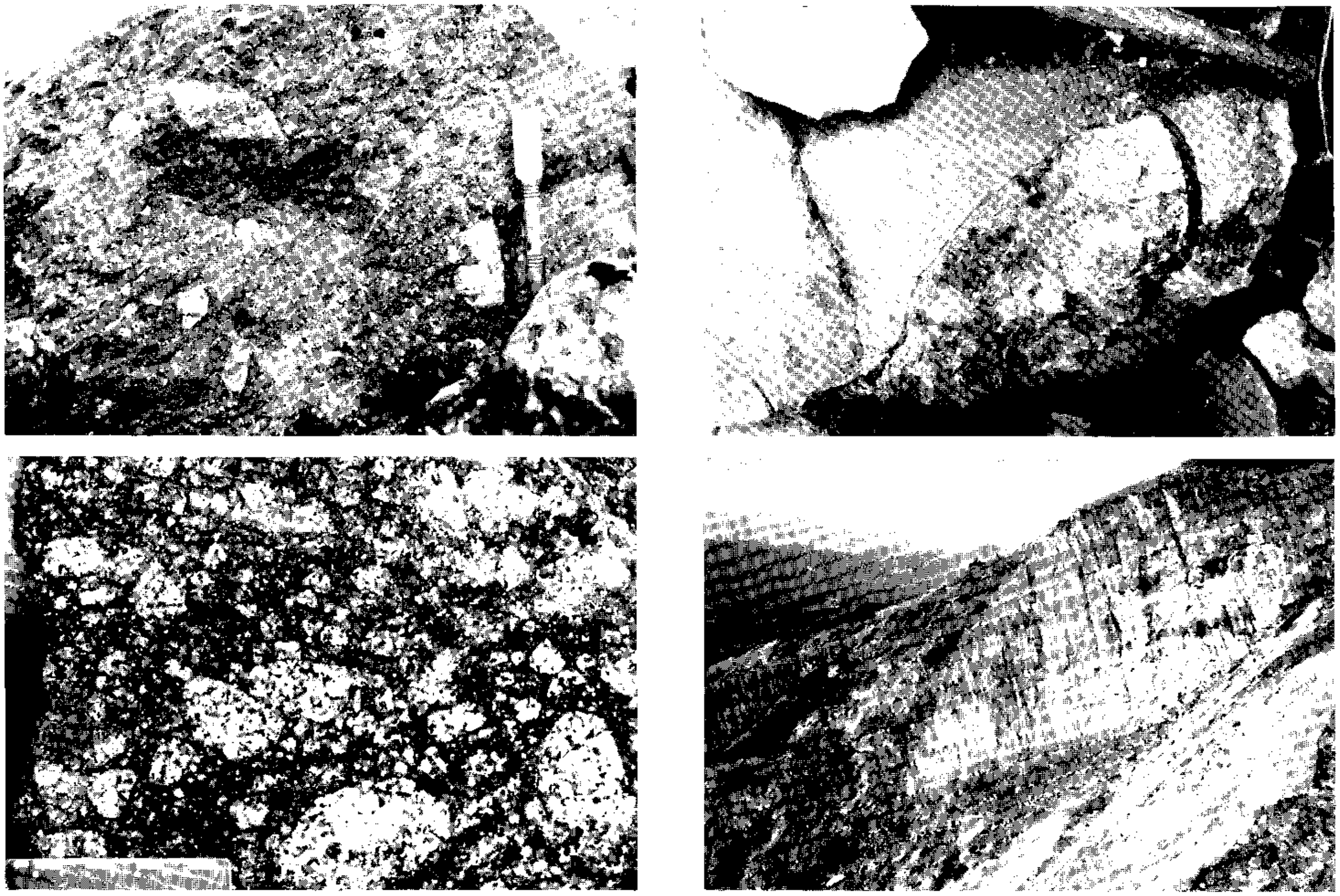

Figure 12: a) (top left) Heterolithic andesite tuff with angular volcanic and country-rock fragments is an important unit in the mid-Cretaceous Byng Creek volcanic complex (BCVC). Scale is 15 cm long. b) (top right) Feldspar-phyric dacite porphyry of the BCVC containing a rafted wallrock fragment with a dark grey, vitreous chilled margin around part of the fragment. c) (bottom left) Brecciated granodiorite country rock that has been shattered and milled by explosions associated with the emplacement of the BCVC. Sheeted dykes and sills of BCVC dacite porphyry cut the breccia, Northeast of Peak 1821. Scale is in centimeters. d) (bottom right) Northward view of dacite flows and tuff of the Open Creek volcanics that overlie Yukon-Tanana Terrane rocks in the northeastern part of the map area.

4) **Rhyolite flows** and shallow **intrusions**, including flow-banded rhyolite and quartz -feldspar porphyry plugs, dykes and sills are distributed throughout the BCVC. These rocks typically weather light orange, yellow, white and pink. Sheeted sills and dykes of dacite porphyry and rhyolite cross-cut brecciated and moderately altered granodiorite northeast of Peak 1821 (Fig. 12c).

Rocks of the BCVC nonconformably overlie M'Clintock Lakes granite and the folded sedimentary rocks of the Whitehorse Trough. The western margin of the BCVC is faulted and downdropped against the M'Clintock Lakes granite and Lewes River Group sedimentary strata. The BCVC is interpreted as the erosional remnant of a nested cauldera complex that was uplifted and tilted towards the northeast with the volcanic rocks preserved in the down-tilted, northeast portion of the cauldera. The distribution of volcanic and sub-volcanic rocks suggests that the original cauldera complex was in excess of 15 km across. A sill complex cross-cutting brecciated country rock is interpreted as a feeder zone for the volcanic rocks.

Although the BCVC has lithological similarities to Skukum Group volcanic rocks southwest of Whitehorse (McDonald, 1990, and references therein), the spatial, lithological and cross-cutting relations between the BCVC and the mid-Cretaceous Byng Creek pluton suggest that the two are coeval and that the BCVC is therefore mid-Cretaceous in age. The "Felsic Volcanics" in the adjacent Joe Mountain map area (described by Hart and Hunt, 1994a) may be correlatable with the BCVC.

