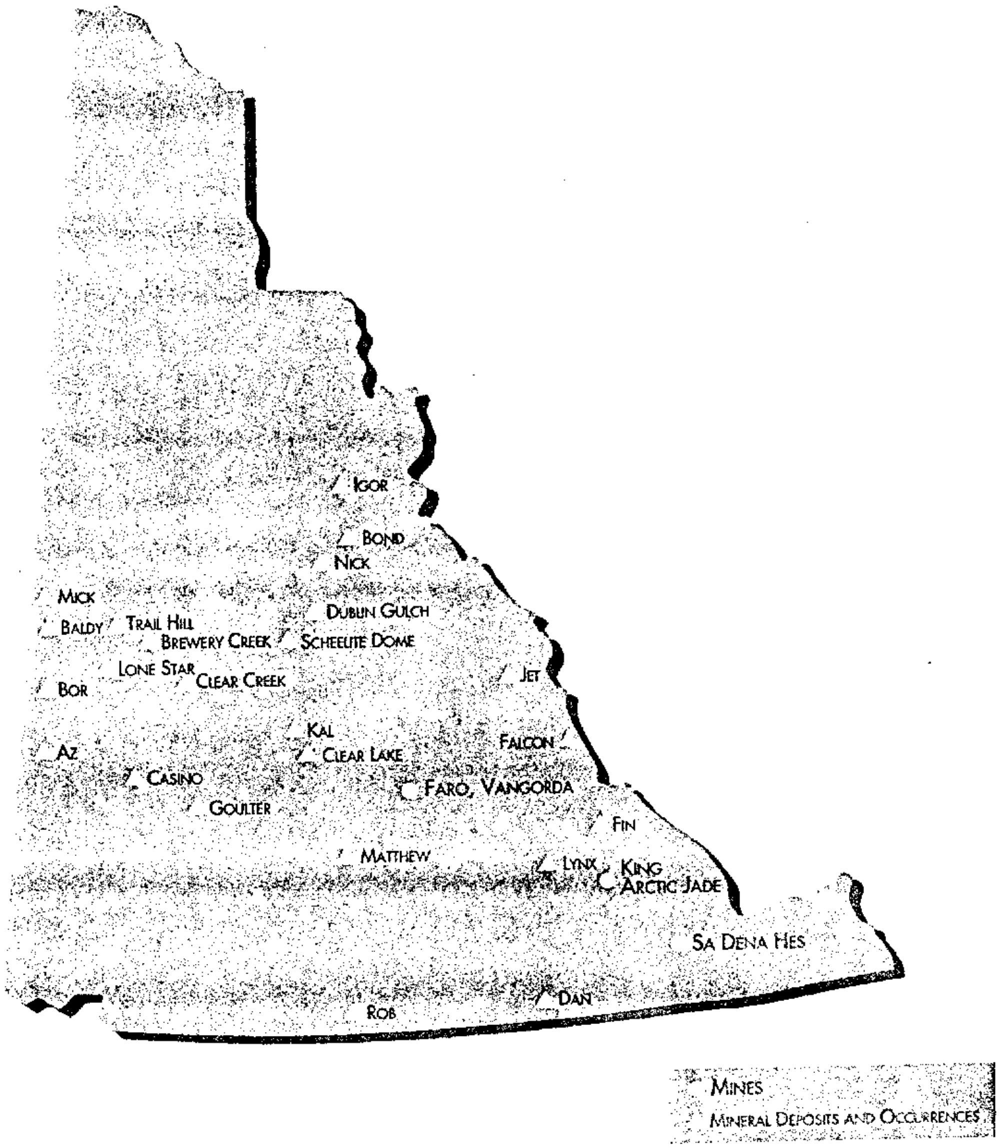
Indian and Northern Affairs Canada / Affaires indiennes et du Nord Canada

Exploration and Geological Services Division, Yukon Region

Yukon Exploration & Geology 1992



Part A: 1992 Mining and Exploration Overview

B: Exploration and Geological Services Division
Canada/Yukon Mineral Resources Cooperation Agreement and Geoscience Office

C: Geological Fieldwork

Canada

Canada/Yukon Economic Development Agreement
To strengthen and diversify the Yukon economy

Yukon Economic Development

YUKON EXPLORATION AND GEOLOGY 1992

PART A:

1992 MINING AND EXPLORATION OVERVIEW

PART B:

EXPLORATION AND GEOLOGICAL SERVICES DIVISION

CANADA/YUKON MINERAL RESOURCES COOPERATION AGREEMENT AND GEOSCIENCE OFFICE

PART C:

GEOLOGICAL FIELDWORK

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QS - Y083-000-EE-A1

It is recommended that reference to this report be made in the following form:

INAC, (1993). Yukon Exploration and Geology 1992; Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada.

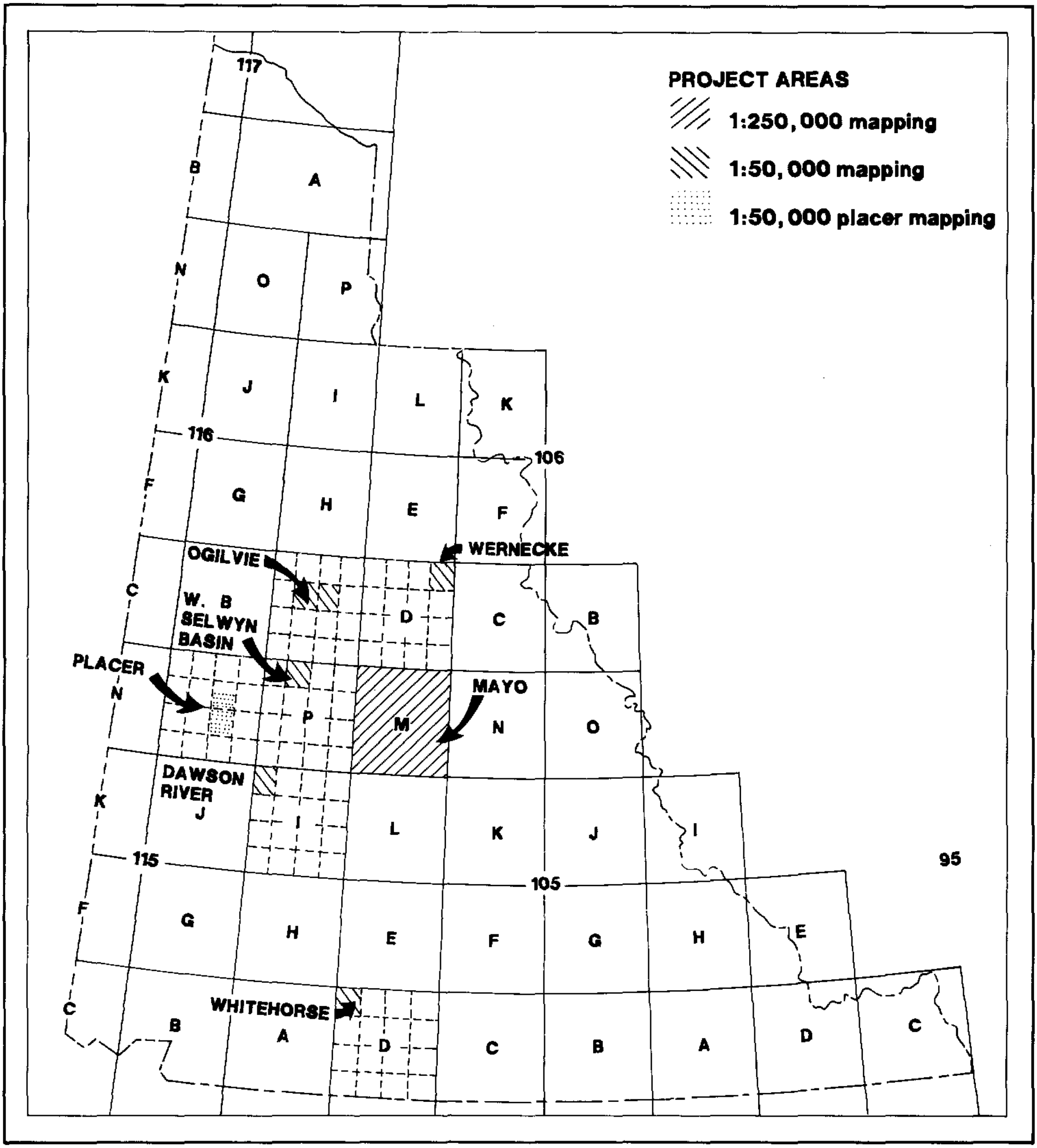
PREFACE

This issue of Yukon Exploration documents a significant year of achievement for government geoscientific activities. Included in this publication are the results from the 1992 field season of the new Canada/Yukon Geoscience Office. In addition, Exploration and Geological Services Division (EGSD) continues to meet client obligations such as maintaining the popular mineral inventory, Yukon Minfile, of which the 1992 update is available in WordPerfect® 5.1 format. Also, EGSD has become involved in resolving environmental issues by appointing an environmental geologist who is chiefly responsible for providing technical advice and insight on development projects.

Yukon Exploration 1992 consists of three parts; Part A is a comprehensive overview of mining and exploration activity in Yukon, Part B summarizes the activities of the Exploration and Geological Services Division of the Northern Affairs Program, Yukon Region and the activities of the Canada/Yukon Geoscience Office, and Part C which documents significant new geoscientific information gathered by EGSD geologists, Canada/Yukon Geoscience Office geologists and affiliated geologists such as students and contractors.

Much of the information contained in Yukon Exploration 1992 and in Yukon Minfile 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.

S.R. Morison
Chief Geologist
Exploration and Geological Services Division
Northern Affairs Program
Yukon Region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1992 YUKON MINING AND EXPLORATION

INTRODUCTION

Exploration expenditures in 1992 showed a 38% drop to about $10 million, from $16 million the previous year. Much of this year's expenditures went toward several advanced mineral development projects which may lead to significant new mine development in Yukon. Two of the largest projects involved delineation of porphyry copper deposits in the Dawson Range (Williams Creek & Casino Minfile #115I 010 & #115J 026) northwest of Carmacks. Two more projects of similar size and significance involved bulk tonnage, low grade gold deposits, one near Dawson (BREWERY CREEK, Minfile #116B 160) and the other north of Mayo (DUBLIN GULCH, Minfile #106D 021).

Claim status remained fairly stable throughout the year, but staking records showed a definite shift in interest away from the epithermal vein gold deposits of the Wheaton River area in the Whitehorse Mining District and argentiferous galena veins of the Rancheria area in the Watson Lake Mining District, toward the enigmatic "Wernecke Breccias" in the Wernecke Mountains and the "gold porphyries" of the Mayo district. Although drilling of the TOM (Minfile #105O 001), NIDD (Minfile #105O 024) and JASON (Minfile #105O 019) deposits at Macmillan Pass ended last year, exploration of the Selwyn Basin for sedimentary exhalative zinc-lead-silver deposits in Earn Group black clastic rocks continued in the area between Macmillan Pass and Watson Lake.

MINING AND MINE DEVELOPMENT

The only hard rock mining operations in 1992 were Curragh Inc.'s lead-zinc-silver mines in the Faro and Watson Lake areas.

Curragh continued open pit production from its 7.1 million tonne VANGORDA deposit (Minfile #105K 055). Reserves are expected to last until the 16.9 million tonne GRUM deposit (Minfile #105K 056) begins production in early 1993. Open pit mining ceased at FARO (Minfile #105K 061) ceased in May, and the underground operations accessed from the pit were curtailed in October. The huge Faro pit will be used to store treated waste from the Grum open pit when it goes into production.

Stripping of Curragh's GRUM deposit (Minfile #105K 056) continued throughout 1992, and by the end of the third quarter, 10.5 million tonnes of overburden had been removed.

Curragh's SÄ DENA HES mine (Minfile #105A 012) in the Watson Lake area also produced lead and zinc concentrates from underground and small open pit operations located on Jewelbox Hill. The Burnick zone on North Hill (Minfile #105A 013) was explored with a short adit.

The KING ARCTIC JADE (Minfile #105H 016) property continued to produce jade for southern and overseas markets. The property is located in the Frances Lake area, north of Watson Lake. Exploration for the resource continues on a seasonal basis.

ADVANCED DEVELOPMENT

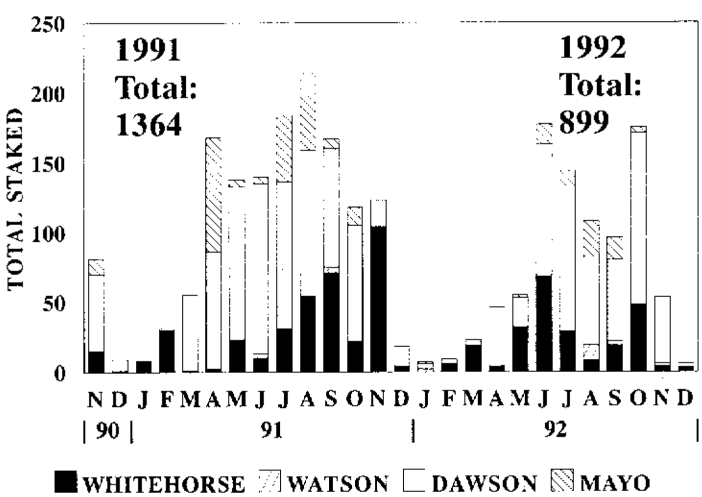
Western Copper Holdings and Thermal Exploration completed an extensive exploration program on the WILLIAMS CREEK oxide copper-gold property (Minfile #115I 010). The tabular deposit is oxidized to a depth of 240 m along its 395 m strike length. New reserves in the Main zone, the largest of 13 zones on the property, are 11.6 million tonnes grading 1.08% Cu and 0.34 g/t Au. The proposed open pit mining operation would use a heap leach–solvent extraction process followed by electrowinning to produce 90 kg copper ingots.

The 1992 program included condemnation drilling of proposed operating facility sites, and trenching and drilling on some of the peripheral zones to give a better understanding of the geology. Numerous engineering and geotechnical studies were continued in 1992 to assist with environmental permitting, pit wall stability, archaeological site identification, and determination of soil stability and permafrost distribution, along with metallurgical and pre-feasibility studies.

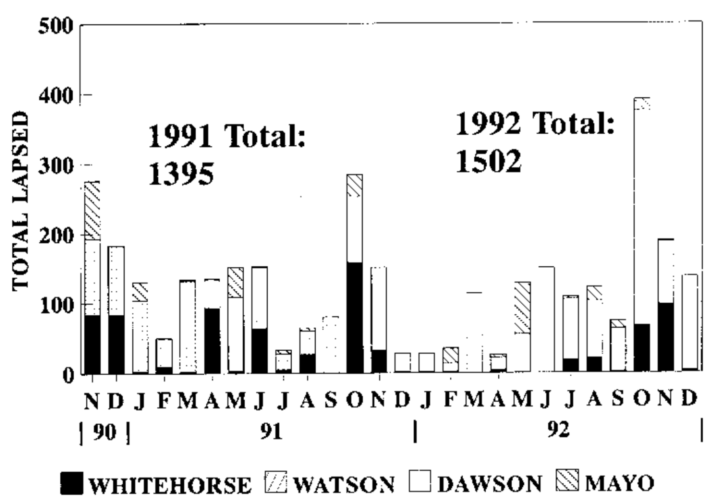
PLACER MINING

The number of operating placer mines remained about the same

PLACER CLAIMS STAKED
NOVEMBER 1990 - DECEMBER 1992



PLACER CLAIMS LAPSED
NOVEMBER 1990 - DECEMBER 1992



1992 EXPLORATION PROJECTS

COMPANY	PROJECT	MINING DISTRICT	MINFILE NUMBER	WORK TYPE	COMMODITY
Arbor Resources	DAWSON	Dawson	115N & O	T,GP,GC	Au
Aurchem Exp.	GOULTER	Whitehorse	115I 093	PD	Au,Ag
BHP Resources	IGOR	Mayo	106E 009	R,PE	Cu,REE,U,Au
BHP Resources	BOND	Mayo	106D 065	R,PE	Cu,REE,U,Au
BHP Resources	VARIOUS	Various	----	R,PE	Cu,REE,U,Au
Big Creek Res	CASINO	Whitehorse	115I 042	DD	Cu,Au
Carmacks Gold	TRAIL HILL	Dawson	115O 007	DD,GP,GC	Au
Cominco Res.	FIN	Watson Lake	105H 047	DD	Zn,Pb,Ag
Cominco Res.	LYNX	Watson Lake	105G 008	G,GC,DD	Zn,Pb
Cominco Res.	VARIOUS	----	----	G,GC	Zn,Pb
Curragh Res.	VARIOUS	----	----	DD,GP,PE	Various
Falconbridge Ltd, NDU Res., Pak-Man, 2001	NICK	Mayo	106D 092	G,T	Ni,Zn
Falconbridge Ltd	FALCON	Watson Lake	105I 044	G,GC	Ni,Zn
NDU Res.	JET	Mayo	105O 005		
First Yukon Silver	BAR	Watson Lake	105B 027	T,G	Zn
Granges Inc.	MATTHEW	Watson Lake	105F 013	G,GC,GP	Au,Pb,Zn
Amax Gold, H-6000	DUBLIN GULCH	Mayo	106D 021-029	PD	Au
Kennecott	LONE STAR	Dawson	115O 072	PD	Au
Kennecott	VARIOUS	Various	----	R,G,PE	Zn,Pb,Cu,Au
Noranda Exp., Loki Gold	BREWERY CR.	Dawson	116B 160	G,GC,DD,PD,T	Au
Noranda Exp.	VARIOUS	----	----	T,DD,G,GC,GP	Various
Placer Dome	VARIOUS	----	----	G	Various
Reed Cr. Mining	TREMBLAY	Whitehorse	115G 102	T,GC	Au
Total Energold, Mitsui	CLEAR LAKE	Whitehorse	105L 045	DD,GC,GP	Zn,Pb,Ag
Western Copper, Thermal Exp.	WILLIAMS CR	Whitehorse	115I 008	T,PD	Cu,Au
YGC Resources, Kennecott	BORDEN CREEK & Various	Dawson	115N 100	DD,P,R	Pb,Zn,Cu

T Trenching; DD Diamond Drilling; PD Percussion Drilling; G Geology GC Geochemistry; GP Geophysics; AG Airborne Geophysics; R Reconnaissance; PE Property Evaluation

as last year. Total production to the end of December was 99 541.52 troy ounces. This figure represents a decline of 10% from last year. The drop can be attributed to depletion of reserves in traditional placer mining districts, low gold prices and the difficulty of raising capital funding. Placer claims in good standing showed a 4% decrease from last year.

BASE METAL EXPLORATION

Total Energold Corp. and Mitsui Kinzoku Resources of Canada Ltd continued exploring the CLEAR LAKE (Minfile #105L 045) shale hosted lead-zinc deposit which is located 80 km northwest of Faro. The deposit is hosted by carbonaceous argillite of the Devono-Mississippian Earn Group, and is bounded to the east by the Tintina Fault and to the west by Mid-Devonian Askin Group shallow water clastic and carbonate rocks. Claims were first staked in the area in 1965 following the discovery of the Vangorda deposit to the southeast. A gravity anomaly with coincident magnetic and EM anomalies was drilled in 1978, resulting in the first mineralized drill intersection. The drilling outlined a sigmoid-shaped massive sulphide body 1000 m long by 120 m wide, which contains approximately 30 million tonnes of massive sulphides, including 5.53 million tonnes grading 11.34% Zn, 1.99% Pb and 40.8 g/t Ag. More recent work has shown that the deposit is folded, faulted and overturned. Evidence of exhalative activity includes silicified hanging wall and footwall rocks, pyritized worm tubes, and a separate tuff and barite unit in the stratigraphic footwall. The 1992 exploration program included 3100 m of diamond drilling, mapping, soil geochemistry, line cutting, and gravity, IP and PLMT (Power Line Magnetotelluric) geophysical surveys. Several mineralized targets were evaluated including Askin Group dolostones on the eastern extension of the Clear Lake property.

First Yukon Silver Resources continued trenching its DAN property (Minfile #105B 027) in the Swift River area, where several showings of massive sphalerite are hosted by Late Paleozoic calc-silicate rocks and felsic tuff along an east-west trend. The 1992 trenching concentrated on the CRESCENT and GOSSAN zones, and showed that the mineralization is stratiform and can be traced continuously for at least 3 km. Trenching also showed that the lower CRESCENT zone consists only of landslide derived deposits from the upper CRESCENT showing (Minfile #105B 026).

Noranda Exploration Co. Ltd worked briefly on the AZ property (Minfile #115F 050), which is located on the southwest flank of Hump Mountain north of White River. The AZ showing consists of poorly exposed copper-gold skarn mineralization formed in a gently dipping layer of limestone or calcareous volcanic rocks overlain by Triassic Nikolai Greenstone (rift basalt).

Under an option agreement with YGC Resources, Cominco Ltd mapped and sampled on the LYNX, WOLF and FOX claims (Minfile #105G 008) near the Robert Campbell Highway north of Watson Lake. Barite and massive sulphide showings occur in intermediate to felsic flows and pyroclastic rocks possibly associated with Devono-Mississippian rifting. The volcanic rocks overlie thick-bedded carbonate of the Silurian to Middle Devonian Askin Group.

Cominco also explored its FIN property (Minfile #105H 047), where sphalerite and galena occur in carbonaceous, calcareous and pyritic laminated mudstone of the Devono-Mississippian Earn Group. A 1000 by 200 m coincident lead and zinc soil anomaly with spotty silver values occurs near the showing, and drilling in 1980 intersected minor laminated sphalerite, galena and pyrite, pyrite-barite nodules and several barite lenses up to 3 m long and 15 cm thick. Drilling to the south in 1984 intersected layers of pyrite and sphalerite mineralization up to 70 cm thick, which assayed 11.6% Zn and 0.4% Pb. A geophysical survey in 1991 produced several EM anomalies, one of which is identical to the anomaly over the main zone. In 1992, the extent of the mineralization was tested by six reconnaissance holes averaging 100 m in depth.

Falconbridge Ltd continued to explore the NICK property (Minfile #106D 092) under option from NDU Resources Ltd. The NICK occurrence consists of a narrow layer of stratabound nickel and zinc massive sulphides which occurs at the contact between calcareous shale of the Ordovician to Lower Devonian Road River Formation and overlying siliceous turbiditic shale of the Devono-Mississippian Earn Group. Work in 1992 consisted of orthophoto based geological mapping and soil sampling.

Falconbridge also worked on NDU's FALCON (Minfile #105I 044) and JET (Minfile #105O 005) claims. Both properties are located in the Selwyn Basin approximately 140 km northeast of Ross River, and cover nickeliferous horizons in black shale, in a similar stratigraphic position to the NICK occurrence. Exploration on these two properties in 1992 consisted of orthophoto-based geological mapping and soil sampling.

In the Wernecke Mountains northwest of Mayo, BHP Minerals Canada Ltd performed reconnaissance mapping and lithogeochemical sampling on the BOND (Minfile #106D 065), IGOR (Minfile #106E 009), and other properties optioned from Archer, Cathro & Associates (1981) Ltd. Mineralized breccias on these properties are hosted by the Middle Proterozoic Wernecke Supergroup and contain iron oxides, copper, uranium, rare earth elements and gold.

Pamicon Developments Limited, Equity Engineering Limited and Westmin Resources Ltd also carried out an exploration program in the Wernecke Breccias. The program included staking of 12 properties, prospecting, rock geochemistry and limited geological mapping. An extensive property evaluation program is planned for early in 1993.

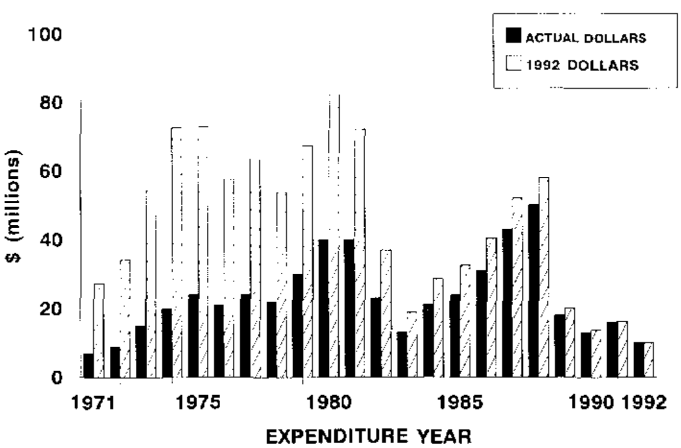
Kennecott Canada Inc. financed an exploration program managed by Archer, Cathro & Associates (1981) Ltd. on the BOR claims (Minfile #115N 100) owned by YGC Resources Ltd. The property is located at the south end of the Matson Creek Road, and covers metasedimentary and metavolcanic rocks assigned to the Klondike Schist (Permian). Previous work by YGC outlined a 7 km long lead-zinc-copper soil anomaly which parallels compositional layering in the schist, and found boxwork-textured schist float containing oxidized disseminated sulphides. Exploration in 1992 consisted of five diamond drillholes totalling 796 m, soil sampling and geophysics. The drillholes tested geochemical anomalies, and returned low grade sulphide mineralization.

Kennecott also financed small exploration programs on the MICKEY (Minfile #116C 116) and BAL (Minfile #116C 133) claim groups searching for polymetallic mineralization. The Bal claims are located north of the Top of the World Highway near the Alaska Border, and the Mickey claims are accessible from the Clinton Creek road.

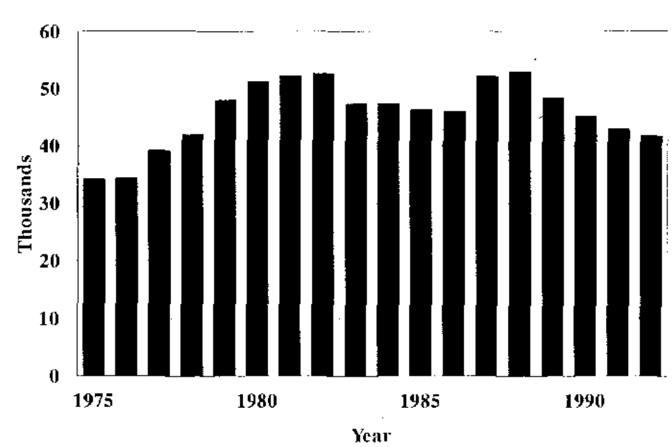
Other base metal exploration programs were conducted by Dromedary Exploration and Kokanee exploration in the Mayo area, and Granges Inc. on their MATHEW claims (Minfile #105F 013) southwest of Ross River.

Big Creek Resources carried out an extensive diamond drilling

EXPLORATION EXPENDITURES
1971-1992



CLAIMS IN GOOD STANDING
1975 - 1992



program on the CASINO property (Minfile #115J 028), optioned from Archer, Cathro & Associates (1981) Ltd in November, 1991. Casino is a very large copper-gold-molybdenum porphyry deposit located at the northwest end of the Dawson Range, 60 km west of the end of the Mt Freegold road. The property was drilled extensively in the late 1960's and early 1970's by Casino Silver Mines, which found uneconomic copper grades but did not assay for gold. The deposit is hosted by the Casino Complex, a subvolcanic suite of breccias, dykes and porphyritic phases dated at about 70 Ma, which intrude granodiorite of the Triassic Klotassin Batholith. The mineralized unit is a conical breccia body measuring about 600 by 350 m on surface, which plunges steeply to the south. The mineralization is zoned, and consists of a leached cap overlying supergene and hypogene-enriched alteration zones. The current drill program twinned existing drillholes using larger diameter core and tested promising new areas on the property. Present reserves are estimated at 378 million tonnes grading 0.3% Cu, 0.34 g/t Au and 0.04% Mo. Included in this calculation is a high grade core of 64 million tonnes grading 0.46% Cu and 0.48 g/t Au. Big Creek Resources Ltd. and Pacific Sentinel Gold Corporation recently amalgamated on a share for share basis. A 50 person camp and two additional drill rigs were moved onto the property in the late fall and an accelerated drill program is proposed for 1993.

GOLD EXPLORATION

In 1992, Loki Gold Corporation and Hemlo Gold Mines completed a two phase exploration program on the BREWERY CREEK (Minfile #116B 160) bulk tonnage oxide hosted gold deposit near Dawson. Gold mineralization is related to low angle faults separating a sill-like Cretaceous latite porphyry from underlying graphitic argillite, and high angle shears cutting both units. The first phase, consisting of 35 km of IP surveys, test pitting and mapping, and bulk density measurements, identified five targets south and east of known mineralization. The second phase included test pitting, reverse circulation drilling (15 holes), soil sampling, geological mapping and environmental baseline studies. The program outlined numerous geochemical and geophysical targets and extended favourable host rocks over a 12 km strike length. Drilling and trenching results were encouraging with hole 92-687 returning one metre grading 42.9 g/t Au and 26 m grading 1.71 g/t Au. Current geological reserves, calculated by Orcan Mineral Associates Ltd, are 16.5 million tonnes grading 1.85 g/t Au in 9 zones.

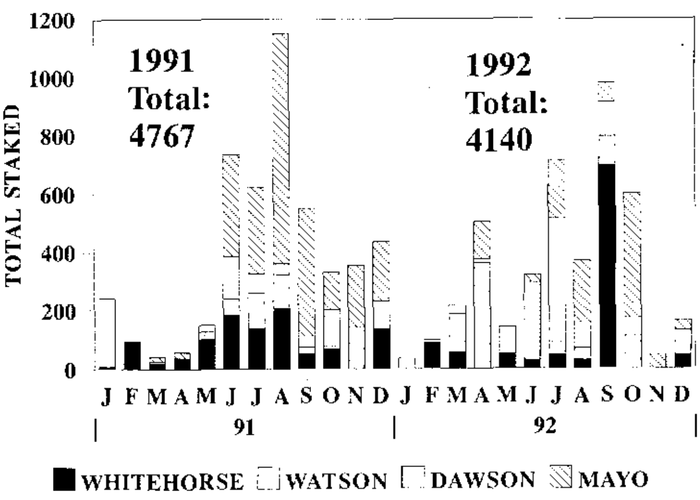
In the Mayo Mining District, Amax Gold continued an extensive drilling and trenching program begun in 1991 on its various property options in the Dublin Gulch and Haggart Creek areas (Minfile #s 106D 021-029), where Jurassic and Cretaceous granite and granodiorite stocks intrude Proterozoic to Lower Cambrian sedimentary rocks. The present work at Dublin Gulch follows Amax's 1991 purchase of the Fort Knox porphyry gold deposit near Fairbanks, Alaska. In 1992, Amax completed 46 reverse circulation holes totalling 5638.8 m.

Southwest of Dublin Gulch, H-6000 Holdings Ltd. conducted a program of grid soil and rock sampling, geological mapping and bulldozer trenching on SCHEELITE DOME (Minfile #115P 003). Scheelite Dome is underlain by a Cretaceous biotite-granodiorite stock which intrudes sedimentary rocks of the Late Proterozoic-Early Cambrian Hyland Group. Although the area is best known for its gold-bearing tungsten skarns, H-6000's program was aimed at finding a deposit similar in character to the Fort Knox deposit.

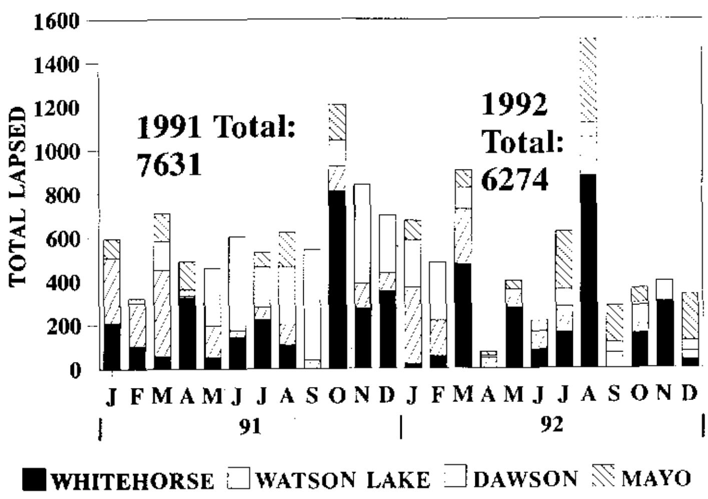
Aurchem Exploration Ltd. continued exploration on its DISCOVERY CREEK (Minfile #115I 093) option 50 km west of Carmacks. Gold and silver-bearing veins occur along two major north-trending structures, named the WILLOW CREEK and ELIZA CREEK zones. The veins cut Paleozoic(?) metasedimentary rocks and Cretaceous granodiorite and diorite. The property is thought to host both porphyry and vein-type mineralization. Work in 1992 consisted of geophysics, soil geochemistry, geological mapping, trenching and reverse circulation drilling.

Arbor Resources Inc. continued to explore its substantial holdings in the Klondike District near Dawson. Exploration in 1992 included geological mapping and trenching. Reconnaissance work was carried out on recently staked ground, and more detailed work was done near the LONESTAR (Minfile #116B 072) occurrence. The detailed work was designed to follow up geochemical anomalies

QUARTZ CLAIMS STAKED
JANUARY 1991 - DECEMBER 1992



QUARTZ CLAIMS LAPSED
JANUARY 1991 - DECEMBER 1992



previously outlined on Eldorado Creek between Gay Gulch and 27 Pup. Trenching revealed a vertical, four metre wide shear zone parallel to Eldorado Creek. This shear zone was traced continuously for 350 m, and similar mineralization has been traced intermittently for a further kilometre along strike.

Kennecott Canada Inc. optioned Arbor's LONESTAR property and carried out a program of trenching and reverse circulation drilling. The Lonestar property is underlain by quartz-muscovite augen schist of Permian age. Gold and silver occurs in mesothermal quartz veins and in oxide material in shear zones.

Northeast of the Lone Star, Carmacks Gold explored for epithermal mineralization in the Trail Hill area on claims optioned from Arbor Resources. The option covered an area consisting of altered Earn Group schists and Klondike Schist (Yukon Tanana Terrane). Carmacks explored with geophysics, geochemistry, prospecting and diamond drilling.

Placer Dome Inc. explored for Fort Knox style mineralization on the VAN and SUN claims north of Stewart River and in the Mt Billings area north of Watson Lake. The company also carried out an extensive regional exploration program and conducted numerous property examinations.

North of Clear Creek, Noranda Exploration Co. Ltd conducted a trenching and reverse circulation drill program on its RUM and RYE claims (Minfile #115P 011).

On Mt Anderson, in the Wheaton River area south of Whitehorse, Adda Minerals conducted further exploration for gold-bearing veins and skarns on the ROB claims (Minfile # 105D 029).

DRILLING STATISTICS: 1992

Project	Company	DIAMOND DRILLING meters	DIAMOND DRILLING # holes	PERCUSSION DRILLING meters	PERCUSSION DRILLING # holes
BREWERY CREEK	Noranda/Loki	---	---	1,233	19
WILLIAMS CREEK	WHC/Thermal	3,781	11	2,805	11
DUBLIN GULCH	Amax Gold	---	---	5,639	46
CLEAR LAKE	Total Energold, Mitsui Kinzoku	3,100	10	---	---
CLEAR CREEK	Noranda	---	---	644	6
BOR	Kennecott Canada	796	5	---	---
Sä DENA HES	Curragh Resources	16,460	79	---	---
FIN	Cominco	~600	6	---	---
TRAIL HILL	Carmack Gold	623.3	8	---	---
CASINO	Big Creek Res.	4572	21	---	---
LONE STAR	Kennecott	1212	20	---	---

EXPLORATION AND GEOLOGICAL SERVICES DIVISION NORTHERN AFFAIRS PROGRAM, YUKON REGION

The Government of Canada manages mineral resources in the Yukon Territory through the Northern Affairs Program of Indian and Northern Affairs Canada, Yukon Region. The Mineral Resources Directorate of the Northern Affairs Program consists of Mineral Rights, Mineral Development, and the Exploration and Geological Services Division.

EXPLORATION AND GEOLOGICAL SERVICES DIVISION (EGSD)

Exploration and Geological Services Division staff presently includes S.R. Morison (Regional Manager/Chief Geologist), J.G. Abbott (Senior Geologist), T.J. Bremner (Geologist), D. Emond (Environmental Geologist), R. Deklerk and D. Ouellette (Staff Geologists), M. Burke (Geotechnician and Core Librarian), A. Wagner (Office Manager), and E. Phillips (Manager, Map Sales). R. Deklerk replaces W.P LeBarge for an 18 month period while the latter completes an MSc degree at the University of Calgary.

EGSD STAFF ACTIVITIES

Stephen Morison (Chief Geologist) is currently involved in the planning and implimentation of the activities of staff at the new Geoscience office set up through the Mineral Resources Sub-agreement of the Canada/Yukon Economic Development Agreement. He continues to use his placer sedimentology expertise to advise client groups and support related geological studies. In addition to this, he continues to provide technical advice for such policy initiatives as the Placer Mining Implementation Review Committee (IRC) and the Yukon Mining Advisory Committee (YMAC). Grant Abbott (Senior Geologist) is chiefly responsible for 1:50 000 scale mapping projects and this year worked on Hart River 116 A/10 and 11 sheets. He is currently located at the MDA Geoscience office where he has taken on the role of scientific authority. Trevor Bremner (Mineral Deposit Geologist) updated the YUKON MINFILE and carried out fieldwork in the Kluane Range (115G) west of Whitehorse collaboration with Peter Reed. Diane Emond returned to the department under the new title of Environmental Geologist. Her new duties include providing technical advice on mining issues to other government departments and client groups, and overseeing various geoscientific projects designed to assist the Placer Implementation Review Committee. In addition, she is the scientific authority for the development of a datatabase of geological processes. Robert Deklerk is responsible for approving placer and quartz assessment reports and visiting active mining properties in the Dawson and Mayo Mining Districts. Dennis Ouellette (Staff Geologist) is responsible for visiting mining properties and approving quartz assessment reports in the Whitehorse and Watson Lake Mining Districts.

YUKON MINFILE, a mineral occurrence inventory, is currently available from Exploration & Geological Services Division by individual 1:250 000 NTS map sheet or as an entire 1500 page, 38 map file. The 1992 YUKON MINFILE update is also available on floppy disks in WordPerfect ®5.1 format. The complete database will be available in WordPerfect ®5.1 early in 1993. A more extensive/intensive database search is available by appointment from the EGSD office. Reports generated by the database computer are more detailed and formatted differently than the capsule summaries found in the paper copy of the Minfile release. Please contact Mike Burke (403-667-3202) for further information or to set up an appointment.

The Division is responsible for publishing several scientific reports including the annual Yukon Exploration report and the Yukon Geology Series and maintaining Yukon Minfile. Yukon Geology Volumes 1, 2 and 3 are compilations of recent geological papers from studies which were supported or assisted by the Exploration and Geological Services Division. Yukon Exploration, previously a compilation of assessment report summaries, has taken on a new look with current statistics and descriptions of actively explored mineral properties, as well as detailed geological descriptions of properties visited by EGSD staff and affiliated geoscientists. This year we have added current research papers produced by the geological staff at the MDA Geoscience office.

The Division also maintains the Yukon outlet of the Canada Map Office and sells topographic, geological (surficial and bedrock), aeromagnetic, aeronautical and land use maps. Geological Survey of Canada publications related to Yukon and northern British Columbia are also available. A library of geological texts and journals and selected air photos covering the Yukon from latitude 60o to 65oN are available for viewing.

AFFILIATED ACTIVITIES

Dennis Brown - PhD detailed structural analysis of the Vangorda deposit. (Completed 1992)

John Knight - PhD study of the trace element chemistry of placer gold.

RECENT PUBLICATIONS

Yukon Minfile Updates - 28 of the 38 sheets available required updates in 1991. Ten maps were also updated.

The updated sheets are available individually or as a set.

95D	105G*	105N*	115I
105A	105H	105O*	115J
105B	105I	106C*	115O&N*
105C*	105J	106D	115P
105D*	105K	115A	116A*
105E	105L	115F&G*	116B&C*
105F*	105M	115H	117A

* DENOTES UPDATED MAPS

INAC, (1992). Yukon Exploration 1991; Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada.

INAC, (1992). Yukon Geology Volume 3; Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada.

EGSD Open File 1992-1, GEOLOGY OF THE OGILVY MOUNTAINS BRECCIAS, COAL CREEK INLIER, (NTS 116B/11, 13, 14) Yukon Territory. By R.A. Lane and C.I. Godwin.

EGSD Open File 1992-2, GEOLOGICAL MAP OF PART OF MAP SHEETS 116A/10 & 116A/11, by J.G. Abbott (Exploration & Geological Services Division, INAC) and C.F. Roots (Geological

Survey of Canada)

EGSD Open File 1992-3, GEOLOGICAL MAP OF KENO HILL AREA (105M/14), by D. Murphy and C. Roots (Geological Survey of Canada).

CANADA/YUKON ECONOMIC DEVELOPMENT AGREEMENT (EDA)

The Mineral Resources Cooperation Agreement is funded under the 1991-1996 Canada/Yukon Economic Development Agreement (EDA). Within this cooperation agreement are three elements; i) Geoscience ii) Mining Technology and iii) Information. The Energy and Mines Branch, Department of Economic Development, Government of Yukon is the prime administrative agency for the Mineral Resources Cooperation Agreement (MRCA).

1. GEOSCIENCE ELEMENT

The long-term objective of the 1:50 000 scale geological mapping program is to develop locally-based expertise in the regional geological setting of Yukon Mineral deposits. An active and successful hardrock and placer exploration industry can be realized by the development of a comprehensive, modern geoscience information base.

Geoscience Office staff includes D. Murphy (Senior Geologist), T. Fuller (Placer Geologist), C. Hart (Project Geologist), S. Johnston (Project Geologist), D. Thorkelson (Project Geologist), L. Walton (Coordinator), W. VanRanden (Draftsperson), and D. Carruthers (Administrative Assistant). Seasonal geological assistance was provided by F. Andersen, D. Brent, N. Hachey, D. Héon, J. Hunt, and C. Wallace. C. Roots from the Geological Survey of Canada and G. Abbott from Exploration & Geological Services Division, Northern Affairs Program are being supported by the Geoscience Program.

STAFF ACTIVITIES

The following mapping programs (see figure 1 for locations) were begun in the most economically important geological provinces:

a) C. Hart and D. Brent in the Whitehorse Trough near Whitehorse (105D/13).

b) S. Johnston and N. Hachey in the Yukon-Tanana terrane in the Mt Pitt area (115I/13)

c) D. Murphy and D. Héon in Western Selwyn Basin in the Clear Creek area (115P/14).

d) D. Thorkelson and C. Wallace in the Wernecke Supergroup in map area 106D/16. and

e) T. Fuller and F. Andersen in surficial deposits of Black Hills Creek (115O/7 & 115O/10).

f) C. Roots and J. Hunt carried out 1:250 000 scale mapping in western Selwyn Basin in the Mayo area (105M), and J. Hunt completed a 1:50 000 scale compilation of the Mount Haldane area (105M/13).

g) G. Abbott continued 1:50 000 scale mapping in the Hart River area (116A/10&11), along the boundary between Ogilvie-Mackenzie Platform and Selwyn Basin.

RECENT PUBLICATIONS

MDA Open File 1992-4, GEOLOGICAL MAP OF THE MAYO MAP AREA (105M), by C.F. Roots and D.C. Murphy (Geological Survey of Canada)

2. TECHNOLOGY ELEMENT

The objective is to increase the economic and environmental efficiency of Yukon placer and hardrock mining operations operations by encouraging innovative exploration, mining and processing technology, as well as projects aimed at reducing or mitigating environmental impacts.

1991-1992 Funded Projects

a) RADAR Remote Sensing Evaluation

b) Engineering/Economic Study of the Costs of Implementing Fisheries Restoration/Compensation Guidelines

c) Report and Video on Placer Dredging

d) Remote Sensing Seminar

e) Yukon Minerals Industry Bibliography

f) Industrial Minerals Update

g) High Pit Wall Stability Analysis in Placer Mines

h) Evaluation of Yukon Placer Drilling Techniques

i) Yukon Placer Implementation Review Committee Report Reproduction

j) Evaluation of Ground Penetrating Radar as a Placer Exploration Tool

k) Diamond Exploration Seminar

l) Tailings Reprocessing Study

3. INFORMATION ELEMENT

The objective of the information element is to communicate information about the mining industry to encourage Yukon residents and businesses to take advantage of economic opportunities in the industry.

a) Binet House Geology Display, Mayo

Completed project reports, maps, and videos are available for purchase or viewing at the Yukon outlet of the Canada Map Office.