Open Creek Volcanic Rocks

Cliff forming exposures of nearly flat-lying, columnar jointed flows with thin ash and lapilli tuff layers occur in the extreme northeastern part of the map area (Fig. 12d). These rocks are light orange weathering, dark grey to blue-grey aphanitic dacite with sparse, clear subhedral quartz phenocrysts. Locally a maroon weathering, basal clastic sedimentary package is present. The volcanic rocks unconformably overlie metamorphic rocks of the Yukon-Tanana Terrane and are continuous with the Open Creek volcanics in the Laberge map area (Tempelman-Kluit, 1984). Two K-Ar whole rock dates of 80±2.3 Ma and 83.4±2.1 Ma (Stevens et al., 1982) from the Laberge area confirm a Late Cretaceous age for these rocks.

Plutonic Rocks

Most of the southwestern quarter of the map area is underlain by granitic rocks. These rocks belong to three plutonic suites that each have distinctive lithological characteristics and ages: M'Clintock Lake, Whitehorse and Mount McIntyre. The M'Clintock Lake suite includes rocks of the M'Clintock Lakes pluton, as well as an elongate body at the head of Byng Creek and a small felsite plug near Mount Byng. The Whitehorse plutonic suite includes the Mount M'Clintock pluton, a small unnamed pluton in the southwestern part of the map area and numerous pendants in the Byng Creek pluton. The Mount McIntyre plutonic suite is represented within the map area by the Byng Creek pluton, associated outliers and swarms of dykes and sills.

M'Clintock Lake (Teslin) Plutonic Suite

Rocks of this suite consist of white to pale grey weathering, well-jointed, coarse-grained granodiorite and granite with 30-40% quartz, 50-60% feldspar and 10% biotite and hornblende. Plagioclase and alkali feldspar are both white and are difficult to distinguish although locally sparse grey or pale pink alkali feldspar phenocrysts were observed. Light grey quartz phenocrysts and aggregates are intergrown with plagioclase. Generally biotite and hornblende occur in equal amounts. Hornblende phenocrysts laths are as large as 6 mm across, biotite is slightly finer grained.

The Mount Byng plug is a recessive, light weathering, vitreous, hornblende-feldspar-porphyritic felsite. Phenocrysts include large white feldspar with acicular green-black hornblende and euhedral quartz. The felsite occurs as sills, north-trending dykes and small plugs in the northwestern part of the map area and as large dykes and small plugs northwest of Mount Byng.

Rocks of the M'Clintock Lakes plutonic suite are cut by pink dykes of the Byng Creek pluton and are therefore mid-Cretaceous and older. Similar rocks northwest of the map area returned a biotite K-Ar date of 118±3 Ma (Tempelman-Kluit, 1984). The Mount Byng felsite yielded a similar K-Ar hornblende age of 121±5 Ma (Bremner, 1991) and may therefore represent a finer-grained phase of the M'Clintock Lakes pluton. Both of these dates are similar to those reported for plutons in the Teslin map area (circa 120 Ma; Gareau and Mortensen, 1993; J.K. Mortensen, pers. comm. 1993). The M'Clintock Lakes and Teslin plutonic suites are both mid-Cretaceous and probably correlative.

Whitehorse Plutonic Suite

In the map area this suite is represented by numerous phases of dark weathering, blocky, medium- to coarse-grained biotite-hornblende granodiorite and quartz diorite. The rocks are composed of 15-20% quartz, 60% plagioclase, 5-10% alkali feldspar and 5-25% biotite and hornblende. More mafic phases containing up to 40% mafic minerals are not uncommon and dominated by hornblende but many of the pendants in the Byng Creek pluton are dominated by biotite.

Dykes from the Byng Creek pluton cut the Mount M'Clintock pluton. Although dates are not available for these rocks in the map area, this suite is lithologically similar to the Cap Creek pluton and other bodies of the Whitehorse plutonic suite (Hart and Hunt 1994a; Hart, 1995) which yield isotopic dates of about 115 Ma and are therefore assigned a mid-Cretaceous age.

Mount McIntyre Plutonic Suite

The main representative of this suite in the Mount M'Clintock map area is the Byng Creek pluton which underlies much of the area between Byng Creek and the M'Clintock River valley. Numerous phases of pink granite, quartz monzonite and quartz syenite compose this pluton and its outliers . Field characteristics include: pale orange-white weathering, pink fresh surfaces and miarolitic cavities. The rock unit is also characterized by extreme texturally variability. Three main phases have been identified:

1) The **coarse-grained, quartz-rich granite** phase predominates. It has a general composition of: 20-40% quartz, 25-40% plagioclase, 20-50% potassium feldspar, 3-15% euhedral biotite and 1-5% lath-like hornblende. Quartz is grey and forms aggregates. Alkali feldspar occurs as coarse grained aggregates and locally as single, large (8 mm), zoned phenocrysts. Plagioclase phenocrysts range from 3 to 5 mm across and are locally sausseritized. Small (1-5 cm), fine-grained mafic clots of hornblende and plagioclase are common.

2) **Granophyric quartz monzonite** is characterized by plagioclase, hornblende and quartz phenocrysts set in a fine-grained to aphyric matrix of pink potassium feldspar and quartz. The phenocrysts compose as much as 50% of the rock and are as large as 8 mm across. Euhedral plagioclase dominates the phenocryst population with 5-10% each of round glassy quartz, acicular hornblende and finer-grained biotite.

3) The **aplite** and **rhyolite** phase is white, yellow and pink, fine to medium-grained, locally quartz-phyric (up to 5%) and flow-banded. Fine-grained biotite or hornblende occurs locally as do white alkali feldspar locally phenocrysts and late-stage quartz and hornblende pegmatitic veins. In addition, quartz-feldspar porphyry with coarse grained phenocrysts form north-trending dykes and plugs in the northwest corner of the map area and in the upper Byng Creek area. In these dykes and plugs, phenocrysts are large and form crowded aggregates.

The complex distribution of the numerous intrusive phases are indicative of an upper level intrusion with chilled and injected phases. This is interpretation is collaborated by the presence of miarolitic cavities and the numerous cross-cutting phases. In addition, hypabyssal phases of the Byng Creek pluton are spatially associated with, and cross-cut the BCVC. This suggests that the Byng Creek pluton and associated rocks are coeval with the volcanic rocks of the BCVC. The Byng Creek pluton and associated rocks are correlated with rocks of the Mount McIntyre plutonic suite which yield mid-Cretaceous isotopic dates of approximately 109 Ma (Morrison et al., 1979; Hart and Hunt, 1994; Hart, 1995). A rhyolite dyke from near Mount Byng that gave a K-Ar whole rock date of 104±4 Ma (Bremner, 1991), is correlated with the Mount McIntyre suite.

STRUCTURE

The rocks in the M'Clintock map area are deformed and have a northwest-trending structural grain. Pre-mid-Cretaceous sedimentary rocks are folded. Faulting, although probably coeval with folding, is spatially associated with structures that are younger than mid-Cretaceous.

Folds

Most folds are upright, open and have wavelengths in the order of one kilometre. However black mudstone and rocks adjacent to, or between limestone beds form tight isoclinal folds on outcrop scale and have well-developed axial plane fracture cleavage.

Faults

For this preliminary review, faults are divided into four sets: north-, northwest-, and east-trending faults and caldera-bounding faults.

North-trending faults cut all units and control local drainage and topography. The amount of offset along these faults is limited to a few kilometres of dextral strike-slip offset, although locally there is up to two kilometres of vertical offset.

Northwest-trending faults dominate in the extreme northeastern part of the map area where they control the physiography of the Teslin River valley. These faults are spatially associated with zones of isoclinally folded and cleaved Laberge Group mudstone. These faults apparently cut the north-trending fault set. The amount of displacement across these faults is uncertain, but the northeasternmost fault juxtaposes Yukon-Tanana Terrane rocks with Laberge Group rocks.

East-trending faults predate the previous two sets and are difficult to assess because they are terminated by younger faults, or have been reactivated.

Arcuate, caldera-bounding faults along the eastern margin of the BCVC have allowed the volcanic rocks to subside with respect to the surrounding country rocks. These faults cut the mid-Cretaceous BCVC rocks but are in turn cut by several northwest-trending faults.

MINERAL DEPOSITS

The Mount M'Clintock map area hosts few mineral occurrences. Of the eight occurrences listed in Yukon Minfile (INAC, 1993), only the Mount Byng (Bremner, 1991) and Texel (ABI) properties have observable mineralization. The Mount Byng occurrence consists of several north-trending quartz veins and associated rusty weathering carbonate alteration zones. The veins are generally not greater than 20 cm wide and the alteration envelopes are about twice the width of the veins. The veins are composed almost entirely of white, locally vuggy, cockscomb quartz with sparse sulphides including pyrite, chalcopyrite and tetrahedrite. A grab sample taken from a trench at the main zone (94CH-12-4) gave Au and Ag values of 44 and 85 grams per tonne respectively (Appendix 1). The Au value is in the range of 18 to 127 g/T reported in Bremner (1991). Elevated Cu, Pb, Bi, As and Sb associated with this sample suggest that these elements are potential pathfinder elements for gold mineralization in this region in addition to Hg and W which were suggested by Bremner (1991).

Vivid orange-weathering, carbonate altered rock is common in the northwestern part of the map area where it occurs as 0.5-2 metre wide alteration zones along faults (Fig. 13). The best developed of these zones are composed of a breccia whose fragments are cemented by chalcedonic and green opaline silica. Open space filling consists of banded and crystalline ankerite and dolomite. A grab sample from one of these veins (94CH 16-5) gave a slightly anomalous Au value of 106 ppb.

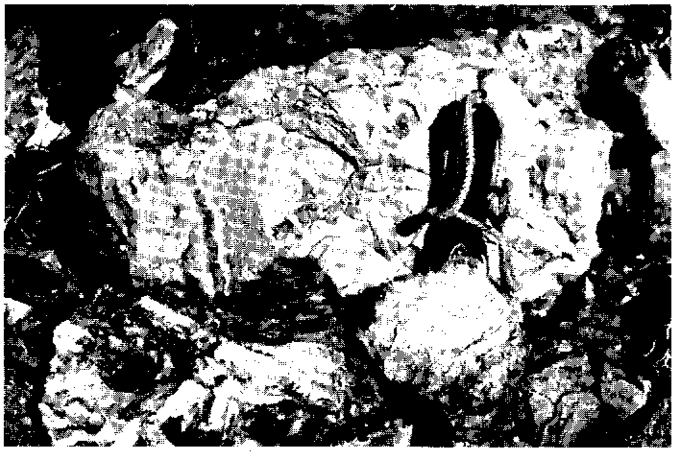

Figure 13: Bright orange weathering carbonate breccias typically contain chalcedonic fragments cemented together by massive or banded ankerite. These breccias occur in fault zones cutting the Joe Mountain volcanic complex.

Placer Deposits

The presence of gold in the west fork of Sheldon Creek is described by Lees (1936, p. 25) who reported numerous workings on Sheldon Creek prior to 1934, including one location above the canyon where seven men obtained $40 worth of gold from an area the size of a tent. Work completed between 1934 and 1984 is not documented. In 1984, Orion Construction explored three sites on the west fork of Sheldon Creek with heavy equipment (Debicki and Gilbert, 1986). Two of these sites were stripped and 3000 cubic yards of material were sluiced from one of them. Bedrock was not encountered in the valley bottom and no production is known. A seismic reflection survey in 1985 (LeBarge and Morison, 1990) defined a basic stratigraphy and thickness of the gravels.

The source of the placer gold in Sheldon Creek is unknown and there are no known mineral occurrences in the drainage. Speculation on a potential source must take into account the following evidence:

- gold occurs in gravels in the west fork suggesting a source region in that drainage;
- no granitic plutons or Cretaceous volcanic rocks (both potential sources) are exposed within the drainage basin. Middle Triassic volcanic rocks underlie the headwaters;
- many of the cobbles in the gravels are composed of vivid orange weathering, carbonate altered sedimentary rock.
- sedimentary rock cobbles in the gravels contain thin (1-5 cm wide), barren white quartz veins.

Although the alteration is not intense and the vein material is thin and barren of mineralization, the sedimentary rocks may be source of the placer gold and is a potential exploration target.