DRILL CORE INDEX: H.S. BOSTOCK CORE LIBRARY

The H.S. Bostock Core Library houses approximately 120,000 metres of diamond drill core from 177 Yukon properties. The facility is located across the street from the 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. The following is a list of the properties now represented in the library (* denotes current additions):

N.T.S.	PROPERTY AND/OR CLAIM NAME	COMPANY
94K,L	DRIFTPILE CREEK	Archer Cathro (Gataga Joint Venture)
95D 5,12	MCMILLAN (QUARTZ LAKE)	Noranda Exploration Company Limited
95D 12	MCMILLAN (QUARTZ LAKE)	Asarco Exploration of Canada
95D 6	MEL	Sovereign Metals Limited
95D 6	MEL	Novamin Resources Limited
95D 5,12	PORKER	Archer Cathro (Hyland Joint Venture)
104G 1	MULE CREEK	Noranda Exploration Company Limited
104M 1	HOBOE	Noranda Exploration Company Limited
105A 2,3,6	LIARD COAL	Placer Dome Inc.
105A 7,10	MT HUNDERE	Canadian Mine Services, CIMA Resources
105B 1	LUCK	Serem Inc., Goldex Resources Inc.
105B 1	FIDDLER	Amax Gold Inc.
105B 1	LORD	Butler Mountain Minerals Corp.
105B 4	BARB	A.M.P. Exploration and Mining Co. Ltd.
105B 4	CAN	Cominco Mining Limited
105B 4	MC, DU	DuPont of Canada Exploration Ltd.
105B 4,5	SWIFT RIVER	DuPont of Canada Exploration Ltd.
105B 7	NITE	Archer Cathro (Wolf Lake Joint Venture)
105B 11	IRVINE	Hudson Bay Exploration and Development
105B 14	SHOOTAMOOK	Total Erickson Resources Ltd.
105C 5	TOG	Dunvegan Exploration Ltd.
105C 8, 9	BAR	Comox Resources Ltd.(J.C.Stephen Exp.Ltd.)
105C 9	MINDY	Newmont Exploration of Canada Ltd.
105C 13	RED MOUNTAIN	Boswell River Mines Ltd.
105C 14	LINDSAY	Joe Lindsay
105D 1	JUBILEE	Golden Slipper Resources, Logan Mines Limited
105D 2	VENUS	Venus Mines Limited
105D 2	PEERLESS, BIG THING	International Mine Services Ltd.
105D 2	BIG THING (ARCTIC)	Arctic Gold and Silver Mines Ltd.
105D 2	JEAN	Univex Mining Corporation
105D 2,3	MIDNIGHT GULCH	Island Mining & Exploration Co. Ltd.
105D 3	MT ANDERSON	Noranda Exploration Company Limited
105D 3	DICKSON HILL	Shakwak Exploration Company Limited
105D 3,4	CHARLESTON	Island Mining & Exploration Co. Ltd.
105D 3, 6	TALLY-HO MOUNTAIN	Tally-Ho Exploration Company Limited
105D 3, 6	TALLY-HO GULCH	Tally-Ho Exploration Company Limited
105D 4	RAM	Inco Metals Company
105D 6	VESUVIUS MTN	Shakwak Exploration Company Limited
105D 8	BUG	Dunvegan Exploration Ltd.
105D 10	WHITEHORSE COPPER	Hudson Bay Exploration and Development
105D 10, 11	WHITEHORSE COPPER	Whitehorse Copper Mines Ltd.
105D 11	POLAR	Mike Nichiporick
105D 11	ARCTIC CHIEF	Whitehorse Copper Mines Ltd.
105D 11	BEST CHANCE NORTH	Whitehorse Copper Mines Ltd.
105D 11	GRAFTER, KODIAK CUB	Whitehorse Copper Mines Ltd.
105D 11	LAST CHANCE, WAR EAGLE	Hudson Bay Exploration and Development
105D 11	GROUSE (JACKSON CREEK)	Whitehorse Copper Mines Ltd.
105D 11	WAR EAGLE	Whitehorse Copper Mines Ltd.
105D 11	TURBINE #4 NCPC	Whitehorse Power Corporation
105D 11	NORTH STAR	Whitehorse Copper Mines Ltd.
105D 11,14	RABBITS FOOT	Whitehorse Copper Mines Ltd.
105D 14	BEE	Silver Sabre Resources Inc.
105D 14	SUITS	United Keno Hill Mines Ltd.
105E 11	MIDAS	Midas Exploration Ltd.
105F 3	QUIET LAKE	Joe Lindsay

N.T.S.	PROPERTY AND/OR CLAIM NAME	COMPANY
105F 6	HIDDEN, AYDUCK	Archer Cathro (CUB Joint Venture)
105F 7,10	STORMY MOUNTAIN	Rio Alto Exploration Ltd.
105F 7,10	GULL	Dupont of Canada Exploration
105F 9,10	PELMAC	Curragh Resources Ltd. (Cyprus Anvil)
105F 9,10	BNOB	Curragh Resources Ltd. (Cyprus Anvil)
105F 14	RISBY TUNGSTEN	Hudson Bay Exploration and Development
*105F 16	LUKESHANE	A. Carlos
105G 2	FYRE	Cassiar Asbestos Mining Corporation Ltd.
105G 2	FYRE (DUB)	Atlas Exploration Ltd.
105G 3	TINTINA	Tintina Silver (Rio Tinto)
105G 6	SANDERS	Archer Cathro (Chevron Canada Ltd.)
105G 6	BOOT	Archer Cathro (Chevron Canada Ltd.)
105G 6	CYR	Newmont Exploration Limited
105G 7	PACK	Conwest Exploration Limited
105G 8	FETISH	Archer Cathro (Finlayson Joint Venture)
105G 11	EAGLE (BEV)	Hudson Bay Exploration and Development
105G 11	BEV	Hudson Bay Exploration and Development
105G 14	DWONK (ANMAK PROJECT)	Curragh Resources Ltd. (Cyprus Anvil)
105G 14	PELLY BANKS	Hudson Bay Exploration and Development
105G 14	ELECTRIC	Pelly Banks Syndicate
105G 14	LEACH, FAULT, CZAR	Dupont of Canada Exploration
105H 5	JULIA	Esso Minerals Canada Limited
105H 8	SUSAN	Union Carbide
105H 10	TOY (REA)	Union Carbide
105I 6	HOWARD'S PASS	Placer Dome Inc.
105I 12	ABBEY	Archer Cathro (Itsi Joint Venture)
105I 15	OMO	Hudson Bay Exploration and Development
105K 1	TENAS	Dupont of Canada Exploration
105K 2	GREW CREEK	Hudson Bay Exploration and Development
105K 3	LYN	J. Graham
105K 3	LYN	Cyprus Exploration Ltd.
105K 3	SUNSET (LYN)	Welcome North Mines Limited
*105K 6	VANGODA	Curragh Inc.
105K 6	ROSE CREEK	Cyprus Anvil Mining Company Ltd.
105K 11	HAL	Northern Homestake Mines Ltd.
105L 8	FELIX	Union Carbide
105L 14	TUM	Cominco Mining Limited
105L 15	ONE HUMP	Anaconda Canada Exploration Ltd.
105M 13	WAYNE	Island Mining & Exploration Co. Ltd.
105M 14	EAGLE	Archer Cathro, Brameda Res. Ltd. & Teck Corp.
*105O 1	JASON	Phelps Dodge
105O 1	TOM	Hudson Bay Exploration and Development
105O 1	FETCH	Inco Metals Company
105O 1	ESS	Archer Cathro (Itsi Joint Venture)
105O 2	TEA	Eisenman Enterprises Limited
106B 4	BIRKLAND	McIntyre Mines Limited
106B 15, 16	GAYNA RIVER	Rio Tinto Mines Ltd.
106C 7	HARRISON	Great Plains Development Inc.
106C 7	GOZ CREEK	(Bonnet Plume River) Barrier Reef Resources Ltd.
106C 13	FAIRCHILD	Magni Mana Cement Company Limited
106C 14	MAMMOTH	Bonnet Plume River Mines
106C 14	PTERD	Archer Cathro (Ogilvie Joint Venture)
106C 15	CAB	Welcome North Mines Limited
106D 1, 2	MARG	Archer Cathro & Associates (1981) Ltd.
106D 7	BLENDE	Archer Cathro & Associates (1981) Ltd.

N.T.S.	PROPERTY AND/OR CLAIM NAME	COMPANY
106D 10	BOND	Eldorado Nuclear Ltd.
106D 10	BOND	Archer Cathro (Wernecke Joint Venture)
106D 11	NICK	Archer Cathro & Assoc., NDU Resources
106D 16	PAGISTEEL	Pacific Giant Steel Ltd.
106E 1	IGOR	Archer Cathro and Associates (1981) Ltd.
106E 1	OTIS, IGOR	Archer Cathro (Ogilvie Joint Venture)
106E 2	FLUNK	Archer Cathro (Ogilvie Joint Venture)
106E 3	FORSTER	Archer Cathro (Ogilvie Joint Venture)
106E 6	BONNET PLUME COAL	Pan Ocean Oil Ltd.
114P 8	MT. HENRY CLAY	Stryker Resources Ltd.
114P 15	CANDY MOUNTAIN	Noranda Exploration Company Limited
114P 15	PANTHER	Canex Placer Ltd.
114P 15	PARTON RIVER	Noranda Exploration Company Limited
115A 3	JACKPOT	Jackpot Copper Ltd.
115A 8	DEVILS' HOLE	Phelps Dodge Ltd.
115F 15	CANALASK	Versluce Mines Ltd.
115F 15,16	CANALASK	Canalask Nickel Syndicate
*115G 5	LORI	Archer Cathro & Associates (1981) Ltd.
115G 5	WELLGREEN	Archer Cathro and Associates (1981) Ltd.
115G 5	WELLGREEN	Hudson Bay Exploration and Development
115G 5	QUILL CREEK	Hudson Bay Exploration and Development
115G 6	CORK	Imperial Oil Ltd.
115H 2	AISHIHIK	Hudson Bay Exploration and Development
115H 5, 12	SEKULMUN	Mike Nichiporick
115H 8	TESLIN	Teslin Exploration Limited
115H 8	LION	Archer Cathro and Associates (1981) Ltd.
115H 8, 105 E	DIVISION MTN	Arjay Kirker Resources Ltd.- Archer Cathro
115H 9	MACK'S COPPER	Arsenault/Versluce Mines Ltd.
115H 15	BUFFALO	Noranda Exploration Company Limited
115I 3	MT NANSEN	Kangaroo Exploration
115I 3	CYPRUS, MT NANSEN	Cyprus Exploration, Area Explorations Ltd.
115I 5	CASH	Archer Cathro (Klotassin J.V., Carmacks synd)
115I 5	FROG	Archer Cathro (CUB Joint Venture)
115I 6	DART	Noranda Exploration Company Limited
115I 6	LAFORMA	Rayrock Mines Limited
115I 6	LAFORMA	Tally-Ho Exploration Ltd.
115I 6	REVENUE CREEK	Shakwak Exploration Co. Ltd.
115I 6	REVENUE, NUCLEUS	Archer Cathro (Nat Joint Venture)
115I 6	CARIBOU CREEK	Doron Exploration Ltd.
115I 6,7	TINTA HILL	Mill City Gold Ltd.
115I 7	WILLIAMS CREEK	Dawson Range Joint Venture
115I 7	WILLIAMS CREEK	Archer Cathro (Dawson Range Joint Venture)
115I 7	GRANITE MOUNTAIN	Dawson Range J V (Canex Aerial Expl. Ltd)
115I 11	MINTO	United Keno Hill Mines Ltd.
115I 13	KERR	Kerr Addison Mines Ltd.
115I 14	PELLY	Occidental Petroleum Inc.
115J 9	KOE	Kerr Addison Mines Ltd.
115O 1	TANTALUS BUTTE	Tantalus Butte Mines (Cyprus Anvil Mining Co. Ltd.)
115O 11	MCKINNON	McKinnon Rand Resources
115O 11	MCKINNON	Volcano Resources Ltd.
115O 14	DAWSYND	Dawsynd Exploration Ltd.
115O 14	LONE STAR	Arbor Resources Inc.
115O 14	DAWSON	Dawson Syndicate Exploration Ltd.
115O 14, 15	TEMPERANCE HILL	United Keno Hill Mines Ltd.
115P 13	URA	Beach Gold Mines Ltd.

N.T.S.	PROPERTY AND/OR CLAIM NAME	COMPANY
115P 14	ZETA	Noranda Exploration Company Limited
116B 2,3	UNEXPECTED	Archer Cathro (Ukon Joint Venture)
*116B 3	XL	Herdis International Canada Inc.
116B 7	MAIDEN	Archer Cathro (Ukon Joint Venture)
116B 7	MARN	Noranda Exploration Company Limited
116B 8	THOR	Anaconda Canada Exploration Ltd.
116B 9, 10	TAK	Noranda Exploration Company Limited
116B 11	COMBINATION	Chevron Standard Limited
116B 13	OD, DASH	Union Miniere Exploration
116B 13	OD, LALA	Union Miniere Exploration
116C 7	CLINTON CREEK	Cassiar Asbestos Mining Corporation Ltd.
116C 8	CASSIAR CREEK	Noranda Exploration Company Limited
116G 1	MILCH	Milchem Canada Inc.
116K 8, 9	RUSTY SPRINGS	Kenton Natural Resources Limited

REVISED STRATIGRAPHY AND NEW EXPLORATION TARGETS IN THE HART RIVER REGION (NTS 116A/10, 116A/11), SOUTHEASTERN OGILVIE MOUNTAINS

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ABBOTT, J.G., 1993. Revised stratigraphy and new exploration targets in the Hart River area, southeastern Yukon. In: Yukon Exploration and Geology, 1992, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 13-23.

ABSTRACT

The Hart River area (maps 116A/10&11) of the southeastern Ogilvie Mountains is underlain by two varied and widespread successions which offer the most potential for discovery of sediment-hosted base metal deposits in the northern Canadian Cordillera. A "shelf sequence", north of the Dawson fault, includes: Middle Proterozoic Wernecke Supergroup; Middle and (?) Late Proterozoic Fifteenmile group; the Late Proterozoic Windermere Supergroup; Ordovician and Silurian carbonate; Ordovician to Devonian(?) Road River Group; Devonian Ogilvie Formation; and Devono-Mississippian Earn Group. The "offshelf sequence" includes: Late Proterozoic Hyland Group; Cambrian volcanic rocks; Lower Cambrian Vampire Formation equivalent; Cambrian Gull Lake Formation equivlalent; Cambro-Ordovician Rabbitkettle Formation equivalent; Ordovician and younger(?) Road River Group; Mississippian Keno Hill quartzite; and Devonian(?) to Jurassic(?) Lower Schist. The most promising exploration targets are: 1)massive sulphide deposits associated with the Hart River volcanic rocks in the Gillespie Lake Group (upper part of the Wernecke Supergroup); 2)sedimentary copper deposits in the Fifteenmile Group; 3)"Anvil-type" pyritic massive sulphide deposits in the transition zone between the Gull Lake and Rabbitkettle Formations; 4)"Howard's pass-type" zinc-lead deposits in previously unmapped black shale and chert of the Road River Group; 5)sulphide deposits associated with Cambrian, Ordovician(?) and Devonian(?) mafic volcanic and intrusive rocks; 6)covered areas at the base of the Lower Schist which may overlie the the Earn Group, with potential for "Macmillan Pass-type" zinc, lead, silver, barite deposits; 7)volcanogenic massive sulphide deposits associated with felsic volcanic rocks in the Keno Hill quartzite.

INTRODUCTION

This report presents preliminary revisions to the stratigraphy of the Hart River region, southeastern Ogilvie Mountains, based on recent 1:50,000 scale geological mapping of NTS areas 116A/10(unnamed) and 116A/11(Two Beaver Lake) (Figure 1), and comments on implications for mineral exploration. Two geological provinces underlie the map areas; a carbonate-dominated "shelf sequence", which includes Ogilvie-Mackenzie Platform, in the north, and the shale-dominated "offshelf sequence" of Selwyn Basin in the south. They underlie most of northern and central Yukon, and in the northern Canadian Cordillera, contain most of the known sediment-hosted base metal deposits, and offer the most potential for new discoveries. The one known mineral deposit in the map areas is the Middle Proterozoic Hart River massive sulphide deposit with proven and probable reserves of 1,068,000 tonnes grading 3.6% Zn, 1.45% Cu, 0.9 % Pb, 49.7 g/T Ag and 1.41 g/T Au (INAC, 1992).

Most exploration for sediment-hosted base metal deposits during the last decade concentrated on known deposits and their immediate surroundings, but the number of known deposits is small and their potential will diminish with continued exploration. Future exploration must return to "grass roots," but with a more focused and detailed approach than the broadly based first passes of twenty years ago when coverage of large areas, without detailed stratigraphic information, precluded detailed searches of smaller areas with higher potential. This study attempts to identify those stratigraphic units which offer the most mineral potential, and which may have been overlooked in the past.

Previous and Present Work

Green (1972) established the regional stratigraphic and structural framework when he completed 1:250,000 scale mapping of Dawson (116B&C), Larsen (116A) and Nash (106D) map areas in 1966. Morin (1979) studied the Hart River deposit. The writer began 1:50,000 scale geological mapping in 1986, when about one month was spent in the area. Mapping resumed in 1991 (2 weeks), and continued in 1992 (5 weeks). C.F. Roots mapped in both sheets for a month in 1987, and his data has been incorporated (Abbott and Roots, 1992; 1993a,b). Mapping of areas 116A/10&11 is incomplete and will continue in 1993.

Regional Setting

The study areas straddle the Dawson fault, which juxtaposes a "shelf sequence" (including Lower and Middle Paleozoic carbonate rocks of Ogilvie-Mackenzie Platform) of Middle Proterozoic through Middle Paleozoic clastic, carbonate, and volcanic rocks to the north (Figure 2) and an "offshelf sequence" (including Late Proterozoic to Middle Paleozoic clastic and volcanic rocks of Selwyn Basin) of latest Proterozoic to Jurassic deeper water clastic and volcanic rocks to the south (Figure 3). Both sequences remain generally consistent across the southern Ogilvie and Wernecke Mountains, and closely resemble those described by Thompson and Roots (1982) in Dawson map area.

The region is part of the Cordilleran foreland thrust and fold belt and strata imbricated by a series of moderately south-dipping, northerly directed thrust faults. Three principal faults (Figure 1); the Dawson, Tombstone, and Robert Service thrusts, are more than 200 km long and juxtapose consistent, distinct sequences of rocks. The most dramatic is the juxtaposition of the "offshelf" sequence against the "shelf" sequence along the Dawson thrust. The Tombstone thrust places the Mississippian Keno Hill quartzite on the Jurassic and older Lower Schist. The Robert Service thrust, immediately south of the map areas, places the Latest Proterozoic and Early Cambrian Hyland Group on the Keno Hill quartzite. Other faults are spaced 1 to 3 km apart, and have a stratigraphic throw of less than 1 km. All units are cleaved and folded, and metamorphosed to sub to lower greenschist facies. Intensity of deformation increases gradually from north to south.

"SHELF SEQUENCE"

Wernecke Supergroup (PQ, PG1, 2, 3, 4)

The oldest exposed rocks in the Ogilvie and Wernecke Mountains belong to the Wernecke Supergroup which includes the Fairchild Lake, Quartet and Gillespie Lake groups (Delaney, 1981). The Fairchild Lake Group is not exposed in the map area, and the oldest rocks are dark grey to black shale, siltstone and sandstone of the Quartet Group(PQ). The Quartet Group grades upward into orange weathering dolostone, silty dolostone, and dolomitic shale and siltstone of the Gillespie Lake Group(PG1).

The Gillespie Lake Group contains the Hart River volcanics, an interval of mafic lava flows and laterally equivalent, laminated tuffs(PG3), bounded above and below by black shale(PG2). The lava flows overlie the Hart River massive sulphide deposit, have a total strike length of about 2 km, and a maximum thickness of about 75 m. Mafic sills(Pd) up to 250 meters thick intrude the Quartet Group and the Gillespie Lake Group. They occur only below the volcanic/tuff interval, are thickest and most numerous beneath the lava flows and the massive sulphide deposit, and are therefore considered to be genetically related to both.

Unit PG2 grades upward over a few meters into orange weathering dolomitic shale and argillaceous dolostone(PG4). The unit gradually becomes more dolomitic and thicker bedded upsection. Unit PG4 closely resembles unit PG1.

Age and Correlation

The Hart River volcanics (PG3), black shale (PG2) and overlying orange to buff weathering silty dolostone(PG4) resemble the lower parts of the Pinguicula group as described by Eisbacher (1978, 1981). However, the Pinguicula group overlies the Wernecke Supergroup with angular unconformity (Eisbacher, 1981). No angular unconformity was observed beneath the Hart River volcanics, but conglomerate, sandstone and shale correlated with the

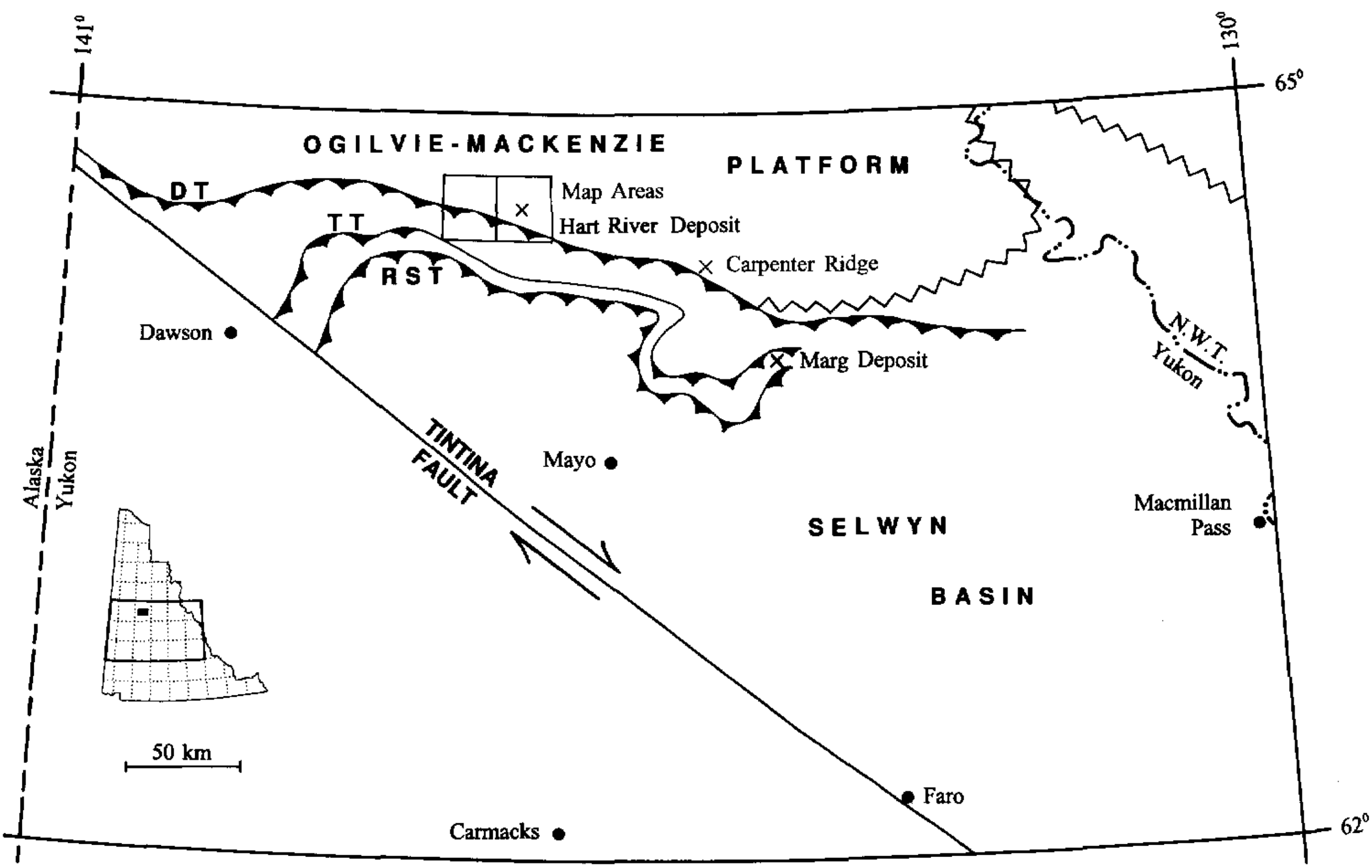

Figure 1. Tectonic setting and location of the study area. DT-Dawson thrust: TT-Tombstone thrust; RST- Robert Service thrust.

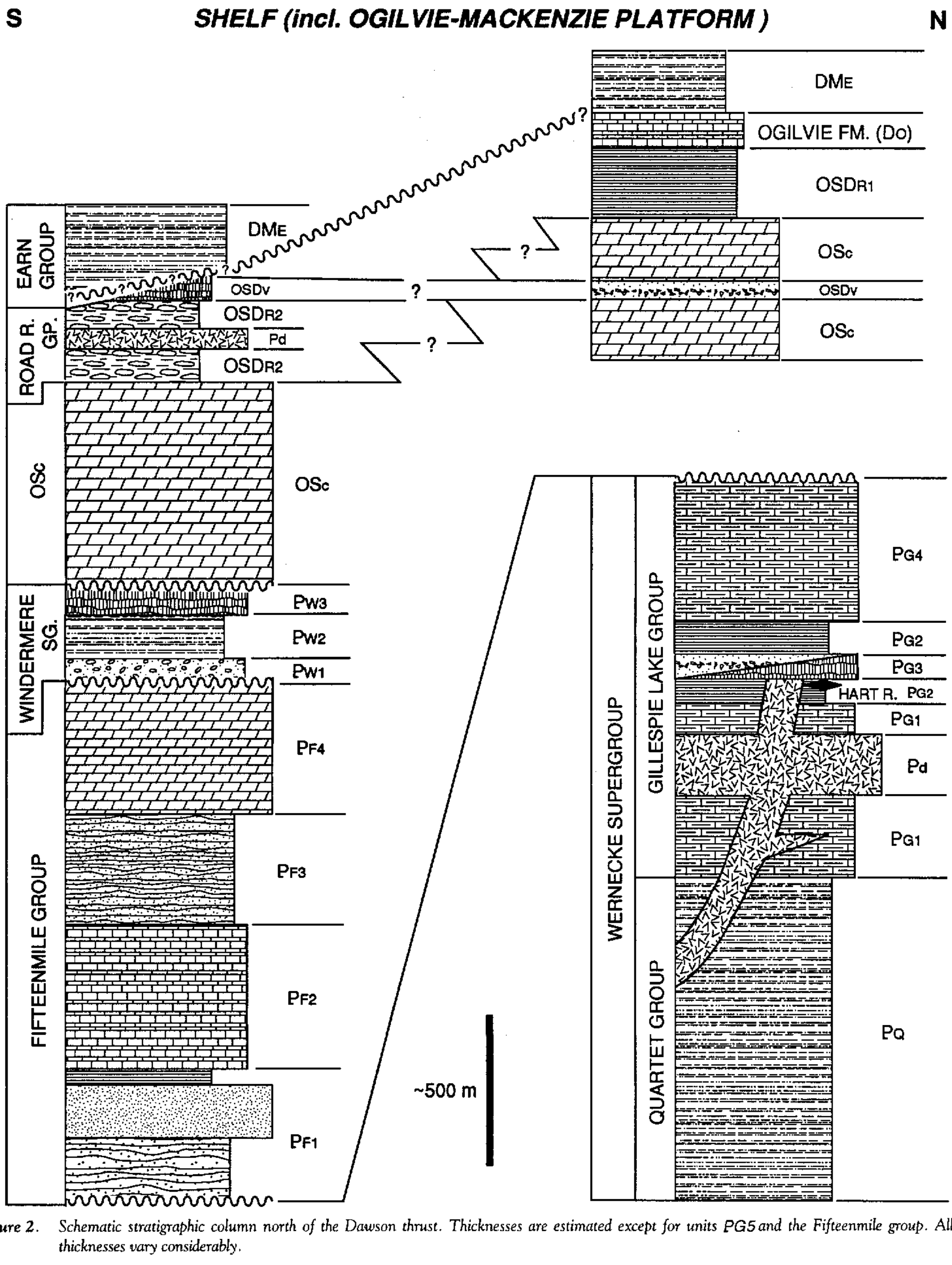

Figure 2. *Schematic stratigraphic column north of the Dawson thrust. Thicknesses are estimated except for units PG5 and the Fifteenmile group. All thicknesses vary considerably.*

Fifteenmile group do unconformably overlie unit PG5 and older units. A preliminary U-Pb age of 1380 ± 6 Ma. has been obtained from zircons in the sills (M. L. Bevier, pers. com., 1992). Both the Hart River volcanics and the massive sulphide deposit are considered to have the same approximate age. Monazite from breccias cutting the Wernecke Supergroup have yielded an an age of 1.27 Ga (Parrish and Bell, 1987), and the Pinguicula Group is considered to be younger than 1.2 Ga (Young and others, 1979). Thus the 1.38 Ga age supports, but does not prove the inclusion of the Hart River volcanics and overlying carbonates within the Gillespie Lake Group.

Other deposits like Hart River are unlikely to be found in the map area, as the volcanics only occur in a small area above the known deposit. However, near Carpenter Ridge, about 75 km to the east, the writer(unpublished data) has recognized previously unmapped lava flows and associated mafic sills in the Gillespie Lake Group. The area between the Hart River deposit and Carpenter Ridge has not been recently mapped and may have potential for new discoveries. Roots (1990a,b) has shown that the volcanics probably do not continue east of Carpenter Ridge. The volcanic/shale interval in the Gillespie Lake Group has not been reported elsewhere.

Fifteenmile group (PF1,2,3,4)

An assemblage of clastic and shallow-water carbonate rocks which overlies the Wernecke Supergroup with angular unconformity is here tentatively correlated with the informal Fifteenmile group (Roots and Thompson, 1992). The Fifteenmile group in the map area comprises four units that are here termed the lower clastic unit(PF1), the lower carbonate unit(PF2), the upper clastic unit(PF3) and the upper carbonate unit(PF4). The lower clastic unit includes maroon, green, and brown shale interbedded with thin to thick beds of maroon quartz sandstone and conglomerate at the base, overlain by thick bedded grey weathering quartz arenite. A thin interval of maroon shale generally marks the top of the unit. In one thrust panel, the lower clastic unit appears to be missing beneath an unconformity at the base of the lower carbonate. The lower carbonate comprises buff to cream weathering, thin to thick bedded, limestone and dolostone. The upper clastic unit comprises dark brown to rusty weathering thinly laminated to thick bedded quartz arenite and sandstone, dark grey to greenish grey shale, and minor thin beds of orange dolostone. A few gossans were noted in the unit. They appear to be derived from very finely disseminated pyrite in the quartz sandstones. The upper carbonate consists of rugged outcrops of well bedded, light grey weathering dolostone. Sedimentary structures in the dolostone are generally well preserved, and include delicate algal laminations, stromatolites, oolites, and lenses of grey to black chert. These features serve to distinguish the Proterozoic dolostone from more massive, featureless Ordovician Silurian dolostone, which in places directly overlies the older carbonate. The dolomite sharply overlies the upper clastic member and the contact may be unconformable.

Age and Correlation

The name Fifteenmile group was assigned by Roots and Thompson (1992) to a broadly similar sedimentary sequence in the western Ogilvie Mountains (Units 3 to 8, Thompson and Roots, 1982). Complex lateral facies and thickness changes, and internal unconformities that Roots and Thompson (1992) attributed to syndepositional extension and growth faulting make correlation with the more laterally consistent strata in the Hart River area difficult. Their units 3 (quartz sandstone and argillite), 4 (grey and orange weathering dolomite), 5 (maroon and black shale with conglomerate, sandstone, and diamictite), and 6 (resistant light grey dolomite) may correlate with the lower clastic, lower carbonate, upper clastic, and upper carbonate units in the Hart River area. Unit 6 closely resembles the upper carbonate unit in the Hart River area, but the underlying units appear to differ in detail. Equivalents to their units 7 and 8 were not recognized and may have been removed by erosion prior to deposition of the overlying Windermere Supergroup.

Young and others (1979) divided Middle and Upper Proterozic successions of the northern Cordillera and western Arctic into three sequences: A(~1.7 to ~1.2 Ga.; includes Wernecke Supergroup), B(1.2 to ~0.8 Ga.) and C(~0.8 to 0.7 Ga.; Windermere Supergroup). The Fifteenmile group certainly belongs to Sequence B, but its correlation within that succession is uncertain. In the Wernecke Mountains, the Pinguicula Group(Eisbacher, 1978) may be equivalent, but correlations are not clear. Young and others (1979) tentatively correlated the Pinguicula Group with the Mackenzie Mountains Supergroup, the Shaler Group on Victoria Island, and the Rae Group in the Coppermine Area. Their correlations, as well as descriptions by Rainbird and others (1992) suggest that the Glenelg and Reynolds Point Formations of the Shaler Group on Victoria Island might correlate with the Fifteen Mile group in the Hart River Area. In such a correlation, the lower clastic unit, the lower carbonate unit and possibly part of the upper clastic unit of the Fifteenmile group would be equivalent to the Lower Clastic, Cherty Carbonate and Upper Clastic Members of the Glenelg Formation. The upper carbonate unit of the Fifteenmile group would be equivalent to the Reynolds Point Formation.

The foregoing correlations are speculative at this point and are presented here because copper occurrences have recently been discovered in the Glenelg Formation on Victoria Island (Rainbird and others, 1992). These include disseminated chalcopyrite, pyrite, with subordinate tennantite and enargite in quartz arenites of the Upper Clastic Member, and "extensive zones of massive sulphide replacement associated with karsting of the Cherty Carbonate Member" (Rainbird and others, 1992). Whether these correlations are correct or not, the fact remains that both the Fifteenmile group and Glenelg Formations belong to Sequence B and are broadly similar clastic and carbonate sequences. The Fifteenmile group has probably not been explored before for stratiform copper deposits and it should be.

Windermere Supergroup (PW1,2,3)

A succession correlated with the Windermere Supergroup (Eisbacher, 1981) includes three units, and is bounded by angular unconformities. At the base is distinctive diamictite (PW1) consisting of angular to rounded clasts of quartz arenite and grey dolostone, generally pebble-sized or smaller, but up to 30 cm across, suspended in a matrix of orange-weathering dolostone, silty dolostone and lesser amounts of grey shale. Some clasts deflect bedding and are interpreted as glacial dropstones. Overlying the diamictite is recessive, orange-brown to dark brown weathering platey siltstone, sandstone, and dark grey shale(PW2). Lapilli tuff, hyaloclastic breccias, and finely laminated eniclastic (?) rocks overlie the shales and siltstones in one locality(PW3).

Age and Correlation

The Late Proterozoic Windermere Supergroup records glaciation, rifting, and possibly, initial sedimentation within the Cordilleran miogeocline (Stewart, 1972; Eisbacher, 1981; Ross, 1991). In the western Ogilvie Mountains, the Mount Harper group has been correlated with the Windermere Supergroup (Roots, 1987: Roots and Thompson, 1992), and includes: basal coarse conglomerate deposited as alluvial fans in half-grabens; mafic volcanic flows and breccias and subordinate andesite and rhyolite; and an upper clastic sequence comprising mainly clastic dolostones. Uppermost beds include quartz wacke and rare chert pebble conglomerate, and contain lower Cambrian trace fossils. A U-Pb age of 751 +26/-18 Ma was obtained from zircon in rhyolite near the top of the volcanic sequence(Roots and Parrish, 1989).

In the Hart River area, units PW1, 2, & 3 may be equivalent to the conglomerate and volcanic rocks of the lower Harper group; however, the glaciogenic interpretation of the diamictite (unit PW1) makes this correlation uncertain.

The Hart River sequence differs from Windermere strata in the Mackenzie Mountains (Eisbacher 1981; Jefferson and Parrish, 1989), but glaciogenic sediments of the Shezal Formation of the Rapitan Group may be equivalent to the unit PW1 diamictite.

Ordovician-Silurian dolostone (OSc)

Massive light bluish-grey weathering dolostone is the most conspicuous and characteristic member of the shelf sequence. Unlike the upper carbonate member of the Fifteenmile group, the Ordovician-Silurian dolostone forms talus, rather than craggy outcrops. Dolomitization and netlike zones of silica replacement have obliterated most sedimentary structures, and the most distinctive feature of the unit is its monotonous homogeneity.

Age and Correlation

No fossils were obtained from the carbonates and their precise age is uncertain. Equivalent strata mapped across the Ogilvie Mountains by Green (1972, unit 8) contain fossils ranging in age from Early Ordovician to Late Silurian, but much of the unit is unfossiliferous. Mustard and others (1988) report archeocyathids from the base of similar carbonate rocks in the western Ogilvie Mountains, and the unit may be as old as Lower Cambrian.

Road River Group(OSDR1,2)

Sharply overlying the Ordovician-Silurian dolostone with apparent conformity, are recessive, black graptolitic shale and chert of the Road River Group. In the northwest corner of map 116A/10, black calcareous shale(OSDR1)characterizes the unit. In the southern parts of both map areas, along the Dawson fault, the shales are blue-grey weathering, noncalcareous, and contain thin beds of black to dark grey chert and argillaceous chert(OSDR2). Graptolites are fairly common throughout the unit, but none of those seen by the writer were well enough preserved to permit accurate identification. Green (1972) reported fossils ranging in age from Middle Ordovician to Late Silurian from the Road River Formation and considered it to be a facies equivalent of the Ordovician-Silurian dolostone.

Paleozoic volcanic and intrusive rocks (OSDv, Pd)

In the northern part of the map area, mafic tuffs less than 50 m thick appear intermittently in the Ordovician Silurian dolostone. Near the Dawson fault, the Road River Group contains mafic sills and volcanic rocks. The mafic volcanic rocks may be either intercalated with, or overlie the graptolitic shales. In one interpretation, shown in Figure 2, these volcanics correlate with those interbedded with the Ordovician Silurian dolostone farther north. If so, the Road River shales are diachronous and at least 200 meters of dolostone in the north correlates with black shale 15 km to the south. Alternatively, the volcanic rocks in the Road River Group are younger than those in the dolostone.

Laterally extensive diorite and gabbro sills, up to 60 meters thick, are spatially related to the volcanics.

Age and Correlation

Along the headwaters of the Beaver River, 60 km to the east, the Ordovician Silurian dolostone contains similar, but much thicker and more extensive volcanic rocks which contain Middle to Late Ordovician fossils (Green, 1972). The volcanic rocks in the Road River Group may also be Ordovician, but could be as young as Devonian. The sills are presumed to be feeders to the volcanics, but some or all could be younger.

Ogilvie Formation (DO)

Recessive, fossiliferous, well bedded grey limestone exposed in a few outcrops in the northwest corner of map 116A/10 is correlated with the Ogilvie Formation. The limestone appears to be gradational with underlying calcareous shales of the Road River Group and is in sharp contact with overlying Devonian black shale and chert.

Age and Correlation

Echinoderm ossicles with twin axial canals and indeterminant brachiopods from the top of the unit were identified by A.W. Norris (written report, 1992) of the Geological Survey of Canada as Emsian (late Early Devonian).

The Ogilvie Formation is widespread in northern Yukon north of 65° latitude, and was mapped to the east in Nash Creek map area (106D; Green, 1972). Farther south near the Dawson fault, the Ogilvie Formation is absent. Only the Hart River exposures are near the southern shelf margin and they provide important stratigraphic constraints on facies relationships of the Earn Group. The Ogilvie Formation is absent along the Dawson fault. Figure 2 shows the limestone removed beneath a sub-Earn Group unconformity, but it could also be represented by facies equivalent black shale.

Earn Group (DME)

Recessive, poorly exposed light brown to blue weathering chert, silver-blue siliceous shale, black shale, sandstone and minor chert grit originally mapped by Green (1972) as unit 13, is here tentatively correlated with the Earn Group (Gordey and others, 1982). These

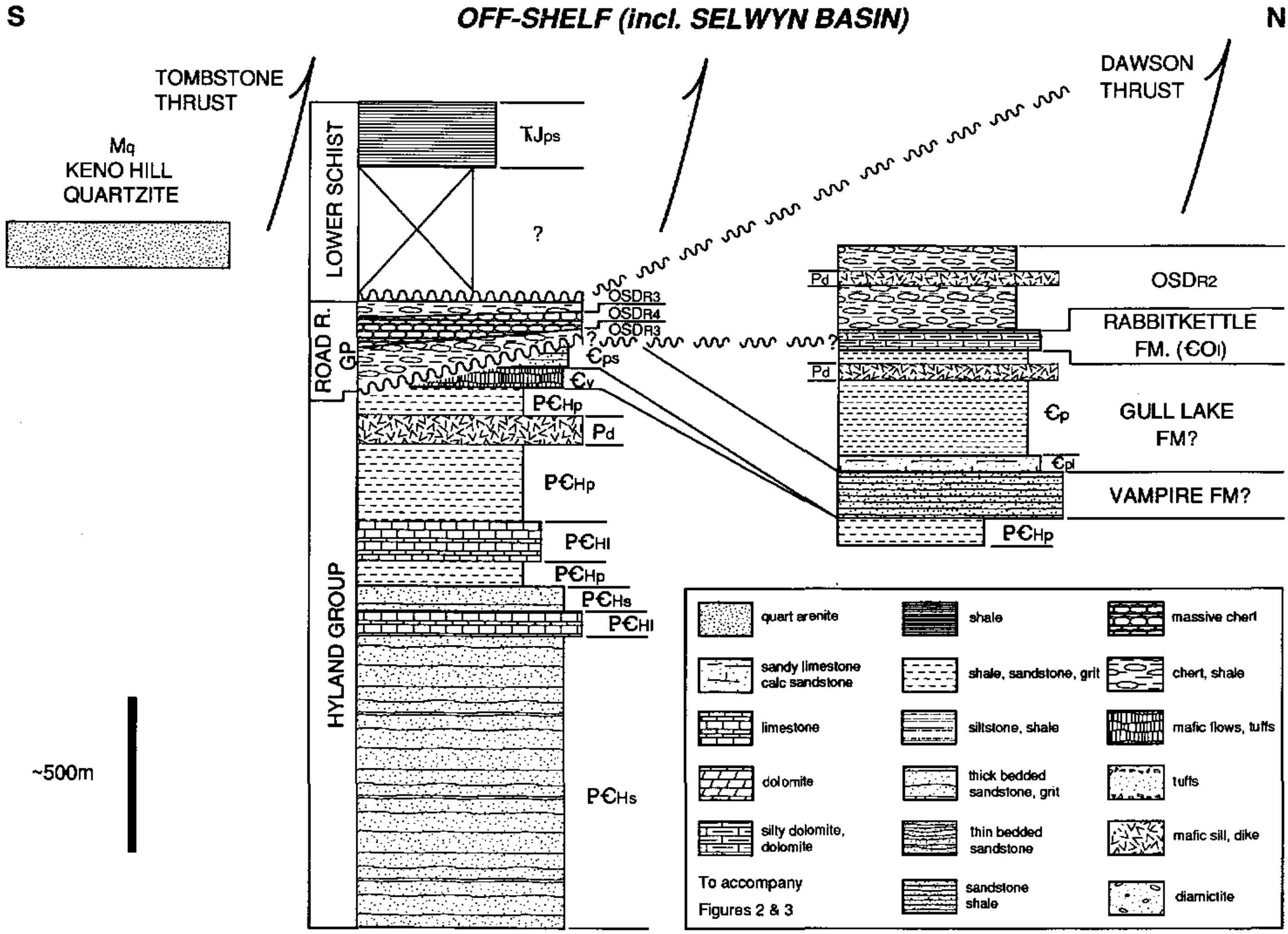

Figure 3. Schematic stratigraphic column south of the Dawson thrust. All thicknesses are estimated and vary considerably.

rocks underlie much of the northeast parts of the map areas, but poor exposure pecludes detailed definition of internal stratigraphy. The lower contact of the Earn Group is generally covered, and whether most of these rocks overlie the Ogilvie Formation or the Road River Group is unclear in most places.

The term Earn Group primarily refers to Devono-Mississippian rocks in Selwyn Basin that include a coarse clastic component. Detailed study in better exposed areas may reveal more appropriate correlations with established formations in other parts of the "shelf sequence" such as the Canol and Imperial Formations, and the McCann Hill chert.

Many streams draining the Earn Group are orange coloured and acidic. A few ferricrete gossans accompany acid springs. Presumably the acidity reflects oxidation of local, finely disseminated pyrite in the shales, although no pyrite was observed in hand specimens. Similar ferricrete gossans are common in most areas underlain by the Earn Group.

"OFFSHELF SEQUENCE"(SELWYN BASIN)

Hyland Group (PЄHs, PЄHl, PЄHp)

The oldest rocks in the "offshelf sequence" belong to the late Proterozoic and Early Cambrian Hyland Group (Gordey, in press) and include three characteristic regional subdivisions : quartzofeldspthic grit, quartzite, and phyllite(PЄHs); limestone(PЄHl); and maroon and green shales(PЄHp). The grit division includes dull grey-brown weathering quartzofeldspthic grit, quartz sandstone and arenite, lesser amounts of interbedded dark grey phyllite and some maroon and green shale. The grit division grades into overlying maroon, green, and grey shale (PЄHs), which also contains lesser amounts of quartzofeldspathic grit and quartzite. Two or more bands of limestone occupy a broad transition between the grit and shale dominated divisions. The limestone is highly variable. Brown weathering, sandy limestone, a few meters thick forms one and possibly more horizons in the lower grit division. Medium grey, massive to thin bedded limestone up to 100 m thick occurs in both the lower and upper divisions, and may in part be laterally equivalent to the brown sandy limestone. The carbonate unit also includes black fetid limestone as a lateral facies equivalent to the grey limestone. A few thick beds of chert occur in and at the base of some limestone units.

Cambrian and Early Ordovician (Єv, Єps, Єpl, Єp, ЄOl)

The Hyland Group is overlain by previously unmapped volcanic, siliciclastic, and carbonate rocks that closely resemble

Cambrian and Early Ordovician strata along the eastern and southern margins of Selwyn Basin.

Extensive mafic volcanic flows and tuffs(unit €v), one to fifty meters thick, overlie maroon and green shales of the Hyland Group. Dark weathering grey and greenish grey phyllite, sandstone, and quartz arenite overlie the volcanic rocks(unit €ps). Next to the Dawson fault, the volcanic rocks are missing and the grey phyllite and sandstone directly overlie maroon, green, and grey phyllite of the Hyland Group.

Along the Dawson fault, unit €ps is overlain by a recessive, drab, brown weathering thinly laminated shale and siltstone sequence(Unit €p) that contains a thin, but heterogeneous and distinctive limestone marker at its base(unit €pl). The limestone is less than about 50m thick and includes yellowish-brown weathering calcareous siltstone, calcareous sandstone, sandy limestone, dark grey-brown shale, and limestone conglomerate. The conglomerate in places consists of pebble to boulder sized clasts of greenish to buff weathering limestone, with lesser amounts of dark grey slate, and minor black chert suspended in a matrix of calcareous siltstone and sandstone. The phyllites overlying the limestone are grey to greenish grey, thinly laminated, and intensely bioturbated in places. Thin beds of quartz sandstone and limestone are uncommon.

About 50 m of thin bedded, platey grey limestone with thin interbeds of dark grey shale (unit€Ol) overlie unit €pl immediately south of the Dawson fault in sheet 116A/10. The limestone is overlain by graptolitic black shale and chert of the Road River Group.

In the southernmost part of sheet 116A/11, the limestone is missing and shale and chert of the Road River Group rest unconformably on rocks as old as the lower grit division of the Hyland Group. It is not clear if the unconformity is older than the limestone, which has changed facies basinward to shale that has been included in the Road River Group, or if the unconformity is younger than the limestone and cuts it out, or both. Significant unconformities in both stratigraphic positions are known elsewhere in Selwyn Basin (Abbott and others, 1986).