Alternatively, the gold may be transported from elsewhere. For example the wide plateau to the south of the creek may have been scoured by glaciers, transported and detrital gold deposited in the Sheldon Creek valley where it has since been reworked by contemporary fluvial action. The east-trending character of the creek may have prevented the scouring and dispersion of placer gold by the general northward advancement of the glaciers and allowed any pre-glacial, or glacially transported placer gold to remain concentrated in the creek.

Regional Silt Geochemistry

Regional stream silt geochemical data from the Geological Survey of Canada (1985) and from the 1994 field season (Appendix 1) define areas in the Mount M'Clintock map area that are anomalous in one or more of Au, Sb, Mo, Hg, U, W, Sn, Cd and As. The majority of silt samples analysed as part of this program were collected from helicopter accessible sites at or near the mouths of drainages. At these locations, potentially anomalous metal values are subject to down-stream dilution by erosional debris. As a result, even slightly anomalous values from these localities may warrant up-stream prospecting and sampling. Furthermore, since numerous, high-grade gold occurrences occur in the Whitehorse map sheet, high values obtained from silts draining those deposits have skewed values considered to be anomalous by the GSC study, to higher thresholds. As a result, Au in silt values from the map area that are at the 80th percentile (~10 ppb) are considered anomalous.

Of 65 silt samples analysed by the GSC, six are considered anomalous in Au (> 10 ppb). Of these, three samples yielded reproducible anomalous values; the remaining three anomalous values likely result from erratically distributed coarse gold. Gold anomalies may be related to veins that may be hosted in north-trending faults (see Hart and Hunt, 1994, p. 59). In the southwestern portion of the map area, anomalous gold values occur in creeks draining across the contact between granodiorite and the diorite of the Cache Creek Group. The distribution of U, Sn, Mo and W anomalies are coincident with the distribution of the Byng Creek pluton.

Exploration Targets

The faulted caldera margins of the BCVC provide possible hosts for epithermal gold deposits. Limestone units adjacent to granodioritic intrusions in the Mount M'Clintock area are possible hosts for skarn mineralization. The Joe Mountain volcanic rocks are associated with numerous slightly elevated gold-in-silt values whose source(s) have not been identified.

CONCLUSIONS

Revision mapping of the Mount M'Clintock map area has resulted in the following advances:

- rocks of three tectonic terranes underlie the map area - Stikinia, Yukon-Tanana and Cache Creek;
- rocks previously mapped as Lewes River with Laberge Group sedimentary rocks are divided into two groups and three units are defined for the Lewes River Group;
- rocks previously mapped as Hutshi Group are divisible into the Middle Triassic Joe Mountain volcanic complex and the mid-Cretaceous Byng Creek volcanic complex;
- the JMVC represents a thick accumulation of mafic submarine flows and associated intrusive units;
- the BCVC is represented by a deeply eroded roots of a sub aerial, felsic pyroclastic-dominated, cauldera complex and is coeval with the Byng Creek pluton;
- plutonic rocks are represented by three mid-Cretaceous plutonic suites at circa 120, 115 and 109 Ma;
- gold-bearing quartz veins and copper (gold-molybdenum-tungsten skarns) are the most likely mineral deposit types to be located in the map area.

ACKNOWLEDGMENTS

This paper benefited from thorough reviews from Stephen Johnston and Charlie Roots. Conodont identifications by Mike Orchard, of the Geological Survey of Canada have allowed us to piece together a stratigraphy. Steve Gordey (GSC) was responsible for the initiating studies by O. Schönicke and T. Weihe, and G. Jakobs which helped to provide additional background information for this project. Larry Carlyle supplied information about mineralization on his claims in the Mount Byng area. Will vanRanden supplied logistical support for the field project.

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Appendix 1

SAMPLE	LOCATION UTM Zone 8V	DESCRIPTION	Au (ppb)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	As (ppm)	Sb (ppm)	Mo (ppm)	Ba (ppm)
		Detection Limits	*5*	*0.2*	*1*	*2*	*1*	*5*	*5*	*1*	*2*
94CH-11-2	675585N 52992E	Rusty weathering, carbonate altered breccia - low temperature carbonate. Banded druzy and fine-grained spongy carbonate. 0.40 m wide.	<	<	1	12	36	<	<	<	7
94CH-12-4	675545N 53450E	Mount Byng property: Rusty weathering, vuggy, cockade quartz vein with open space voids and vugs filled by limonite and MnO. Multiiple stages of veining, some vugs are scoroditic. Minor fine grained chalcopyrite associated with massive quartz. Max. 0.20 m wide.	44.9 g/t	85.3 g/t	472	438	9 also 226 ppm Bi 38 ppm Mo	741	405	38	67
94CH 4-1	6756900N 541700E @ 1460m	Orange weatherning, crystalline carbonate (ankerite) with brecciated wallrock fragments	<	<	12	6	21	<	<	<	12
94CH 15-6	6747400N 542350E @ 1790m	Quartz stockwork, milky white quartz with coxcomb vugs, float.	7	0.2	7	3	6	12	<	4	28
94CH 16-5	6752500N 538300E @ 1720m	Massive grey quartz stockwork cutting and parallel with northwest-trending, rusty weathering alaskite dyke	106	0.4	13	<	2	<	<	13	13
J94-5-7b	6762015N 541010E	Quartz vein (1 to 5 cm wide) with minor pink carbonate (5%) and brecciated rock fragments. The vein is sheared with graphitic margins. No visible sulphides.	<	<	20	12	49	<	<	11	210
J94-8-2	6758375N 530300E	Andesite cut by calcite veins 3 to 5 cm wide in three, 20 cm wide shear zones approx. 40 cm apart. Crack seal veins with wall rock fragments in the centre. No visible sulphides.	<	<	1	3	7	<	<	<	10

Appendix 1: Geochemical assay data for rock and silt samples taken from the Mount M'Clintock map area. Au by fire assay with AA finish, all other elements by ICP. All analyses by Bondar-Clegg and Co., North Vancouver, B.C. Results for Hg, Ni, Co, Cd, Bi, Fe, Mg, Te, Cr, V, Sn, W, La, Al, Mn, Ca, Na, K, Sr and Y available upon request from authors.

INTERPRETATION OF AN AIRBORNE MULTIPARAMETER GEOPHYSICAL SURVEY OF THE NORTHERN DAWSON RANGE, CENTRAL YUKON: A PROGRESS REPORT

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JOHNSTON, S.T., and SHIVES, R.B.K., 1995. Interpretation of an airborne multiparameter geophysical survey of the northern Dawson Range, central Yukon: A progress report. In: Yukon Exploration and Geology, 1994. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 105-111.

Abstract

Much of the Yukon-Tanana Terrane escaped Pleistocene glaciation with the result that there is <1% outcrop across much of the terrane and weathered rock commonly extends to depths of >75 m. Weathering has in many cases removed all obvious signs of mineralization and has resulted in the dispersion of soluble metals in the near surface. For these reasons, exploration based on traditional prospecting methods and soil geochemical surveys has met with limited success. Geological mapping is hindered by the lack of exposure and by the complex geology. To address these problems a detailed airborne geophysical survey, combining gamma ray spectrometric, magnetic and VLF sensors, was flown in the Dawson Range, central Yukon-Tanana Terrane. Spectrometric data were used to determine the average surface concentration of potassium (K), uranium (U) and thorium (Th). Lithological units are characterized by relatively consistent geochemical signatures permitting improved geological mapping based on the distribution of spectrometric domains. Alteration haloes, commonly characterized by the addition of K and magnetite, are identifiable as areas of low Th/K rations and as total field magnetic highs.

Preliminary interpretation of the survey indicates that: (1) mid-Cretaceous plutonic rocks of the Dawson Range Batholith are divisible into concordant, sill-like bodies consisting of weakly and moderately potassic, hornblende quartz diorite and hornblende biotite granodiorite phases respectively. Leucocratic granite previously thought to be part of the batholith forms late, high-level discordant plugs that are highly potassic and that intrude the batholith and its wall rocks. Copper mineral occurrences are spatially associated with these late potassic intrusions; (2) sub-volcanic and volcanic rocks previously interpreted as mid-Cretaceous rocks of the Mount Nansen Group are geophysically indistinguishable from, and commonly continuous with Late Cretacious rocks of the Carmacks Group; and (3) late Cretaceous dykes and plutons coeval with the Carmacks Group are commonly characterized by alteration-related Th/K lows and by total field magnetic highs. Copper mineral occurrences are spatially associated with these intrusions.

INTRODUCTION

The Dawson Range (Fig. 1), a geologically complex crystalline welt in central Yukon-Tanana Terrane, hosts a series of mineral occurrences including Klazan, Revenue, Mount Cockfield, Casino, Mount Nansen, Williams Creek and Minto. However, no significant new mineral deposits have been located in the Dawson Range since the early 1970's. The paucity of exploration success is attributable, in part, to the lack of fresh outcrop, much of which had been well prospected by the early 1970's. Glaciers that spread across much of the Yukon in the Pleistocene scoured bedrock of regolith and weathered rock. However, the Dawson Range largely escaped glaciation. The result is that there is less than 1% outcrop by area over much of the range, and weathered rocks commonly extend to depths of greater than 75 m. Weathering has in many cases removed all obvious signs of mineralization and resulted in the dispersion of soluble metals in the near surface. For these reasons, traditional prospecting methods and soil geochemical surveys have met with limited success. The lack of exposure and the complexity of the geology of the Dawson Range hinders geological mapping and results in highly interpretative maps.

To address these problems an Airborne Multiparameter Geophysical (AMG) survey, combining gamma ray spectrometric, magnetic and VLF sensors was flown in the Dawson Range (Fig. 1). Although AMG surveys are new to the Yukon, they have been used successfully throughout the rest of Canada (Broome et al., 1987; Ford, 1993; Charbonneau and Legault, 1994). These studies have demonstrated that AMG surveys are an inexpensive and efficient method of mapping lithological units and of identifying mineralization-related alteration haloes in poorly exposed terrains. Two and-a-half 1:50 000 scale NTS map sheets in the northern Dawson Range (115 J/9, 10 and the west half of 115 I/12) were flown in August, 1993 (Geological Survey of Canada, 1994a;b). A 1:100 000 scale compilation geology map for the northern Dawson Range, updated with the aid of the geophysical data (Johnston, 1995) provides the basis for this report. This paper reports on the interpretation and application of the geophysical data from a study area within the northern Dawson Range (Fig. 2). The data have been used to improve the existing geological map, to distinguish lithological units spatially associated with mineral occurrences, and to identify alteration haloes that may be related to mineral deposits. In August, 1994, three additional NTS map sheets from the southern Dawson Range (115 I/3, I/6 and I/11) were flown. Processing of this data is in progress.

PREVIOUS WORK

Previous work includes regional 1:250 000 scale geological mapping of the Snag (115 J) and Carmacks (115 I) map sheets by Tempelman-Kluit (1974; 1984), 1:50 000 scale mapping of the 115 J/9 and J/10 map sheets by Payne et al. (1987), and 1:50 000 scale mapping of the 115 I/12 map sheet by Johnston (1993) and Johnston and Hachey (1993). Johnston and Hachey (1993) reviewed the geological setting of the Dawson Range. Metamorphic rocks underlying the Dawson Range are included in the Yukon-Tanana Terrane (YTT) (Wheeler et al., 1991) (Fig.1), regional reviews of which are provided by Tempelman-Kluit (1976) and Mortensen (1992). Recent advances in the understanding of the magmatic evolution and mineral deposits of the YTT are discussed in Johnston and Mortensen (1994) and Mortensen et al. (1994). Detailed studies of mineral deposits in the northern Dawson Range include Godwin (1975; 1976) on the Casino deposit. Payne et al. (1987) reviewed the geology of the known mineral occurrences in the 115 J/9 and J/10 map sheets.

THE AIRBORNE MULTIPARAMETER GEOPHYSICAL SURVEY

The AMG survey was designed to collect high resolution, quantitative gamma ray spectrometric, VLF-EM and total field magnetic data, using an Aerospatiale AS-350 Asta helicopter equipped with 42 litres of NaI gamma ray detectors. North-trending flight lines were spaced 500 m apart. Data were processed assuming a mean terrain clearance of 120 m and an air speed of 120 km/h. The gamma ray flux emitted by a volume of rock is proportional to the concentration of radioactive elements in the rock. Spectrometric data can therefore be used to determine the average surface concentrations of the radioactive elements potassium (K), uranium (U) and thorium (Th). More detailed descriptions of AGM survey methods are in Grasty et al. (1991) and in Shives and Ford (1994). Data were presented as colour contoured 1:150 000 scale maps (Geological Survey of Canada, 1994a,b). Contour maps of K concentrations, Th/K ratios and magnetic data for the study area are shown in Figure 3.