Age and Correlation

Mafic flows and tuffs similar to unit €v also overlie maroon and green shale of the Hyland Group in central Niddery Lake map area (105O), where they have been dated as Lower Cambrian on the basis of a single archeocyathid (Cecile and Abbott, 1989). Similar volcanic rocks are widespread west of the study area where they have been assigned an Precambrian or later age by Green (1972). In Dawson map area, similar volcanic rocks overlie the Hyland Group and are overlain by Middle Ordovician graptolitic chert (Roots, 1988). Roots (1988) reports an Early Ordovician conodont from limestone pods within the volcanic rocks, but also suggests that some of the volcanics may be as old as Lower Cambrian. Thus, volcanic rocks west of the Hart River area may be both Lower Cambrian and Lower Ordovician in age.

Unit €ps occupies the same stratigraphic position and resembles the latest Proterozoic(?) and Lower Cambrian Vampire Formation (Fritz, 1982) in eastern Selwyn Basin. The Vampire Formation forms a transitional facies between quartz arenite of the Lower Cambrian Backbone Ranges Formation to the east and the variegated shales in the upper part of the Hyland Group to the west.

Trilobites were collected in an isolated outcrop of unit €pl, from a 30 cm-thick bed of clastic limestone interbedded with noncalcareous phyllite and a few thin beds of quartz sandstone. The exact stratigraphic position of the limestone is uncertain, but it appears to be near the base of the unit. W.H. Fritz (written report, 1992) of the Geological Survey of Canada identified the fossils and placed them in the Bonnia-Olenellus Zone of the Lower Cambrian. In eastern Selwyn Basin similar strata, including a basal archeocyathid-bearing limestone conglomerate marker, belong to the Gull Lake Formation, and are basinal equivalents of the Sekwi Formation (Gordey, in press).

No fossils were obtained from unit €Ol, but the limestone has a strong lithologic similarity, and occupies the same stratigraphic position as the Late Cambrian and Early Ordovician Rabbitkettle Formation in southeastern Niddery map area and north-central Nahanni map area (Abbott, 1983; Gordey, in press).

The Cambro-Ordovician sequence closely resembles the stratigraphy of the Anvil Pb-Zn-Ag District (Gordey, 1987; Pigage, 1989) along the southern margin of Selwyn Basin near Faro (Figure 1). The stratiform, pyritic massive sulphide deposits are associated with the margins of a discontinuous a black shale facies, and occupy a 150 m thick stratigraphic interval in the transition zone between the Gull Lake Formation (locally Mount Mye Fm.) and the overlying Rabbitkettle Formation (locally Vangorda Fm.) (Pigage, 1990).

In most parts of Selwyn Basin and Kechika Trough in northern British Columbia, the Rabbitkettle Formation and equivalent Kechika Group rests with angular unconformity on older strata, and the Gull lake Formation and equivalent strata are absent. Abbott and others (1986) suggested that the Late Cambrian sub-Rabbitkettle unconformity represents a rift event and high heat flow. The Anvil deposits may have formed and been preserved in a graben related to this rift event.

The Gull Lake Formation has only recently been recognized as a locally preserved, but regional unit. Thus, past exploration for sediment-hosted Pb-Zn deposits of the same age as the Anvil deposits may have been hampered in many parts of Selwyn Basin. The Gull Lake Formation along the Dawson fault is an underexplored target.

Road River Group (OSDR2, 3, & 4)

Immediately south of the Dawson fault, in map 116/A10, dark blue weathering black, graptolitic, siliceous shale and chert closely resembles the Road River Group north of the fault and is included in the same unit (OSDR2). The unit, south of the fault, however, overlies the thin bedded shaley Cambro-Ordovician limestone, unlike the north side where it overlies massive Ordovician-Silurian dolostone.

The Road River Group changes markedly farther southwest, in map 116A/11, where it overlies older strata with pronounced angular unconformity and includes two mappable divisions. The most prominent division (OSDR4) is thick to very thick bedded, bioturbated grey chert. The chert forms resistant ribs up to 100 m thick that appears to be bounded above and below by similar, recessive olive green shale and small amounts of silver-blue weathering siliceous shale interbedded with variable amounts of brown weathering, thin beds of chert(OSDR3).The chert is structurally repeated in upright isoclinal folds and along thrust faults, and unit OSDR3 could not be consistently subdivided into an upper and lower unit. The lower shaley unit thickens from a meter or less in the north to 100m+ in the south. It unconformably overlies all older units.

Age and Correlation

No fossils were identified from units OSDR3 or 4, but the resistant middle chert division strongly resembles, and occupies the same stratigraphic position as Lower to Middle Ordovician chert in Niddery map area (Cecile and Abbott, 1989), and Middle Ordovician chert in Sheldon and Tay River Map areas (Gordey, pers. com., 1992). The age of the unconformity below the Road River Group, as previously stated may be Late Cambrian, or Early to Middle Ordovician. If Late Cambrian, the lower shale and chert division may be equivalent to the Rabbitkettle limestone; if Early or Middle Ordovician, the limestone was probably removed beneath it. Stratigraphic relations with younger strata and the upper age of the Road River Group south of the Dawson fault are unknown.

Mafic sills (Pd)

Extensive, laterally continuous fine to coarse grained diorite and gabbro sills (Pd) up to 100 meters thick occur at several levels in the Lower and Middle Paleozoic sequence. Many sills intrude the upper division of the Hyland Group below the Cambrian volcanics, and the two may be related. Some sills occur less than 100 m stratigraphically below the volcanics and if Lower Cambrian, must have been emplaced close to the sediment-seawater interface. Other sills intrude the Cambrian sequence (Ꞓp) and the Road River Group (OSDR2)along the Dawson Fault. They may be related to the volcanic rocks in the Road River Group, north of the fault.

Keno Hill quartzite (Mq)

The Keno Hill quartzite (Mq) is exposed in the hanging wall of the Tombstone thrust, in the extreme southwest corner of sheet 116A/11. The unit consists primarily of dark grey weathering, massive to very thick bedded vitreous quartz arenite, and a few thin intervals of jet black slate. These rocks are intensely deformed and their true thickness and internal stratigraphy is not known. A subunit of thin bedded, phyllitic quartzite, and graphitic and chloritic phyllite, mapped by Green (1972) just south of the map area was not seen by the writer.

Age and Correlaton

A Mississippian age for the quartzite was determined from conodonts recently collected in the Dawson area by R. Thompson, and identified by M. Orchard of the Geological Survey of Canada(Mortensen and Thompson, 1989). In western Selwyn Basin, the Keno Hill quartzite is primarily confined to the panel of rocks bounded below by the Tombstone thrust, and above, by the Robert Service thrust. The exception is one locality near Kathleen Lakes where it occurs in the footwall of the Dawson thrust. Its absence in the footwall of the Tombstone thrust and great lateral persistence in the hangingwall panel suggests that the Tombstone thrust may be a reactivated Paleozoic fault which controlled Devono-Mississippian sedimentation. The parallel Robert Service thrust might also have a similar history, but this possiblity is difficult to assess because Paleozoic strata have largely been removed by recent erosion from the hangingwall panel.

East of Mayo, the MARG volcanogenic massive sulphide deposit (Turner and Abbott, 1990) is associated with latest Devonian felsic metavolcanic rocks. The volcanics are tectonically interleaved with the KHQ and appear to be confined to the same thrust panel as the KHQ. The volcanics have been traced westward from the Marg deposit to the Keno Hill District (Murphy and Roots, 1992), but their presence farther west is unknown. The close spatial association between the volcanics and the KHQ makes the westward continuation of the Keno Hill quartzite an obvious exploration target.

Lower Schist (ŦJps)

An extensive, largely covered interval along the footwall of the Tombstone thrust was originally mapped by Green (1972) as the "Lower Schist" and considered to be Jurassic in age. The only exposure of this unit in the map area is a small area of talus immediately beneath the thrust. It consists mainly of grey-brown weathering black slate with some weakly calcareous, micaceous siltstone, silty shale, and minor cross-laminated, micaceous quartz sandstone. The fragments appear to be weakly hornfelsed, probably by the buried extension of a mafic sill mapped by Green (1972), 2 km to the west.

Age and Correlation

Although a Jurassic age is possible, the micaceous, calcareous siltstones resemble Triassic strata which underlie the Lower Schist(Green, 1972) along strike to the west in Dawson map area, and which are widespread in other parts of Selwyn Basin (Tempelman-Kluit (1972, Gordey, 1981, Cecile and Abbott, 1989). In addition, Mortensen and Thompson (1989) obtained a Middle Triassic age (232.2 +1.5/-1.2 Ma) from a mafic sill intruding the Keno Hill quartzite, in the hanging wall of the Tombstone thrust, 50 km to the west. The sills continue intermittently eastward past the map area in the hanging wall of the Tombstone thrust. The lone sill intruding the "Lower Schist" in the footwall of the thrust near the map area probably belong to the same suite. These two lines of evidence suggest that the Lower Schist in the map area is Middle Triassic or older.

Black shale, sandstone, and siltstone included in the "Lower Schist" by Green(1972) form a continuous unit beneath the Tombstone thrust that extends east from the Tintina fault near Dawson City for 250 km. The Jurassic age is based on fossils collected at the extreme western and eastern ends of the belt (Poulton and Tempelman-Kluit, 1982). Recent work along the east end of the belt in the Mt. Westman area by Abbott(1990a,b) has shown that the basal strata in the "Lower Schist" are black shale interbedded with distinctive chert grit and bedded barite that are probably Devonian in age and correlative with the Earn Group. These rocks unconformably overlie the Hyland Group. At the western end, chert pebble conglomerate and black shale of the Earn Group, limestone of the Permian Tahkandit Formation and Triassic siltstone and shale occur intermittently beneath the fossiliferous Jurassic strata. Thus, the covered interval being considered here may also include the Devonian Earn Group, Upper Paleozoic, and Triassic strata.

SUMMARY OF MOST FAVOURABLE EXPLORATION TARGETS

The revised stratigraphy presented here, while still preliminary, provides a more accurate framework in which the exploration geologist can assess the mineral potential of the southern Ogilvie Mountains, and focus upon specific targets to explore in detail. In the writer's opinion, the following units offer the most potential. They are ordered by age, not importance.

1. GILLESPIE LAKE GROUP: Unmapped mafic lavas associated with the Hart River massive sulphide deposit may be found between map sheet 116A/10 and Carpenter Ridge.

2. FIFTEENMILE GROUP: The Fifteenmile group belongs to the same general stratigraphic sequence, and broadly resembles, the lower part of the Shaler Group in the Arctic Islands. Pyritic sediment-hosted copper deposits have recently been discovered in the Glenelg Formation of the Shaler Group. The Fifteenmile group has probably never been explored for sediment-hosted copper deposits.

3. GULL LAKE, RABBITKETTLE FORMATIONS: Previously unrecognized Cambrian and Lower Ordovician strata are equivalent to the Gull Lake and Rabbitkettle Formations. Pyritic massive sulphide deposits in the Anvil District are associated with black shale in a transitional interval between the Gull Lake(Mt. Mye) and Rabbitkettle(Vangorda) Formations.

4. ROAD RIVER GROUP: Black shale and chert of the Road River Group contains the Howard's Pass zinc-lead deposit. Large areas shown as Hyland Group on early maps are underlain by the Road River Group.

5. MAFIC VOLCANICS AND ASSOCIATES SILLS: Mafic volcanic rocks and associated high level sills occur in at least two stratigraphic positions in both the shelf and offshelf sequences. Many of these rocks are shown on early maps and are well exposed, but they do reflect the same environment as the Hart River Deposit.

6. KENO HILL QUARTZITE: The MARG volcanogenic massive sulphide deposit and associated felsic volcanic rocks of Devono-Mississippian age were recently discovered east of Mayo They are overlain by, and tectonically interleaved with, the Keno Hill quartzite. The volcanic rocks have been traced westward by recent mapping as far as the Keno Hill Mining District, but their presence farther northwest remains unknown. The panel of rocks containing the Keno Hill quartzite, and bounded by the Tombstone and Robert Service thrusts, is an exploration target from the Keno Hill District to Dawson City.

7. LOWER SCHIST: The base of the Lower Schist is largely covered and may include the Devono-Mississippian Earn Group. The Earn Group contains sediment-hosted zinc, lead, silver deposits at Macmillan Pass and elsewhere in Selwyn Basin.

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THE VANGORDA DEPOSIT

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BROWN, D., and MCCLAY, K.R., 1993. The Vangorda deposit. In: Yukon Exploration and Geology, 1992, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p.27-32.

NTS map sheet: 105 K/6
Coordinates: 62° 15′ N, 133° 12′ W
Area: Anvil District
Access: Robert Campbell Highway
MINFILE #: 55
Company: Curragh Inc.
Commodities: Zinc, Lead, (Silver, Gold)

INTRODUCTION

The Vangorda deposit is a small (7.1 million tonne), SEDEX-type, Pb-Zn-Ag (barite) massive sulphide ore body, in the Anvil district, Yukon, Canada (Figure 1). The deposit is currently being open pit mined at approximately 13,000 tonnes per day by Curragh Inc. A project was begun at the start of mine development in 1990 in order to define the deformational style of the deposit and, by extrapolation, that of the other massive sulphide deposits in the Anvil District. In addition, the detailed understanding of the structural controls on the ore body are beneficial during development stages for grade control, and for short-term planning during mining. The sulphide textures that result from deformation, metamorphism, and remobilsation are important metallurgical factors that have significant effects on the milling properties of sulphide ores.

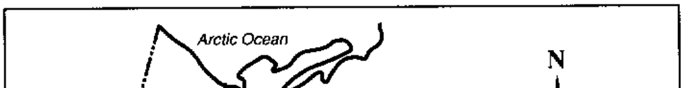

Figure 1. *Generalised map of the Selwyn Basin and Kechika Trough showing the location of the Anvil District.*

REGIONAL GEOLOGY

The Anvil District (Figure 2) is part of the Omineca Crystalline Belt of the western Canadian Cordillera (Monger et al. 1982). The district is structurally overlain by the allochthonous Yukon-Tanana terrane (Coney et al. 1980) and is adjacent to a major orogen-scale dextral strike-slip fault, the Tintina Fault. Rocks in the Anvil District consist of late Precambrian to upper Paleozoic metasedimentary and metavolcanic rocks that are correlated with Selwyn Basin stratigraphy (Jennings and Jilson 1986) which formed part of the ancient North American miogeocline until the Early Cretaceous. These rocks have been intruded by mid-Cretaceous granitoid rocks of the Anvil Plutonic Suite (Pigage and Anderson 1985; Jennings and Jilson 1986).

Five deformation events have been recognised in the Anvil District, the first two of which (D_1 and D_2) are regionally significant (Jennings and Jilson 1986). D_1 is interpreted to be related to the pre- to mid-Cretaceous docking of the allochthonous Yukon-Tanana terrane onto the continental margin (Tempelman-Kluit 1979) causing inversion of the rift basin, northeast-directed nappe emplacement, folding, thrusting and metamorphism of the continental margin sediments. D_1 deformation resulted in the development of northeast-verging F_1 folds and a penetrative regional foliation (S_1), and regional metamorphism. D_2 deformation is related to emplacement, uplift, and unroofing of the Anvil Batholith (Jennings and Jilson 1986). D_2 resulted in southwest-directed folding, development of a wavy, shallowly southwest-dipping, penetrative foliation (S_2), and greenschist to amphibolite facies metamorphism (Jennings and Jilson 1986; Smith and Erdmer 1989). F_2 folds are nearly coaxial with F_1 and, where seen, the interference pattern is typically type 3 (Ramsay, 1967; see Jennings and Jilson 1986, figure 21). Northwest-southeast - dipping, brittle to ductile extensional faulting, related to unroofing of the Anvil Batholith, is late- to post-D_2 folding (Pigage and Jilson 1985; Brown and McClay 1992). However, many faults in the district have subhorizontal to shallowly-plunging slickensides indicating at least a late phase of strike-slip movement (Brown and McClay, 1992, in press). The D_3

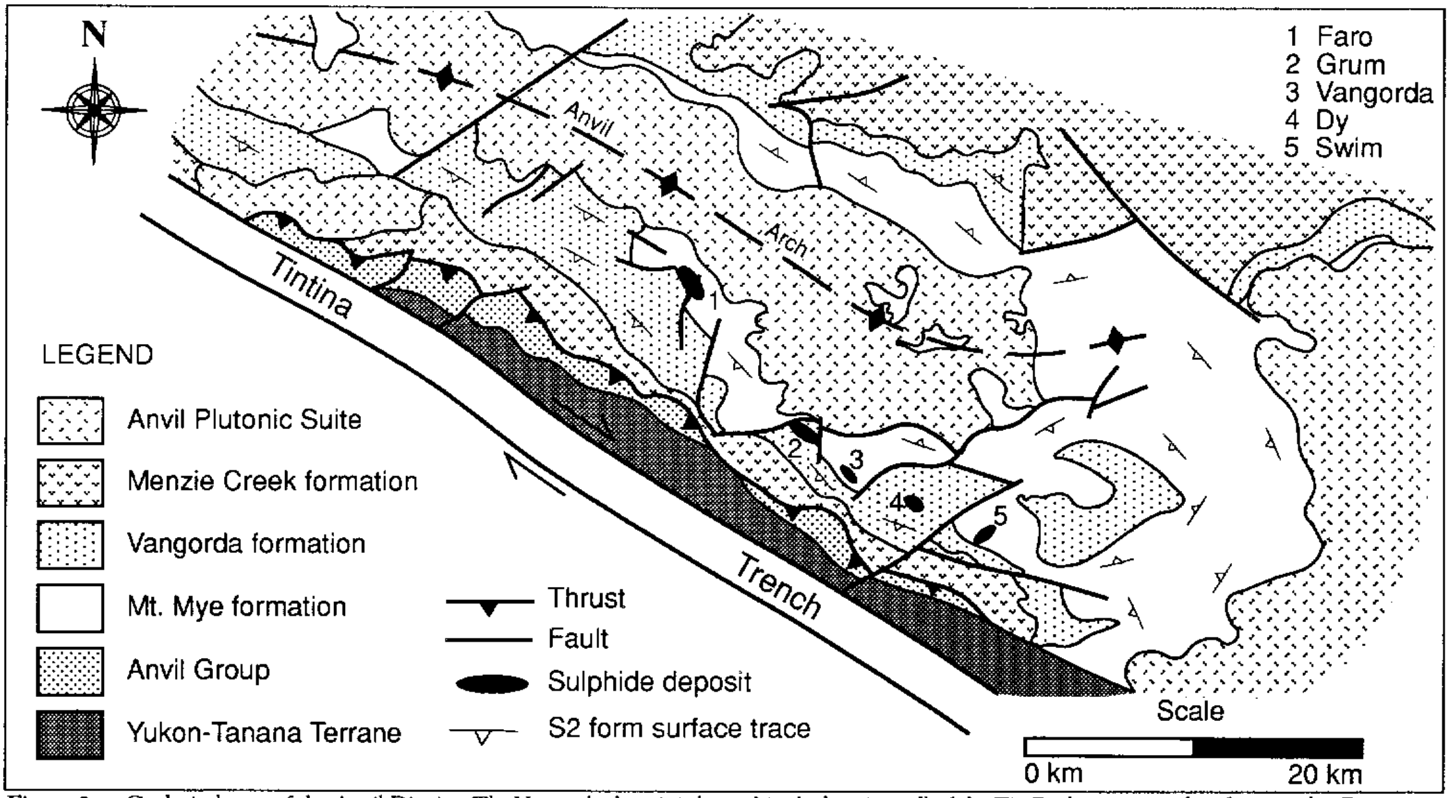

Figure 2. *Geological map of the Anvil District. The Vangorda deposit is located in the hangingwall of the Tie Fault, in greenschist facies rocks. Deposits to the northwest are Faro and Grum, respectively. The large deposit immediately southeast of Vangorda is Dy.*

to D_5 deformation events produced minor folding and steeply dipping crenulation foliations that locally overprint the D_1 and D_2 structural elements.

The lithostratigraphy of the Anvil District consists of up to 5 km of polydeformed metasedimentary and metavolcanic rocks that have been intruded by Cretaceous granites (Figure 3). The massive sulphide deposits are hosted by, or straddle the boundary between two lithostratigraphic units of importance to this paper, the Mt. Mye formation and the overlying Vangorda formation. The Mount Mye formation consists of noncalcareous schists and phyllites and has an apparent structural thickness of at least 2 km, though its base is not exposed. The Vangorda formation consists of calcareous schists and phyllites and varies from between 0.5 to 2 km in structural thickness.

The Anvil mining district, is the largest Pb-Zn play in northern Canada with estimated geological reserves before mining of 120 million tonnes with a combined Pb + Zn grade of 9.3% (Jennings and Jilson 1986). The district contains five SEDEX-type Pb-Zn-Ag (barite) deposits (Carne and Cathro 1981) of economic significance that lie along a curvilinear trend on the southwest flank of the Anvil Batholith (Figure 2). The deposits are interpreted to have formed in second and third order extensional rift basins (Jennings and Jilson 1986; Shanks et al. 1987), similar to those described elsewhere in Selwyn Basin and Kechika Trough by McClay (1991) and MacIntyre (1992). The massive sulphide deposits are variably affected by the deformation events, with D_1 and D_2 being dominant (Jennings and Jilson 1986). The Faro deposit is deformed by D_1 through to and D_4 and metamorphosed to amphibolite facies. Grum, Vangorda, and Dy are mostly affected by D_1 and D_2, with only minor F_3 crenulation folding, and reach greenschist facies metamorphism.

THE VANGORDA DEPOSIT

Lithostratigraphy

The Vangorda deposit is hosted by the Mount Mye formation which consists of greenschist facies, light to medium grey noncalcareous, weakly carbonaceous, muscovite-chlorite phyllite with lesser, interlayered, carbonaceous phyllite, calcareous phyllite, and metabasite. The overlying Vangorda formation, which is exposed in the northwest end of the open pit, consists of light to medium grey, calcareous, weakly carbonaceous muscovite-chlorite phyllite and light grey, calcareous quartz-calcite (+ dolomite) phyllite with interbanded metabasite, carbonaceous phyllite, and phyllitic limestone.

Ore lithofacies

The Vangorda deposit consists of a number of stacked sulphide lenses of varying thickness and bulk sulphide composition. Ore lithofacies are interbanded on a scale of centimetres to metres and commonly display a complete gradation from one to another. These are accompanied by, and interbanded with, Mount Mye formation phyllites. A footwall biased muscovite alteration zone is also developed but is not continuous.

Ribbon-banded, carbonaceous, pyritic quartzite: these are well banded, fine grained, carbonaceous, phyllitic to siliceous quartzite and interbanded, sulphide-bearing (pyrite, sphalerite, and galena) coarsely crystalline quartzite. Banding ranges from 0.2 mm to 2.0 mm in thickness and typically contains 10% to 30% sulphides. This lithofacies is typically low grade ore.

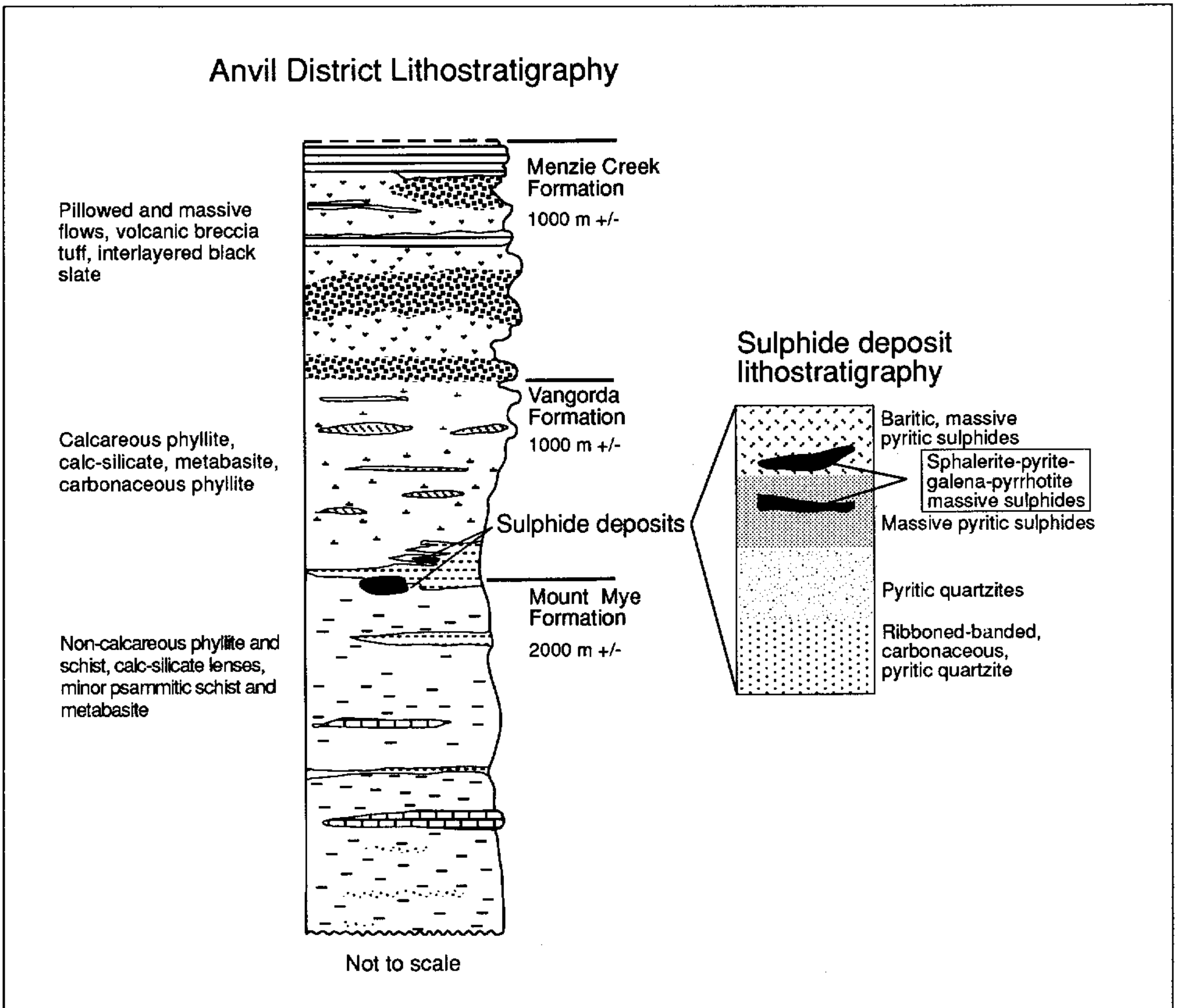

Figure 3. *Lithostratigraphic column of the Anvil District with the generalised ore lithostratigraphic sequence of the Vangorda deposit (modified from Jennings and Jilson, 1986).*

Pyritic quartzite: consists predominantly of quartz with up to 40% pyrite with subordinate sphalerite and galena. These rocks are moderately to poorly banded with, locally, a well developed micaceous (muscovite-chlorite) foliation. Chalcopyrite + pyrrhotite infills subvertical fractures. The pyritic quartzite is commonly gangue but may locally attain ore grades.

Massive pyritic sulphides: these are typically massive pyrite with subordinate sphalerite, galena, pyrrhotite, and minor magnetite and chalcopyrite. Quartz, barite, and carbonates are disseminated throughout or occur in aggregates. Total sulphide content varies from between 60% to nearly 100%. Banding is developed on a scale of centimetres to metres as alternating massive pyrite and of pyritic quartzite, often grading from one to the other. A muscovite-chlorite foliation is common. The massive pyrite lithofacies is gangue.

Baritic, massive pyritic sulphides: these consist of up to 50 % barite with pyrite, sphalerite, galena, together with minor pyrrhotite and magnetite. Quartz and carbonate are major gangue components. Clasts of pyrite and phyllite are common within the banded sulphide. Total barite content varies but may be has high as 50 %. Millimetre- to centimetre-scale interbanding of pyrite-rich and barite-rich layers is ubiquitous. Massive barite has not been observed. There is a complete gradation between the baritic massive sulphide ores and the massive pyritic ore. This lithofacies is the major ore type in the Vangorda deposit.

Pyrrhotite-sphalerite-pyrite-magnetite-galena (breccia): this lithofacies consists predominantly of pyrrhotite and sphalerite with subordinate pyrite, magnetite, and galena. This lithofacies is typically highly strained with a well developed foliation in both the sulphides and the micaceous sulphides. These rocks often contain breccia clasts of other rock types around which the foliation anastomoses. Tailed

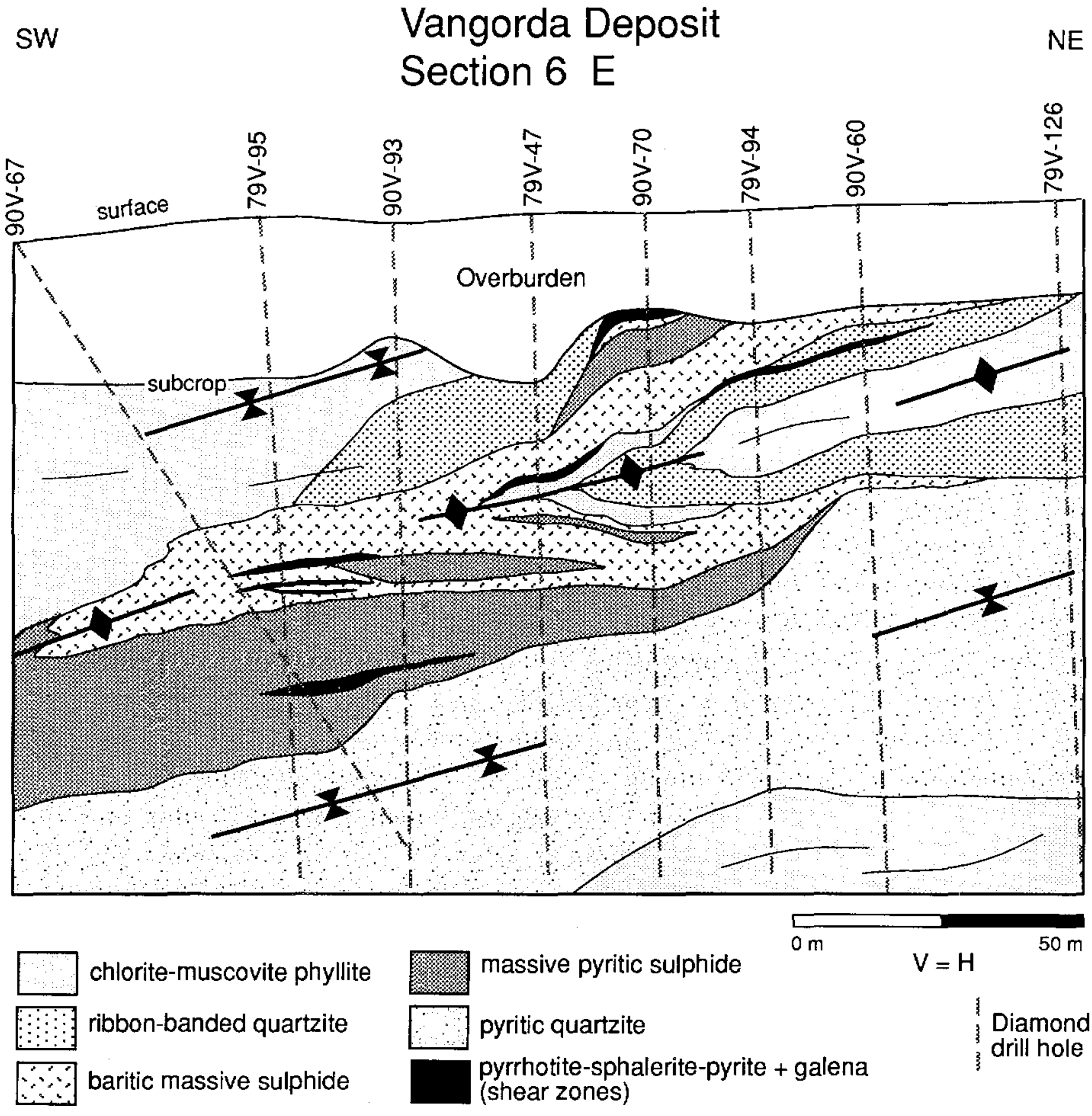

Figure 4. *Detail of cross section 6 through the Vangorda deposit. The baritic lithofacies shows extensive mobilisation into the hinge zone of the F2 structure. The major structure containing the ore deposit is a southwest-facing synformal-antiform. High strain zones denoted by the pyrrhotite-sphalerite-pyrite-galena lithofacies occur along the fold limbs and in the hinge zone.*

porphyroblasts, winged inclusions, foliation boudins, and rolling structures are common. This lithofacies, though relatively minor, is typically high grade ore.

Metamorphism

Both the regional D_1 and D_2 deformation events were accompanied by metamorphism in the Vangorda deposit. D1 metamorphic mineral assemblages found in lithons in phyllites (see below) in the Vangorda deposit consist of chlorite + muscovite with, locally, biotite-chlorite intergrowths. These assemblages broadly indicate that the D_1 metamorphic grade was low to mid-greenschist facies. D_2 regional metamorphic grade in the Anvil District decreases outward from the Anvil Batholith in a Buchan-type facies series (Jennings and Jilson 1986; Smith and Erdmer 1989). In the Vangorda deposit, D_2 silicate assemblages in phyllites consist of transposed and recrystallised muscovite and chlorite, suggesting there may not have been any significant new mineral growth during the D_2 event. The D_2 metamorphic grade is also interpreted to be lower greenschist facies.

Structure

All sulphide lithofacies and phyllites in the Vangorda deposit have been penetratively deformed by the D_1 and D_2 deformation events, making definition of any primary depositional features difficult on a scale other than microscopic (c.f. Brown and McClay 1992, in press). However, the Anvil District macro-scale sulphide lithostratigraphic sequence defined by Jennings and Jilson (1986) may be a relic primary feature. The hangingwall and footwall, phyllite and sulphide lithofacies contacts are locally faulted, but are generally gradational.

The Vangorda deposit has an overall elongate shape in a northwest-southeast orientation and plunges shallowly northwest, parallel to the regional F_2 fold axes. The orebody is approximately 900 m long by 200 m wide and varies in thickness from 20 m to 60 m. It consists of a number of complexly folded and faulted lenses of massive and disseminated sulphides and baritic massive sulphides in quartzitic and graphitic phyllites. In cross section the deposit is folded by a series of southwest-verging, northwest-plunging, tight, symmetric to slightly asymmetric F_2 folds (Figure 4). These folds have a wavelength of 50 m to 75 m. The cross section shows a thickening and concentration of baritic massive sulphides in hinge zone of a SW-verging synform-antiform fold pair. Relatively thin pyrrhotite, sphalerite, pyrite, and galena-rich zones occur along the limbs of the folds and in the baritic rocks in the hinge, parallel to the F_2 axial surface.

F_1 folds are rarely observed in the Vangorda deposit, possibly as a result of the penetrative overprinting by the F_2 folding. Lithons in the phyllites and the ribbon-banded, carbonaceous quartzite are interpreted to contain a S_1 foliation (Figure 5a). Banding in the sulphide lithofacies is locally at a moderate to high angle to the phyllite contacts and is generally pervasively folded by F_2 folds, suggesting that it is also S_1.

The dominant fold phase in the Vangorda deposit is F_2. F_2 folds are typically east-west- to northwest-southeast-plunging, tight to isoclinal (interlimb angle is commonly between 5o to 25_) similar style folds (Figure 5b). Within the different sulphide lithofacies the F_2 fold morphology is variable, but, in general, a similar style is maintained.

In the surrounding phyllites there is a penetrative, wavy, predominantly southwest-dipping F_2 axial planar crenulation foliation (S_2). S_2 is defined by transposed chlorite/muscovite porphyroblasts and remobilised carbon. In the ribboned-banded, carbonaceous quartzite, a differentiated axial planar S_2 foliation is also well developed. However, S_2 in other sulphide lithofacies is found only rarely in fold hinges and high strain zones. In high strain zones, shearing has disrupted the S_1 banding and a new, inhomogeneous foliation is developed, parallel to the F_2 axial surface.

Steeply south- to southwest-plunging to subvertical, open F_3 folds refold the S_2 foliation and tighten F_2 folds. There is only a minor crenulation foliation associated with the F_3 folding.

Within the ore lithofacies rocks there are zones characterised by well foliated pyrrhotite + sphalerite + magnetite + galena and pyrite with angular to rounded inclusions of brecciated quartz, phyllite, and sulphides. These zones display textures such as winged inclusions (Hanmer and Passchier 1991), tailed and rotated clasts, foliation boudins, and brecciation (Figure 5). These structures indicate very high strains and are interpreted to be the product of shearing within sulphide shear zones. The shear zones occur along the limbs of F_2 folds, and range in width from several millimetres up to several metres thick and clearly show an increase in pyrrhotite. A

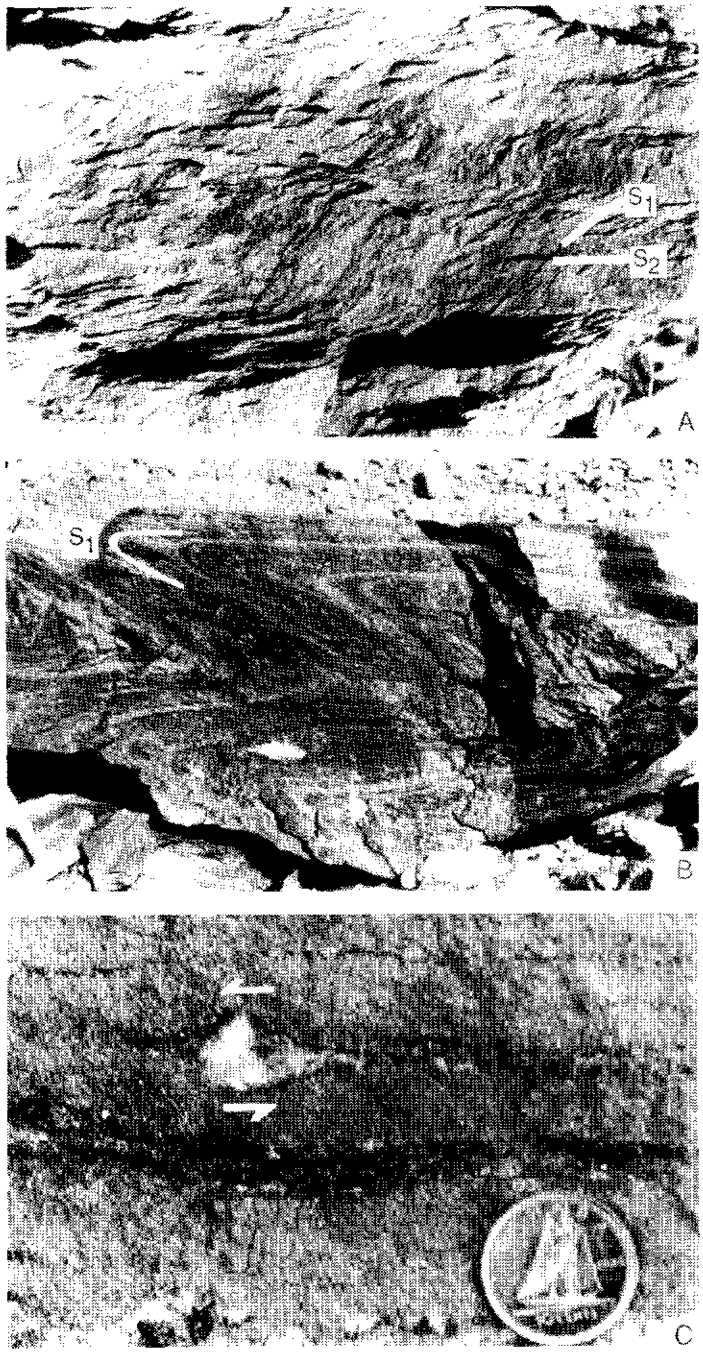

Figure 5. *(a) Lithon texture defined by S1 and S2 in Mt. Mye formation phyllites. Coin provides scale. (b) F2 fold folding S1 banding in ribbon-banded, carbonaceous quartzite. Hammer in bottom left corner provides scale (c) Winged quartz inclusion in massive pyritic sulphides. Arrows indicate a sinistral sense of shear (note, however, that this sample is not in situ.)*

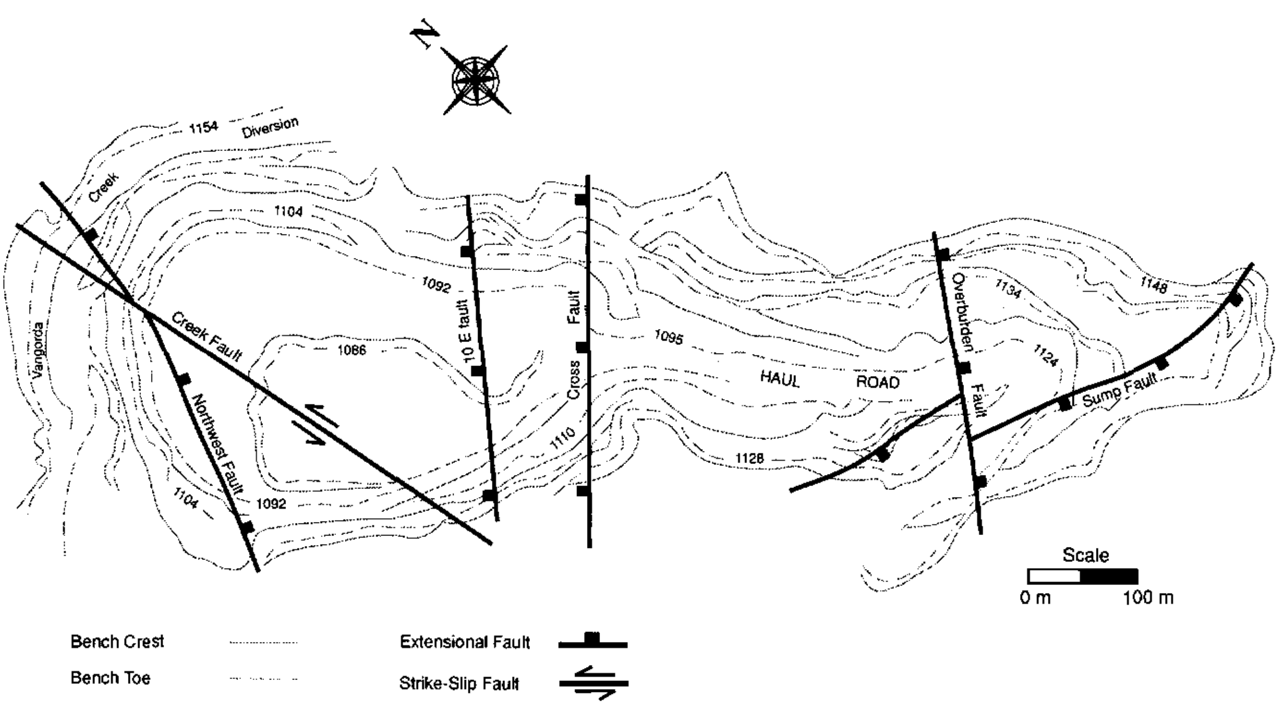

Figure 6. *Generalised status map of the Vangorda open pit showing the locations of the major faults.*

similar increase in pyrrhotite content in high strain zones was also noted in the Ducktown deposit of Tennessee by Brooker et al. (1987)

The present down-plunge extent of the ore body is controlled by faulting. All faults examined in open pit exposures truncate the S_2 foliation and the F_2 folds and the sulphide shear zones, and therefore clearly post-date or are late D_2 folding. The deposit is truncated in the northwest by the steeply southeast-dipping Northwest fault, and in the southeast by the moderately to steeply south-dipping Sump fault (Figure 6). The deposit is cut in half by the steeply to moderately north-northwest-dipping Cross fault. Smaller faults, with offsets up to 5 m, commonly form graben and half-graben structures. Slickensides on these fault surfaces are steeply-plunging indicating a final phase of extensional movement.

However, there are also subhorizontal to shallowly plunging slickensides on many fault surfaces, thus indicating a late stage of strike-slip to oblique-slip movement (Figure 6). In the northern end of the deposit the Creek fault offsets the Northwest fault by approximately 50 metres. Sets of variably oriented slickensides attest to a complicated kinematic history for many of these faults, and a strike-slip reactivation of previously formed extensional faults is possible. In open pit exposures there is clear evidence of strike-slip faults cutting extensional fault structures. In the northern end of the open pit, minor NE-directed thrusting appears related to the strike-slip faulting. Thrusting may be the result of a transpressional component to the strike-slip movement.

At the southern end of the deposit, in the hangingwall of the Sump fault, low-angle, post-D_2, northeast-directed thrusts occur within phyllites, cutting the S_2 foliation. Displacement along these thrust may be up to 10 m.

DISCUSSION

This paper illustrates the macroscopic deformational style of the Vangorda deposit. The deposit is deformed by four significant and one minor phase of deformation. The first two phases, D_1 and D_2, resulted in ductile and brittle deformation (i.e. folding and development of sulphide shear zones, fracturing), metamorphism, and remobilisation. These were followed by brittle extensional faulting and brittle strike-slip faulting, respectively. Minor F_3 folding has also been observed but its relationship with post D_2 faulting is unclear.

Though there is a very good correlation in macroscopic structural style between the host phyllites and the sulphides, the Vangorda deposit has mesoscale textures that reflect extensive shearing of the orebody, especially in the baritic and pyrrhotitic massive sulphides. There are abundant shear indicators such as tailed and winged clasts and inclusions and pressure solution fabrics in these lithofacies. These, together with other common features such as piercement veins, rootless folds, limb thinning and hinge zone thickening of folds, point to extensive mechanical mobilisation of the sulphide in the Vangorda deposit. The location of the pyrrhotitic (breccia) in the large-scale folds indicate significant shearing along the limbs. These shear zones may provide a mechanism by which large-scale mobilisation occurs in massive sulphide deposits.

Faults in the Vangorda deposit clearly offset F_2 and S_2 and therefore post-date or are late D_2. Major faults (i.e. Northwest fault, Cross fault, and Sump fault) dip steeply towards the northwest or southeast and have moderate to steeply-plunging slickensides. Slickensides indicate a final oblique- to dip-slip component of movement. The lack of marker horizons make it difficult to impossible to determine the exact amount of offset on many faults or to determine their kinematic history. A post-extensional phase of strike-slip faulting strikes NE-SW and N-S. The Creek fault offsets the Northwest fault sinistrally approximately 50 metres. It is not clear if strike-slip faults are reactivated extensional faults.

The tight to isoclinal, similar fold style and complex internal deformation indicates that the Vangorda deposit has undergone significantly high strains. Strain partitioning has produced breccia zones and shear zones in part controlled by the sulphide and matrix rheologies. Shear zones in particular are localised in the baritic massive sulphide facies or along lithofacies boundaries, commonly along the limbs of the large F_2 fold structure.

An understanding of the location, orientation, and expression of structures and structural elements within a deformed and metamorphosed deposit are of interest to the mine geologists and engineers in the day to day operations of the mine. For instance, the orientation and location of features such as faults, joints, and various foliations provide important information that can be used to help predict and assess pit wall stability, potential problems with water, location of road access to the active mining area, and to predict loading pattern and charge of blasts. Likewise, an enhanced understanding of the location and orientation of folds and faults, and which are major and which minor, are of importance in grade control during mining. By paying careful attention to these factors dilution of the ore can be significantly reduced and mine development factors can be more efficiently assessed and the costs of mine operations reduced. These and other aspects of a structural analysis of a developing mine are beyond the scope of this paper but point to the importance of continuous and detailed mapping during mine operation.

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PLACER GEOLOGY OF BLACK HILLS CREEK (PARTS OF 115O/7 & 10)

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FULLER, E.A., and ANDERSEN, F.J., 1993. Placer geology of Black Hills Creek. In: Yukon Exploration and Geology, 1992, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 33-38.

ABSTRACT

Mapping in the Black Hills Creek drainage has identified auriferous gravel resources in valley bottom and terrace deposits of the main stream. Both low-level and high-level terrace gravels and modern floodplain contain fine gold grains. Bulk gold counts determined from sluice box testing of 57 samples indicates concentrations decrease in the downvalley direction. Geochemical analysis of matrix samples (finer than 60 mesh) mimics bulk results. The apparent lower concentration of detrital gold in a downstream direction may be explained by lack of bedrock sources and insignificant enrichment from tributaries.

Bedrock terraces high above the creek level record periods of stability at high base levels which was followed by incision and aggradation of alluvial sediments in late Tertiary? time. Thick sediments in low-level terraces indicate a long period of aggradation followed by organic accumulation. Holocene activity has degraded the valley fill and redistributed sediment downstream in fining upward meander stream deposits. Permafrost is present in black muck sequences.

INTRODUCTION

Black Hills Creek is one of several placer gold bearing creeks draining from Henderson Dome (Figure 1). It flows southeasterly into Stewart River drainage, south of the Klondike. Black Hills drainage basin is comprised of several tributaries including: Childs Gulch, McCrimmon Creek, Kernine Creek and several unnamed and informally named creeks and gulches. This creek was first staked in 1898 and was worked sporadically in the early years (Bostock, 1979). Robert Henderson, of Klondike fame, may have prospected on Black Hills during its early exploration (Gilbert, 1981). Historic mining activities are in evidence as shown by hand workings. A milestone was reached when Yukon Consolidated Gold Corporation (YCGC) drilled the valley between 1936 and 1938 (Gutrath, 1985) for dredging possibilities and it reportedly contained $1,000,000 in gold but was considered uneconomic at that time (Bostock, 1979). Yukon Gold Placers Limited did prospecting and assessment work on Black Hills Creek in 1950 (Debicki, 1983). Territorial Gold Placers mined Black Hills from 1975 to 1981 (Sinclair et al., 1976; Morin et al., 1977; Morin et al., 1978; Debicki, 1983), and Queenstake Resources had a large scale mining operation during the 80's (Debicki, 1983; Gutrath, 1985; Debicki and Gilbert, 1986). Present placer mining is being carried out by Paydirt Holdings and Van Resources on Black Hills Creek, Dorados Development on Childs Gulch, and Jasper Equipment Limited on Maisy May Creek, an adjacent drainage. Black Hills Creek continues to be a gold producer in the Yukon and is an important area to continue development.

The objectives of surficial mapping of the Black Hills Creek drainage was to extend the knowledge of potential placer mining reserves south of the Klondike region and provide information on surficial and bedrock geology of the drainage basin. No surficial geology maps exist for this drainage. The most recent geology map is reconnaissance scale and out of print; it requires updating (Bostock, 1942). Hence the need for up-to-date maps and information. The purpose of this report is to present preliminary findings and ideas gleaned from the 1992 fieldwork

REGIONAL GEOLOGY

The area lies entirely within the unglaciated Klondike Plateau, a subdivision of the Yukon Plateau; smooth topography and

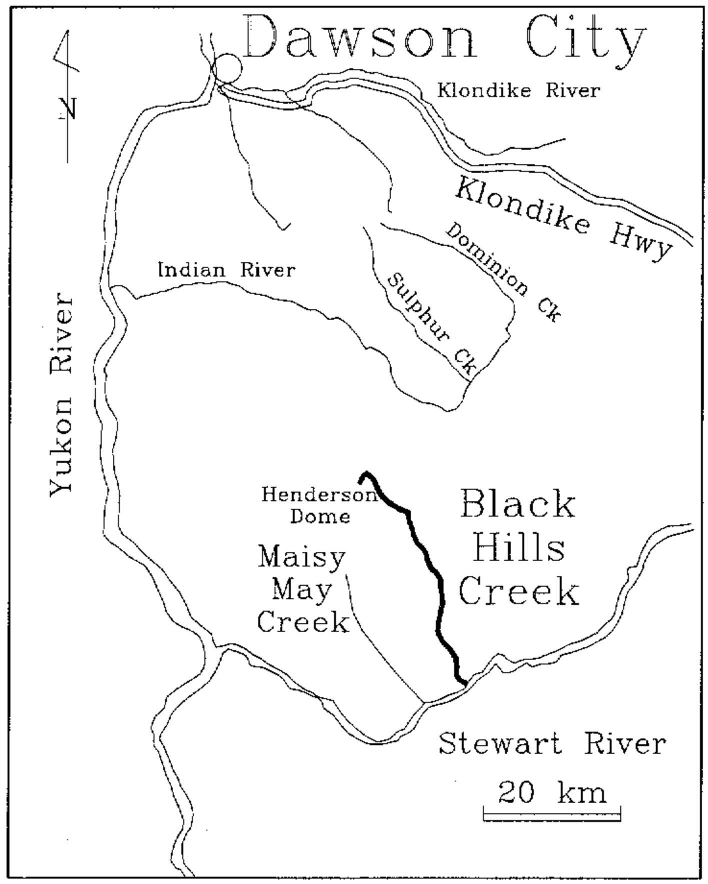

Figure 1. Location map of Black Hills Creek.

concordant ridge elevations with V-shaped valley sides and flat valley bottoms are typical (Bostock, 1948).

The Black Hills Creek drainage is incised into metamorphic rocks of the Yukon Group and volcanic rocks of the Carmacks Group (Bostock, 1942). The area lies within Nisling Terrane (Tempelman-Kluit, 1991) of the more extensive Yukon-Tanana tectonostratigraphic terrane (Gabrielse and Yorath, 1991; Mortensen, 1992). Yukon Group is comprised of metamorphic rocks including; mica schist, quartzite, crystalline limestone, amphibolite, undifferentiated gneiss, and foliated granitic rocks. Published surficial geology mapping has been limited to stream deposits (Bostock, 1942) and pingo distribution (Hughes, 1969).

METHODS

The main valley and tributary valleys were mapped during the 1992 field season by Ted Fuller and Farrell Andersen of the Canada/Yukon Geoscience office. The field season ran from June 31 to September 17, 1992 and concentrated mainly on Black Hills Creek itself. Both bedrock and unconsolidated materials were mapped from natural exposures and mining cuts in valley bottoms and terraces above the valley floors. Airphoto interpretation was carried out on 1949 and 1988 series photos and is being compiled on 1:50000 topographic base maps. Airphoto analysis provides the basis for the maps but requires ground truthing. Because of the limited availability of natural exposures, soil pits were dug on terrace surfaces to obtain more samples and observe the near surface geology. Soil profiles were described as well as sedimentology and stratigraphy of Quaternary deposits in Black Hills drainage basin.

Fieldwork included sampling unconsolidated sediment for testing for heavy minerals in a sluice box. Fifty seven 20-litre (0.26 cu yd) samples were collected and washed through an 8 foot box. Following cleanup, the gold grains were counted and heavy mineral concentrate saved for future microscope work. Minerals identified in the field include: magnetite, hematite, pyrite, barite, and garnet. Panning was carried out during traverses to provide indications of gold variability with small samples and heavy mineral suites.

Soil samples were collected from natural and man-made cuts and test pits. These samples were dried and screened to about -2 mm, split using the cone method, and shipped to Northern Analytical Laboratory (NAL) for geochemical analysis by atomic absorption and gold assay. Multielement inductively coupled plasma mass spectroscopy (ICP) on matrix samples was done at International Plasma Laboratory (IPL). A fraction of the matrix was analyzed using the sieve and hydrometer grain size method (ASTM) to help characterize the sediments. Four bulk samples were split and analyzed by Saskatchewan Research Council by ICP on a heavy mineral fraction split in conjunction with counting and description of gold grains. The coarse fraction was retained for pebble lithology provenance studies and roundness.

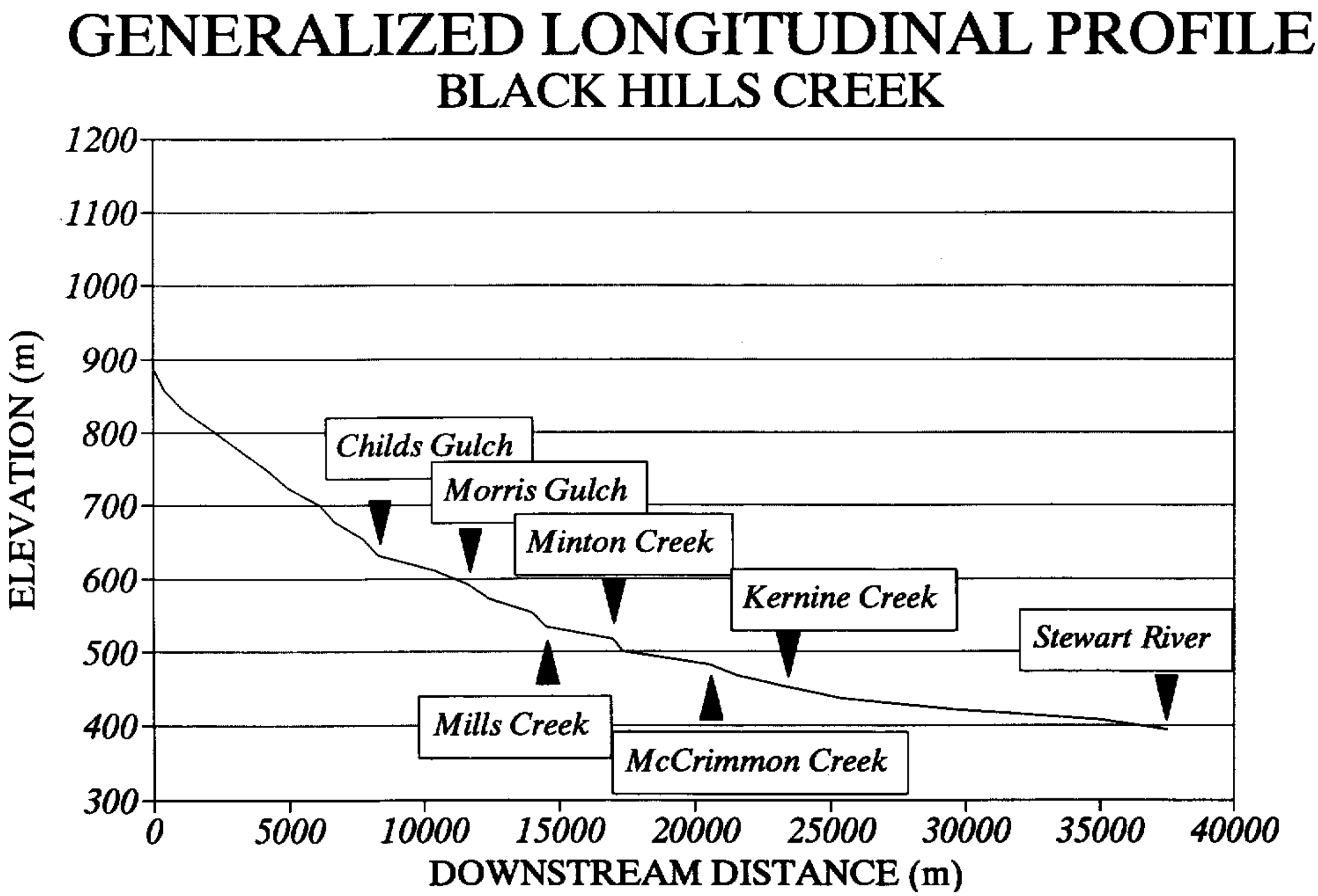

Figure 2. *Longitudinal valley profile of Black Hills Creek generalized from topographic map.*

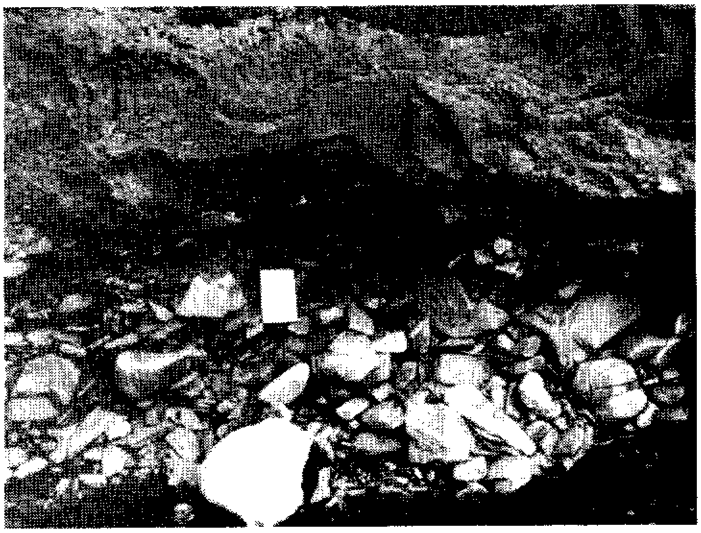

Figure 3. *A dark brown-black muck sequence measured 24 m in length on Black Hills Creek downstream from Morris Gulch. Lower part of photograph shows 90 cm bouldery cobbly matrix supported gravel, overlain by pebbly gravel then overlain by fine grained horizontally bedded green micaceous sand 8 m thick with ice lenses at top (not visible). View is to the northeast with Black Hills Creek flowing to the right.*

A few stream sediment samples were collected as a check on a regional geochemical release (GSC Open File 1364) and analyzed by NAL.

BEDROCK GEOLOGY

Bedrock is, in general, poorly exposed in the drainage. However, man-made exposures exist in mined out sections. It was important to map lithology distribution in bedrock as well as in float for clast provenance and direction of transport. By far the most abundant rock types are metasedimentary. Their lithologies include varieties of mica schist; biotite-quartz, biotite-muscovite-quartz, and biotite-quartz-feldspar types. These schists are flaggy, well foliated, grey and brown rocks. Quartzite, another common lithology, includes foliated quartzite and micaceous quartzite. It has a blocky nature and ranges in colour from tan to brown, white to grey, and rarely orange. Crystalline limestone, while not abundant, is widespread in the drainage area. It appears to form lensoid masses within the schists. In places, schists have been metamorphosed to hornfels and calcsilicate (upstream of Childs Gulch, on Childs Gulch, Morris Gulch, Minton Creek, and an east flowing tributary).

Orthogneiss is subordinate to metasedimentary rocks. They include felsic to mafic varieties; the latter dominating the former type. Granitoid rocks outcrop in the Childs Gulch area and between Childs Gulch and Morris Gulch. Tourmaline bearing pegmatites cut hornfels and calcsilicate near Minton Creek. Mafic intrusives occur in the east side of the drainage as small outcrops of green to dark green, medium to coarse grained gabbro. Amphibolite is medium to coarse grained, green to dark green, with lineated, foliated and gneissic varieties. Garnets locally occur within the amphibolite. Gabbro and amphibolite appear to be spatially related.

Unmetamorphosed Carmacks Group volcanic rocks, a Tertiary sequence, were not subdivided during mapping but include: andesitic porphyry, basalt, rhyodacite, breccia, and tuff. They tend to outcrop in the headwaters and along roads leading down into Black Hills Creek.

There is an overall northwest trending structure to the metamorphic geology which is modified by folding. Dips are moderate to shallow. Mineral lineations trend toward the southeast at shallow to moderate plunges. Faults, where observed, crosscut the foliation at various angles. Slickensides and gouge occur on some fault surfaces.

SURFICIAL GEOLOGY

Black Hills Creek is set in gently rolling topography with V-shaped cross-sections and downvalley slopes averaging 130 m/km (Figure 2). Valley bottoms are flat, poorly drained, and vary in width to about 800 m. The limit of pre-Reid glaciation extended to upstream of the mouth of Maisy May Creek (Hughes et al., 1969). A fill of glaciofluvial outwash of pre-Reid age presumably extends downstream of the terminus. A sand and gravel plain chokes the former mouth of Black Hills Creek and may have led to stream aggradation at the maximum of glaciation. Loess, ventifacts (wind polished stones), and sand wedges were observed on this surface similar to those reported for McQuesten area on a pre-Reid glaciofluvial surface (Fuller and Hughes, 1987).

The surficial geology of the drainage has been subdivided into four mappable categories; (1) fluvial terraces (Ft), (2) fluvial active floodplains (Fa), (3) colluvial veneer (Cv), and (4) bedrock or near

Figure 4. *Vertical gravel face exposed in pit upstream from Dome Creek. Shows well imbricated clast supported gravel with brown (dark grey on photo) gravel overlying grey gravel.*

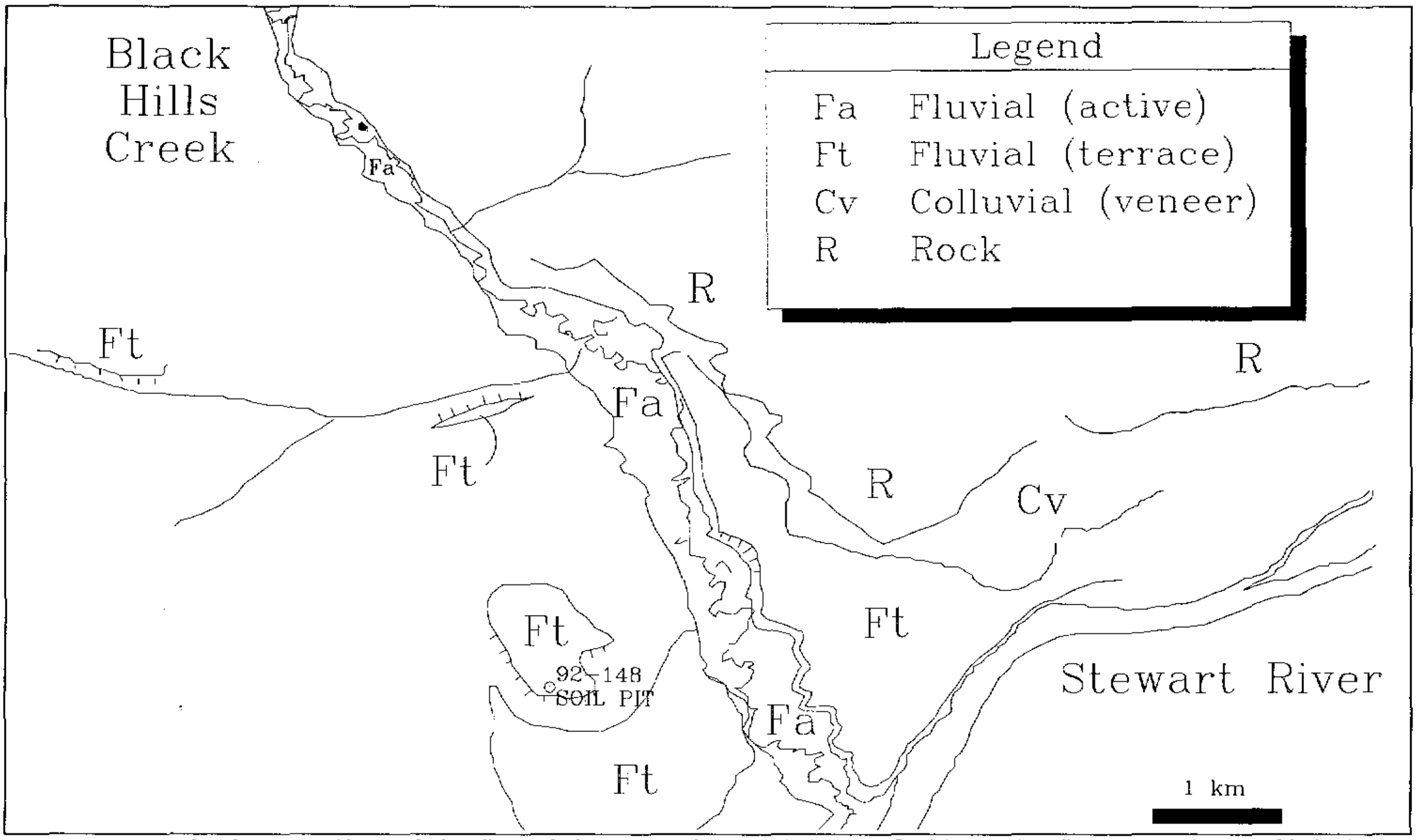

Figure 5. *Surficial geology map of lower Black Hills Creek showing fluvial terraces (Ft), active floodplain (Fa), colluvial veneer (Cv), and bedrock areas (R). Soil pit location on high fluvial terrace.*

bedrock (R). These designations are based on surface expression (morphology) and materials mapped during field investigation.

Fluvial terraces (Ft) are abandoned floodplains above present stream levels and appear on air photographs as level to slightly undulating and gently sloping surfaces. They commonly merge with slope deposits at their uppermost limits. They are comprised of variable amounts of loess, organic silt, sand, gravel, diamicton, and mud. The terraces are floored in bedrock benches near and high above the present valley bottom. Fluvial active floodplains (Fa) include the modern floodplain adjacent to present or former stream channels and the areas disturbed by mining activities within them. Morphology is flat valley floors with meander scroll bar and oxbow lake development particularly in the lower reaches. Deposits in this active setting include; organic silty sediments, sand, gravel, and diamicton. A fining-upward sequence of channel gravels overlain by overbank sands is typical. Colluvial veneer (Cv) covers most of the slopes underlain by bedrock and contains unsorted mixtures (diamictons) of angular and subangular, gravelly and rubbly material sometimes mixed with gravel. Slope morphology in colluvium is generally smooth. Bedrock or near bedrock (R) occurs where exposed by placer mining activities in creek valleys and on benches, in road cuts, and naturally along steep valley sides and on ridges. It is both weathered and unweathered and typically blocky.

Gravel deposits, the principal placer reserve material, are found in both active alluvium and on rock terraces high above the present creek levels. Two broad distinctions can be made; low level terraces and high level terraces. The low level terraces are comprised of cobbly to bouldery gravel overlying metamorphic bedrock near present base level. Pebbles and cobbles are derived from local bedrock and are generally subangular to subrounded. Metamorphic clasts always dominate over volcanic clasts. The main gravel type is clast supported, poorly sorted, subrounded, pebbly to cobbly gravel with medium to coarse sand matrix. Other types include sand matrix supported gravel and imbricated cobbly gravel. Sand deposits sometimes blanket the underlying gravel. An example of a low-level terrace is on Black Hills Creek just downstream from Morris Gulch. An eight metre high section is comprised of a bouldery channel gravel lying on bedrock and overlain by horizontally stratified sand (Figure 3).

High level terraces are built on rock benches up to 100 m above present base level. They are composed of brown gravel overlying grey gravel with a muddy sediment capping which is frozen at depth. The brown colour is believed to be due to weathering. Mining activities have stripped off an overlying mud unit which can be at least 2 m thick and includes thin buried organic horizons. Upstream from the mouth of Dome Creek, the best high level terrace exposure is found in an abandoned pit. A face up to 3.5 m high and about 100 m in length stands at 77° slope. Clast supported cobbly gravel with coarse to medium sand matrix shows well imbricated discoid shaped cobbles with long axes trending E-W (Figure 4). The top 1.2 m is brown coloured, the lower 1.2 m is light grey coloured gravel. The top surface has been disturbed by stripping activities. The poor sorting and cobbly nature, coupled with good imbrication, suggests this is a braided river deposit from a former higher level Black Hills Creek.

A good example of outwash derived from glaciation is present

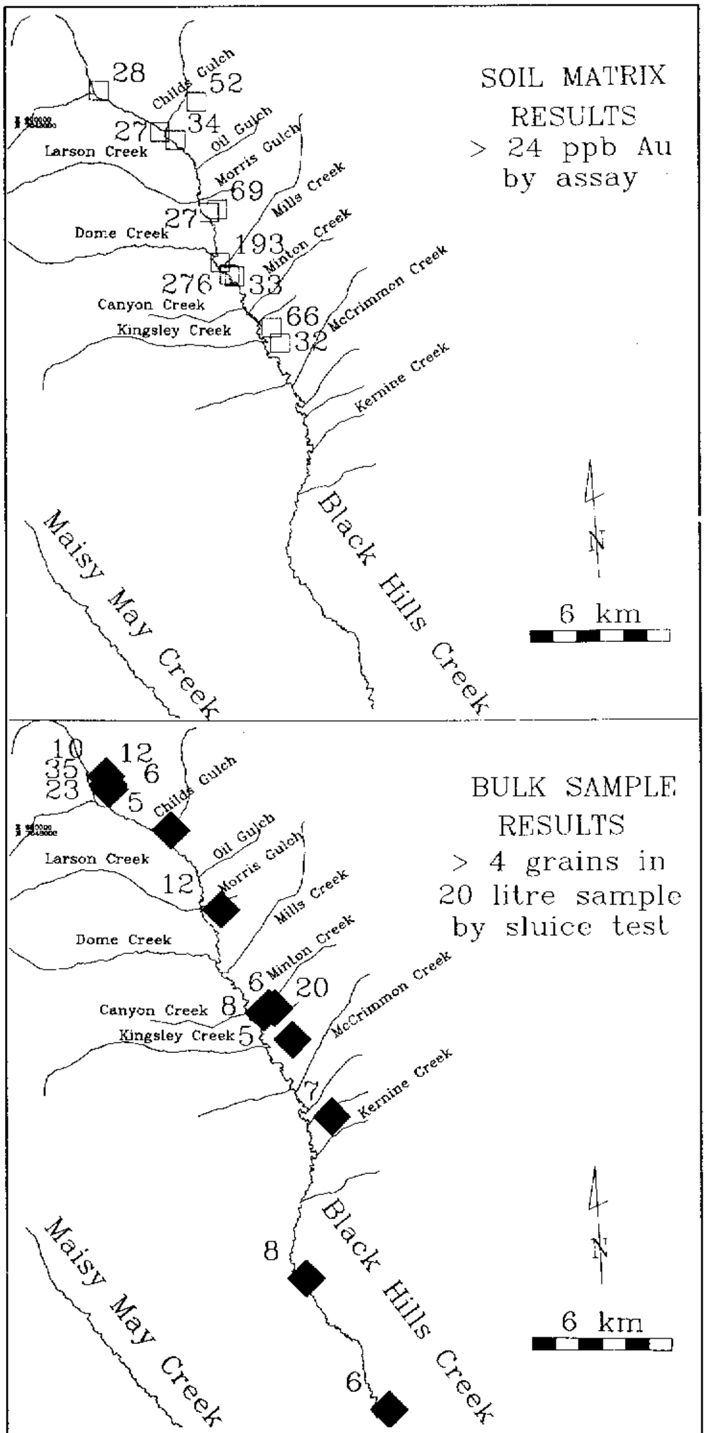

Figure 6. *Assay results for gold in matrix samples (greater than 24 ppb Au) and gold grain counts from 20-litre sluiced samples (greater than 4). Highest values appear to be in upper part of drainage.*

on the high level terrace where Black Hills debouches onto the Stewart River valley. Here, a sand covered plain with braided river channel scars and deflated surfaces contains pebble lithologies not seen in the upstream section. There is no natural or man-made exposures on this terrace and the following description is based on a soil pit from station 92-148 (Figure 5). Colour codes refer to the Munsell colour chart.

PIT DESCRIPTION

-3.0-0.0 cm	forest litter partially decayed dark brown leaves, roots, knick knick aspen vegetation, dry site
0.0-12 cm	dark reddish brown (5YR3/5) silt with widely spaced ventifact pebbles, polished and pitted, interpreted as loess.
12-45 cm	olive brown (2.5YR4/4) fine sand (10-15 cm thick) overlying a buried light tan silt loess (10 cm thick) both are well sorted
45-140 cm	in W corner of pit, younger, less weathered sand wedge of medium sand, light olive brown, colour zoned parallel to margins, older more weathered, strong brown medium sand wedge on E side
55-160 cm	gravel extends from 55 cm to base of pit and is brownish yellow (10YR6/8), less weathered gravel is yellow (5Y7/6), all is same parent clast supported poorly sorted pebble gravel with maximum 10 cm size and dominant size is 2.5 cm, vertically oriented stones very common, 80% subrounded pebbles, 5% cobbles (>10 cm), matrix is

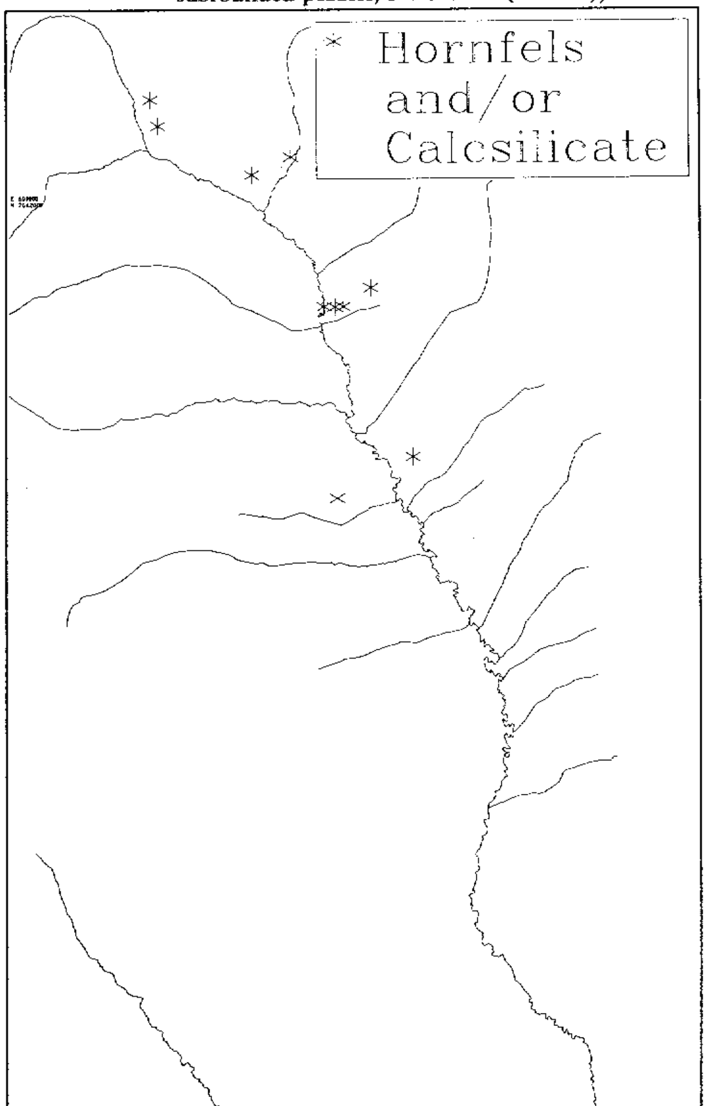

Figure 7. Location of hornfels and/or calcsilicate in outcrop on Black Hills Creek drainage.

loam, hard when dry, firm when moist, smears when wet, some rotted pebbles in top 1 m this pit lacks the red strong colours of some McQuesten pre-Reid soil pits.

RESULTS

The 1:50 000 scale mapping has outlined terrace gravel deposits along Black Hills Creek valley. The valley opens up onto the Stewart River terrace in its lowest reach (Figure 5). The modern stream has cut meander scrolls and left abandoned sloughs in the valley floor. Gravelly Sediment from a former higher level Stewart River has been eroded and reworked into Black Hills Creek near its mouth. Terrace remnants on the tributaries of Black Hills may have merged with the main terraces but since tributaries are narrow for much of their length there is very little room for their preservation following downcutting. These remnants are largely untested for gold potential (Figure 5).

Distribution of gold grains based on 57 test samples (Figure 6) indicates higher values upstream on benches and in valley floor where mining is currently being carried out. There is a suggestion that creeks draining from the east are more prone to gold values than those from the west (linked to bedrock type). This is biased from the distribution of terraces which are most prevalent along the east wall of the valley. Hornfels and calcsilicate outcrops match areas of previous mining and correlate with enhanced values in our 'bulk' sample testing.

CONCLUSIONS

Placer gold deposited in paleodrainages of Black Hills Creek and tributaries was redistributed following downcutting and incision to a lower base level. Gold grains tend to be fine (less than 10 mesh), and flat. Other heavy minerals include magnetite, hematite, pyrite, barite, and garnet. Gold values may be genetically linked to areas of contact metasomatised country rocks.

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PRELIMINARY GEOLOGY OF THE THIRTY-SEVEN MILE CREEK MAP SHEET (105D/13)

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HART, C.J.R., and BRENT, D., 1993. Preliminary geology of the Thirty-Seven Mile Creek map sheet. In: Yukon Exploration and Geology, 1992, Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 39-48.

ABSTRACT

Thirty-seven Mile Creek map area, northwest of Whitehorse, straddles the contact between Coast Plutonic Complex and rocks attributed to northern Stikine terrane. Late Triassic Little River granodiorite and Late Paleocene (57 Ma) Annie Ned granite underlie the western part of the map area. Upper Triassic to Middle Jurassic volcanic and sedimentary rocks of the Lewes River and Laberge groups underlie the eastern part of the map. The contact between Coast Plutonic Complex and Stikine Terrane is marked by the Takhini deformation zone – a region of greenschist, gneiss, mylonite, and amphibolite whose protolith is volcanic rock of Lewes River Group. Potential mineral deposits in this map area include epithermal and mesothermal quartz veins, and magnetite skarns.

INTRODUCTION

The Whitehorse Geological Mapping Project (WGMP) was initiated in 1987 and entailed the geological mapping of 105D/2,3,6,11 and part of 7 of the Whitehorse map area (Fig. 1; Doherty and Hart, 1988, Hart and Pelletier, 1989a, 1989b, Hart and Radloff, 1990). These map sheets cover regions in the Wheaton River, Carcross and Whitehorse areas with significant mineral potential. The second phase of the WGMP plans to cover 105D/13-16 - the northern portion of the Whitehorse map area. In 1992, the Thirty-seven Mile Creek map sheet (105D/13) was geologically mapped at a scale of 1:50 000. This report is meant to accompany that map, published as Indian and Northern Affairs Canada Open File 1993-4.

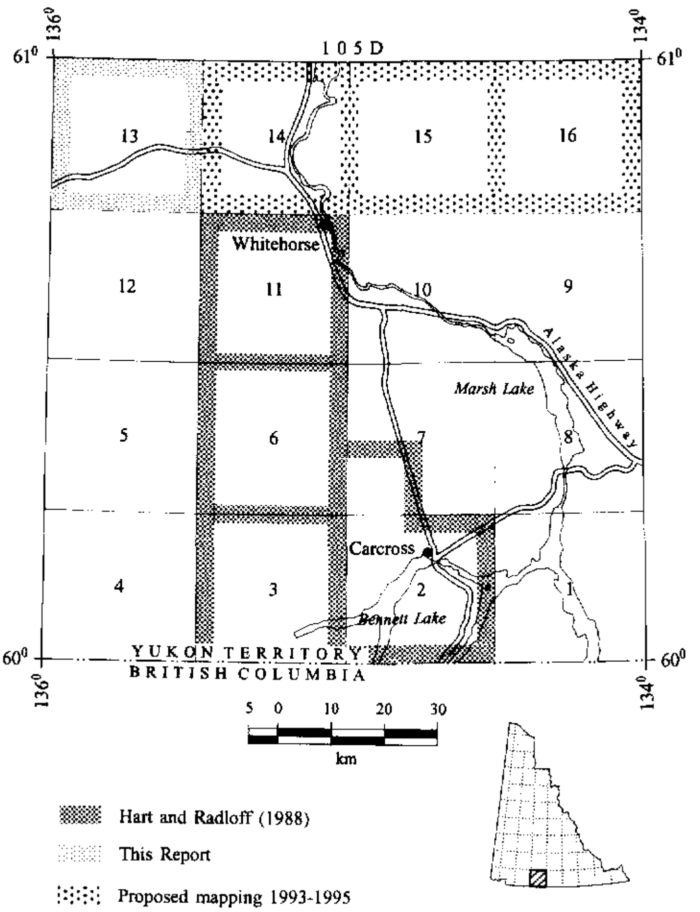

Figure 1. *Locations of geological mapping by the Whitehorse Geological Mapping Project, in the Whitehorse map area (105D). This report refers to mapping in 105D/13 in the northwest part of the map.*

PREVIOUS WORK

Large-scale regional geological maps by Cockfield and Bell (1926, 1944) and Wheeler (1961) are the only previous coverage of the region. The geology of 105D/13 shown by Wheeler (1961) is compiled largely from Fyles (1950) who concentrated on the granitic rocks in the region. In addition to the recent completion of phase 1 mapping of the WGMP, adjacent areas to the north and west were mapped relatively recently by Tempelman-Kluit (1974, 1984).

ACCESS

Road access in the region is very good. The map sheet is crossed by the paved Alaska Highway. Secondary roads parallel to the Ibex River, Thirty-seven Mile Creek and the north bank of the Takhini River (Old Dawson Trail) are in good condition and require 4WD vehicles only during wet periods. The Old Dawson Trail along the Little River is not drivable. Spur roads used for woodcutting are ubiquitous throughout the low-lying areas in the eastern half of the map sheet. Access to the Miners Range in the northeastern part of the map sheet, as well as some more remote peaks, was by helicopter.

PHYSIOGRAPHY AND GLACIATION

Thirty-seven Mile Creek map area straddles the contact between the Coast and Intermontane belts in the southern Yukon Territory. The southern and western portions of the map area display typical Coast Belt physiography with large local relief and large massif style mountains. Peaks are at approximately 6000 feet above sea level. The Intermontane Belt portion of the map sheet is composed of lower, hummocky hills and small mountains mostly below 4500 feet above sea level. The map sheet is crossed east-west by the meandering Takhini River, and northwesterly by the Little River, Ibex River and Thirty-seven Mile Creek. All occupy broad valleys filled with great thicknesses of Quaternary sediments. Much of the region below tree line, at about 3800 feet above sea level, was involved in the Takhini forest fire of 1959. Consequently, this area is now underlain by deadfall and second growth.

Glaciation has strongly influenced the physiographic character of the region. Glacial striae measured by Wheeler (1961) and the authors indicate complex flow patterns over much of the region. This complexity likely results from the meeting of two glacial fronts - one from the east, and another from the southwest. Sedimentary rocks sourced in the west and metamorphic rocks sourced in the southwest constitute most of the glacial erratics and add support to two source regions. Deglaciation features including drift, lateral moraine, kame, and lacustrine deposits are locally thick and areally extensive. Numerous shoreline deposits of Quaternary lakes occur between 4500-4000 feet and 3000-2500 feet above sea level throughout the map area.

REGIONAL GEOLOGY

The map sheet comprises parts of the eastern Coast Plutonic Complex and rocks attributed to the northern Stikine terrane (Fig. 2). The Coast Plutonic Complex is composed of granitoid rocks ranging in age from Early Jurassic to Eocene. Locally, pendants of metamorphic rocks of uncertain age and origin occur in the granitoids. Some of these metamorphic rocks may be part of the high-grade metasedimentary Nisling terrane. Northern Stikine

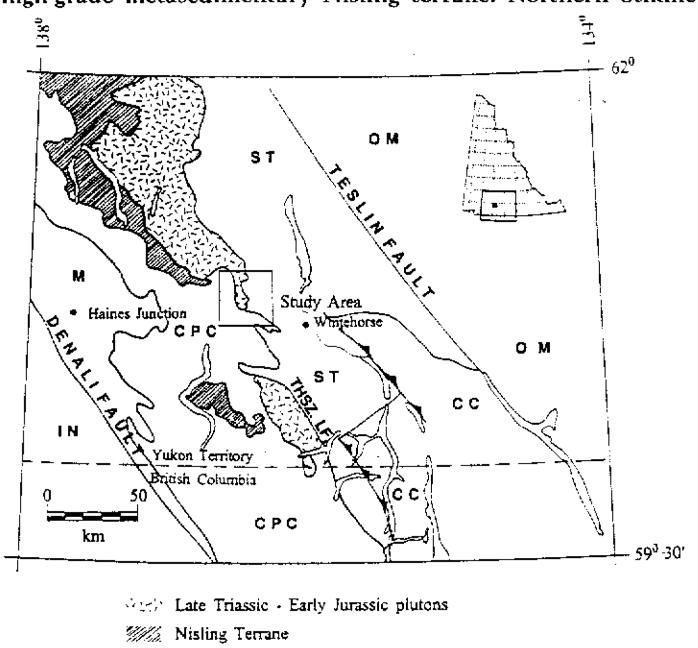

Figure 2. Regional tectonic setting of the map area. Note that map sheet 105D/13 straddles the eastern Coast Plutonic Complex (CPC) and rocks attributed to the western part of the northern Stikine terrane (ST). CC = Cache Creek terrane, IN = Insular Belt, OM = Omineca Belt, THSZ-LFZ = Tally Ho shear zone-Llewellyn fault, m = undifferentiated metamorphic rocks.

terrane is composed of Late Triassic volcanic rocks of the Lewes River Group and an overlying thick succession of clastic rocks belonging to the Whitehorse Trough. The Whitehorse Trough is composed of the sedimentary portion of the Lewes River Group and the coarse clastic rocks of the Laberge Group.

A Late Triassic-Early Jurassic, northwest-trending structural contact is inferred between Stikine and Nisling terranes. In the southern Yukon this contact is considered to be the Tally Ho shear zone , a belt of ductily deformed volcanic and sedimentary rocks (Hart and Radloff 1990). The Llewellyn fault traverses much of the western margin of the Stikine terrane in southern Yukon and northern British Columbia.

GENERAL GEOLOGY

The Thirty-seven Mile Creek map sheet is underlain by a diversity of rock types (Fig. 3, 4) that can be divided into three northwest-trending belts. South and west of the Ibex River and Thirty-seven Mile Creek are dominantly granitic rocks of the Coast Plutonic Complex. North and east of this boundary are volcanic (Lewes River Group) and sedimentary (Laberge Group) rocks of northern Stikine terrane. A strongly deformed package of schist and amphibolite along the western margin of Stikine terrane at the contact with the Coast Plutonic Complex forms the third belt.

The westernmost margin of the Whitehorse Trough is exposed only in the southeastern portion of the map sheet. Chert-rich clastic sediments of the Tantalus Formation outcrop in the northeastern portion of the map area and are overlain by a succession of intermediate to mafic volcanic flows and tuffs of the Carmacks Group.

Layered rocks

Lewes River Group

The oldest rocks in the map area are the Late Triassic Lewes River Group (Tempelman-Kluit, 1984; Hart and Radloff, 1990; Fig. 5). They are composed of the dominantly volcanic Povoas Formation and the overlying mainly sedimentary Aksala Formation. The Aksala Formation includes the volcaniclastic Annie member, and the overlying Hancock (carbonate) and Mandanna (clastic) members. The base of the Lewes River Group is not exposed in the map area. The stratigraphic level of the Lewes River Group becomes younger eastward across the map area.

Povoas Formation

Povoas Formation is exposed throughout most of the eastern half of the map area. The thickness of this unit is unknown since the base is not exposed, the upper contact is often erosional or gradational, bedding is rare, and the section is commonly broken by faults of unknown displacement.