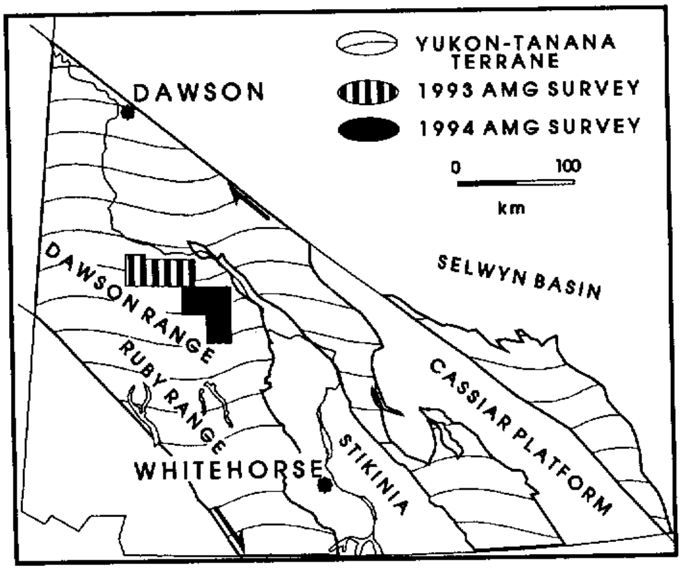

Figure 1. Area of the 1993 and 1994 Airborne Multiparameter Geophysical surveys.

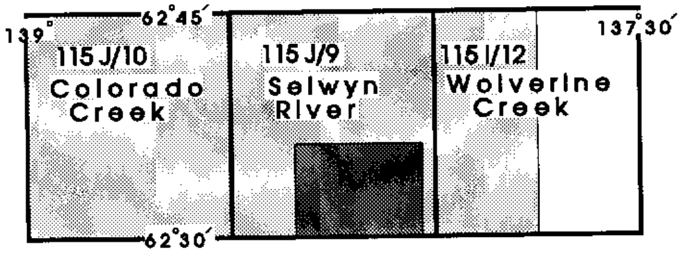

Figure 2: Location of the 1993 AMG survey (light grey) and the location of the study area (dark grey).

Numerous factors besides bedrock radioelement concentrations impact on the number of gamma rays available for detection and can produce discrepancies between measured radioelement concentrations and bedrock radioelement concentrations. Overburden, vegetation cover and high levels of soil moisture and surface water all diminish the numbers of measurable gamma rays originating from bedrock. Measured radioelement concentrations are, therefore, usually lower that bedrock concentrations. Locally severe topography can result in departures from assumed air speed and terrain clearance. Reduced air speed and terrain clearance are conditions commonly observed where flight lines involve flying up steep slopes and result in measured radioelement concentrations that exceed bedrock concentrations. Increased airspeed and terrain clearance are conditions commonly observed where flight lines involve flying down over steep drops and produce the opposite effect. Where flight lines coincide with deeply incised valleys, measured radioelement concentrations may exceed bedrock concentrations due to the detection of gamma rays originating from the valley walls or from over-correction for terrain clearance. It is therefore necessary to consider topography and surface conditions when interpreting spectrometric data.

INTERPRETATION AND DISCUSSION

Interpretation of the AMG data focused on (1) improving the existing geological maps and (2) refining our understanding of mineral occurrences within the study area. We distinguished lithological units spatially associated with mineral occurrences, and identified alteration haloes that may be related to mineral deposits.

Geological mapping

Geochemical analyses and ground based spectrometric and magnetic analyses (Johnston and Shives, unpublished data; Shives and Ford, 1994) indicate that lithological units underlying the survey area each exhibit relatively distinct and consistent geochemical, spectrometric and magnetic characteristics: (1) metamorphic rocks exhibit low but variable radioelement concentrations and weak magnetic total field; (2) plutonic rocks exhibit higher total radioelement concentrations. Highly evolved intrusions exhibit elevated potassium concentrations and a diminished magnetic total field relative to intermediate and mafic granitoids; (3) volcanic rocks commonly display low Th/K ratios and highly variable magnetic patterns. The identification of spectrometric and magnetic domains can therefore assist in the delineation of lithological units.