Povoas Formation comprises dark-weathering, massive to pillowed, fine- to medium-grained basalt and basaltic andesite flows and autoclastic breccia (Fig. 6). Diagnostic augite phenocrysts and less common feldspar phenocrysts commonly compose up to 40% of the rock. Much of the augite is coarse-grained and the rock locally appears gabbroic. Monolithic andesite tuff with fist-sized fragments and hyaloclasite are major constituents locally. Greywacke, agglomerate, epiclastic rocks and thin carbonate beds are also part of

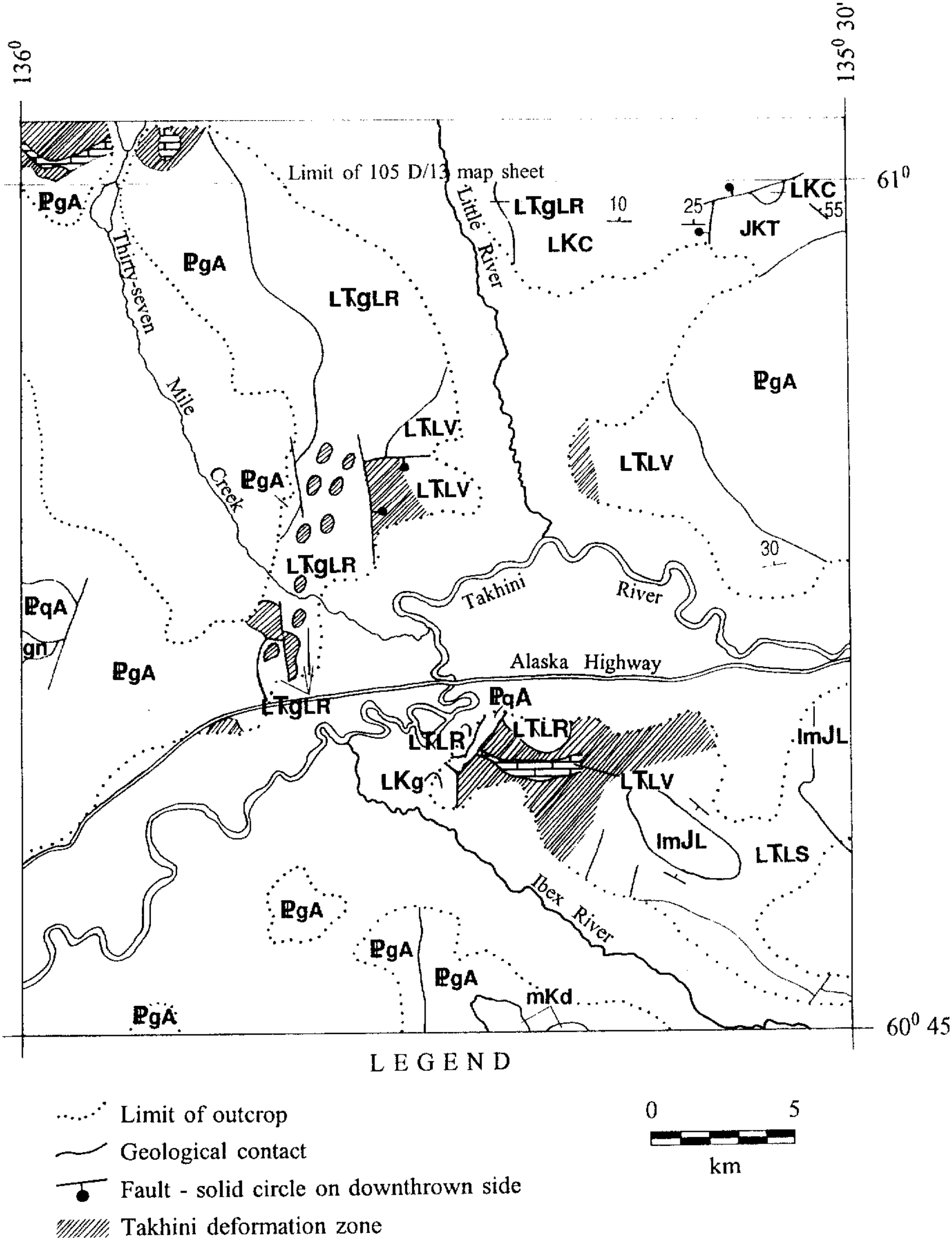

Figure 3. *Generalized geology of the Thirty-seven Mile Creek map sheet (105D/13).(Late Paleocene) PgA, Annie Ned granite; PqA rhyolite, quartz-feldspar porphyry; (Late Cretaceous) LKc, Carmacks Group; LKg, hornblende-biotite granodiorite; (mid-Cretaceous) mKd, altered hornblende quartz diorite; (Upper Jurassic to Upper Cretaceous) JKT, Tantalus Formation; (Lower and Middle Jurassic) lmJL, Laberge Group; (Late Triassic) LTgLR, Little River granodiorite; (Late Triassic) LTLV, Lewes River Group volcanic rocks; LTLC, Lewes River Group clastic rocks; LTLR, Lewes River Group undifferentiated orthogniess.*

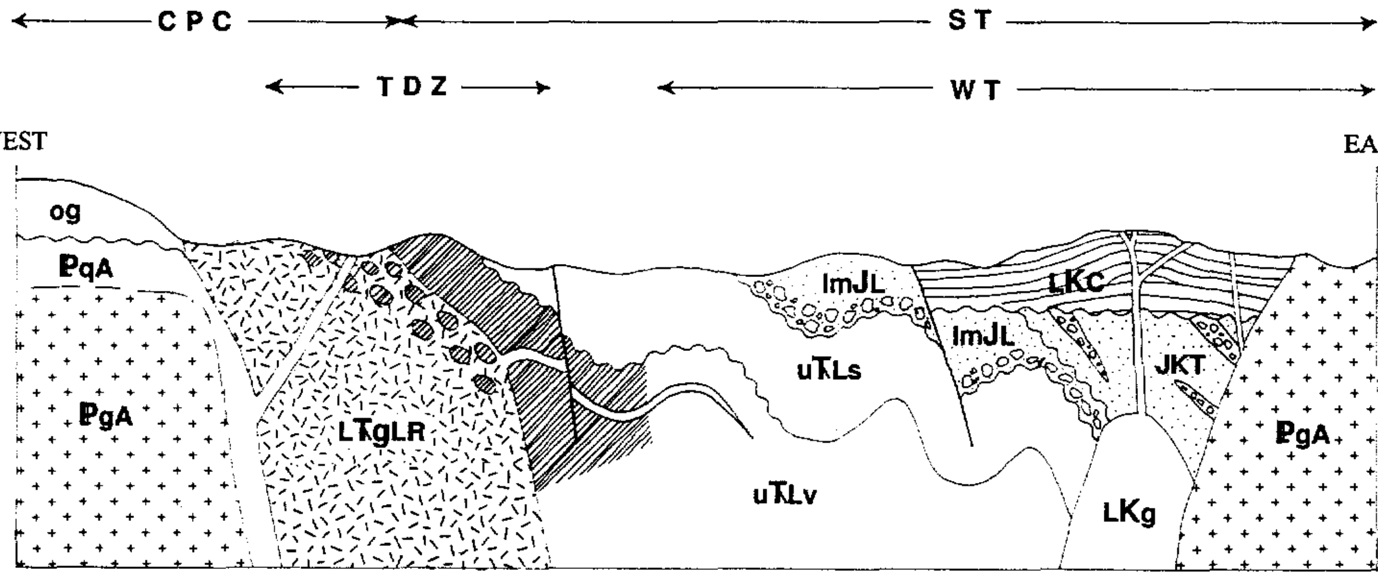

Figure 4. Schematic cross-section looking north, through the Thirty-seven Mile Creek map area (105D/13). Rock unit symbols are those used in Fig. 3. CPC = Coast Plutonic Complex, ST = Stikine terrane, WT = Whitehorse Trough, TDZ = Takhini deformation zone.

the Povoas Formation but are volumetrically less significant. Most of the Povoas Formation is strongly chloritized, epidotized, and locally strongly altered with an alteration assemblage indicative of interaction with sea water.

Metamorphosed and deformed rocks presumed to part of the Povoas Formation form a northwest-trending belt adjacent to the Coast Plutonic Complex. This belt forms the westernmost exposures of Lewes River Group and is here termed the Takhini deformation zone. Numerous screens and pendants of the deformed rocks are hosted in the Little River Batholith.

Aksala Formation

Rocks of the Aksala Formation are limited to the easternmost part of the map area. These rocks constitute the dominantly sedimentary portion of the Lewes River Group, which is divisible into four members: the Annie, Casca, Hancock and Mandanna. These members are mapped on the basis of lithology alone and do not represent discrete, time-restricted stratigraphic units. The coarse-grained volcaniclastic rocks of the Annie member are overlain by the finer-grained, more mature clastic and carbonate rocks of the other units. Observations in other areas of the Whitehorse and Laberge map areas indicate that the Casca, Hancock and Mandanna members are locally diachronous and represent essentially time-equivalent facies of each other (Hart and Radloff, 1990, Tempelman-Kluit, 1984) . Measured sections east and southeast of the map area indicate a stratigraphic thickness of greater than 1000 m for rocks the Aksala Formation (Wheeler, 1961). In other parts of the Whitehorse Trough, Hart and Radloff (1990) have suggested that the Aksala Formation is greater than 1800 m-thick.

Annie Member

Coarse, angular, immature volcaniclastic and epiclastic rocks and intercalated lava flows, tuff and minor limestone form the Annie member of the Aksala Formation. These rocks are composed almost entirely of the erosional products of the Povoas Formation, and were deposited largely by gravity flows (lahars). This member is massive to poorly bedded. It was deposited unconformably upon Povoas Formation rocks and is in part diachronous. The local presence of well-bedded arenite and sub-rounded clasts in agglomerate indicates that some horizons in the Annie member were hydraulically modified.

The thickness of this member varies from 0 to greater than 1000 m-thick. In the project area, it ranges up to 500 m-thick.

Hancock and Casca members

These members are dominantly carbonate and occur at or near the top of the Lewes River Group. The Hancock member is composed of light grey, massive, micritic limestone, calc-rudite and bioclastic limestone. The Casca member is composed of limey

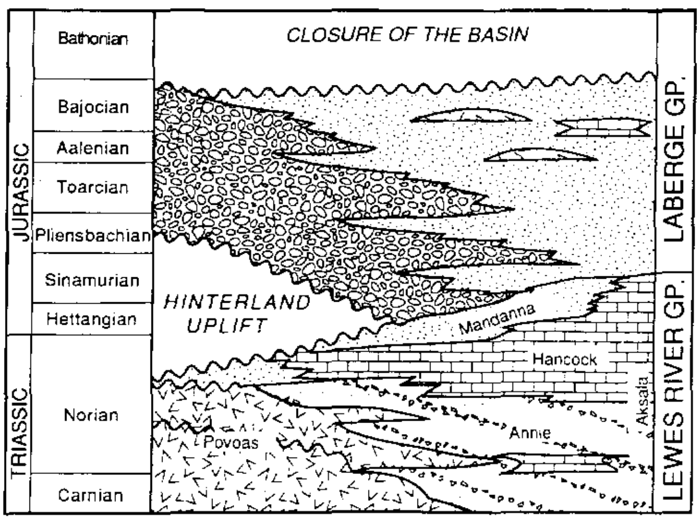

Figure 5. Schematic stratigraphic section showing relationships and nomenclature of rock units composing the Lewes River Group and Laberge Group. The sedimentary portion of the Lewes River Group and the Laberge Group together compose the fill of the Whitehorse Trough. Figure is modified from Hart and Radloff (1990), nomenclature is that of Tempelman-Kluit, 1984.

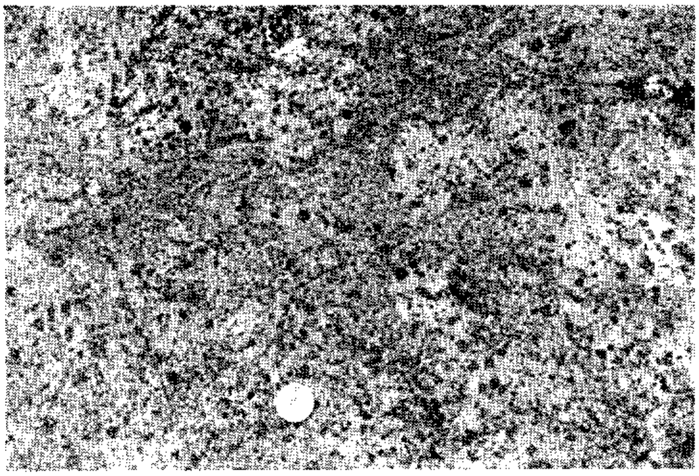

Figure 6. *Typical Povoas Formation autoclastic, augite- and feldspar-phyric basalt flow.*

mudstone which is typically peripheral to the Hancock. It is uncertain as to whether or not the thick marble in the south-central portion of the map area is deformed Hancock member, or an unusually thick carbonate in the Povoas Formation. The latter interpretation is preferred since it is interbedded with rocks of the Povoas Formation.

Mandanna Member

Red, purple, green and grey well-sorted clastic rocks of the Mandanna member typically occur at the top of the Lewes River Group. These rocks are considered to be transitional with the overlying Laberge Group. In sections where all Aksala members are present, Mandanna member may occur below, with and above Hancock and Casca members. It is dominated by planar, finely laminated sandstone and litharenite with greywacke, conglomerate and shale. Sedimentary structures such as cross-bedding, ripple-lamination, graded bedding, scours, channels, rip-up clasts, bioturbation, and the oxidized nature of much of this member, attest to a shallow water origin. Mandanna rocks are a clastic, generally shallow water facies-equivalent of the carbonate rocks.

Macrofossil and conodont ages for Lewes River Group from outside the map area span Late Triassic time from Carnian to latest Norian (Tozer, 1958, Wheeler, 1961, Morrison, 1981, Doherty and Hart, 1988, M. Orchard, personal communication, 1990). Povoas Formation is dominantly Carnian. Hancock member is mostly latest Norian, and by analogy, so are Mandanna member rocks. However, since Mandanna member is transitional with overlying rocks of the Lower Jurassic Laberge Group, part of it may be Lower Jurassic.

Laberge Group

Lower Jurassic Laberge Group is composed of basal conglomerate, sandstone and tuff overlain by a thick sequence of conglomerate and facies-equivalent greywacke and argillite. Only the basal portion of the Laberge Group is exposed in the map area. These are lithologically similar to, and difficult to discern from the underlying Mandanna member. In this transitional zone, both Laberge Group and Mandanna member may be red or maroon. In most of the Whitehorse Trough, Laberge and Lewes River groups are separated by Hancock limestone. Where this important marker unit is missing, Mandanna clastics grade into Laberge clastics and the placement of a contact between these two groups is difficult.

In the map area Laberge Group is recognized by the presence of a feldspar-hornblende crystal-lithic tuff with distinctive, large grey quartz-eyes. This unit does not have a muddy matrix. Although locally maroon or green, unweathered surfaces are characteristically blue-grey. Examples of this rock that are clearly volcanic are rare, and hydraulically modified tuffaceous sandstone exposures are more common. This unit, known elsewhere as the Nordenskiold dacite (Tempelman-Kluit, 1984), is characteristic of the lower Laberge Group and not the Lewes River Group.

Since the basal Laberge Group package is gradational with underlying Mandanna member strata it is younger than latest Norian. The association of the basal package with the Nordenskiold dacite suggests that these rocks could be as young as upper Pliensbachian (H. Tipper personal communication, 1989, G. Johannson personal communication, 1992). This confines deposition of the basal package possibly from Hettangian to upper Pliensbachian.

Tantalus Formation

Tan-and buff-brown-weathering, interbedded chert-rich sandstone, shale and conglomerate with coaly plant fragments form a greater than 800 m-thick succession in the northeastern part of the map area. These rocks appear to have been deposited unconformably on top of folded Lewes River Group. They are dominated by quartz and chert clasts and lack an igneous clastic component.

Rocks in Thirty-seven Mile Creek map area assigned to the Tantalus Formation were originally thought to be Laberge Group and therefore to be mid-Jurassic in age (Wheeler, 1961). However, the lithological similarity to Tantalus Formation elsewhere in the southern Yukon and the abundance of coaly plant fragments support correlation with Tantalus Formation.

The age of the Tantalus Formation in Thirty-seven Mile Creek map area is uncertain. Elsewhere Tantalus Formation rocks have yielded ages ranging from Late Jurassic to Late Cretaceous (Hart and Radloff, 1990). Since these rocks are overlain by Carmacks Group volcanics, they are at least older than latest Cretaceous.

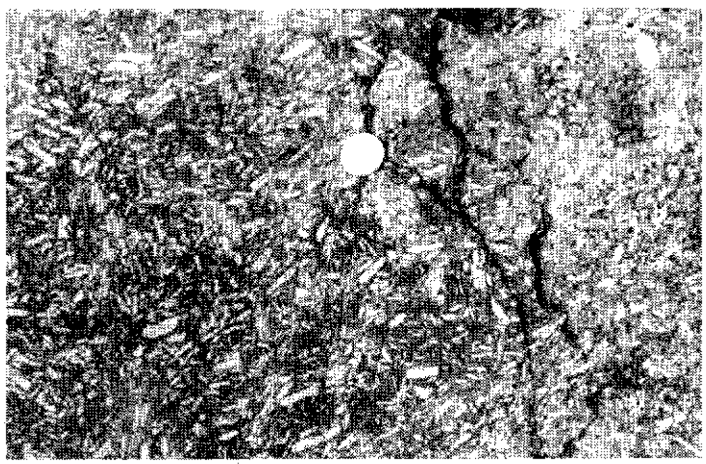

Figure 7. *Large bladed plagioclase phenocryst, trachytic andesite porphyry flow. This unit is typical in the lower part of Late Cretaceous Carmack Group stratigraphy in southern Yukon Territory. Exploration and Geology 1992*

Carmacks Group

Thick accumulations of dark-weathering, massive to thickly bedded, dark purple-green, fine-grained andesite and basaltic andesite flows, tuff and breccia compose the Carmacks Group in the northeastern part of the map sheet. These exposures are the southern limit of a large and extensive (greater than 800 km^2) succession of Carmacks Group. In the map area, these rocks are greater than 800 m thick. These rocks unconformably overlie more steeply dipping Tantalus Formation clastics, the Little River Batholith and Lewes River Group volcanic rocks.

Carmacks Group is easily distinguished from the volcanic rocks of the Lewes River Group by their: 1) lack of obvious large black augite phenocrysts, 2) lack of pervasive chloritization, and 3) thick successions of nearly flat-lying resistant flows. Carmacks Group successions are characterized by numerous, stacked, monotonous flows, breccias and tuffs overlying a basal package of more diverse flow types and heterolithic breccias. Andesite porphyry flows with large bladed plagioclase feldspars (Fig. 7) are intercalated with coarse, heterolithic clastic sediments and epiclastic rocks in the basal package.

In southern Yukon Carmacks Group volcanics have been dated as Late Cretaceous in age (i.e. 70-84 Ma; Grond et al., 1984, Tempelman-Kluit, 1984, Hart and Radloff, 1990, Hart, 1993). K-Ar dates of 69.1 and 72.4 Ma on andesite flows from 20 km north of the map area support a Late Cretaceous age. These rocks are equivalent to the Wheaton River and Grey Ridge volcanics as described by Hart and Radloff (1990) and Hart (1993).

Granitic rocks

Orthogneiss

Strongly foliated and weakly gneissic, medium-grained, feldspathic, hornblende-biotite-quartz orthogneiss occurs as a small pendant in the roof of the Paleocene Annie Ned granite. It contains thin, anastomosing, but mostly concordant stringers of amphibolite which fill late-stage brittle fractures. This rock is similar to Selwyn gneiss found in the Aishihik and Carmacks areas and may be Paleozoic in age. Alternatively, this rock may be a tectonized Mesozoic granodiorite.

Felsic mylonite

Light pale green, green or buff, strongly sheared, mylonitic quartz felsite occurs as sills and lenses up to 5 m-wide in Povoas Formation deformed in the Takhini deformation zone. Some exposures have been thermally metamorphosed to form feldspathic quartz-mica schist. The protolith of these rocks may have been granitic dykes which intruded Povoas Formation basalt prior to their deformation.

Little River batholith

Coarse-grained, biotite-hornblende-alkali feldspar megacrystic granite and granodiorite crops out in a belt between deformed Povoas Formation basalt, which it intrudes, and the Annie Ned granite, by which it is cut. The Little River batholith is easily recognized in the field by its large (up to 15 cm-long), pink alkali feldspar megacrysts. Although most phases of the batholith contain these randomly distributed megacrysts, locally they accumulate in masses or may be sparse or missing. The megacrysts often contain zones of plagioclase and hornblende poikilocrysts. Large, euhedral grey quartz-eyes are also characteristic of this unit. Hornblende quartz diorite forms a marginal phase of this batholith.

Little River batholith generally appears unaltered, but locally, intense propylitic alteration has altered the plagioclase to sericite and the mafic minerals to chlorite. Consequently the rock has a grey-green appearance and is cut by thin chlorite stringers. Elsewhere this rock contains several percent of disseminated epidote.

Little River batholith includes screens and pendants of deformed Povoas Formation basalt. As a result it is younger than the deformation event in the Takhini deformation zone. But since the batholith is cut by the Eocene Annie Ned granite, it is older than 58 Ma. Granitic clasts in Lower Jurassic Laberge Group conglomerate just outside the map area are lithologically similar to the Little River batholith. If the clasts were derived from it then the Little River batholith is at least 195 Ma. This rock has many lithological similarities to the Bennett Batholith near Bennett Lake (Hart and Radloff, 1990).

Mid-Cretaceous(?) granitoids

Several small (less than 2 km^2) exposures of mesocratic granitoid rocks of uncertain age occur in the southwestern portion of the map area. Dark grey-weathering, resistant, strongly altered and locally foliated hornblende granodiorite crop out as pendants in the roof of the Annie Ned granite. Alteration of the mafic minerals to chlorite causes some feldspar to appear green; weak potassic alteration gives other feldspars an unusual pink colour. These pendants, mapped as volcanic rocks by Wheeler (1961), likely represent the country rock into which the Annie Ned granite intruded. They resemble altered equivalents of hornblende granodiorite of the Whitehorse plutonic suite and consequently are assumed to be mid-Cretaceous in age.

Late Cretaceous(?) quartz monzonite

Fresh, medium- to coarse-grained, buff pink, hornblende-biotite quartz monzodiorite outcrops in at least two locations in the south-central portion of the map sheet. Deformed Povoas Formation basalt and crosscutting andesite feldspar-hornblende porphyry dikes of unknown age occur as xenoliths in the quartz monzodiorite. The quartz monzodiorite is in turn cut by dikes of Eocene rhyolite. A speculative age of Late Cretaceous is assigned to this rock.

Paleocene Annie Ned granite and Flat Creek pluton

Annie Ned granite underlies much of the western part of the map area; the lithologically similar circular Flat Creek pluton occurs in the northeastern portion of the map area. These intrude all other units except for a set of mafic dykes. The Annie Ned granite has steep margins, a flat upper contact, and a border phase of quartz-feldspar granite porphyry. The granite has dark grey, lichen-covered weathered surfaces, but its crumbly recessive nature causes this rock to have numerous fresh, cream to buff orange exposures. Despite its recessiveness, this rock forms high, and steep hills and cliffs. This unit is further characterized by horizontal and widely spaced vertical joint sets made more pronounced by intense weathering. Talus boulders quickly disintegrate and the crumbly nature has given rise to descriptions of `rotten granite'. The weathering of this rock was

Figure 8. *Looking north at east-trending felsic sills from the Late Triassic? Little River batholith (light coloured) concordantly cutting deformed Lewes River Group greenschist (dark at top of photo) in the Takhini deformation zone. The package is subsequently cut by north-trending resistant, basaltic dykes (dark).*

Figure 9. *East-trending felsic sills (light coloured, at top) concordant with the foliation of greenschist and gneiss in the Takhini deformation zone are tightly folded around north-northwest-trending, shallowly plunging folds. This photograph, taken looking to the north, shows an apparent easterly vergence in the fold. Pen in centre is 15 cm-long.*

the focus of a study by Fyles (1950) who attributed its recessiveness to large pores. Thorough descriptions of this rock are provided by Fyles (1950, p. 56) and Wheeler (1961, p. 97).

Lithologically, this rock is a medium- to coarse-grained, miarolitic, leucocratic, hornblende-biotite granite and alaskite. Large, euhedral smoky-grey quartz-eyes, or aggregates of quartz-eyes are characteristic of this rock. The mafic minerals are finer-grained and occur as aggregates rather than single crystals. Sparse, white alkali feldspar megacrysts occur locally. Although the granite is fairly homogenous, flow-banded rhyolite and granite porphyry are distinct marginal phases of this unit.

Pale orange-weathering, light blue-grey flow banded rhyolite and feldspar-phyric rhyolite intrudes deformed Povoas Formation basalt and contains screens of the Little River granite. Flow banding, and associated lineations are essentially vertical, thus supporting an intrusive origin for the rhyolite.

Quartz-feldspar granite porphyry is composed of large euhedral alkali feldspar and smoky-grey quartz-eyes and small hornblende phenocrysts in a fine-grained matrix. This rock covers a small area under a pendant of country rock and probably represents the roof of the Annie Ned batholith. The rock is identical to that found associated with the Early Eocene Bennett Lake and Mount Skukum volcanic complexes.

The Annie Ned batholith acquires its name from exposures near Annie Ned Creek on the Alaska Highway. It is similar to rocks of the Nisling Range (Tempelman-Kluit, 1974), Ibex (Hart and Radloff, 1990) and Bennett (Woodsworth et al., 1992) plutonic suites. A K-Ar date from the Flat Creek pluton incorrectly indicated that this lithology was 223 Ma (Lowdon, 1960). Subsequent K-Ar and U-Pb zircon dates from the Annie Ned batholith indicate a Late Paleocene age (57.6 Ma) for this granite (Morrison, et al. 1979, Armstrong and Ghosh unpublished).

Dykes

Several suites of dykes cut the rocks in this region. From oldest to youngest they include:

1) mylonitic felsite cutting, and deformed with Povoas Formation basalt (Late Triassic);

2) granitic dykes from the Little River batholith, dominantly east-trending, cuts only Povoas Formation, and 3-10 m thick (Late

Figure 10. Barren, waxy, milky white quartz vein discordantly hosted in sheared and metamorphosed basalt of the Takhini deformation zone. This vein probably formed due to metamorphic devolatization during deformation of the basaltic host rock.

Triassic-Early Jurassic; Fig. 8);

3) coarse feldspar and acicular hornblende-phyric andesite, cuts Little River batholith, 3-5 m thick, north-trending (Late Cretaceous?);

4) resistant, buff orange rhyolite and granite porphyry, 3-10 m-thick, cuts all units except 5), north-trending (Paleocene);

5) resistant, brown weathering, fine-grained, locally feldspar-phyric and strongly magnetic basaltic andesite, north-trending, cuts all units (Eocene; Fig. 8).

Structures

Takhini deformation zone

The most prominent structural feature on the map is a northwest-trending zone of ductily deformed and metamorphosed Povoas Formation volcanic and sedimentary rocks. This zone, here called the Takhini deformation zone (TDZ), is up to 12 km-wide, and is located along the contact between rocks of the Coast Plutonic Complex and westernmost Lewes River Group. It is composed of sheared basalt, breccia, tuff and carbonate, mylonitic felsite, greenschist, augite gneiss, chloritic and biotite schist, and amphibolite. The pervasive zone of ductily deformed rocks appear to grade abruptly into discreet anastamozing shears and undeformed rocks of similar protolith. The present western margin of the TDZ is marked by a zone of screens and pendants of deformed greenschist among the Little River and Annie Ned batholiths.

The most intensely deformed rocks are gneissic. Coarse-grained, polymineralic and siliceous rocks have elongation lineations on their foliation surfaces. Fragments in breccia and tuff locally have aspect ratios of about 10:1.

Metamorphic grade is generally not higher than greenschist except along the westernmost portion of the belt. Acicular amphibole on foliation planes of greenschist and basaltic gneiss have random orientations which suggests that their development post-dates deformation. Similarly, biotite and muscovite are considered to be post-kinematic. Foliation planes and included elongation lineations are re-oriented as a result of subsequent folding.

Since some of the deformed rocks occur as xenoliths in the Little River batholith and as clasts in the lowest Laberge Group conglomerate, deformation was likely Late Triassic in age. Augite gneiss clasts in a Late Carnian conglomerate south of Whitehorse supports an early Late Triassic deformation event (Hart and Radloff, 1990). Folding of the fabric was probably coincident with folding of the Whitehorse Trough strata in Middle Jurassic to Early Cretaceous time. Local thermal metamorphism of these rocks probably occurred during the emplacement of the Little River and Annie Ned batholiths.

Faults

The map area is underlain by numerous small faults with unknown amounts or senses of displacement. These faults are visible on aerial photographs as lineaments, and on the ground as topographic depressions, but since they juxtapose similar rocks, the sense of displacement is uncertain.

The most prominent faults recognized in the map area are north-trending. The sense of displacement is known for only a few of these faults. Motion is typically normal. Several prominent and continuous north-trending airphoto lineaments and swarms of lineaments may be faults. If so, displacement on them is not large (less than 1 km). An east-northeast-trending set of lineaments are probably small strike-slip faults. A similar set of faults has been observed west and south of Whitehorse (Hart and Radloff, 1990). There, displacement is usually sinistral and less than 1 km. Both sets of fault cut the Annie Ned batholith and therefore are younger than 57 Ma.

Folds

Northwest-trending, open folds are recognized in sedimentary rocks of the upper Lewes River Group and Laberge Group. Since bedding is difficult to discern in most of the Lewes River Group volcanic package, folds were not recognized, but almost certainly occur. Folds occur in the Takhini deformation zone. The initial foliation and gneissosity is folded in a manner similar to the aforementioned sedimentary rocks (Fig. 9). The timing of the folding is constrained to be post Laberge Group and pre-Carmacks Group – Middle Jurassic to Middle Cretaceous.

Mineral Deposits

Eight mineral occurrences are listed on map sheet 105D/13 by Yukon Minfile (1991). All were investigated. Mineralization was not observed at any of those listed. The Ingram (Yukon Minfile #45, YEX #44), a lead-zinc-silver vein could not be located and is probably on the map sheet to the south (105D/12; see Wheeler, 1961, p. 136).

Molybdenite was observed on fracture surfaces of the Annie Ned granite in outcrops north of the Alaska Highway, and supports molybdenum anomalies found in the region by Kennco Exploration Limited in 1970 (Yukon Minfile #81). Malachite staining, and rare chalcopyrite in the contact alteration zone of Lewes River basalt adjacent to the Annie Ned batholith, attest to the high background copper values of the Lewes River Group (Hart and Radloff, 1990, p. 77, 112; Tempelman-Kluit and Currie, 1977).

Magnetite skarn was found in deformed marble in the Takhini deformation zone. A grab sample yielded elevated zinc values (7994 ppm). A selected sample from a magnetite skarn immediately north of the map area (105E/4, Yukon Minfile #8) gave 2.8% Cu and 9.5 g/t Ag with elevated zinc values. These showings are similar in character to the Jackson deposit (Yukon Minfile #76, Grouse of Hart and Pelletier, 1989b, p. 34) west of Whitehorse, and give encouragement to the possibility of discovering deposits similar to those of the Whitehorse Copper Belt. Several thin (10-40 cm) quartz veins, and sweats were encountered along the eastern margin of the Takhini deformation zone, but all were barren (Fig. 10).

Four silt samples from the Thirty-seven Mile map area have anomalous values (Geological Survey of Canada, 1985). In the northwest corner of the map sheet two adjacent samples have mercury values of 95 and 152 ppb respectively. Anomalous mercury values are typically associated with high-level epithermal veins. In the northeastern part of the map sheet, in the Miners Range, a silt sample yielded a gold value of 40 ppb. A sample from a stream draining a region of thick glacial drift from near the Alaska Highway in the eastern part of the map area gave a value of 30 ppb Au. Geochemical assays of samples collected during the mapping project are listed in Appendix 1.

DISCUSSION

This mapping project was initiated partly to determine the mineral potential along-strike from the numerous vein deposits found in the Wheaton River area. Deposits in that area are associated with large faults. These faults were not found in the Thirty-seven Mile Creek map area. They may be found further west or have been obscured by the intrusion of the Annie Ned batholith and other Early Tertiary granites.

The rocks, style and timing of deformation in the Takhini deformation zone are all similar to that found in the Tally Ho shear zone (Hart and Radloff, 1990) and may be its northern extension. However, unlike the Tally Ho shear zone, the Takhini deformation zone is locally flat-lying, folded, and not bounded by brittle faults.

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Appendix 1: Geochemical assay data for rock and silt samples (Au, fire assay; all others ICP; all done by iPL, Vancouver)

Sample # s, silt r, rock	Lat.	Long.	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	As ppm	Sb ppm	Hg ppm	Bi ppm	Cd ppm	Ba ppm	Mo ppm	W ppm	Ni ppm	Cr ppm	%Fe
621714 s	60° 59.8'N	135° 32.0'W	27	0.2	53	62	278	nd	nd	nd	nd	1	149	2	nd	21	31	2.46
92CH8-4 r	60° 49.6'N	135° 43.6'W	11	1.4	157	161	7994	7	nd	nd	11	53.3	15	4	nd	15	23	23.2
92CH18-4 r	60° 48.2'N	135° 31.9'W	16	nd	213	17	54	nd	nd	nd	nd	1.3	5	3	nd	7	29	1.99
92CH29-2 r	61° 0.5'N	135° 59.0'W	11	9.5	2.8%	24	4385	13	nd	nd	nd	28.4	nd	4	nd	69	23	27.8
92CH30-2 r	60° 54.7'N	135° 35.8'W	45	0.6	57	123	337	nd	nd	nd	nd	1.1	54	2	nd	63	100	5.36
DETECTION LIMITS (nd=below detection limits)				0.1	1	2	1	5	5	3	2	0.1	2	1	5	1	1	0.01

Sample descriptions: 92CH8-4, magnetite skarn with garnet and diopside; 92CH18-4, milky white, cox-comb quartz vein, no sulphides; 92CH29-2, magnetite skarn with chalcopyrite and bornite; 92CH30-2, andesite flow with 15% disseminated pyrite

PRELIMINARY RESULTS OF 1:50 000 SCALE GEOLOGIC MAPPING IN WOLVERINE CREEK MAP AREA (115I/12), DAWSON RANGE, SOUTHWEST YUKON

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ABSTRACT

The oldest rocks in Wolverine Creek map area belong to a Devono-Mississippian metamorphic assemblage consisting of heterogeneous quartzite and orthogneiss. The quartzite unit is commonly micaceous, and includes interlayered metapelite, metacarbonate, and amphibolite interpreted as metamorphosed mafic igneous rock. The orthogneiss is dominated by leucocratic, medium to coarse grained metaplutonic rock, and mesocratic to melanocratic, fine to medium grained metaplutonic and probably metavolcanic rock. Fabrics in the metamorphic assemblage indicate two pre-Early Jurassic tectonic events, the youngest of which involved top-to-the-north shearing. Regional amphibolite grade metamorphism led to development of migmatite in the metapelite and orthogneiss, and recrystallized hornblende in the orthogneiss.

The metamorphic rocks are crosscut by post-tectonic intrusions including: quartzo-feldspathic pegmatite, spinel peridotite, and alkalic syenite of Early Jurassic Minto Plutonic Suite; and quartz monzonite of middle Cretaceous Dawson Range Batholith. These metamorphic and plutonic rocks are nonconformably overlain by a thick (about 700 m) succession of mafic lava flows, and tuffs of Upper Cretaceous Carmacks Group. Monzo-syenite plutons and a rhyolite plug are regarded as cogenetic, epizonal equivalents of Carmacks Group. Major faults, including Big Creek Fault, Wolverine Creek Lineament, and probably Hoochekoo Fault, were active during Carmacks Group volcanism. Porphyry, vein and skarn mineralization are associated with each of the post-tectonic magmatic events.

INTRODUCTION

This paper reports on the results of 1:50 000 scale geologic mapping conducted during the summer of 1992 in the Wolverine Creek map area (115I/12), Dawson Range, herein termed the study area (Figs. 1, 2). This work is part of a continuing study aimed at better understanding the structural, metamorphic, and metallogenic evolution of Dawson Range, a metamorphic and magmatic welt which trends northwest across southwest Yukon (Fig. 1).

The physiography of the study area is typical of Dawson Range. The area is a deeply incised, little glaciated terrain. Elevation ranges from about 550 m a.s.l. to about 1600 m a.s.l., and average about 1050 m a.s.l. The treeline occurs at about 1250 m. Exposures of bedrock are rare. Ridge tops are locally characterized by weathered, castellated outcrops. Felsenmeer, scree, and talus occur on ridge tops and slopes. Access to the study area is provided by a 40 to 50 minute helicopter trip out of Carmacks.

Previous work includes reconnaissance work by Cairnes (1916); 4 inches to 1 mile mapping by Bostock (1936) and Johnston (1963); and 1:250 000 scale mapping by Tempelman-Kluit (1984). Carlson (1987) and Payne et al. (1987) reported on the results of mapping of a total of five 1:50 000 scale map sheets in Dawson Range. Detailed studies of mineral deposits in Dawson Range include: Godwin (1975; 1976), on the Casino deposit; Pearson and Clark (1979) on the Minto (Williams Cr.) deposit; and McInnes et al. (1990) on the Laforma deposit

REGIONAL GEOLOGY

A Paleozoic and older metamorphic assemblage constitutes the oldest rocks in Dawson Range. This assemblage consists of penetratively deformed pericratonic quartzose clastic rocks, marble, meta-volcanic rocks, amphibolite, and orthogneiss (Mortensen, 1992; Wheeler and McFeely, 1991). Plutonic rocks of Minto Plutonic Suite, a part of Early Jurassic Klotassin Suite (Tempelman-Kluit, 1974; Woodsworth et al., 1991), and Middle Cretaceous granite of Dawson Range Batholith (Payne et al., 1987) intrude the metamorphic assemblage. Temporally associated with Dawson Range Batholith are volcanic rocks and sub-volcanic dykes and plugs of Middle Cretaceous Mount Nansen Group (Bostock, 1936; Tempelman-Kluit, 1978). These rocks are in turn overlain by volcanic and sedimentary rocks of Upper Cretaceous Carmacks Group (Bostock, 1936; Tempelman-Kluit, 1978). Carmacks Group is correlated with a set of subvolcanic epizonal intrusions (Fig. 1).

Dawson Range is host to a series of mineralized zones, including Klazan, Revenue, Mount Nansen, and Casino (a deposit with mine potential). Mineralization is related to porphyry systems and includes copper-molybdenum, gold, gold-silver and polymetallic veining, and magnetite-gold skarn (Carlson, 1987).

Factors controlling distribution of mineralization are poorly understood. Porphyry deposits are spatially associated with northwest-trending Big Creek Fault, paralleling and occurring southwest of the fault. However, the age of Big Creek Fault and the type of movement along the fault remain a matter of much conjecture (Tempelman-Kluit et al., 1991; Carlson, 1987;

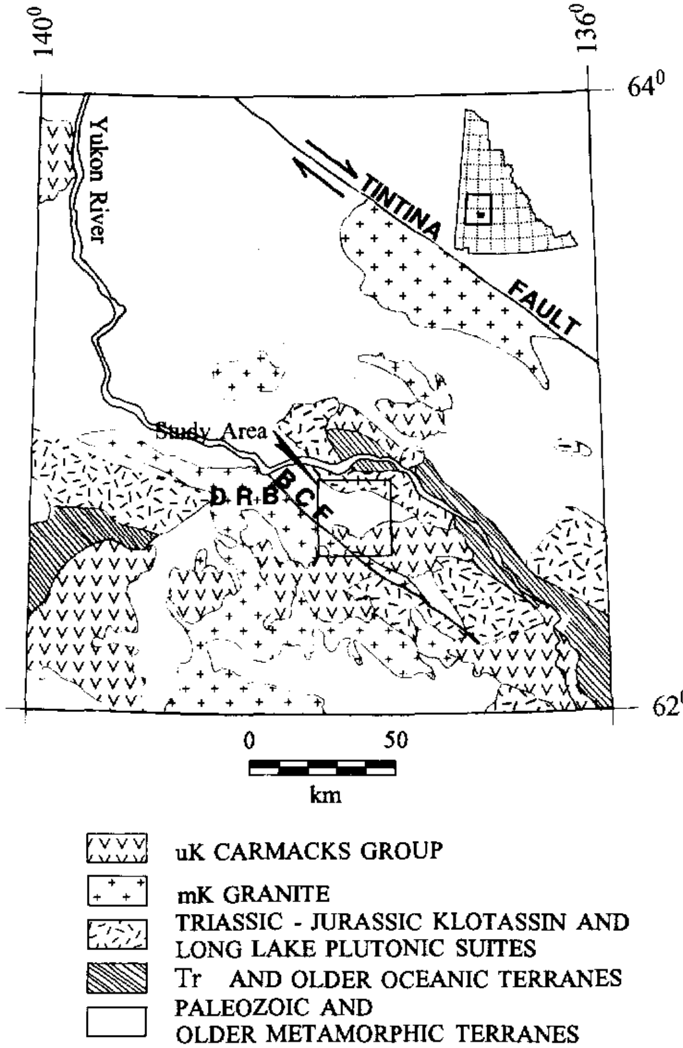

Figure 1. *Regional geology of central Yukon. Middle Cretaceous granitic rocks of Dawson Range Batholith (DRB) intrude Paleozoic and older metamorphic rocks and form the core of Dawson Range. Big Creek Fault (BCF) is indicated. Detailed geology of Wolverine Creek map area (study area) is shown in Fig. 2.*

Tempelman-Kluit, 1984). The timing of mineralization extends from about 123 Ma to about 70 Ma (Carlson, 1987; Godwin, 1975; 1976).

GEOLOGY OF THE WOLVERINE CREEK MAP AREA

Metamorphic assemblage

Rocks of the metamorphic assemblage crop out in the northern half and southwest corner of the study area (Fig. 2). Two principal units were recognized: 1) a heterogeneous quartzite unit (Pq); and 2) a heterogeneous orthogneiss unit (Po). Each of the units is divided into subunits.

Heterogeneous quartzite (Pq):

This unit consists largely of fine to medium grained micaceous quartzite, and subordinate micaschist, marble and calc-silicate, and amphibolite. Quartzite is black to tan, weathers brown, orange or grey, and consists of greater than 90% translucent quartz grains. Colour banding is common, consisting of alternating black and tan brown bands 1 to 3 cm wide, and is thought to represent primary compositional layering. The black colour is thought to reflect the presence of graphite. In one sample small (less than 3 mm) rounded quartz granules were observed along a surface parallel to the colour banding. Small amounts (1% to 10%) of fine grained biotite, muscovite, and feldspar are commonly present. Garnet is rare. Accessory minerals include apatite, zircon, monazite, epidote, allanite and unidentified opaque grains. Foliaform lenses of milky white quartz ranging from 1 cm to 3 m in length are common. In more pelitic rocks migmatite is locally developed and consists of cross-cutting quartzofeldspathic veins and foliaform lenses of aplite. Alteration products include chlorite (after biotite and garnet) and sericite (after feldspar).

Buff to brown weathering, grey, medium grained, feldspathic, muscovite biotite micaschist occurs as layers 1 m to 100 m thick and is most common in the southwest portion of the study area. The rock consists of up to 50% mica with lesser amounts of quartz and feldspar. Fine garnet porphyroblasts are locally present.

White, medium to coarse grained marble is rare and occurs as discontinuous lenses 1 m to 50 m thick and 10 m to 200 m in length. Marble weathers orange and consists of greater than 90% calcite. Other mineral constituents includes quartz, feldspar, phlogopite, diopside, epidote, and garnet. Pale green weathering, white to green, garnet diopside epidote calc-silicate with minor calcite occurs as lenses within marble and as isolated lenses enclosed in micaceous quartzite.

Green weathering, black to dark green, medium to coarse grained amphibolite occurs as continuous and discontinuous horizons, 1 cm to several tens of meters thick. Garnet and diopside are locally present. Additional components include biotite, feldspar, quartz, titanite, and epidote. Chloritic alteration of hornblende and biotite is common, as is sericitic alteration of feldspar. Amphibolite commonly occurs along contacts with orthogneiss (Po).

Heterogeneous Orthogneiss (Po):

Grey weathering, grey, medium to coarse grained, leucocratic, equigranular hornblende and biotite hornblende quartz diorite to granodiorite gneiss (Po_1) underlies 50% of the area mapped as orthogneiss. Mafic minerals comprise less than 20%, and commonly less than 10% of the rock. Hornblende is the dominant mafic mineral. Significant amounts of biotite is locally present and imparts a schistose texture to the rock. In one sample both biotite and muscovite were observed. Feldspar occurs as milky white subhedral grains; potassium feldspar locally occurs as pink megacrysts greater than 2 cm in length. Streaky grey quartz occurs interstitially to other grains. A migmatitic phase, consisting of micaceous and non-micaceous aplite, is commonly developed. The aplite occurs as cross-cutting and foliaform sills and lenses which are locally characterized by a mafic selvage along their margins. Accessory minerals include zircon, titanite, apatite, epidote, allanite and opaque grains. Partial replacement of biotite and hornblende by chlorite is common. Feldspars are commonly sericitized.

A fine to medium grained, orange to grey weathering, grey green to dark grey, biotite and biotite hornblende quartz diorite and diorite schist and gneiss (Po_2) comprises much of the rest of the orthogneiss unit. Mafic minerals commonly account for 50% of the rock. Hornblende is the dominant mafic silicate mineral, although

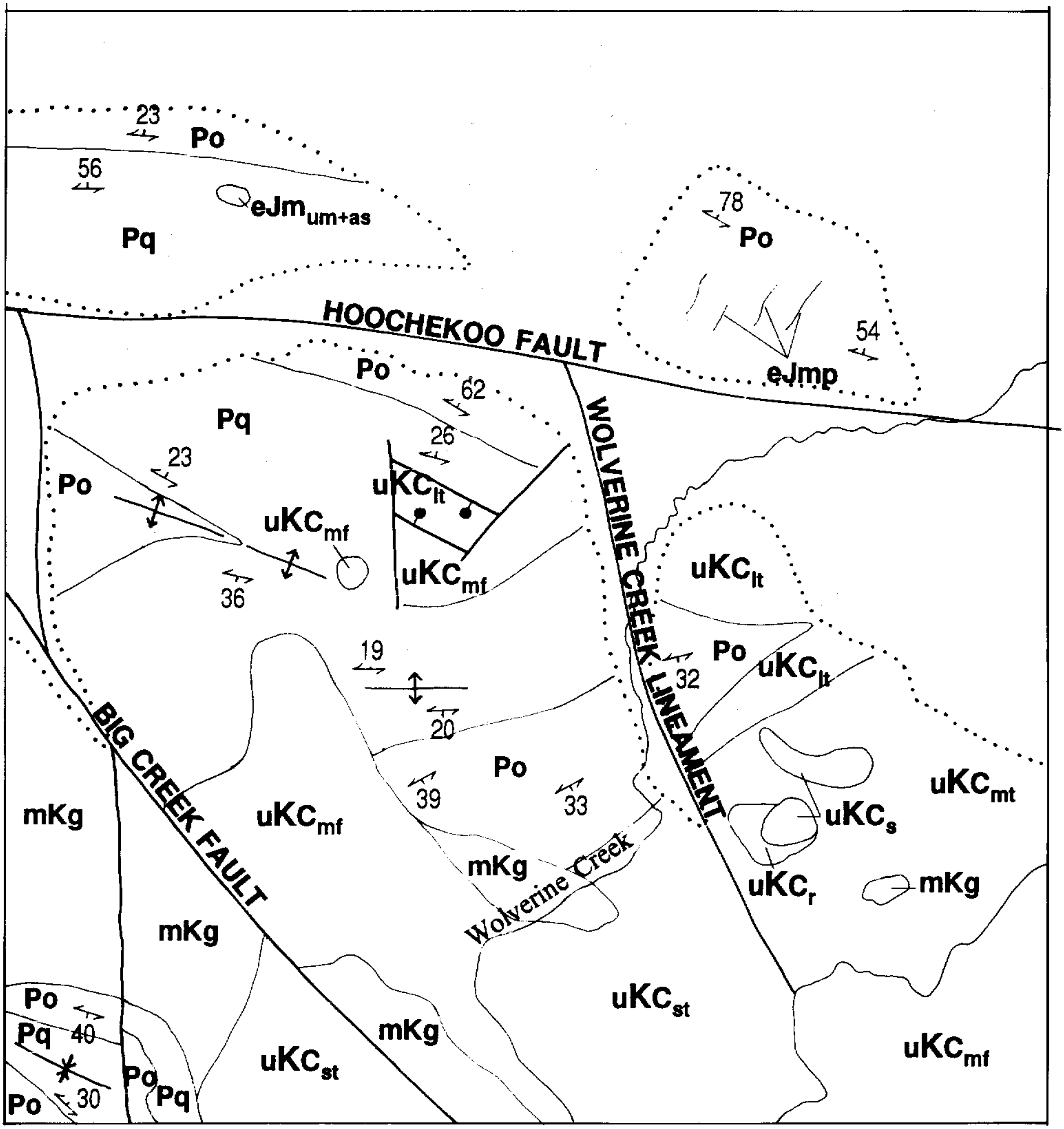

Figure 2. *Detailed geology of Wolverine Creek map area (study area). Dotted lines indicate the limit of mapping; contacts and major faults are indicated by light and heavy lines, respectively. Orientation data reflect the attitude of S_2. Units are defined in the text.*

biotite is commonly present. Feldspar occurs as anhedral grains interstitial to hornblende. Quartz is rare to absent. Thin (1 cm - 2 cm) concordant and discordant, discontinuous aplite veins are common and impart a migmatitic texture to the rock. Intimately interfoliated with this gneiss are 1 m to 25 m thick, discontinuous horizons of quartzite, garnetiferous micaschist, calc-silicate, and marble.

Gneiss subunit Po_2 is distinguished from gneiss Po_1 on the basis of: 1) finer grain size; 2) more mafic, less siliceous composition; 3) more schistose fabric; and 4) more heterogeneous texture. However, contacts between the Po_1 and Po_2 gneisses are gradational over large distances (greater than 100 m). 1 m to 100 m foliaform horizons of the Po_1 gneiss are present in the Po_2 gneiss, and vice versa. It is, therefore, often difficult to ascertain in which unit an individual exposure should be included.

Locally interfoliated with both types of orthogneiss, although more common in the Po_2 subunit, are 1 m to 100 m thick bands of medium to coarse grained, black weathering, dark green hornblende amphibolite similar to that described for the quartzite unit. The contacts between orthogneiss and amphibolite are sharp to gradational over a short (less than 10 cm) distance.

A light orange to light grey weathering, pink, leucocratic potassium feldspar augen orthogneiss is commonly present adjacent to the contact with the quartzite unit. Biotite is common but constitutes less than 3% of the rock. In one sample biotite and muscovite were observed. Quartz occurs as clear, elongate lenses up to 1 cm in length, and as streaky, milky white anhedral grains interstitial to feldspar. Anhedral to subhedral plagioclase grains are commonly characterized by a pistachio green colour, the result of epidote alteration. Potassium feldspar occurs as anhedral grains intimately intergrown with quartz and plagioclase, and as large (greater than 3 cm in length) pink, poikilitic megacrysts.

Protoliths and age of the metamorphic assemblage

Rocks of the quartzite unit are inferred to be metamorphosed pericratonic clastic rocks. This is consistent with the quartzose nature of the unit, the local preservation of rounded quartz pebbles, and the presence of metapelitic rocks. A pericratonic sedimentary origin is also suggested by the presence of thin marble horizons. Rocks of the orthogneiss unit are inferred to be metamorphosed igneous rocks, including both metavolcanic and metaplutonic varieties. The Po_2 subunit is thought to consist largely of metavolcanic rocks based on its heterogeneous, fine grained texture, and on the presence of interfoliated quartzose rocks and marble. The coarser grained Po_1 subunit is thought to consist largely of metaplutonic rocks based on its more homogeneous, coarser grained nature. Amphibolite occurs in both subunits and may represent metamorphosed mafic flows and dykes.

The metamorphic assemblage is thought to be mainly Devono-Mississippian based on correlation of the assemblage with the Middle Unit of Yukon-Tanana Terrane (Mortensen, 1992), and Nasina Assemblage of Nisling Terrane (Wheeler and McFeely, 1987). The Middle Unit of Yukon-Tanana Terrane is characterized by "carbonaceous phyllite, schist, and quartzite with rare marble and pebble conglomerate, all interlayered with abundant mafic and felsic metavolcanic rocks" (Mortensen, 1992). U-Pb zircon analyses yield Devono-Mississippian ages for the metavolcanic rocks (Mortensen, 1992). Nasina Assemblage is similarly comprised of carbonaceous sedimentary rocks, with rare marble and pebble conglomerate. Meta-plutonic and meta-volcanic rocks are present, and yield Mississippian U-Pb zircon ages (Mortensen, 1992).

Minto Plutonic Suite (eJm)

Hornblende granodiorite of Minto Plutonic Suite is thought to crop out along the northern margin of the study area (Tempelman-Kluit, 1984). This area was not, however, mapped this past summer. Three types of plutonic rocks of Minto Plutonic Suite were observed, including: 1) quartzo-feldspathic pegmatite (eJm_p); 2) spinel peridotite (eJm_{um}); and 3) alkalic syenite (eJm_{as}) (Fig. 2).

Quartzo-feldspathic pegmatite (eJmp)

Grey weathering, white and pink, massive pegmatitic dykes up to 3 m wide and continuous for tens of meters intrude orthogneiss of the metamorphic assemblage in the northeast Wolverine Creek map area. The dykes consist largely of megacrysts of pink potassium feldspar and white plagioclase feldspar with minor quartz and mica. The dykes cut across and post-date fabric in the orthogneiss, and are inferred to be part of Minto Plutonic Suite based on their proximity to the Minto Suite intrusion mapped by Tempelman-Kluit (1984).

Spinel peridotite (eJmum)

One exposure of dun brown weathering, dark green to black, spinel peridotite was observed. Subhedral grains of olivine are fresh and unaltered. Pyroxene grains occur interstitial to olivine. Up to 10% magnetite is locally present. Accessory minerals include ruby red chrome spinel (P. Erdmer, pers. comm., 1992). Spinel grains are mantled by a thin (0.1 mm) white weathering substance of uncertain mineralogy. A subtle planar fabric is commonly present and is defined by grain size and compositional layering. The rock is characterized by a set of microveins consisting of talc and serpentinite.

The exposure of ultramafic rock occurs in the northern part of the study area, is approximately 35 m in length and 20 m in width, and is surrounded on all sides by thick overburden; the nature of the contact with the surrounding metamorphic rocks could not be ascertained. Because the peridotite is characterized by fresh, unaltered olivine, and because no gneissosity or fabric development comparable with the fabric in the surrounding metamorphic assemblage was observed, the ultramafic body is interpreted as a post-tectonic intrusion. It is included in Minto Plutonic Suite because: 1) it is spatially associated with the Minto Suite intrusion mapped by Tempelman-Kluit (1984); and 2) similar post-tectonic ultramafic intrusions within the Klotassin Plutonic Suite (Woodsworth et al., 1991; J.K. Mortensen, pers. comm. 1992;), which has been correlated with the Minto Plutonic Suite (Carlson, 1987; Payne et al., 1987). Tempelman-Kluit (1974; 1984; and pers. comm. 1992) however, interpreted ultramafic rocks cropping out along the northeast margin of Dawson Range as tectonic slivers which mark the surface trace of a major fault.

Alkalic syenite (eJm_{as})

A light brown to orange weathering, blue-grey, equigranular, medium grained, leucocratic potassic syenite crops out in the immediate vicinity of the above described ultramafic intrusion. The rock consists largely of anhedral potassium feldspar grains with minor quartz. Secondary rock fabrics were not observed. The syenite was included in Minto Plutonic Suite based on its lack of fabric and its spatial association with ultramafic rock thought to be part of Minto Plutonic Suite.

The age of Minto Plutonic Suite

Minto Plutonic Suite is thought to be mainly Early Jurassic based on correlation of the suite with Klotassin Plutonic Suite (Carlson, 1987; Payne et al., 1987). U-Pb zircon ages for intrusions of Klotassin Suite cluster between 185 Ma and 192 Ma. Parts of the suite may, however, be as old as 212 Ma (Mortensen, 1992).

Dawson Range Batholith (mKg)

Granitic rocks of middle Cretaceous Dawson Range Batholith crop out as isolated exposures in the south-central and southwestern part of the study area (Fig. 2). These outcrops are regarded as inliers of an extensive plutonic body exposed by erosion of nonconformably overlying strata. The batholith is texturally heterogeneous, and consists of white to orange weathering, light grey to pink, fine to coarsely crystalline, leucocratic, biotite quartz monzonite, granite, feldspar quartz porphyry, and quartz porphyry. Biotite is rare, accounts for only 1% to 3% of the rock when present, and occurs as fine anhedral flakes to coarse grained booklets. Equal amounts of plagioclase and potassium feldspar occur as fine to coarse grained subhedral phenocrysts. Quartz occurs as milky anhedral clots interstitial to feldspar grains, as clear eyes up to 1 cm across, and as doubly terminating bipyramidal crystals. Pegmatite and aplite veins are common. Pegmatite veins are up to 1 m wide and consist of 1 cm to 20 cm long potassium feldspar grains with minor quartz, plagioclase, and mica. Aplite veins are similar to, but finer grained than, the granitic host rocks.

In one locality granitic rocks of the batholith host irregular siliceous breccia. The breccia consists of a cherty, aphanitic pink to orange matrix in which irregularly shaped but well rounded, aphanitic white to pink chert clasts are present. Clasts typically account for 40% to 80% of the breccia. Locally in the southwest corner of the map sheet granitic rocks of the batholith are altered and consist of rusty weathering, fissile quartz sericite and quartz chlorite schist.

Age of Dawson Batholith

Tempelman-Kluit (1984), based on numerous K-Ar age determinations, concluded that the batholith was largely mid-Cretaceous. This is consistent with K-Ar ages for the batholith in the vicinity of Casino which range from 99 Ma to 102 Ma (Godwin, 1975).

Carmacks Group (uKc)

Carmacks Group crops out across the southern two thirds of the study area (Fig. 2) and is divided into seven units: 1) a quartz pebble and cobble conglomerate (uKc_{pc}); 2) mafic lava flows (uKc_{mf}); 3) hornblende bearing crystal lithic tuff (uKc_{lt}); 4) mafic tuff (uKc_{mt}); 5) heterogeneous sandy tuff and volcanoglomerate (uKc_{st}); 6) a rhyolitic intrusive (uKc_{r}); and 7) monzo-syenitic intrusions (uKc_{s}) (Figs. 2 and 3).

Quartz pebble and cobble conglomerate (uKc_{pc})

Grey weathering, light grey to black, fissile, poorly cemented conglomerate varies from boulder conglomerate to coarse sand and is typically poorly sorted and clast supported. Thin and discontinuous recessive partings define a weak and irregular bedding. Clasts are angular to subrounded, elongate (non-spherical), range in size from 1 cm to 25 cm across and consist almost entirely of quartzite, black quartzite, micaceous quartzite and micaschist.

Conglomerate unconformably overlies older rocks of the metamorphic assemblage and is locally preserved beneath mafic flows at the base of Carmacks Group. Conglomerate and sandstone also occurs within mafic flows near the base of Carmacks Group (Fig. 3).

Mafic flows (uKc_{mf})

Vesicular to massive mafic lava flows weather dark orange brown to brown and grey, are dark green grey to blue grey, and are commonly porphyritic. Crude, sub vertical columnar jointing is common. Vesicular flows are rare, probably as a result of preferential weathering and erosion of vesicular flows. Vesicles locally constitute up to 50% of the rock and are commonly filled or partially filled with one or more of chlorite, calcite or quartz. Phenocrysts constitute 3% to 50% of the rock and include, in order of decreasing abundance, clinopyroxene, olivine, hornblende, glomeroporphyritic plagioclase, biotite, and potassium feldspar. Magnetite is ubiquitous and locally forms up to 5% of the rock. Phenocrysts occur in a groundmass consisting of feldspar with minor biotite, pyroxene and apatite. Mafic flows are commonly fresh and little altered. Alteration products include sericite after feldspar, chlorite after biotite, and iddingsite after olivine. Secondary calcite and chlorite are commonly present in the matrix. Where mafic flows immediately overlie basement they locally include pebble to boulder sized xenoliths of the underlying basement rocks.

Mafic flows occur throughout Carmacks Group. A thick (greater than 500 m) sequence of mafic flows occurs near the base of the sequence and overlies either the pre-Carmacks basement or Carmacks Group conglomerate. Another thick (at least 500 m) sequence of mafic flows forms the highest stratigraphic levels of Carmacks Group (Fig. 3).

Hornblende porphyritic crystal lithic tuff (uKc_{lt})

Dark blue-grey porphyritic crystal lithic tuff weathers pale grey to green grey, and is characterized by porphyritic acicular hornblende grains up to 2 cm in length. Porphyritic feldspar and pyroxene grains are rare. Feldspar grains are white, equidimensional, and less than 0.5 cm in length. Stubby black to green pyroxene grains are less than 0.5 cm in length. Where hornblende, feldspar, and pyroxene grains are present the rock has a crowded porphyry appearance. Crystals are commonly broken and angular. Locally the rock is conglomeratic, with rounded clasts of feldspar and hornblende bearing crystal lithic tuff up to 20 cm in width. Clasts and matrix consist of hornblende and feldspar hornblende porphyritic crystal lithic tuff.

The crystal lithic tuff is preserved in a graben-like structure in

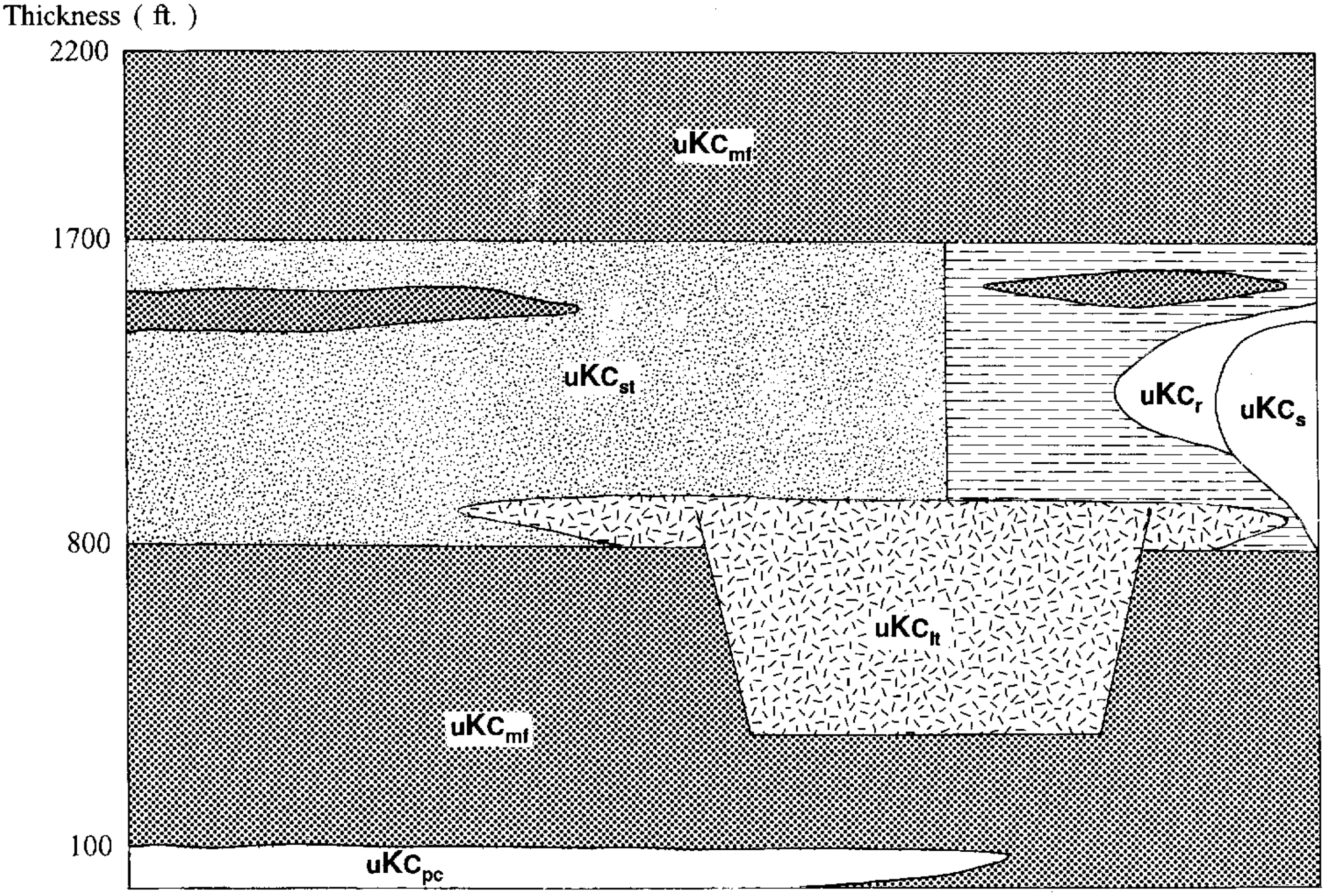

Figure 3 *Schematic stratigraphic section showing estimated thicknesses, and stratigraphic relationships for units of Carmacks Group in Wolverine Creek map area.*

the central part of the study area and appears to be faulted down against mafic flows that occupy the stratigraphically lowest part of Carmacks Group. Along the east side of the study area the crystal lithic tuff appears to underlie mafic tuff. The thickness of this unit is poorly controlled but is thought to be variable, and may be as much as 300 m (Fig. 3).

Mafic tuff (uKc_{mt})

Orange brown weathering, grey to dark blue grey mafic tuffs exhibit well developed bedding defined by fining and coarsening upward sequences 10 cm to 1 m thick, and by variations in colour. The tuffs consist largely of angular lapilli and finer grained aphanitic mafic rock fragments. Pyroxene phenocrysts locally account for up to 20% of the rock. Rarely mafic tuff grades into thin (1 cm thick) beds of light brown sandy tuff.

Mafic tuff is interbedded with mafic to intermediate (dacitic) flows, underlies much of the area around Mount Pitts and is thought to be about 500 m thick. Along the south margin of Mount Pitts, mafic tuff overlies a thin (50 m) sequence of mafic flows which directly overlie granitic basement. To the north of Mount Pitts mafic tuff overlies crystal lithic tuff. Mafic tuff is bounded on the west by a fault (Wolverine Creek lineament). Its stratigraphic relationship with heterogeneous sandy tuff present west of the fault remains unclear (Fig. 3).

Heterogeneous sandy tuff and volcanoglomerate (Ukc_{st})

Orange brown to pink weathering, tan to blue-grey to mauve, banded, vesicular and massive sandy tuff, welded tuff, volcanoglomerate, volcanic sandstone and red mudstone are included in this unit. Sandy tuff comprises more than 50% of the unit and is similar to and can be mistaken for a well sorted lithic sandstone. The sandy tuff grades into massive glassy flows, vesicular flows and laminated tuffs. Locally the tuffs are characterized by glassy laminae separated by 2 cm thick tuffaceous horizons. Interbedded with the tuffs are crystal lithic chert pebble volcanoglomerate, sandstone, and mudstone. Crystals include angular fragments of pyroxene and olivine (?). Black, grey and red chert occurs as well rounded clasts 1 cm to 5 cm across. Rounded clasts of maroon vesicular basalt up to 10 cm across were also observed. Sandstones are red, poorly sorted and are characterized by a bedding parallel fissility along which the rock breaks into 1 cm to 2 cm thick plates. Red weathering, massive mudstone, was observed at one locality.

The sandy tuff unit is thought to be greater than 500 m thick, is interbedded with and overlies mafic flows between Big Creek Fault and Wolverine Creek Lineament (Fig. 3), and is thought to directly overlie the pre-Carmacks basement southwest of Big Creek Fault.

Rhyolite intrusive (uKc_r)

Grey to black weathering, dark grey, aphanitic cherty rhyolite or dacite is characterized by flow banding. Flow bands are black to tan, 1 mm to 5 mm thick. In one locality, flow banding wraps around eye shaped lenses of aphanitic rhyolite clasts 5 cm to 10 cm in length. In one in situ outcrop, flow banding was vertical.

Rhyolite underlies a roughly circular area characterized by significant relief just west of Mount Pitts, and is at least 1000 m thick. Although contact relations with adjacent units could not be ascertained the rhyolite is interpreted as a plug that intrudes flows and tuffs of the mafic tuff unit (Figs. 2 and 3). This interpretation is based on: the presence of vertical flow banding; the roughly circular map pattern; and the significant thickness of rhyolite. However, apophyses of rhyolite were not observed intruding mafic tuff and it is conceivable that the rhyolite is a thick flow which has been locally preserved in a graben structure. This is consistent with the presence of thin rhyolite to dacite flows preserved elsewhere in the mafic tuff unit.

Monzo-syenitic intrusions (uKc_s)

Light pink grey weathering, varicoloured pink to green medium grained equigranular, leucocratic, pyroxene biotite monzo-syenite intrudes mafic tuffs and flows and rhyolite in the vicinity of Mount Pitts. Biotite forms less than 10% of the rock, and commonly less than 5%. Trace amounts of altered pyroxene are commonly present. Subhedral grains of plagioclase and poikilitic potassium feldspar constitute the bulk of the rock; quartz rarely forms more than 5% of the rock. Accessory minerals include unidentified opaque grains, apatite, titanite, and zircon. Alteration products include iddingsite (after pyroxene); chlorite (after biotite) and sericite – calcite (after feldspar).

Monzo-syenite is exposed as two circular inliers which probably represent the exposed upper parts of a single intrusion (Figs. 2 and 3). Dykes and apophyses of monzo-syenite are common in adjacent wall rocks. These granitoids are regarded as epizonal plutonic roots of Carmacks Group which intruded previously erupted Carmacks Group volcanic rocks.

The age of Carmacks Group

The type area of Carmacks Group as defined by Bostock (1936) is located in the study area. The group is considered to be Upper Cretaceous, based on K-Ar age determinations which range from 84 Ma to 68 Ma (Hart et al., 1993). This is consistent with a K-Ar biotite age determination for the monzo-syenite on Mount Pitts of about 72 Ma (Tempelman-Kluit, 1984).

STRUCTURE

Metamorphic assemblage

Planar elements

Rocks of the metamorphic assemblage are characterized by a planar fabric element (S_1) defined by compositional banding, schistosity, and gneissosity, in hand sample-, outcrop-, and map-scale. In quartzose rocks compositional banding is expressed as parallel grey, tan brown, and black bands up to 2 cm thick. In one sample quartz pebbles defined a horizon which parallels color banding. Recessive partings parallel and enhance color banding. Pelitic, marble, and amphibolite horizons 1 m to 100 m thick define compositional bands which are grossly parallel to compositional banding observed in hand sample and at outcrop-scale. In orthogneiss compositional banding consists of alternating quartzo-feldspathic bands with relatively mafic horizons on the cm to km scale. Quartzose rocks and marble also define compositional bands tens of meters thick.

Parallel with compositional banding is a schistosity and a gneissosity. In quartzose rocks aligned mica grains define a schistosity. A spaced cleavage, along which micaceous quartzite breaks into slabs, corresponds with micaceous laminae. In quartzite, lenses of milky white, remobilized quartz define lenses which lie along and enhance the S_1 fabric. In more pelitic rocks, aplitic migmatite, consisting of discontinuous foliaform lenses, imparts a gneissic character to the schist. In orthogneiss alignment of hornblende, mica and feldspar grains define a schistose fabric. Elongation and shearing of quartz and feldspar has produced a gneissic character. Migmatite, similar to that described for pelitic rocks, further enhances the gneissic character of the orthogneiss.

A second planar fabric (S_2) is recognized. However, S_2 is identical in most respects to S_1 and can only be distinguished from S_1 where fold hinges affecting S_1 are present and where S_2 occurs at an angle to and truncates S_1 (Plate 1). Locally S_2 is characterized by back-rotated amphibolite boudins bound by discrete north-dipping extensional shears consistent with top-to-the-north shearing (Plate 2). S_2 is the dominant fabric element in the study area; orientation measurements reflect the attitude of S_2. S_2 dips homoclinally to the north north of the Wolverine – Selkirk drainage. South of this drainage S_2 strikes east-west and dips moderately to the north and south (Fig. 2).

A third planar fabric (S_3) is restricted to pelitic rocks and consists of a weakly developed crenulation schistosity. The crenulation schistosity overprints and post-dates S_2, strikes irregulary, and is generally vertical to sub-vertical.

Folds

Deformation of S_1 has produced tight to isoclinal, recumbent to moderately inclined, horizontal to gently plunging folds (F_2). Symmetric and asymmetric folds were observed. The axial surfaces of F_2 folds parallel the S_2 fabric in the enclosing rock. S_2 is deformed. In schistose rocks open kink and box folds (F_3) with amplitudes and wavelengths of less than 10 cm are locally developed. F_3 axial surfaces parallel the S_3 crenulation schistosity. Map scale folding of S_2 is indicated by variation in the dip of S_2 (Fig. 2). Map scale folds plunge gently to the east. It remains unclear whether F_3 kink folds observed in hand sample and outcrop are parasitic structures related to the map-scale folds.

Linear elements

In quartzose rocks a linear element (L_2) is commonly evident and is defined by streaking and rodding of quartz. Locally L_2 is defined by rootless isoclinal fold hinges. A streaky fabric, thought to reflect extended and sheared quartz, parallels the rodding lineation. In orthogneiss and amphibolite L_2 is defined by alignment of mineral grains including hornblende and plagioclase. Tails on sheared feldspar augen and, in quartzo-feldspathic horizons, a streaky shear fabric, parallels the mineral lineation. Locally L_2 is

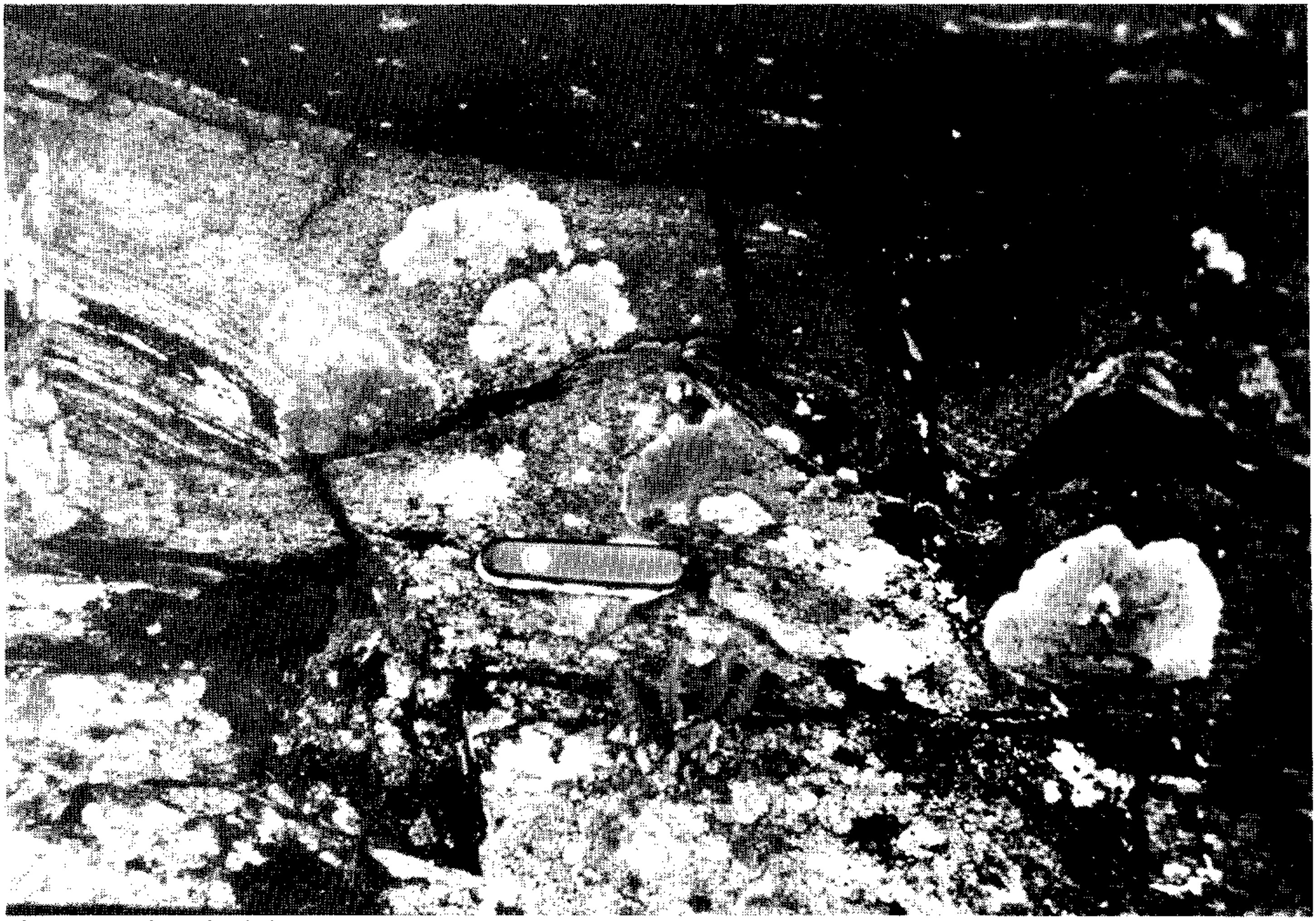

Plate 1. *A photo taken looking to the east of orthogneiss of the metamorphic assemblage (Po). Back-rotated amphibolite boudins are bound by gently north-dipping extensional shears, indicating top-to-the-north shearing.*

defined by tight to isoclinal folds affecting compositional banding. L_2 trends to the north in the northern part of the study area and to the northeast to east throughout the remainder of the map area.

An additional linear element (L_3) is restricted to pelitic horizons. L_3 parallels the hinges of F_3 folds, and lies within the S_3 crenulation schistosity.

Timing relationships

Fabric elements attributable to D_1 (S_1) and D_2 (S_2, F_2, and L_2) tectonic events are cut by massive quartzo-feldspathic pegmatite (eJm_p), and intruded by undeformed peridotite (eJm_{um}), and alkalic syenite (eJm_{as}). These post-tectonic intrusions are included in Minto Plutonic Suite, restricting tectonism to pre-Early Jurassic. The age of fabric elements attributable to D_3 (S_3, F_3, and L_3) is poorly constrained. It remains unclear whether map-scale folding is attributable to the D_3 event. Dawson Range Batholith is not regionally deformed suggesting that D_3 is pre-mid-Cretaceous. However, D_3 structures are only evident in pelitic rocks. It is, therefore, unlikely that it would have had any significant affect on the massive granitic rocks which constitute Dawson Batholith. D_3 is restricted to pre-Upper Cretaceous by undeformed rocks of Carmacks Group which unconformably overlie folded rocks of the metamorphic assemblage.

Brittle structures

Three major faults, Big Creek Fault (Tempelman-Kluit, 1984), Hoochekoo Fault (Tempelman-Kluit, 1984; Payne et al., 1987), and Wolverine Creek Lineament, are recognized in the study area (Fig. 2). In addition, there are a number of related smaller faults. The faults are defined on the basis of: truncation of aeromagnetic domains; topography (Big Creek and Hoochekoo faults occupy major valleys); juxtapositon of different structural levels of the basement metamorphic assemblage; brittle shearing of granitic rocks of Dawson Range Batholith; the attitude of volcanic flows of Carmacks Group; and by the juxtaposition of different rock types in Carmacks Group. The Wolverine Creek Lineament occupies the the Wolverine Creek drainage and forms a distinct linear feature evident on air photos.

Timing relationships

Brittle faults affect rocks of Dawson Range Batholith and are therefore younger than mid-Cretaceous. No shearing of Carmacks Group rocks was observed. However, faults appear to control the distribution of rock types in Carmacks Group. In addition, Carmacks Group flows on either side of Big Creek Fault dip moderately away from the fault. Mafic flows of Carmacks Group in the southern part of the map sheet overlie and truncate the

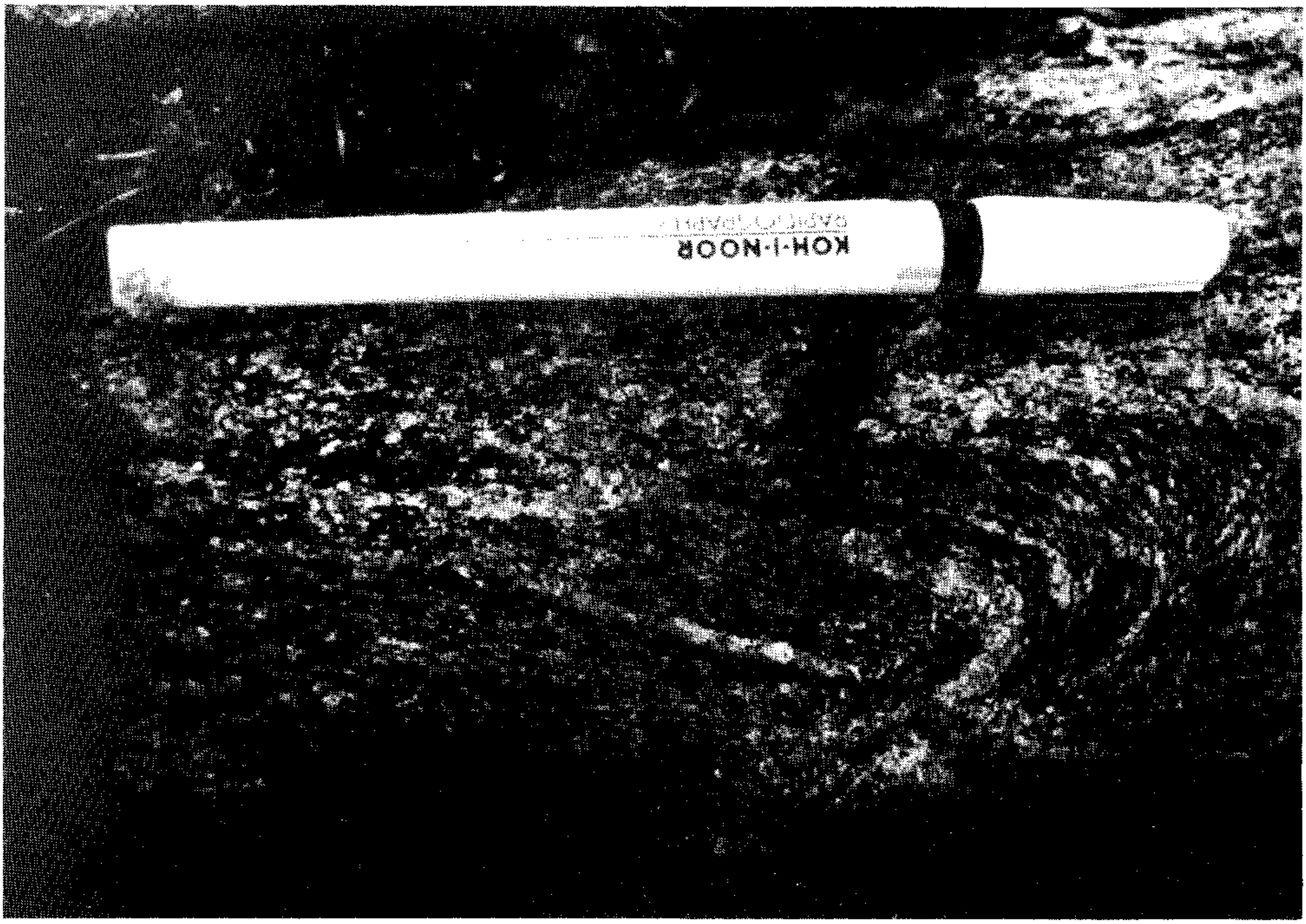

Plate 2. *A planar fabric (S_1), defined by gneissic banding and by mineral alignment, in mafic orthogneiss was deformed into a tight fold (F_2). The upper limb of the fold is truncated (just beneath pen) by feldspathic gneiss. The feldspathic gneiss is characterized by a planar fabric (S_2) (parallel with pen), defined by gneissic banding and mineral alignment. S_2 parallels the axial surface of the fold affecting S_1.*

Wolverine Creek Lineament. Elsewhere the Wolverine Creek Lineament separates different units of Carmacks Group (Figs. 2 and 3). These relationships suggest that faulting was syn-depositional with Carmacks Group.

METAMORPHISM

Regional metamorphism

Regional metamorphism of the metamorphic assemblage is indicated by the occurrence of biotite, muscovite, and garnet in pelitic rocks. In orthogneiss, metamorphism is indicated by the occurrence of biotite and hornblende. Marble and calc-silicate is characterized by diopside, garnet, and epidote. Quartz and feldspar has been recrystallized in all these rocks. Migmatite occurs in pelitic rocks and orthogneiss. The grade of metamorphism is difficult to determine because the metamorphic assemblage lacks diagnostic aluminosilicate indicator minerals. The occurrence of migmatite, and the developement of amphibolite in mafic horizons, is consistent with metamorphism at lower to middle amphibolite facies. Previous workers (Payne et al., 1987; Carlson, 1987) have suggested that rocks northeast of Big Creek Fault are higher grade than rocks southwest of the fault. However, we saw no evidence to suggest that rocks on either side of the fault are of different metamorphic grade.

Metamorphism was synkinematic. Mica parallel the axial surfaces of F_2 folds. Recrystallized feldspar and hornblende define a mineral lineation that parallels a stretching lineation defined by sheared quartz and feldspar (L_2).

Contact Metamorphism

In one locality where orthogneiss of the metamorphic assemblage is in contact with quartz monzonite of Dawson Range Batholith, significant alteration of the orthogneiss had occurred. Orthogneiss adjacent to the intrusion weathers rusty red. Primary fabrics are locally obliterated by abundant porphyroblasts of magnetite, rusty limonite (after magnetite), and garnet. Skarning is restricted to a 400 m-wide zone of country rock adjacent to the margin of the intrusion. Mafic flows of Carmacks Group that overlie the contact are not altered or skarned.

MINERALIZATION

Mineralization is associated with magmatic rocks of Minto Plutonic Suite, Dawson Range Batholith, and Carmacks Group. Rocks of the metamorphic assemblage in the vicinity of the ultramafic and alkalic syenite Minto Suite intrusions are characterized by up to 10% disseminated pyrite. Mineralization (Au, Ag, Pb, Cu, and Mo) of Dawson Range Batholith has been identified in the central part of the map area (the Rand, Pitts, and Panther properties), where it is associated with skarning of wall rocks, and in the vicinity of Hayes Creek (the Noranda ECL, Delta, Chat, and Tad properties). Significant amounts of drilling and trenching has been completed in both areas. Mineralization consists of metalliferous vein stockworks which are largely confined to the batholith. Mineralization is associated with brecciation. Cross-cutting breccia veins that cut both the granite and adjacent wall rocks of the metamorphic assemblage contain sulphides including galena. Sediments along a creek adjacent to the Hayes Creek mineralized zone has been mined for placer gold. In Carmacks Group, felsic cherty tuff horizons commonly host disseminated sulphides, quartz-calcite-sulphide veins, and malachite staining. On Mount Pitts, tuffs and flows adjacent to monzo-syenite intrusions contain disseminated sulphides and quartz-ankerite veins.

SUMMARY AND CONCLUSIONS

1. The oldest rocks in the area constitute a metamorphic assemblage which is divided into a meta-sedimentary quartzite unit and a meta-volcanic and meta-plutonic orthogneiss unit. The assemblage is correlated with the Devono-Mississippian Middle Unit of Yukon-Tanana Terrane, and Nasina Assemblage of Nisling Terrane. The assemblage was regionally deformed and metamorphosed at least twice prior to the Early Jurassic.

2. Early Jurassic intrusions of Minto Plutonic Suite include: 1) quartzo-feldspathic pegmtite dykes; 2) spinel peridotite; and 3) alkalic syenite. The ultramafic and syenite intrusions are spatially associated and may represent phases of one intrusion. Wall rocks adjacent to the ultramafic and syenitic intrusions are characterized by disseminated sulphide minerals.

3. Middle Cretaceous quartz monzonite of Dawson Range batholith intrudes the metamorphic assemblage. Intrusion has locally resulted in magnetite-garnet skarning. Mineralization is associated with vein stockworks and with siliceous breccia hosted by the granitic rocks.

4. A heterogeneous assemblage of tuff and lava constitutes Upper Cretaceous Carmacks Group. Two intrusive phases, including a rhyolite plug and a monzo-syenite intrusion, are considered cogenetic with the Carmacks. Major faults, including Big Creek Fault, Wolverine Creek Lineament, and probably Hoochekoo fault, were active during the deposition of Carmacks Group. Mineralization is associated with the monzo-syenite intrusions and the felsic cherty tuff.

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Brian Parsons of Trans North Air provided safe helicopter support throughout the summer. Philippe Erdmer and Craig Hart are thanked for field visits. Microprobe analysis of spinel from peridotite of Minto Suite was conducted by Philippe Erdmer. Interpretation of data presented here benefited from discussions with the staff of the Canada-Yukon Geoscience Office, and with Dirk Tempelman-Kluit, Philippe Erdmer, and Jim Mortensen. Derek Thorkelson is thanked for assisting in thin-section studies and reviewing the paper. Craig Hart is thanked for educating us about Carmacks Group. Drafting assistance was provided by Will van Randen.

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GEOLOGICAL OVERVIEW OF CLEAR CREEK MAP AREA (NTS 115P/14), WESTERN SELWYN BASIN

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ABSTRACT

Clear Creek map area of central Yukon is underlain by deformed and metamorphosed Proterozoic and Paleozoic rocks of western Selwyn Basin (Hyland Group, unnamed carbonate unit, Road River and Earn groups) and mid-Cretaceous felsic intrusions. Metasedimentary rocks are disposed in a warped northwest- to northeast-dipping structural panel with younger, structurally shallow rocks in the north and older, structurally deeper rocks in the south. Younger rocks in the north are deformed into Lost Horses syncline, a southwest-overturned tight to isoclinal syncline with an axial surface trace extending across the northern part of the area. Older rocks at deeper structural levels in the south are deformed by a suite of fabric elements that probably post-date Lost Horses syncline, indicate a top-to-the-northwest sense of tectonic transport, and are probably related to Early Cretaceous displacement on the Tombstone thrust. Subsequent deformation warped the panel into its current orientation. All structures are intruded by mid-Cretaceous felsic intrusions including hornblende-biotite (rare muscovite) granite, quartz monzonite, granodiorite, syenite, and quartz syenite. Mineral occurrences are mainly precious metal, tin, and/or tungsten bearing vein, skarn, and breccias associated with felsic intrusions. Bedded barite occurs in Earn Group strata. New analyses of mineralized samples confirm earlier data reporting significant gold values in veins cutting felsic intrusions and nearby country rock, and correlation of anomalous gold with anomalous bismuth in some veins.

INTRODUCTION

Three 1:50 000 scale map areas in the McQuesten River 1:250 000 scale map area have been selected for detailed study during the 1992-1996 term of the Canada/Yukon Economic Development Agreement (NTS 115P/14, 15, 16). Clear Creek (115P/14), the first of these map areas, was completed during two months of field work in the summer of 1992. This report summarizes the results of the 1992 field season and is meant to accompany a 1:50 000 scale geological map (Murphy et al., 1993).

Clear Creek map area lies approximately half way between Mayo and Dawson City (Fig. 1). Much of the southern part of the area is accessible along a summer-use gravel road branching east off the Klondike Highway near Barlow Lake, approximately 70 km north of Stewart Crossing. Built to serve the numerous historical and currently operating placer mines along Clear Creek and tributaries, the Clear Creek trunk road provides access to both forks of Clear Creek. Numerous side roads allow truck access to different parts of the southern part of the map area (Figs. 1 and 2). Access to the area north of the Little South Klondike River was by helicopter, either from Dawson City or Mayo.

The area lies within the Stewart Plateau physiographic subdivision (Matthews, 1986). It is generally characterized by low to moderate elevations (2000 to over 6000 feet above sea level), moderate local relief, and little area above treeline (4000 to 5000 feet above sea level). Rock exposure is generally poor with little outcrop continuity except along ridgetops above treeline and along the edges of some valley bottoms, notably along the Little South Klondike River. Contiguous areas of relatively good exposure are along the West Ridge in the eastern part of the area and in the Syenite Range north of the Little South Klondike River (Fig. 2). The area was glaciated and remnants of glacial deposits are locally preserved (Bostock, 1964; Morison, 1983a,b; 1985).

The area has been explored for minerals since the 1885 discovery of fine gold in bars of the Stewart River below the mouth of the McQuesten River (Bostock, 1964). Placer gold (Clear Creek and tributaries; Josephine Creek) and locally, placer tungsten, have been the major interest in the area; Bostock (1964) reports that lode exploration was stimulated by the discovery of the rich silver-lead veins at Keno Hill in 1919. In the 1970's and 1980's, the area was explored for tin and tungsten especially around known mid-Cretaceous felsic intrusives. Most recently, the target has been low-grade, bulk tonnage gold deposits like Fort Knox near Fairbanks, Alaska.