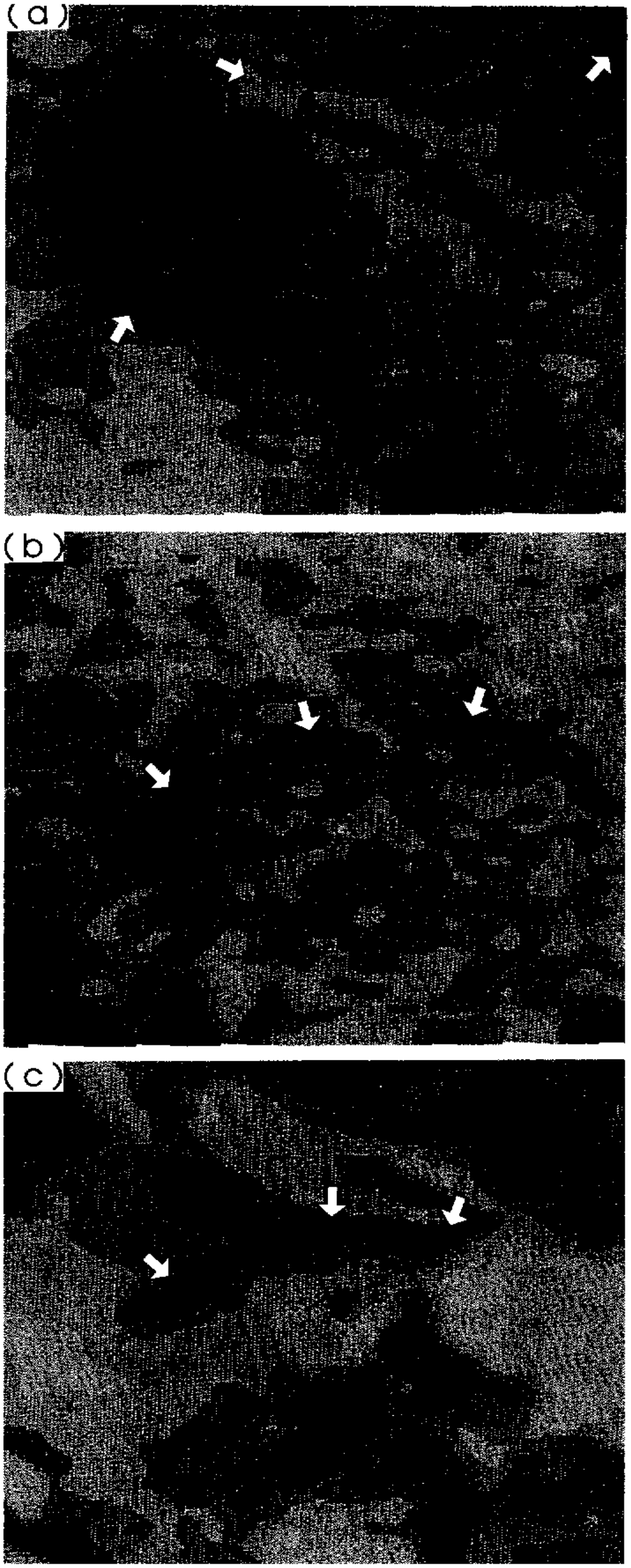

Figure 3. Contour plots of geophsycial data. (a) *K concentration map with highly potassic areas indicated in black and weakly potassic areas in light grey. Arrows indicate potassic plugs (black areas), and a synformal pendant of weakly potassic metamorphic rocks (light grey) within the Dawson Range Batholith.* (b) *Th/K ratio map with low Th/K ratios indicated in black. Arrows indicate a broad arcuate zone of low Th/K ratios.* (c) *residual total field magnetic potential map with highly magnetic areas shown in black. Arrows indicate an arcuate zone of elevated total field magnetic values. The arcuate highly magnetic - low Th/K zone is an alteration halo developed adjacent to an intrusion of the Prospector Mountain Plutonic Suite.*

The existing geology map (Payne et al., 1987) for the study area is shown in Figure 4a. The map and accompanying cross-section illustrate that: (1) the Dawson Range Batholith was previously regarded as an igneous 'stew' which appears to consist of intermingled mafic, intermediate and felsic phases; (2) the batholith was thought to be a steep-sided intrusion which includes relatively steeply oriented pendants (xenoliths) of metamorphic wall rock; and (3) both mid-Cretaceous dykes of the Mount Nansen Group and Late Cretaceous dykes of the Mount Prospector Plutonic Suite, an intrusive suite that is considered to be coeval with the Carmacks Group, were mapped in the study area. From spectrometric and magnetic data (Fig. 3) and from field examination of the study area it is evident that: (1) the felsic phases of the Dawson Range Batholith, identifiable by high concentrations of potassium and weak magnetic values, define discordant plugs that intrude the more mafic phases of the batholith and its wall rocks; (2) metamorphic rocks within the batholith are more extensive than previously thought and define a synform cored by intermediate rocks of the Dawson Range Batholith. Mafic and intermediate phases of the Dawson Range Batholith are sheet or sill-like bodies that are concordant with foliation in the 'pendant' and in adjacent metamorphic wall rocks. The sills are folded and dip regionally to the northeast (Fig. 5); and (3) dykes correlated with the mid-Cretaceous Mount Nansen Group are characterized by low Th/K ratios and are highly magnetic, similar to dykes and intrusions of the Prospector Mountain plutonic suite. In addition, Mount Nansen dykes in the study area are continuous with a dyke included in the Prospector Mountain plutonic suite, defining one continuous intrusion. These data indicate that dykes previously