Previous work

The bedrock geology of the Clear Creek area was first systematically mapped in the late 1940's during a Geological Survey of Canada 1:250 000 scale regional mapping program (Bostock, 1964). An interpretation of the geology of the area based on Bostock's (1964) geology was presented by Wheeler and McFeely (1991). Abercrombie (1990) investigated the ZETA (Yukon Minfile #115P 47) silver-tin greisen veins, the petrology, isotopic characteristics, and age of the Lost Horses syenite. Emond (1992) and Emond and Lynch (1992) investigated the igneous geochemistry, petrography and evaluated the relationship of igneous geochemistry to mineralization for felsic intrusions in McQuesten River map area, including several in Clear Creek map area. Morison

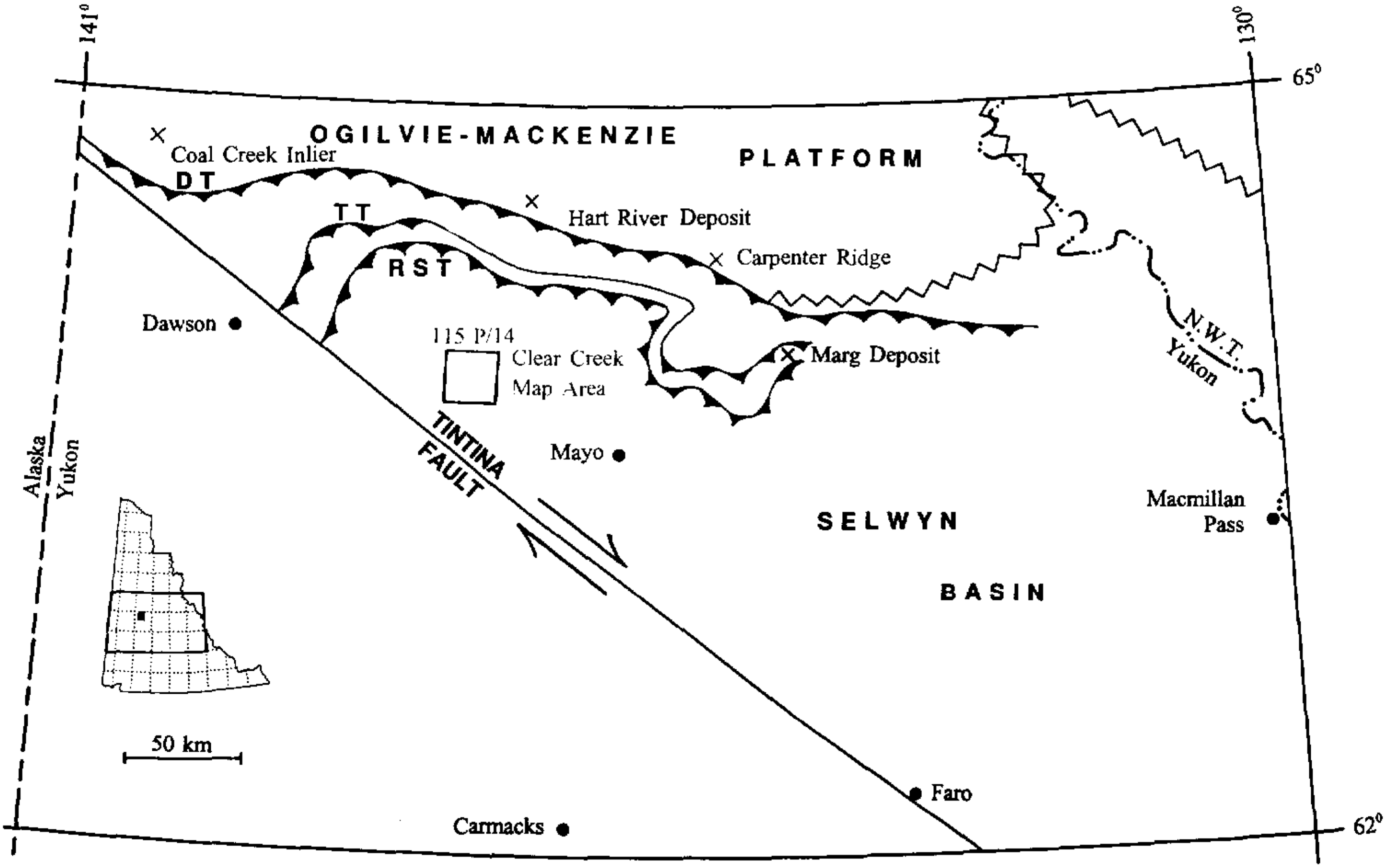

Figure 1. *Location of Clear Creek map area with respect to important geological and geographic features (modified from Abbott, this volume). Wavy line is Lower Paleozoic platform to basin transition.*

(1983a,b; 1985) mapped and described the surficial geology and sediments in the Clear Creek drainage basin.

REGIONAL GEOLOGICAL FRAMEWORK

Rocks of Clear Creek map area form part of western Selwyn Basin, a locus of Late Proterozoic and Middle Paleozoic basinal clastic sedimentation which lay between coeval inner miogeoclinal sedimentary rocks of the MacKenzie/Ogilvie Platform to the north, and east and 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 attributed to 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 involved in a Jura-Cretaceous thrust system made up of the Robert Service and Tombstone thrust sheets (Tempelman-Kluit, 1970; Abbott, 1990 and references therein; Mortensen and Thompson, 1990; Fig. 1). Underlying and defining one of the largest sheets in the Canadian Cordillera, the Robert Service thrust extends eastward from the Dawson area through the Keno Hill district into the western part of Lansing map area. It typically juxtaposes Upper Proterozoic Hyland Group against Mississippian Keno Hill 'quartzite' and carries most of the rocks assigned to Selwyn Basin. The underlying Tombstone thrust sheet comprises the Proterozoic and Palezoic Selwyn Basin rocks and, locally, Mesozoic clastic rocks, lying in the footwall of the Robert Service thrust (Abbott, 1990 and references therein). It juxtaposes these rocks against an immediate footwall ranging in age from Devonian(?) to Late Jurassic (Poulton and Tempelman-Kluit, 1982; Abbott, 1990 and references therein).

GEOLOGY OF CLEAR CREEK AREA

Clear Creek map area is underlain primarily by variably deformed and metamorphosed low- to very low-grade metasedimentary rocks of Proterozoic and Paleozoic age. These are intruded by unfoliated mid-Cretaceous felsic intrusive rocks that are primarily granite or quartz monzonite in composition but include syenite, quartz syenite, and granodiorite (Bostock, 1964; Wheeler and McFeely, 1991; Emond, 1992; Emond and Lynch, 1992).

Metasedimentary rocks

Five metasedimentary rock units were identified in the area (Figs. 2): Hyland Group (undifferentiated), a carbonate unit of unknown age, two units correlated with Road River Group, and Earn Group. The stratigraphic thicknesses of the various units are not known; structural thicknesses are illustrated in cross-section (Fig. 3). The ages of these units in Clear Creek map area are not known. Macrofossils were not observed and both the state of strain and metamorphic grade of rocks in the area likely preclude microfossil preservation.

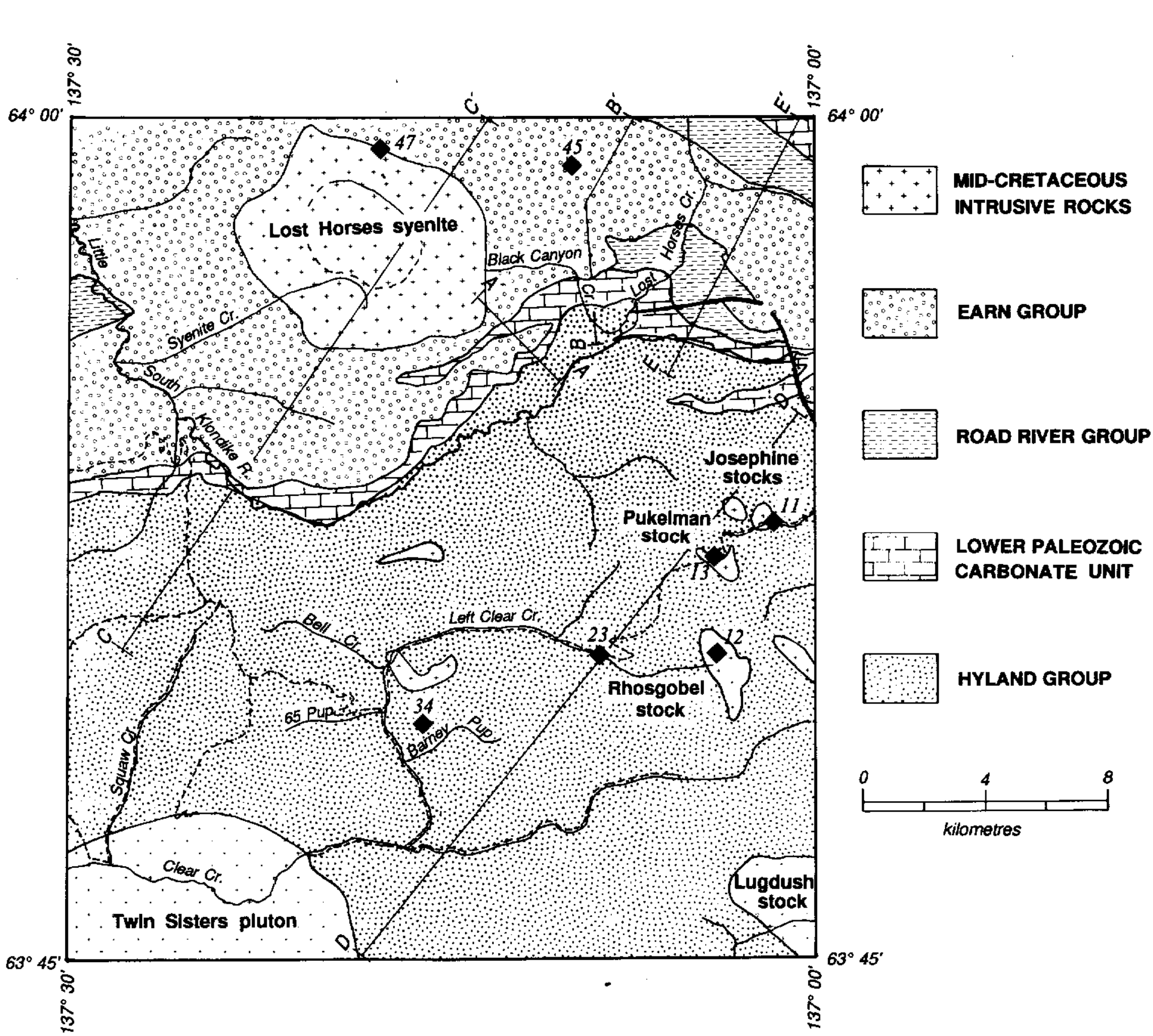

Figure 2. Geology of Clear Creek map area. Lines of cross-sections A-E shown in Fig. 3 are indicated. Dashed lines are summer roads. Numbered diamonds are selected mineral occurrences as enumerated in Yukon Minfile.

Hyland Group

Underlying most of the southern part of Clear Creek map area, Hyland Group (Gordey, in press; informally known as "grit unit") consists of metamorphosed and deformed coarse- to fine-grained clastic rocks. Good exposures of Hyland Group occur along the Clear Creek trunk road in the western part of the map area and in the West Ridge area (Fig. 2).

Hyland Group is composed primarily of prominently foliated and lineated quartzofeldspathic and micaceous psammite (metamorphosed sandstone) and muscovite-chlorite phyllite. Less common, but locally important, are gritty or pebbly psammite (metamorphosed coarse grained or pebbly sandstone), metamorphosed pebble conglomerate, marble, and calcsilicate rocks. The amounts of psammite and phyllite vary throughout the area but due to structural and possibly stratigraphic complexity, subdivision of Hyland Group is not yet possible at the current scale of mapping. Sedimentary structures (including bedding) in Hyland Group are rarely preserved but graded bedding and channel scours where observed generally indicate an upright stratigraphy. Hyland Group rocks in Clear Creek map area are uniformly characterized by the presence of fine-grained white mica (muscovite) and chlorite indicative of the lower greenschist facies of regional metamorphism. Near mid-Cretaceous intrusions, Hyland Group rocks are metamorphosed to cherty reddish to dark maroon biotite hornfels. Biotite, andalusite, sillimanite, cordierite, staurolite, and chloritoid occur within the thermal aureoles.

Foliated and lineated plagioclase-quartz-chlorite rock occurs locally in Hyland Group. These have yet to be observed in outcrop, occurring as rubbly piles in felsenmeer. These rocks are interpreted as metamorphosed felsic to intermediate igneous rocks. It is not clear if these rocks were originally volcanic or plutonic. A sample was submitted for U-Pb geochronometry.

The base of Hyland Group is not exposed. In Mayo map area, Hyland Group is thrust over Keno Hill 'quartzite' along the Robert Service thrust (Tempelman-Kluit, 1970; Green, 1972; Roots and Murphy, 1992a,b; Murphy and Roots, 1992). The thrust underlies Hyland Group of McQuesten River map area, either directly, or indirectly beneath rocks older than Hyland Group.

The upper part of Hyland Group and its contact with the overlying carbonate unit is exposed north of West Ridge. There, mixed psammite and phyllite grade upward into grey and green siltstone-laminated phyllite with metre-scale composite beds of pebbly psammite and meta-conglomerate. Non-calcareous phyllite grades upward into medium grey calcareous phyllite of the overlying carbonate unit.

The age of Hyland Group of the Nahanni region is Early Cambrian and older (Gordey, in press). There are no new data from Clear Creek area to better constrain its age.

Carbonate Unit

Overlying Hyland Group with apparently conformable contact and extending from east to west across the map area is a laterally persistent carbonate unit composed of calcareous (locally dolomitic) phyllite, thin- to medium-bedded marble, and rare limestone-pebble conglomerate. Near felsic intrusions, this unit is metamorphosed to cherty calcsilicate hornfels. All rock types are well foliated, with the intensity of foliation and lineation development diminishing upsection to the north from its base. It is best exposed in cliff sections along the Little South Klondike River.

The age of the carbonate unit is unknown. The unit is broadly similar to published descriptions of the Cambro-Ordovician Kechika Group or equivalent Rabbitkettle Formation (Abbott et al., 1991 and references therein), but other correlations, such as with a carbonate unit of Hyland Group (Gordey, in press), cannot be ruled out.

Road River Group

The carbonate unit is overlain with apparently conformable contact in the eastern and western parts of the map area by a distinctive sequence of rocks that is correlated with the Ordovician to Devonian Road River Group. Road River Group comprises two units, a generally recessive basal grey to black shale/phyllite, cherty shale/phyllite and chert unit, and an upper locally limy or dolomitic siltstone, shale/phyllite and sandstone unit. The upper siltstone unit weathers a distinctive beige-orange colour, is generally massive to well-laminated and displays rare ripple cross-lamination.

Most or all of this sequence is absent in the central part of the map area where the carbonate unit is overlain directly by rocks that more closely resemble Earn Group (see below). Road River Group is best exposed between Lost Horses Creek and the eastern edge of the map area. The upper part (beige-orange siltstone, see below) is also well exposed along the Little South Klondike River northwest of the confluence with Syenite Creek.

The age of the Road River Group in Clear Creek area is not known. Regionally, the lower chert/shale unit is Early Ordovician to Silurian. Calcareous or dolomitic siltstone similar to the upper unit found along the southwestern margin of Selwyn Basin adjacent to Pelly-Cassiar Platform is Silurian to Early Devonian (Abbott et al., 1991 and references therein).

Earn Group

Dark shale/phyllite, siltstone, sandstone, and chert-pebble conglomerate correlated with the Devonian to Early Mississippian Earn Group underlies most of the northern part of the area. Shale/phyllite is the dominant rock type; less common coarser clastic rocks form prominent strike ridges and cuestas. The best exposure of the Earn Group is between Lost Horses Creek and the eastern edge of the map area (Fig. 2).

Earn Group overlies Road River Group in the eastern and western parts of the map area and the carbonate unit in the central part. This relationship suggests that the base of the Earn Group is an unconformity along which Road River Group is locally removed.

Igneous rocks

Felsic intrusive rocks underlie much of the northern and southern parts of the map area and occur in bodies ranging in size from metre-scale dykes to stocks several km2 in area. They are primarily granitic to quartz monzonitic in composition (e.g. Lugdush, Twin Sisters, Rhosgobel, Pukelman) although the largest body, the Lost Horses syenite, is concentrically zoned from a quartz syenite core to a syenite rim. Melanocratic variants of these bodies occur but are less common and less volumetrically significant. Fine- to coarse-grained generally porphyritic dykes spanning a similar range of compositions are widespread in the area but are only common around the larger bodies. Emond (1992) investigated the petrology and geochemistry of the felsic plutons in the northern McQuesten River area, including several bodies in the Clear Creek area.

K-Ar (biotite) dates on felsic intrusions from the McQuesten River region range from 83-108 Ma (Emond, 1992; Stevens et al. 1982). U-Pb dating to more precisely constrain the ages of the bodies in the Clear Creek area is underway.

Structural geology

Metasedimentary rocks in Clear Creek map area are disposed in a warped northwestwardly to northeastwardly dipping structural panel defined by bedding, foliations, and axial surfaces of folds. Older, structurally deeper rocks lie in the southern part of the map area and younger rocks generally appear towards the north (Fig. 3). This trend reverses at the axial surface trace of the Lost Horses syncline in the northernmost part of the map area. Progressively older rocks reappear north of this axial surface trace (Figs. 2, 3).

The outcrop pattern is a result of at least three phases of regional deformation, which vary in intensity across the area. The earliest recognized phase of deformation is displayed by the younger rocks at the northern end of the map area. Second phase structures are found only in rocks older and structurally deeper than the siltstone unit of the Road River Group. Later phase(s) of deformation is(are) manifest by the overall northward dip of the structural panel and its warping from a northwestward to northeastward strike and variable shallow to moderate dips. The earliest two phases predate the emplacement of mid-Cretaceous intrusions; the relationship of plutonism to late warping is not clear.

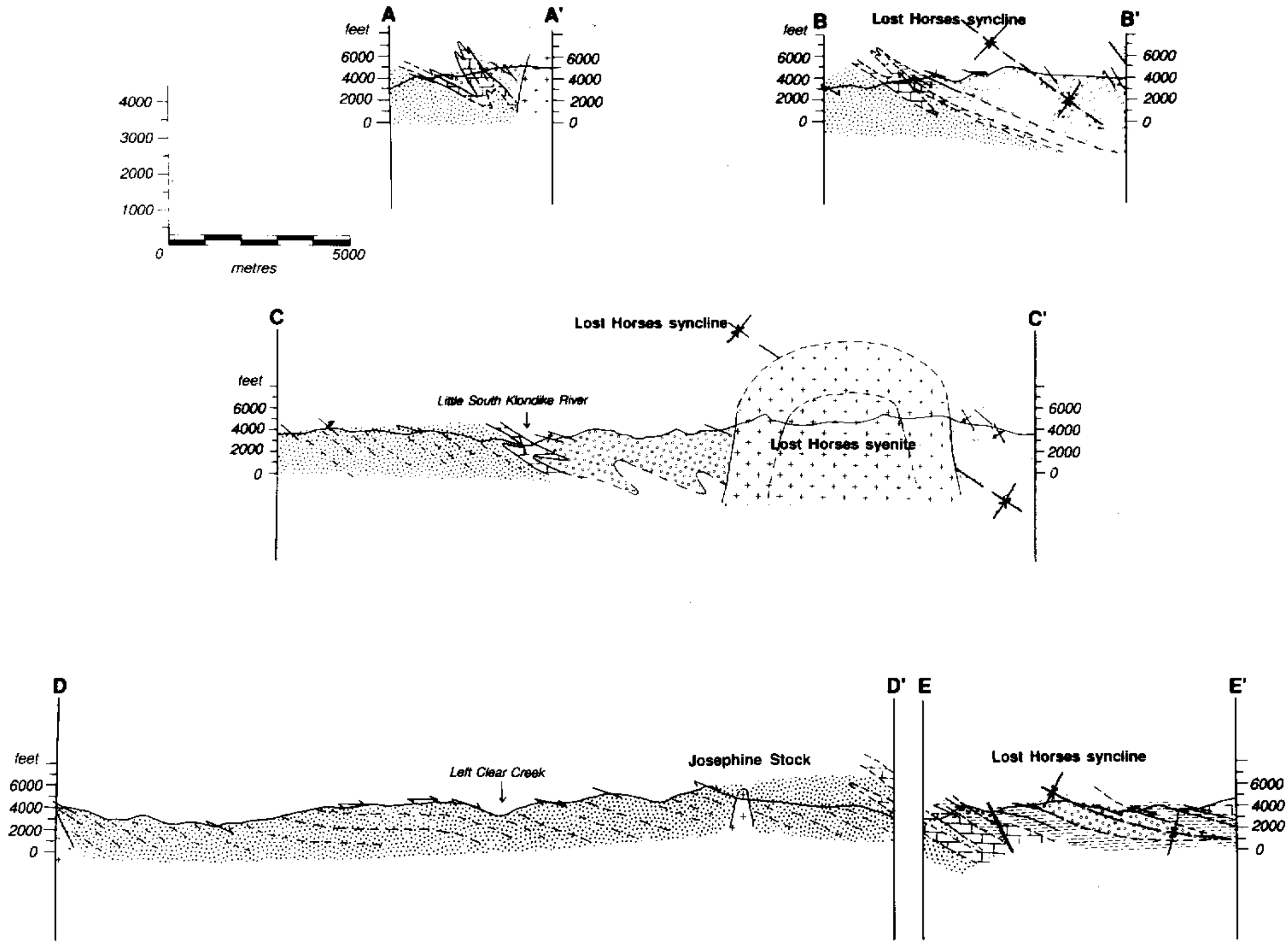

Figure 3. Cross-sections of parts of Clear Creek map area. Ornamentation as in Figure 2. Lines of section are indicated in Figure 2.

Earliest phase of deformation, D_1

The Lost Horses syncline (Figs. 2, 3) is the largest structure formed during D_1 deformation. It is an isoclinal southwest-overturned syncline outlined by the mirror-image repetition of the Paleozoic sequence and the congruent change in vergence of parasitic folds and cleavage-bedding relationships. North of the axial surface trace, stratigraphic sequence and facing criteria indicate that the sequence is inverted; parasitic folds and cleavage-bedding relationships on this limb verge to the northeast. The southwest-vergent anticline-syncline pair outlined by the stratigraphically upright carbonate unit southeast of the Lost Horses syenite is a second-order structure parasitic on the lower limb of the Lost Horses syncline (Fig. 3). The carbonate unit and units of the Road River Group do not close in Clear Creek map area; however, Bostock's (1964) mapping suggests that these units close to the east in NTS 115P/15.

Second phase of deformation, D_2

Below the siltstone unit of the Road River Group, D_1 southwest-vergent folds and fabric elements are less obvious or aren't present and a geometrically and kinematically distinct suite of shear zone fabrics occurs. These planar and linear fabric elements progressively become more intense at deeper structural levels.

Two planar and one linear D_2 fabric elements can be seen at most outcrops of lower Road River Group, the carbonate unit, and Hyland Group. S_p is a prominent, primarily northeast- to northwest-dipping foliation defined most clearly by the parallel orientation of fine-grained micas and less clearly by the shape fabric of strained clastic grains in psammite. S_p' is a set of discretely spaced northwest, southwest or west-dipping planes across which S_p is sigmoidally deflected in a systematic down-to-the-northwest manner. Sp' is discontinuous, passing asymptotically both up- and down-dip into S_p. L_p, a prominent northwest-trending elongation, quartz fibre, and mineral-streaking lineation, is contained within both S_p and S_p'.

At the shallow structural levels near the top of Hyland Group, bedding and Sp are generally inclined to each other with northeast-vergence. S_p is axial-planar to tight, outcrop-scale, generally northeast-vergent folds of bedding. At deeper structural levels to the south, bedding is more difficult to recognize: S_p is generally parallel to a compositional layering defined by variations in mica content. Commonly at this level compositional layering and S_p are deformed into tight to isoclinal northwest-vergent folds with an axial planar foliation morphologically identical to S_p. Compositional layering at these levels is commonly extended into asymmetrical sigmoidal boudins by displacement along down-to-the-northwest S_p' planes. L_p occurs at all structural levels, commonly associated with a suite of tension cracks oriented sub-perpendicular to it.

These observations suggest that compositional layering at the deeper structural levels and S_p are both transposition fabrics that evolved in a shear zone. S_p' planes are morphologically identical to shear bands or extensional crenulation cleavages. The relationship of L_p to boudinage, tension cracks, and shear bands suggests that it is parallel to the direction of finite extension and it is therefore likely to closely approximate the sense of displacement across the shear zone. The sense of inclination of S_p' to S_p and L_p is constant, indicating top-to-the-northwest displacement parallel to L_p. This sense of displacement is further supported by the sense of truncation of L_p fibres on S_p, the vergence of asymmetric isoclinal folds of compositional layering, the sense of subtle obliquity of tension cracks to L_p, the geometry of rare sigmoidal tension gash arrays, and difference in style of deformation of differently oriented pre-and syn-kinematic veins.

Mappable second-phase folds are rare; the northeast-vergent folds of the contact between Hyland Group and the carbonate unit inferred near the confluence of Lost Horses Creek and the Little South Klondike River are second-phase structures. These folds are inferred to fold the axial surfaces of the first-phase anticline-syncline pair southeast of Lost Horses syenite.

Later phases of deformation, D_2+

All first- and second-phase planar structures are tilted into a warped generally northerly dipping panel. Two directions of warping are indicated: the strike of all planar elements changes from east-west to northeast-southwest to northwest-southeast across the map area from west to east. Secondly, the general northerly dip changes from moderate in the north to shallow in the central part to moderate in the south.

Regional structural considerations

The sequence of structures identified in the Clear Creek area is similar to that found elsewhere in the Canadian Cordillera. Abbott (1990) and Roots and Murphy (1992a) described a suite of structures and fabrics from the Keno Hill area that resemble and probably correlate with second-phase structures and fabrics from the Clear Creek area. The regional distribution of these fabrics suggests that they are related to displacement on the Tombstone thrust (Abbott, 1990). The Tombstone thrust is probably Early Cretaceous in age based on the Late Jurassic age of the youngest rocks in the footwall of the thrust (Poulton and Templemen-Kluit, 1982) and the late Early Cretaceous age of cross-cutting plutons. The area around Keno Hill also displays warps of Tombstone-age fabrics similar to those of the Clear Creek area (Murphy and Roots, 1992). The mid-Cretaceous (M.L. Bevier, pers. comm., 1992) Roop Lakes batholith intrudes the axial surface of the Mayo Lake antiform constraining it to be pre-mid-Cretaceous in age.

Southwest-vergent structures of early Middle Jurassic age have been described from the Omineca Crystalline Belt in British Columbia (Murphy, 1989; Ricketts et al., in press; Murphy et al., in press;). As the age of the southwest-vergent structures in the Clear Creek area is unknown, correlation of these structures with the early Middle Jurassic structures found elsewhere in the Canadian Cordillera would be premature.

Mineral Occurrences

Clear Creek map area hosts several known mineral occurrences (Fig. 2). Most of these are associated with the suite of mid-Cretaceous felsic intrusions, including precious metal veins and stockworks (of note, RHOSGOBEL Yukon Minfile #115P 12, PUKELMAN #115P 13, ZETA #115P 47) and tin and/or tungsten skarns, veins, and breccias (RHOSGOBEL, BARNEY #115P 34). Earn Group strata host barite occurrences (OMEGA #115P 45 and ZETA #115P 47).

Mineral exploration in western Selwyn Basin has focused most recently on low-grade, bulk tonnage gold deposits similar to the Fort Knox deposit near Fairbanks, Alaska (Hollister, 1991). The Fort Knox deposit is hosted by porphyritic mid-Cretaceous hornblende-biotite granite and granodiorite and characterized by gold-bearing quartz stockworks, quartz-feldspar veins, and shears. Pervasive alteration is absent except where vein density is high. Gold is associated with bismuth, molybdenum, and tungsten (Bakke, A., oral communication, 1992).

Several factors make the Clear Creek area prospective for Fort Knox-type deposits. Placer gold occurs in streams draining watersheds underlain by porphyritic mid-Cretaceous granitic rocks some associated with precious metal, tin, and tungsten skarn, breccia, and vein occurrence. Gold is generally correlated with bismuth (Emond and Lynch, 1992). Geochemical analyses of samples collected during the 1992 field season: 1) confirm anomalous gold values on the PUKELMAN occurrence, 2) confirm earlier assessment reports indicating that similar potential for gold mineralization exists at the neighbouring RHOSGOBEL occurrence, and 3) further substantiate the general correlation of elevated gold with bismuth identified by Emond and Lynch (1992), especially for quartz veins on the RHOSGOBEL occurrence (Appendix 1).

Veins, breccia zones, and felsic porphyry dykes are commonly coplanar and breccia zones and felsic dykes are commonly spatially related. Although there is some scatter in vein orientations, steeply dipping, ESE-WNW striking orientations predominate.

Significant gold values in veins at the head of Clear Creek provides evidence for a local source of some of the placer gold in Clear Creek. Fine and coarse gold of varying fineness is present in the creeks, however (N. Harper, pers. comm., 1992), suggesting multiple sources and that some may be derived from the weathering of glacial deposits (S. Morison, pers. comm., 1992).

CONCLUSIONS

1. Clear Creek map area is underlain by multiply deformed and metamorphosed Upper Proterozoic and Lower to Middle Paleozoic sedimentary rocks.

2. Metasedimentary rocks are disposed in a generally northward-dipping structural panel resulting from at least three phases of deformation. First-phase deformation is found at the shallow structural levels at the northern end of the map area. Second-phase deformation, probably Early Cretaceous in age, first appears in the lower part of the Paleozoic stratigraphy and increases in intensity to the deeper structural levels progressively exposed in

the southern parts of the area. The latter phase(s) of deformation are open warps of the earlier structures.

3. All structures are intruded by undeformed mid-Cretaceous felsic intrusions ranging is size from metre-scale dykes to stocks.

4. Tin, tungsten and/or precious metal-bearing skarns, veins, and breccias are associated with mid-Cretaceous intrusions. Barite occurs in Earn Group rocks at the northern end of the map area.

5. Geochemical analyses confirm earlier studies identifying the potential for Fort Knox-style gold mineralization at granite-hosted or related occurrences. In particular, samples of quartz-tourmaline and quartz veins from the PUKELMAN and RHOSGOBEL occurrences are elevated in gold and bismuth.

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Appendix 1. Selected geochemical analyses and sample descriptions (Au by fire assay; others by ICP, all by iPL, Vancouver, BC)

JOSEPHINE

Sample number	Au ppb	Ag ppm	Sn ppm	W ppm	Zn ppm	Pb ppm	Cu ppm	As ppm	Bi ppm	Mo ppm	Sb ppm	Sample description
92DH-007a	98	0.1	11	40	60	8	20	95	<	2	10	chalco.-bearing qz vein in diorite
92DH-007b	250	0.4	10	211	65	5	22	245	<	6	7	pyrite, fluorite bearing qz vein in diorite
92DH-016	110	1.3	<10	12	5	7	14	225	<	2	68	brecciated psammite with banded arsenopyrite-silica-limonite cement
92DM-035	159	0.4	<10	11	12	9	2	521	<	1	6	breccia with pyrite-bearing silica cement
92DM-037b	5040	0.7	<10	0.1%	1	9	5	8.1%	392	9	58	arsenopyrite-bearing quartz vein

PUKELMAN

Sample number	Au ppb	Ag ppm	Sn ppm	W ppm	Zn ppm	Pb ppm	Cu ppm	As ppm	Bi ppm	Mo ppm	Sb ppm	Sample description
92DH-146	150	0.4	<10	165	37	11	10	3466	<	4	5	float of thin quartz veins cutting intrusive
92DH-149	148	0.2	10	24	42	6	6	390	<	5	<	as above
92DH-150	351	0.2	<10	6	37	7	6	466	<	4	<	as above (float)
92DH-151	960	0.3	<10	32	37	8	6	1291	<	5	<	as above
92DH-152	106	0.2	<10	707	52	<	13	71	<	1	<	float of thin quartz vein in biotite-rich metasedimary hornfels

RHOSGOBEL

Sample number	Au ppb	Ag ppm	Sn ppm	W ppm	Zn ppm	Pb ppm	Cu ppm	As ppm	Bi ppm	Mo ppm	Sb ppm	Sample description
92DH-154	2330	5.8	<10	55	1	10	3	5	66	1	7	bull quartz with thin tourmaline stringers (float in trench)
92DH-158	2330	0.4	<10	0.2%	25	11	13	53	26	10	<	2 cm-sized quartz vein in slightly altered intrusive
92DH-164	7200	0.5	<10	185	10	7	17	32	155	8	<	locally rusty bull quartz with tourmaline stringers (float in trench)
92DH-165	15000	1.4	<10	91	2	5	9	10	318	42	7	rusty quartz (float in trench)

NATURE OF THE ROBERT SERVICE THRUST ON FORK PLATEAU AND IMPLICATIONS FOR MINERAL EXPLORATION, MAYO MAP AREA

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ROOTS, C.F., 1993. Nature of the Robert Service thrust on Fork Plateau and implications for mineral exploration, Mayo map area. In: Yukon Exploration and Geology 1992; Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 71-76

ABSTRACT

Revision geological mapping has shown that the Robert Service thrust is imbricated and isoclinally folded in Mayo map area. On Fork Plateau, highly deformed Keno Hill quartzite and meta-diorite that occur above the hanging wall Hyland Group are inferred to be antiformal windows resulting from folding of the fault surface. The occurrence of vuggy meta-diorite on Fork Plateau, geochemically anomalous headwater creeks and placer mining downstream, indicates that the Fork Plateau may warrant further exploration.

INTRODUCTION

Mayo map area was one of the first to be systematically mapped at reconnaissance scale by the GSC (Bostock, 1947) because of the importance of the Ag-Pb-Zn deposits at Keno Hill. Since the compilation of this map, more recent mapping in this and surrounding regions has necessitated an update and the GSC began revision mapping in 1989. The progress of fieldwork is reported in Roots (1991), Roots and Murphy (1992a) as well as interim geological maps (Murphy and Roots, 1992; Roots and Murphy, 1992b).

Fieldwork in 1992 included reconnaissance mapping in the Moose Lake area (Fig. 1) and in the thermally metamorphosed rocks surrounding the McArthur pluton (94 +/- 1 Ma, U-Pb zircon; M.L. Bevier, pers. comm., 1992). These results will be described in a map of the southern Mayo map area (Roots, in prep.). Traverses were also made in the Mount Haldane region, the results of which are being compiled with previous work in a new 1:50 000 – scale map. (Hunt et al, in prep.). This report presents a third highlight of the 1992 field season: Fork Plateau was mapped with particular attention to the nature of the Robert Service thrust, which passes through the hinge of the Mayo Lake antiform.

REGIONAL FRAMEWORK

Mayo map area, at the northern edge of the Selwyn Basin, comprises portions of two regional thrust sheets (Fig. 1). The more northerly Tombstone thrust sheet includes a mid-Paleozoic to Upper Triassic succession characterized by a pronounced foliation and lineation (Abbott, 1990a; Murphy and Roots, 1992a). The Tombstone thrust lies in lowlands at the northern edge of the map area, where it is recognized by the abrupt juxtaposition of the highly strained (hanging wall) with the low-strain footwall (Abbott, 1990a,b). The southern two-thirds of Mayo map area is part of the Robert Service thrust sheet. In it, uppermost Proterozoic to Cambrian gritty schists, correlated with the Hyland Group (Gordey, in press), are successively overlain by dark clastic strata of Road River and Earn groups (Roots and Murphy, 1992a). These rocks are folded and faulted in the south, but generally weakly strained; to the north however they gradually become more strained at deeper structural levels. Where examined in detail, the Robert Service thrust is seen to be folded or imbricated by the kinds of structures that persist to the base of the Tombstone sheet (Abbott, 1990; Murphy and Roots, 1992; Roots and Murphy, 1992a). Post-kinematic (about 100 Ma) granitic stocks intrude both thrust sheets.

ROBERT SERVICE THRUST

The Robert Service thrust (Tempelman-Kluit, 1970) was defined near the Dempster Highway (200 km west of Mayo) where gritty sediments of the Hyland Group (Latest Proterozoic and Cambrian) are clearly thrust over the Keno Hill quartzite[1] (Mississippian age, Mortensen and Thompson, 1991). North of Dawson the thrust is a sharp, planar, south-dipping contact. In northern Mayo map area the Robert Service thrust is difficult to distinguish. Where Hyland Group overlies Keno Hill quartzite, the rocks are pervasively foliated, and the boundary is not a single planar discrete surface, nor is a single fault obvious in underground workings that cross the transition (M. Phillips, pers. comm., 1992). Green (1971) interpreted the variety of rocks structurally above the Keno Hill quartzite as latest Proterozoic or Cambrian and proposed a thrust fault. Murphy and Roots (1992) re-interpreted this complex package (Unit 1 of Green, 1971) as a structurally imbricated (isoclinally folded and/or faulted) succession of rocks derived from both the footwall Keno Hill quartzite as well as hanging wall Hyland Group. Deformation of the Robert Service thrust was inferred by Roots and Murphy (1992a) to have occurred during displacement on the underlying Tombstone thrust. Fabrics associated with Tombstone thrust overprint the Robert Service thrust sheet as far south as the Stewart River – Nogold Creek valley.

1 Keno Hill quartzite is not a formally defined unit, although it is widely used and well described (Boyle, 1965; Tempelman-Kluit, 1970). Parentheses normally used for informal units are here omitted for clarity.

FORK PLATEAU[2]

Fork Plateau is a remnant of a Tertiary peneplain rising steeply 1100 m above Mayo Lake on its north and south sides. The rolling upland (1800 m elevation) was unglaciated and consequently is deeply weathered with extensive felsenmeer. The sides were scrubbed by glaciers into valleys now occupied by the two arms of Mayo Lake, and in north-facing cirques. Both Bostock's (1947) and Green's (1971) map of Fork Plateau mark the upper contact of the Keno Hill quartzite along the top of the north-facing cliffs. Figure 2 shows the distribution of rock units and a cross section of Fork Plateau.

LITHOLOGY

Brown weathering schist, phyllite (Unit PCh)

Quartzose mica schist, ranging widely in muscovite and quartz content, and interfoliated with sparse chlorite and muscovite phyllite, occurs along the north rim of the plateau and on the south side, where the foliation is nearly parallel to the slope. All schists are fine-grained and recrystallization has obliterated primary sedimentary features, except in the thick-bedded, quartz-rich rocks. Many schists have a streaky appearance, suggesting that quartz domains were stretched along the dominant southeast-dipping lineation (Fig 3). Along the north rim are some exposures of shear domains several centimetres wide separated by darker, anastomosing shear planes. Rocks on the south slope contain quartz veinlets and quartz segregations deformed in isoclinal and rootless folds.

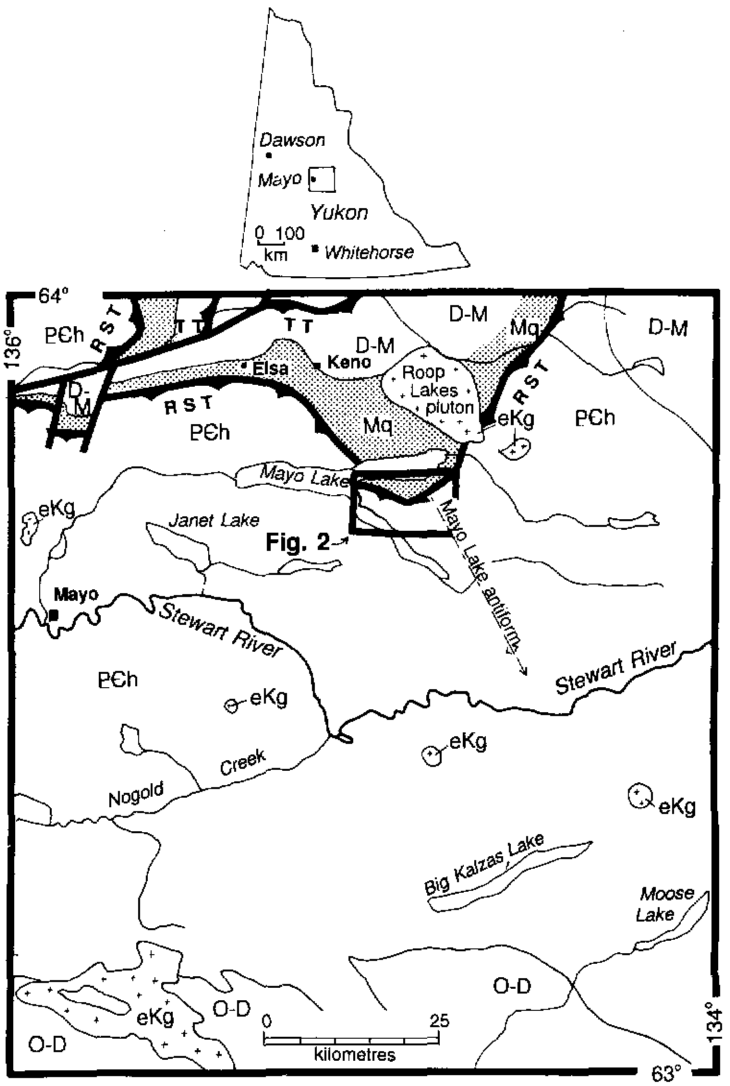

Figure 1. *Generalized geological map of Mayo map area (105M) from Roots and Murphy (1992a), showing location of the study area in the fork of Mayo Lake. PCh: Hyland Group; O-D: Road River and Earn groups in southern part of the area; D-M: undiferentiated Devono-Mississippian strata conformably below Keno Hill quartzite; Mq: Keno Hill quartzite; eKg: early Cretaceous granitic rocks and felsic intrusions.*

Most phyllitic rocks contain muscovite, although chloritic phyllite bands occur west of the headwaters of Edmonton Creek. Pyrite and carbonaceous layers 10 cm - thick are commonly associated with phyllite.

At locality B (Fig. 2) is a 50 metre thickness of powdery schist containing a convoluted carbonaceous seam, several centimeters thick. Such powdery rocks are described by Green (1971, p. 27) as 'crush breccias' that were inferred to have resulted from the brittle deformation of phyllite between layers of quartz grains.

Carbonate rocks

Pale brown weathering, grey recrystallized limestone crops out on the west side of Ledge Creek (Fig. 2, locality C). It exhibits mesoscopic isoclinal folds with axial surfaces parallel to southeast-dipping foliation and some hinges parallel to the regional southeast plunging mineral lineation. This isolated exposure is similar to pods of carbonate that are scattered throughout the Hyland Group.

Near the west end of the north rim of Fork Plateau, a 2 m-wide bed of dolomitic intraformational conglomerate lies within the brown schist (Fig. 2, locality D). Its most striking feature is the complete lack of penetrative fabric. Cross-bedding, rip-up clasts and lag deposits of flat pebbles of dololutite are clearly visible on weathered surfaces (Fig. 4). The dolostone bed can be traced about 50 m. Similar dolomitic oncolite-bearing rocks were observed west of Mount Hinton in approximately the same structural position relative to the Robert Service thrust. (D. Murphy, pers. comm, 1992).

Black phyllitic quartzite (Unit Mq)

This unit underlies most of the north side of Fork Plateau. It also occurs on the crest of Fork Plateau, topographically above Unit PCh, and as prominent knobs on the south slope. Outcrops on steep slopes are cliffs; those on hilltops are rubble, but all have a smooth, slate-blue weathering cast, or are obscured by lichen (diagnostic is the bright yellow and black Rhizocarpon geographicum, which uniquely grows on quartz-rich, Ca-poor rocks). Rubble of very clean, cream-coloured quartzite occurs at Locality E (Fig. 2), in association with black phyllitic quartzite and metadiorite.

Most of the quartzite is laminated and in the north facing cliffs is thickly layered. The occurrences on top of the Plateau, however, are streaked with quartz segregations elongated to the prominent southeast-plunging lineation (Fig. 5).

The prominent quartzite in the north-facing cliffs is an extension of the belt of Keno Hill quartzite trending southeast from

2 The plateau names are unofficial but shown on geological maps, including Bostock (1947) and Green (1971).

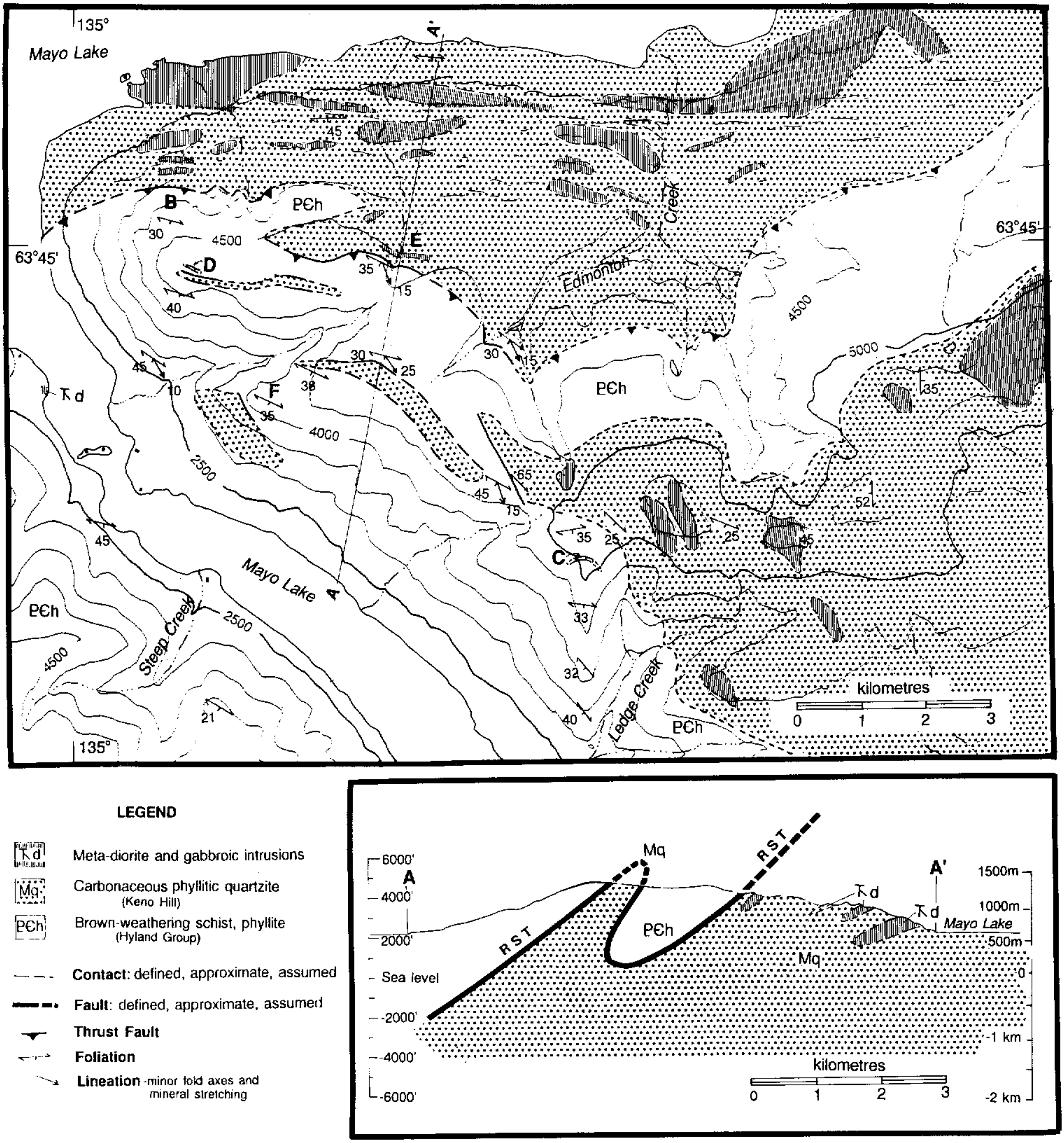

Figure 2. Generalized geological map and cross section of Fork Plateau (north side modified from Green (1971).