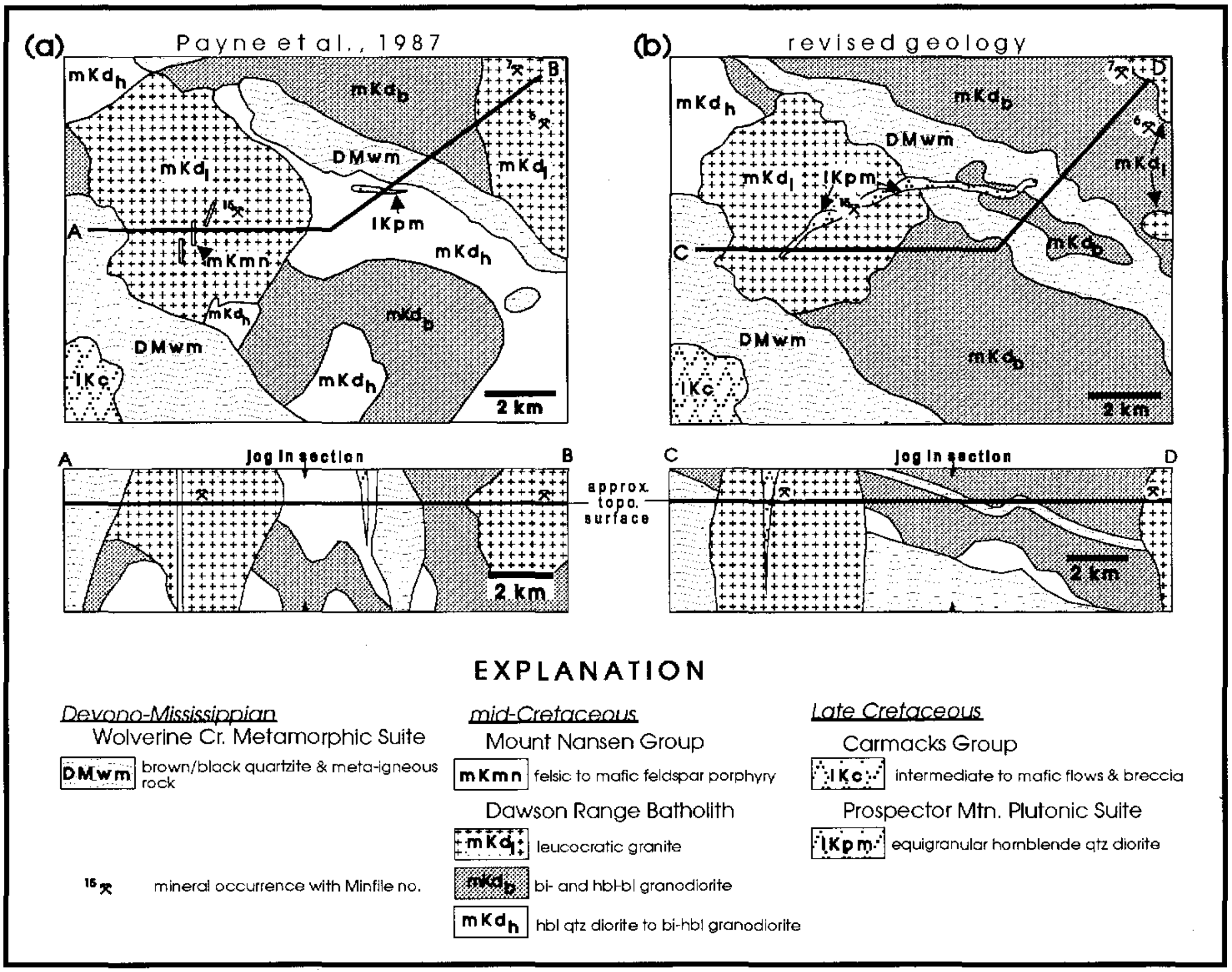

Figure 4: Geology maps and associated schematic cross-sections of the study area. (a) geology from Payne et al. (1987); (b) revised geology based on interpretation and ground- checking of data from the AMG survey.

correlated with the mid-Cretaceous Mount Nansen Group are Late Cretaceous intrusions of the Prospector Mountain plutonic suite. A revised geology map and cross-section based on these observations are shown in Figure 4b.

Mineralization

Refinement of our understanding of mineral occurrences within the study area consisted of distinguishing, based on the revised geological map, lithological units spatially associated with mineral occurrences and identifying alteration haloes that may be related to mineral deposits. Hydrothermal alteration associated with mineralization is commonly evident as the additions of potassium and magnetite (Drummond and Godwin, 1976; Barnes, 1979). Typically little change in Th and U concentrations is observed and therefore alteration haloes are characterized by low Th/K ratios and by total field magnetic highs.

Three Minfile occurrences, 115 J-6, J-7 and J-15 (Payne et al., 1987; INAC, 1992) are present within the study area (Fig. 4). Occurrences 6 and 7 are work targets about which little is known. Occurrence 15 (the CROCK) consists of disseminated chalcopyrite in a chilled margin along the contact between leucocratic quartz monzonite and a younger diorite intrusion (Craig and Laporte, 1972; Marion and Caine, 1984; Payne et al., 1987; INAC, 1993).

Minfile occurrences 6 and 7 occur in what was previously mapped as a relatively large area underlain by a felsic phase of the Dawson Range Batholith (Fig. 4a) (Payne et al., 1987; INAC, 1993). On the revised geological map (Fig. 4b) it is apparent that these occurrences are spatially associated with the margins of a discordant felsic plug that intrudes the mafic and intermediate phases of the Dawson Range Batholith. The felsic plug is characterized by miarolitic cavities and siliceous breccia; no quartz veining or stockwork was observed. These observations suggest that mineralization may be related to the development of a porphyry-style alteration system during the shallow-level emplacement of the felsic pluton. Relatively high concentrations of K, slightly depressed Th/K ratios, and a slightly elevated magnetic total field in the vicinity of these mineral occurrences (Fig. 3) is consistent with the presence of a weakly developed alteration halo that may have developed within a porphyry system.

Figure 5: A view looking to the north of dark weathering carbonaceous quartzite of the Devono-Mississippian Wolverine Creek Metamorphic Suite overlying light weathering biotite hornblende granodiorite of the mid-Cretaceous Dawson Range Batholith. Foliation in the quartzite is gently folded and is parallel to the contact (indicated by arrows) and to a weakly developed planar fabric, interpreted as a magmatic flow fabric, in the underlying granitic rocks.

Minfile occurrence 15 (the CROCK) is spatially associated with a dyke swarm previously correlated with the Mount Nansen Group (Fig. 4a). Based on this spatial association mineralization was inferred to have been a consequence of the mid-Cretaceous magmatic event that emplaced igneous rocks of the Mount Nansen Group (INAC, 1993). The geophysical data (Fig. 3) and the revised geological map (Fig. 4b) show that the 'dykes' are spectrometrically similar to, and define a single arcuate intrusion continuous with, an intrusion of the Prospector Mountain plutonic suite. This intrusion and its wall rocks are characterized by a significant Th/K low and by a significantly elevated magnetic total field (Fig. 3), consistent with the presence of an alteration halo that may have developed during intrusion and coeval mineralization. These observations suggest that the CROCK developed during Late Cretaceous Prospector Mountain plutonism and coeval Carmacks Group volcanism.

CONCLUSIONS

1. AMG surveys are, despite deleterious topographic and surficial effects, an efficient means of determining the approximate bedrock concentrations of K, U and Th.
2. Lithological units are commonly characterized by consistent geochemical, and therefore spectrometric and magnetic, signatures which permit improved geological mapping based on the recognition of geophysically defined domains. Revision of the geological maps can result in significant changes in the interpretations of relationships between units and of the relative ages of units. Felsic phases of the Dawson Range Batholith were revealed as late plugs that intrude older concordant more mafic phases of the batholith. Inferred mid-Cretaceous dykes of the Mount Nansen Group were shown to be a Late Cretaceous intrusion of the Prospector Mountain plutonic suite.
3. AMG surveys can be used to distinguish lithological units spatially associated with mineral occurrences and to identify alteration haloes that may be related to mineral deposits. Two mineral occurrences are shown to be spatially associated with alteration interpreted to be a weakly developed porphyry system associated with a felsic plug that intrudes the Dawson Range Batholith. The CROCK mineral occurrence is spatially associated with an arcuate intrusion of the Late Cretaceous Prospector Mountain plutonic suite. Alteration haloes associated with the mineral occurrences, particularly with the CROCK, are identifiable as areas of low Th/K ratios and total field magnetic highs.

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