Keno Hill. The belt across the top of Fork Plateau is more carbonaceous and more intensely foliated and lineated than typical Keno Hill quartzite, but its grain-size uniformity and purity are higher than any Hyland Group rock.

Meta-diorite and gabbro intrusions (Unit Td)

The "greenstone" of the Keno Hill mining camp is present on the north side of Fork Plateau typically exposed in cliff bands. It occurs as large rubble mounds atop the plateau. A single outcrop occurs on the south shore of Mayo Lake. At the west end of Fork Plateau, it is massive, with chloritized hornblende phenocrysts 8 mm-long and 3 mm-wide. On the crest near the east end of the plateau it is similar, with common veins and blebs of quartz and calcite, locally with large bladed crystals.

The mafic intrusive rocks in all these places lack pervasive foliation. Some appear to have been broadly folded, and the

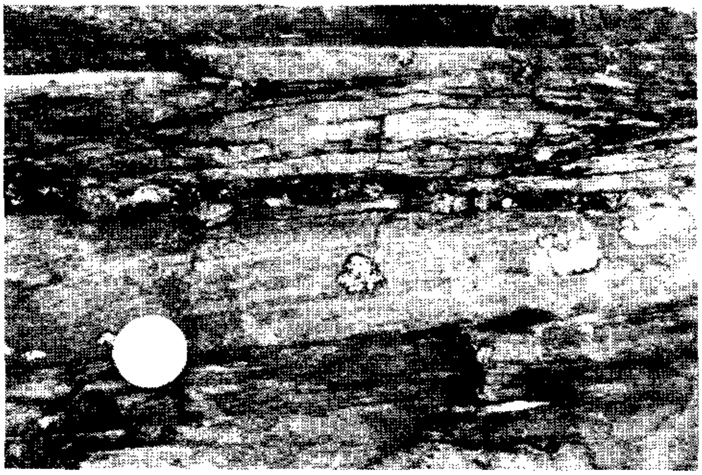

Figure 3. *Highly strained quartz schist at locality B, about 100 m above the Keno Hill quartzite. These rocks lie on at the base of the Robert Service thrust sheet. Note the light-coloured streaming of quartz-rich parts of the schist and the tight fold with attenuated limbs at top centre. This view is southward, perpendicular to the direction of transport. Canadian dollar coin provides scale.*

lenticular outcrop pattern brings to mind giant boudins. Because the enclosing rocks reveal no evidence of having been baked by the intrusion it is likely that the intrusions have been transposed along the foliation, relative to their host rocks. The intrusions have escaped a penetrative fabric, perhaps as a result of the competency contrast between schist and massive meta-diorite.

Structural considerations

Bedding and primary structures have been obliterated from almost all rocks. Brown schist, phyllite and phyllitic quartzite exhibit a nearly uniform southwest-dipping foliation defined by parallel alignment of platy minerals and coplanar long axes of polycrystalline quartz streaks. The mineral streaking and elongation lineation and axes of minor folds uniformly plunge southeastwardly (Fig.6).

Locally rootless, isoclinal folds have been observed. Those in Hyland Group directly above Keno Hill quartzite on the north slope verge to the northeast. At higher levels in the Hyland Group, but

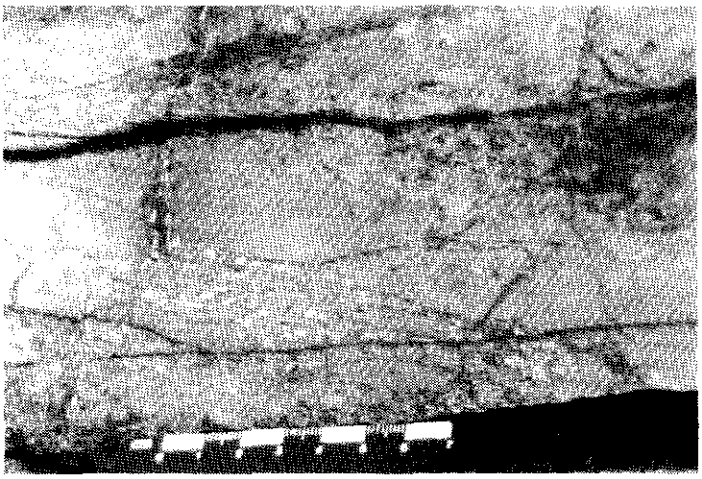

Figure 4. *Weathered surface of dolomitic breccia at locality D. Note the rectangular 2 cm-sized clasts above the scale bar. The carbonate occurs in a 2 m-thick bed enclosed in quartz schist.*

structurally below the Keno Hill quartzite on top of the plateau, folds verge to the southwest. These observations suggest that Hyland Group between exposures of Keno Hill quartzite is synformally infolded. Infolds of Keno Hill rocks as suggested on Fork Plateau are also indicated in nearby areas. On the south side of Mount Albert, 10 km northwest, is a 15 m-thick septum of clean quartzite interpreted by Murphy and Roots (1992) as footwall Keno Hill quartzite caught in a similiar infold of the Robert Service thrust. In the northeast corner of Mayo map area, foliated Hyland Group rocks dip northeast beneath upper Paleozoic schist (Gordey, 1990b). This may be another manifestation of an overturned limb of the Robert Service thrust (Roots and Murphy, 1992b)

Structural evolution

The following events have affected rocks of the Fork Plateau:

- Clastic sediments deposited from Latest Proterozoic to at least Mississipian time.

- In the Middle Triassic, mafic dikes and sills were emplaced at least to the level of the Keno Hill quartzite across the most northerly part of the present exposure (Mortensen and Thompson, 1990).

- In Jura-Cretaceous time, rocks in the southern part of the map area were detached and thrust northward as the Robert Service thrust sheet. The outcrop-scale evidence of displacement in the Mayo area has been overprinted by Tombstone thrust age fabrics, but near Dawson, this panel is characterized by slaty cleavage, south-dipping isoclinal folds and fault imbrication that suggest northward telescoping of the section.

- Northwestward, followed by northeastward translation of the Robert Service thrust sheet and underlying Paleozoic rocks on the Tombstone thrust. This imparts the high-strain fabrics in the Keno Hill region and in rocks of the Robert Service thrust sheet as far south as the Stewart River as described in Roots and Murphy (1992a).

- Late open folding, including formation of the Mayo Lake antiform.

- Intrusion of quartz monzonite ca. 100 Ma, including Roop Lakes pluton northeast of Fork Plateau, with an associated hydrothermal vein system.

IMPLICATIONS FOR MINERAL EXPLORATION

Changes in the relative values of metals, improved efficiency in mining and honing of ore deposit models have led to periodic shifts in the kinds of deposits sought in this region. The principal kinds were: argentiferous galena in veins until the mid-sixties, then stratiform sediment-hosted zinc-lead deposits and recently bulk tonnage low-grade gold deposits related to mid-Cretaceous granite.

The silver-lead-zinc-bearing quartz and siderite veins of the Keno Hill camp fill northeast-trending fractures. A mineral zoning study by Lynch (1986) linked the veins genetically to the Roop Lakes pluton, which lies 5 km northeast of Fork Plateau. The mesothermal ore deposits are about 15 km west of the exposed edge of the pluton, where host rocks and structures are favourable; epigenetic mineralization occurs at a greater distance.

Interest in recent years has turned toward large tonnage - low grade gold deposits with the discovery of the Fort Knox deposit in Alaska (Hollister, 1991). In Mayo map area, high gold and tungsten

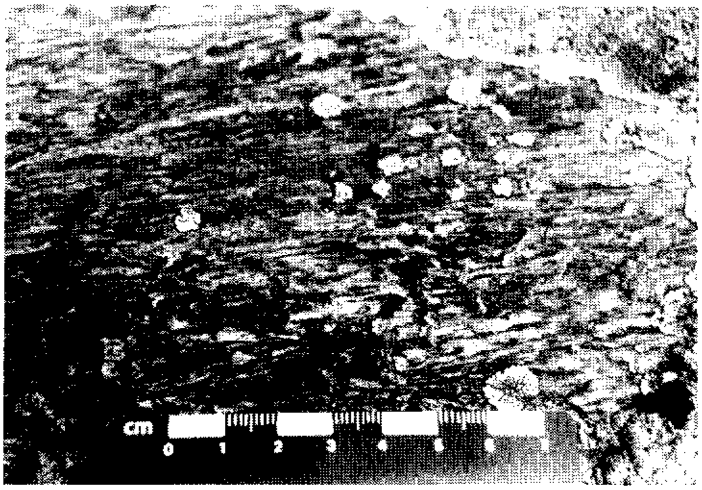

Figure 5. *Strongly lineated phyllitic schist from the top of Fork Plateau. View is perpendicular to the plane of foliation, and white quartz is extended southeast. This texture is diagnostic of the strained Keno Hill quartzite. Light-coloured vegetation is distinctive yellow-black lichen Rhizocarpon geographicum.*

Figure 6. *Outcrop of brown-weathering schist at the south edge of Fork Plateau (looking east at locality F). Note the quartz veinlets transposed into the regional foliation near hammer.*

values are reported from skarn (Hyland Group carbonate rocks) in the immediate hanging wall of the Robert Service thrust about 10 km southwest of Elsa. (Wayne prospect, Yukon Minfile 105M #29). These may indicate the presence of a high-level gold-bearing hydrothermal system associated with buried felsic intrusive rocks.

Fort Knox-type mineralization may also occur on Fork Plateau where the potential is suggested by placer gold in Ledge Creek and Edmonton Creek, and some silt geochemical anomalies. Regional stream sediment surveys (Friske and Hornbrook, 1989) reveal two Zn, Cu, Ni and Ag anomalies on Fork Plateau, suggesting an igneous source.

CONCLUSION

The presence of highly strained black phyllitic quartzite and mafic intrusives on the top of Fork Plateau indicates that the Robert Service thrust is not planar as shown on previous maps. Furthermore, the vergence reversals of minor structures in adjacent rock implies that it may have been folded. North of Mayo Lake the Robert Service thrust is a zone in which upper Keno Hill quartzite and lower Hyland Group rocks are imbricated, possibly by isoclinal folding (Murphy and Roots, 1992a).

To the south of Fork Plateau the Robert Service thrust is believed to underlie highly strained rocks of the Hyland Group. The repetition of the Robert Service thrust surface on Fork Plateau suggests that the Keno Hill quartzite may be exposed further south.

ACKNOWLEDGEMENTS

Julie Hunt completed traverses on Fork Plateau in 1992, and Fred Roots assisted with boat traverses in 1991. Will Thompson provided prompt and efficient helicopter service, and I am also grateful to the placer mining inspector, Bob Leckie for visits to local camps. Don Murphy enthusiastically discussed this geology and edited the manuscript. This project is part of a 1:250,000 scale re-mapping of Mayo map area (105M) that was initially funded by the Geological Survey of Canada and now is included within the scope of the Canada-Yukon Mineral Development Agreement.

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DEVELOPMENT OF WERNECKE BRECCIA IN SLATS CREEK (106D/16)MAP AREA, WERNECKE MOUNTAINS, YUKON

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THORKELSON, D.J. and WALLACE, C.A., 1993. Development of Wernecke breccia in Slats Creek (106D/16) map area, Wernecke Mountains, Yukon. In: Yukon Exploration and Geology, 1992. Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 77-87.

ABSTRACT

Wernecke breccia comprises numerous intrusive hematitic breccia zones exposed in the Wernecke and Ogilvie mountains of central Yukon. The breccias were emplaced in Middle Proterozoic time into Middle Proterozoic strata of Wernecke Supergroup, Fifteenmile group, and possibly Pinguicula group. Significant mineralization of Cu, U, Co, Ag and Au within and near breccia zones occurred during widespread Fe, CO2, and Si metasomatism. Following a period of hydrothermal activity and intense fracturing, breccia zones in the study area were generated in open spaces produced by extensional faulting or rapid expansion of volatile-rich fluids. A strong spatial correlation between breccia and crosscutting mafic to felsic intrusions indicates a magmatic linkage. Metasomatism extended from before brecciation to after cooling of the igneous intrusions. The metasomatising fluids may have been partly derived from residual liquids of possible tholeiitic magma chambers fractionating at depth. Regional deformation and metamorphism incurred during Racklan orogeny in Middle Proterozoic time preceded brecciation; the breccias developed in fully lithified rock. Previous models of breccia genesis invoking evaporite or mud diapirism are considered invalid.

INTRODUCTION

Numerous mineralized breccia zones of Mid-Proterozoic age, collectively termed Wernecke breccia, are exposed in the Wernecke and Ogilvie Mountains of central Yukon (Fig. 1)(Bell, 1978; 1986a; 1986b; Laznicka and Gaboury, 1988; Lane, 1990). The breccias are hosted mainly by Middle Proterozoic strata of the Wernecke Supergroup, and to a lesser degree by Middle Proterozoic Fifteenmile group and possibly Pinguicula group. Locally, impressive mineralization of copper, uranium, cobalt, silver and gold occurs within and adjacent to the breccia bodies. Ongoing exploration by the minerals industry underlines the potential of Wernecke breccia as a viable economic target.

This report provides a preliminary evaluation of Wernecke breccia as part of a 1:50,000 scale geological mapping project of Slats Creek (106D/16) map area (study area) in the Wernecke Mountains (Thorkelson and Wallace, 1993). This mapping, carried out in the summer of 1992, builds on 1:250,000 scale mapping by Green (1972) and 1:100,000 scale mapping by Bell (1986a)(Fig. 2). It will be followed up with petrographic and chemical analysis, and field investigations of neighbouring map areas planned for the summers of 1993 and 1994. The study area is remote and mountainous, with peaks rising to over 2200 m. (7000 ft.) from valleys as low as 600 m. (2000 ft). It is drained by the Bear and Bonnet Plume rivers which flow northward as part of the Mackenzie River watershed. Access to the study area was obtained by helicopter from Mayo, 150 km to the southwest.

Wernecke breccia is well exposed in the study area, providing a good opportunity to determine breccia origin and mode of emplacement. Low (sub-greenschist) grades of regional metamorphism, and weakly to moderately developed cleavage in host rocks rarely obscure original rock textures. However, metasomatic alteration of breccia and host rock, the process apparently responsible for mineralization, has commonly overprinted primary breccia textures.

STRATIGRAPHY

Five principal stratigraphic units are exposed in the study area (Fig. 3). The lowest three units, Fairchild Lake Group, Quartet Group, and Gillespie Lake Group, constitute Lower(?) to Middle Proterozoic Wernecke Supergroup (Delaney, 1981). Overlying these groups are two units tentatively correlated with Middle Proterozoic Pinguicula group (Eisbacher, 1978). Overlying (?)Pinguicula group with apparent disconformity is Lower Paleozoic carbonate (Green, 1972).

Wernecke Supergroup

Wernecke Supergroup was comprehensively described by Delaney (1981), and will be only briefly discussed here. In the study area, Fairchild Lake Group consists of greenish grey weathering laminated fine-grained sandstone, siltstone and calcareous siltstone, overlain by black weathering siltstone and shale, and buff to light grey weathering carbonate. Locally, a conspicuous white weathering bed of limestone exposed at the top of Fairchild Lake Group (Fig. 4) is conformably overlain by black to rusty weathering shale of basal Quartet Group (Delaney, 1981). Above the basal shale, Quartet Group comprises a succession of dark grey to rusty weathering pyritic shale, siltstone and fine-grained thinly bedded (5-20 cm) sandstone. Bedding surfaces are generally planar, although the

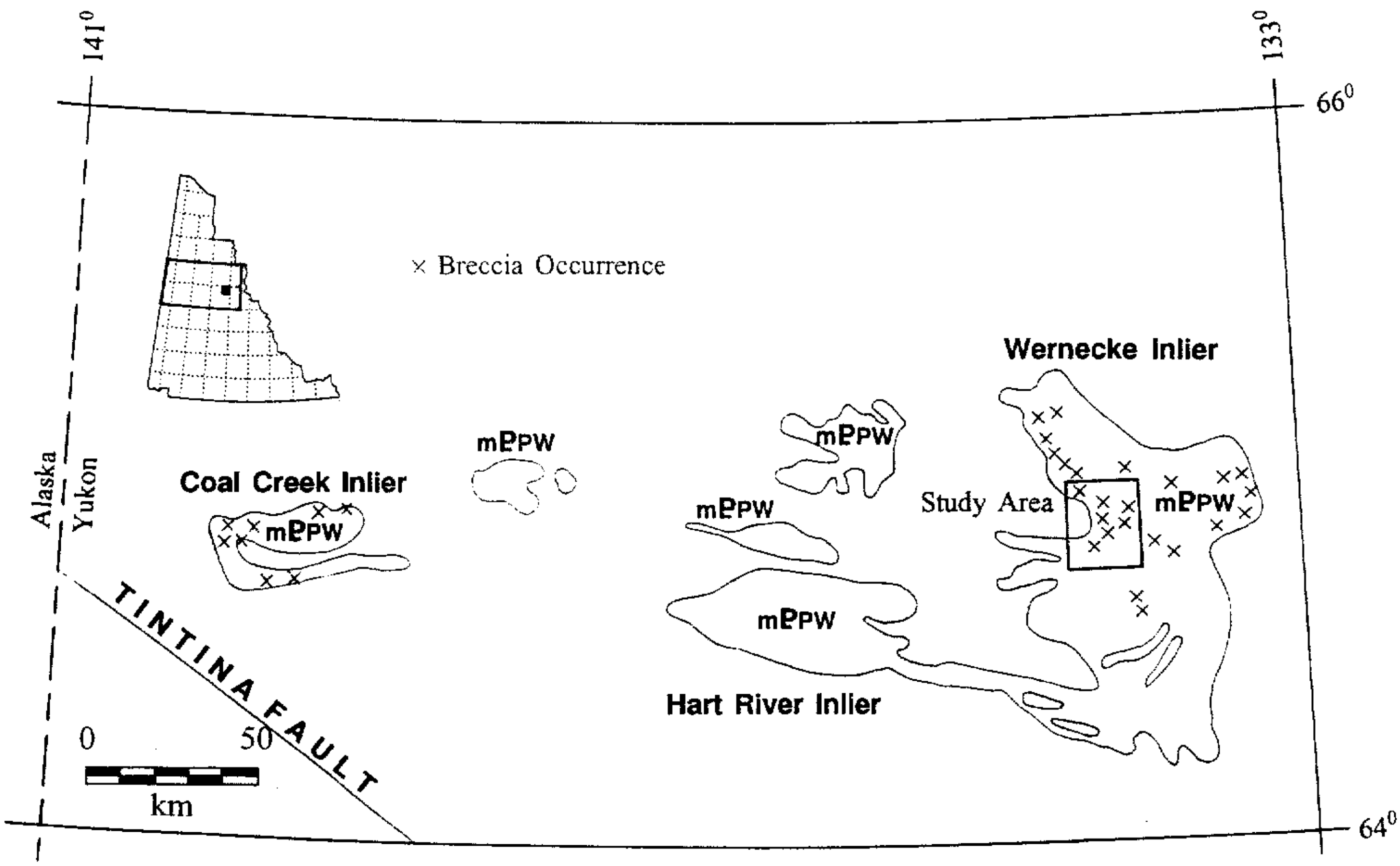

Figure 1. *Distribution of Middle Proterozoic Wernecke Supergroup (mPPW) in Yukon, showing location of study area in the Wernecke inlier, Wernecke Mountains (Slats Creek map area, NTS 106D/16). X, zones of Wernecke breccia.*

coarser beds are wavy to cross-laminated. Toward the top of the succession, where the Quartet grades into Gillespie Lake Group, the beds typically thicken and coarsen to 50-100 cm-thick units of fine-grained quartzose sandstone. These sandstone beds are interbedded with brown to orange weathering silty dolostone of the basal Gillespie Lake Group. Upsection, the Gillespie Lake comprises locally stromatolitic orange weathering dolostone and silty dolostone (Fig. 5). Locally, thick successions of the dolostone are punctuated by metre-scale interbeds of black weathering shale. South of Bear River (Fig. 2), the dolostone is interbedded with a thick (approximately 200 m) epiclastic succession comprising a lower member of green-weathering laminated mudstone, and an upper member of brown to black weathering siltstone and shale. North of Bear River, this succession is absent, and well exposed strata which lie an equal distance above Quartet Group are dolomitic. Locally abundant pockets, veins and stockworks of red weathering sparry carbonate (ankerite?) occur within and at the base of Gillespie Lake Group. The spar is interpreted as chemical infilling of karst cavities.

Following Delaney (1981), we interpret depositional environments of Wernecke Supergroup strata as: (1) a deep marine basin for lower Fairchild Lake Group grading upward to (2) a shallow marine clastic-carbonate shelf at the top of the Fairchild Lake, followed by (3) a deep marine basin for Quartet Group, shallowing upward to (4) a mainly carbonate shelf for the Gillespie Lake. The abundance of pyrite in the Quartet suggests anoxic conditions during deposition of much of Quartet Group. In contrast, algal mats, mudcrack casts (Fig. 6), and karst features indicate shallow water to partly emergent conditions during evolution of Gillespie Lake Group.

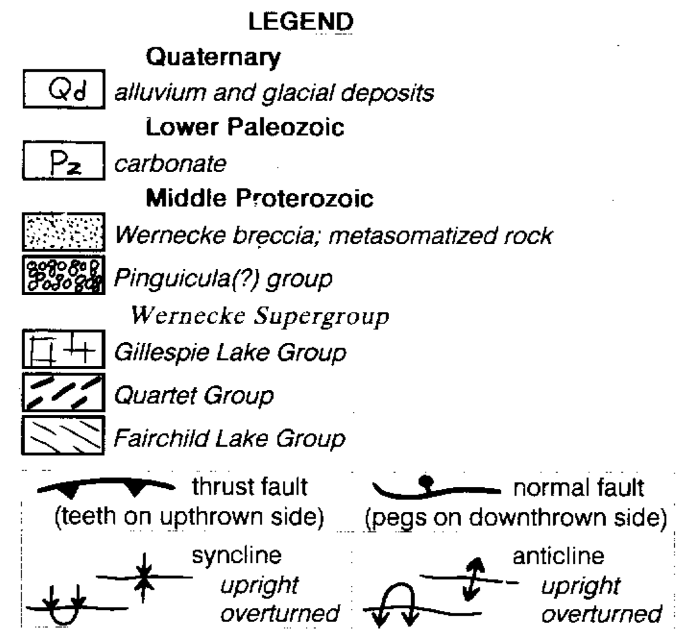

Figure 2. *Simplified geological map of Slats Creek map area (study area), showing locations of Yukon Minfile occurrences discussed in text (INAC, 1992; Thorkelson and Wallace, 1993).*


65°N
EATON
BLAND
SLAB
BONNET PLUME RIVER
Qd
GNUCKLE
PITCH
FORD
SNOWSTAR
CHIEFTAIN
BEAR RIVER
Pz
134°30'W
134°W
FACE
PAGISTEEL
64°45'N

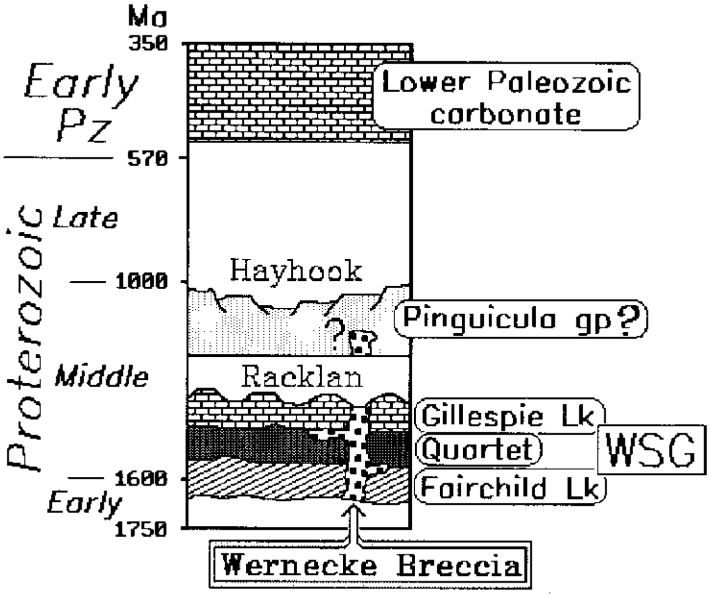

Figure3. Schematic stratigraphy of the study area. WSG=Wernecke Supergroup. Timing of Racklan orogeny and Hayhook extensional event are indicated.

Pinguicula group

Two units tentatively correlated with Pinguicula group (Eisbacher, 1978) are restricted to the southwestern and northeastern corners of the study area where they are exposed in fault blocks and half-grabens. One unit, exposed in the southwestern corner of the study area (Fig. 2), consists of thinly bedded maroon and green weathering mudstone, siltstone, conglomerate, and dolostone, faulted against the Gillespie Lake Group. The conglomerate contains pebbles of white quartzite. The other unit, exposed in the northeastern corner of the study area, comprises steeply dipping, maroon to grey, amygdaloidal lava flows which were probably deposited subaerially. The flows are bounded on the west by a body of Wernecke breccia, and siltstones of the Fairchild Lake Group. The lavas are not included in the Fairchild Lake Group because their apparent subaerial origin is inconsistent with marine conditions represented by the Fairchild Lake. Furthermore, volcanic strata are scarce in Wernecke Supergroup (Abbott, 1993), but common in the Pinguicula (Eisbacher, 1978). The stratigraphic relationship between the Pinguicula(?) strata in the northeastern and southwesern parts of the study area is unknown.

Lower Paleozoic carbonate

Massive grey carbonate of probable Cambrian to Devonian age is well-exposed in the western part of the study area (Green, 1972; Norris and Dyke, in press). It lies with angular unconformity on folded strata of the Wernecke Supergroup. This unit is not known to be associated with economic mineralization, and was therefore examined in a cursory manner, and mapped as a single unit.

Regional context of Proterozoic strata

Young et al. (1979) classified Middle to Late Proterozoic successions of northwestern North America into three sequences (A, B, and C), on the basis of two regionally extensive unconformities. Sequence A, the oldest, was deformed and partly eroded prior to deposition of Sequence B. Subsequent block faulting occurred during and after deposition of Sequence C.

Sequence A includes Wernecke Supergroup (Yukon); Hornby Bay, Dismal Lakes, and Coppermine River groups (Northwest Territories); and Purcell Supergroup and Muskwa Assemblage (British Columbia)(Bell, 1968; McMechan, 1981). It was deposited between approximately 1.7-1.2 Ga. Purcell and Wernecke supergroups and Muskwa Assemblage contain thick (up to 14 km) fine to medium grained clastic, and carbonate successions (McMechan, 1981; Delaney, 1981; Bell, 1968). The Coppermine Homocline strata comprise fluvial sediments overlain by carbonates and volcanic rocks (Kerans et al. 1981). On the basis of stratigraphic and structural data, Bell (1982) suggested that Wernecke Supergroup represents the distal part of a miogeoclinal wedge, and that the broadly similar but thinner Hornby Bay-Dismal Lakes successions represent the proximal part.

Sequence A may have been deposited in an intracratonic basin, as suggested by evidence from southern British Columbia. There, Sequence A rocks reveal western-sourced paleocurrents, and yield isotopic signatures which resemble those of coeval strata in Australia (Ross et al., 1992). Sequence A strata underwent contractional deformation, cleavage formation, and low-grade metamorphism prior to deposition of Sequence B (McMechan and Price, 1982). In Yukon, the tectonism is known as Racklan orogeny (Fig. 2)(Gabrielse, 1967; Eisbacher, 1978; Young et al., 1979) and is commonly equated to East Kootenay orogeny in the south (Young et al. 1979, McMechan and Price, 1982). The timing of deformation is thought to be about 1300 Ma. In Yukon, Racklan deformation is considered to have occurred between ca. 1380 Ma, when sills in the Hart River inlier were emplace into Gillespie Lake Group (Abbott, 1993), and ca. 1270 Ma, when Wernecke breccia (postorogenic, this study) was emplaced at the NOR occurrence, 120 km north-northwest of the study area (Parrish and Bell, 1987). In southern British Columbia, East Kootenay orogeny occurred prior to emplacement of ca. 1365 Ma (J.K. Mortensen, pers. comm., 1992) postorogenic Hellroaring Creek stock (McMechan and Price, 1982).

Sequence B is restricted to the Yukon and Northwest Territories, where it unconformably overlies Sequence A. It includes Pinguicula group (Eisbacher, 1978), Fifteenmile group (Roots and Thompson, 1992), and Mackenzie Mountains Supergroup (Young et

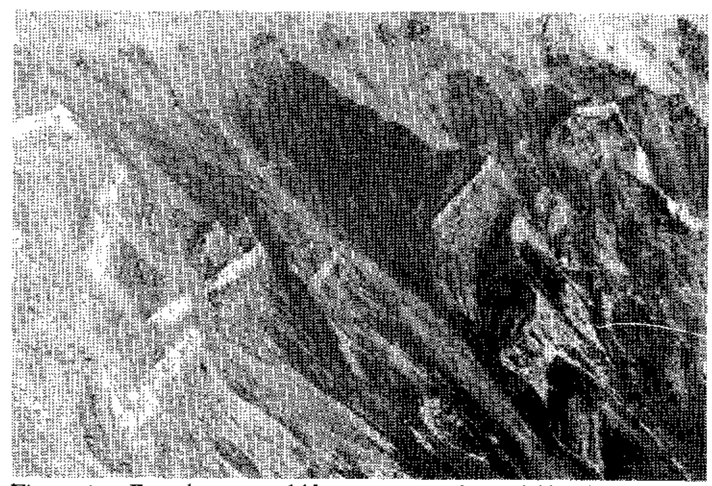

Figure 4. Easterly verging folds in transitional Fairchild Lake Group to Quartet Group strata delineated by a white weathering limestone marker unit, northeastern part of study area.

Figure 5. *Minor folds in thinly bedded dolostone of Gillespie Lake Group.*

Figure 6. *Mudcrack casts in Gillespie Lake Group silty dolostone.*

al., 1979) which were deposited between about 1300 and 780 Ma. Sequence B comprises carbonate and siliciclastic rocks, and minor volcanic strata. Contrasting stratigraphic characteristics among the three groups has impeded recognition of lateral continuity of constituent stratigraphic units. This absence of definite regional correlations may be a result of syndepositional block faulting and development of isolated coeval basins, or different ages of deposition among the groups within the Middle to Late Proterozoic interval (cf. Roots and Thompson, 1992).

Sequence C was deposited on the older strata with disconformity to angular unconformity, after a period of extensional block faulting known as the Hayhook "orogeny," approximately 780 million years ago (Fig. 2)(Young et al., 1979; Roots and Thompson, 1992). The widespread deposition of dominantly clastic sediments of Sequence C occurred from about 780 Ma to 570 Ma. The constituent successions, Windermere Supergroup and Hyland Group, represent the basal succession of the Late Proterozoic and Paleozoic Cordilleran miogeocline (Ross et al., 1989).

STRUCTURE

At least four phases of structural deformation are indicated in the study area. The first phase is represented by folding and local development of cleavage in the Wernecke Supergroup, particularly in pelitic rocks of the Fairchild Lake and Quartet groups. Stratigraphic conformity within the Wernecke Supergroup infers that the folding was entirely postdepositional. The second phase is indicated by local kink bands in phase one cleavage. Both phases predated emplacement of Wernecke breccia, as indicated by clasts of kinked phyllite within breccia whose matrix is devoid of fabric. Subsequent phases of deformation include normal and reverse faulting. The reverse faulting, which offset strata as young as Lower Paleozoic carbonate, predates, and probably postdates events of normal faulting. The early phase of normal faulting may have been related to genesis and emplacement of Wernecke breccia, and/or Hayhook extensional tectonism, in Proterozoic time.

Predominance of Precambrian over Phanerozoic deformation is indicated by the profound angular unconformity between the Wernecke Supergroup and the overlying succession of Lower Paleozoic carbonate. In several locations, the angular contact between the Paleozoic strata and folded rocks of the Wernecke Supergroup is well exposed (Fig. 7). Within and immediately southwest of the study area, the Paleozoic strata are exposed mainly as gently tilted homoclinal panels. Contractional deformation in Mesozoic time, which resulted in development of a fold and thrust belt throughout

Figure 7. *Angular unconformity between Lower Paleozoic carbonate and underlying deformed Gillespie Lake Group, 15 km southwest of study area.*

Figure 8. *Thrust relationship between Gillespie Lake Group (hanging wall) and Lower Paleozoic carbonate, southwest of Bear River.*

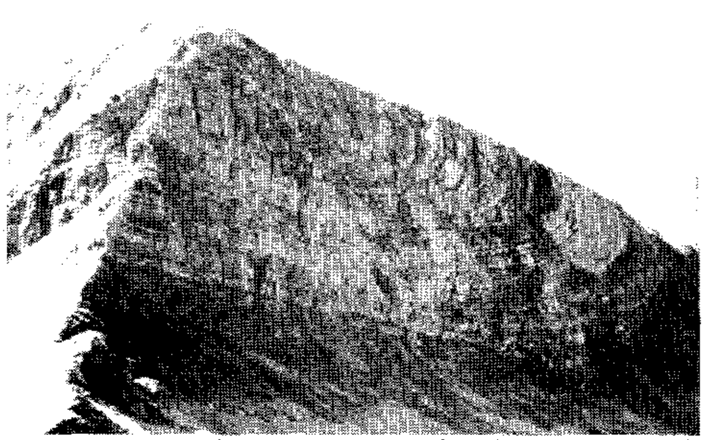

Figure 9. *East-southeast verging overturned syncline in upper Fairchild Lake Group in northwestern part of study area.*

much of the northern Cordillera (Gabrielse, 1967), was minor in the study area.

Despite the subordinate aspect of the Phanerozoic deformation, determining the age of many structures is not straightforward. Clearly, the reverse fault in the southwestern part of the map area, which places Wernecke Supergroup over Lower Paleozoic carbonate (Fig. 2), is a Phanerozoic structure whose hanging wall was displaced toward the north or northwest (Fig. 8). A normal fault in the western side of the study area, north of Bear River, separates Lower Paleozoic carbonate from Wernecke Supergroup; this fault is also of Phanerozoic age, and probably postdates motion on the reverse fault. However, other folds and faults may have been active strictly in the Proterozoic, or may have been reactivated in Phanerozoic time. Adding to the uncertainty is the variability of contractional structural trends in Wernecke Supergroup. They range from north-northeasterly trending (east-southeast-verging) in the northwestern part of the map area (Fig. 9), to northwesterly trending (northeast-verging) in the central and southeastern part of the map area, to westerly trending (north-verging) in the southern part of the map area.

Several block faults parallel the trend of breccia zones, and juxtapose non-brecciated Gillespie Lake strata with breccia-hosting Fairchild Lake and Quartet rocks. The coincidence of these faults with breccia implies that they may have been active during and after breccia formation. The breccia zone at the SLAB Yukon Minfile occurrence (Fig. 2)(INAC, 1992) may coincide with a fault which separates Pinguicula(?) lava flows from metasomatized Fairchild Lake Group. Contact relations along these breccia/fault zones require more study.

Wernecke breccia

Previous work

Field, petrological, geochemical, and geochronological studies of Wernecke breccia have been reported by several authors (e.g., Bell, 1982; 1986b; Parrish and Bell, 1987; Laznicka and Gaboury, 1988; Hitzman et al., 1992). Although descriptions of the breccia from various localities are remarkably consistent, interpretations of its origin and mode of emplacement vary greatly. Recognition of potentially economic mineralization in the breccia and adjacent host rock has encouraged previous and ongoing mineral exploration.

The size of individual breccia zones ranges from tens to thousands of square metres (Bell, 1986a; Lane and Godwin, 1992). Some breccia zones are isolated irregular-shaped bodies, but many are elongate and distributed with other zones of Wernecke breccia in linear arrays. Linear breccia distribution is particularly evident in the Coal Creek inlier, where correlative units termed Ogilvie Mountains breccia (Lane, 1990) occupy portions of major fault zones.

Wernecke breccia has been generally described as variably metasomatized clasts of siltstone and dolostone of Wernecke Supergroup set in a sandy to hydrothermally precipitated matrix (Laznicka and Gaboury, 1988). Clasts are commonly angular to subangular, but are locally rounded. Hydrothermal activity before, during and after emplacement resulted in development of metasomatic assemblages dominated by hematite, carbonate, silica, chlorite, and albite. Metasomatism also resulted in local enrichments of Cu, U, Co, Ag, and Au.

Crosscutting relationships have been reported from many of the breccia zones, leading most workers to regard Wernecke breccia as intrusive. Emplacement occurred as pipes, dykes, and sills of breccia into all stratigraphic levels of Wernecke Supergroup and, in the Coal Creek inlier, into lower Fifteenmile group (Sequence B)(Lane, 1990). The rate, medium of transport, and other aspects of breccia intrusion are not well constrained. Genetic models include emplacement in the form of diatremes (Tempelman-Kluit, 1981), evaporite diapirs (Bell, 1989), and mud diapirs (Lane, 1990). U-Pb dating of monazite related to breccia provided a ca. 1270 Ma age (Parrish and Bell, 1987). The degree of lithification of Wernecke Supergroup strata at the time of breccia emplacement was addressed by Lane (1990) who suggested that parts of the Fairchild Lake Group were only partly consolidated.

Similarities between Wernecke breccia and other breccias of similar age and environment were noted by Bell and Jefferson (1987) and Hitzman et al. (1992). A particularly strong connection was drawn with the economic Olympic Dam breccias in Australia, on the basis of similar breccia characteristics and probable proximity of ancestral North America with ancestral Australia in Proterozoic time.

Breccia in the study area

Characteristics of Wernecke breccia determined in this study of Slats Creek map area are consistent with those reported in previous studies. The breccias are typically variegated, with abundant clasts of conspicuous pink, red, and maroon altered siltstone in a green to red mottled matrix. Clasts of weakly altered to unaltered grey and black siltstone, and brown to orange dolostone are also common, and locally dominate clast assemblages. Breccia of the SLAB occurrence (Fig. 2) hosts unaltered clasts of kinked grey phyllite and biotite-porphyroblastic metasiltstone, probably derived from nearby Fairchild Lake Group rocks. The breccias developed in the Wernecke Supergroup, and were emplaced into that sequence, and possibly into or alongside downfaulted volcanic strata tentatively correlated with the Pinguicula group (SLAB occurrence).

Clast sizes are typically in the pebble to cobble range, but in places, such as the SLAB and FACE occurrences, they include boulder-size fragments ranging up to 15 m across. Generally, the boulder-size clasts are less altered than surrounding smaller clasts. All of the clasts appear to be derived from the Wernecke Supergroup, except for rare clasts(?) of massive chlorite, and fragments of possible igneous rock requiring further study and verification. Locally, elongate clasts are aligned parallel to breccia contacts. Well-rounded clasts are uncommon, but locally conspicuous.

Matrix of most of the breccia consists of a bewildering intergrowth of fine- to medium-grained hematite, carbonate, chlorite, quartz and other minerals. This assemblage is considered a product of metasomatism and hydrothermal deposition, and strongly overprints original breccia textures in most of the breccia bodies. Specular and earthy hematite are commonly disseminated throughout both clasts and matrix. In a few locations, such as the PAGISTEEL occurrence, high concentrations of Fe are locally present as zones of massive specularite. Fe-enrichment is also locally manifested by disseminated magnetite. Anomalously weak alteration of breccia on the SLAB occurrence provides a good opportunity to decipher original textures. There, the original breccia matrix is clastic, and consists of granule- to silt-size grains of quartz, microcline, biotite, and other minerals, plus fragments of metasedimentary rocks.

Cu, U, Co, Ag, and Au occurrences are widely distributed in Wernecke breccia and surrounding metasomatized country rock (Bell, 1986b; Laznicka and Gaboury, 1988). Local concentrations of Cu, mainly in the form of chalcopyrite, malachite and possibly chalcocite, form spectacular regions of mineralization (e.g., SLAB and CHIEFTAN occurrences). Local mineralization of Co in the form of erythrite, and U in the form of brannerite and uraninite is present. Ag and Au concentrations are locally elevated. An encouraging Au assay (this study) of 1500 ppb was obtained from breccia of the SIHOTA occurrence, 30 km west of the study area.

Contacts between breccia and country rock vary from abrupt to gradational. Some of the abrupt contacts are faults across which breccia is juxtaposed with unaltered, unbrecciated strata, commonly of the Gillespie Lake Group. Others, however, are intrusive contacts along which breccia was emplaced into unaltered country rock. This relationship was noted near the PITCH and SLATS occurrences, where red-clast hematitic breccia intrudes siltstone and dolostone unaffected by metasomatism. There, metasomatism of breccia clearly preceded and did not continue after breccia emplacement. The reverse relationship is recognized in the SLAB occurrence, where relatively unaltered breccia was emplaced into highly mineralized (Cu, Co, U), previously metasomatised siltstone. Crosscutting (intrusive) relations are well preserved at the GREMLIN occurrence, 20 km northwest of the study area.

Gradational relationships between breccia and host rock are well developed in several places, especially around the BLAND, EATON, and FORD occurrences. In such localities, unaltered host rock (typically dark siltstone) grades into altered host rock (typically purplish brown with red bands and hematitic fractures) which grades into progressively more metasomatized and fractured rock toward the breccia. The transition from host rock to breccia occurs across a zone of crackle breccia in which highly fractured host rock has undergone incipient fragmentation. Metasomatic alteration increases toward the breccia zone, where clasts are typically reddened, and specular hematite is abundant, particularly in matrix. The width of the metasomatic aureole from unaltered siltstone to Wernecke breccia ranges from tens to hundreds of metres.

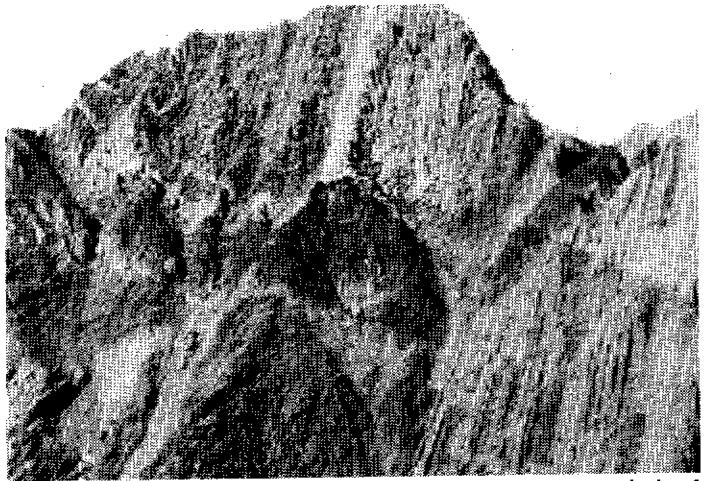

***Figure 10**. Mafic dyke crosscutting steeply dipping dolostone beds of Gillespie Lake Group, south of Bear River.*

Dykes, sills and small stocks of igneous rock are scattered throughout the study area. None have been dated, but some may be coeval with ca. 1380 Ma Hart River sills (Fig. 10)(Abbott, 1993). The intrusions, which range from gabbroic to granitic in composition, are particularly common within and near zones of Wernecke breccia (cf. Laznicka and Gaboury, 1988). Mafic intrusions emplaced within breccia and host rock of the SLAB occurrence consist mainly of interlocking scapolite and tremolite-actinolite grains which pseudomorph plagioclase and augite, respectively. Granitic and intermediate intrusions in breccia of the GNUCKLE occurrence may be suitable for isotopic dating. A granitic to rhyolitic intrusion near the SNOWSTAR occurrence forms an agmatitic breccia with country rock siltstone, and is within metres of a mafic dyke.

Several of the intrusions emplaced into Wernecke breccia are fractured, altered, and veined with hematite, carbonate, and quartz (cf. Lane, 1990). These metasomatic features, shared by the host breccia, are considered products of breccia-related hydrothermal activity.

Preliminary model

Development of Wernecke breccia is modelled as six stages in Fig. 11. The model is preliminary, and represents a synthesis of observations in the study area. Future field and laboratory studies will test, modify, and expand the ideas presented.

In Stage 1 (Fig. 11), host rock was fractured and metasomatised. Influx of fluids rich in CO2, silica, and metals, largely along bedding-parallel fractures, led to intense alteration of Wernecke Supergroup strata in regions tens to hundreds of metres wide. Cu, U, Co, Ag, and Au were locally precipitated in substantial concentrations. This stage of pre-breccia metasomatism is indicated by much greater metasomatism in host rock than in breccia in the SLAB occurrence. The source of the fluids is unknown, but may be related to possible igneous intrusions at depth (Laznicka and Gaboury, 1988) which fractionated along a tholeiitic (Fe-enrichment) trend, leading to Fe-, Si- and CO2-rich residual liquids which were released into the crust.

In Stage 2, open spaces within the altered rock developed, and breccia formed during continued fracturing and alteration.

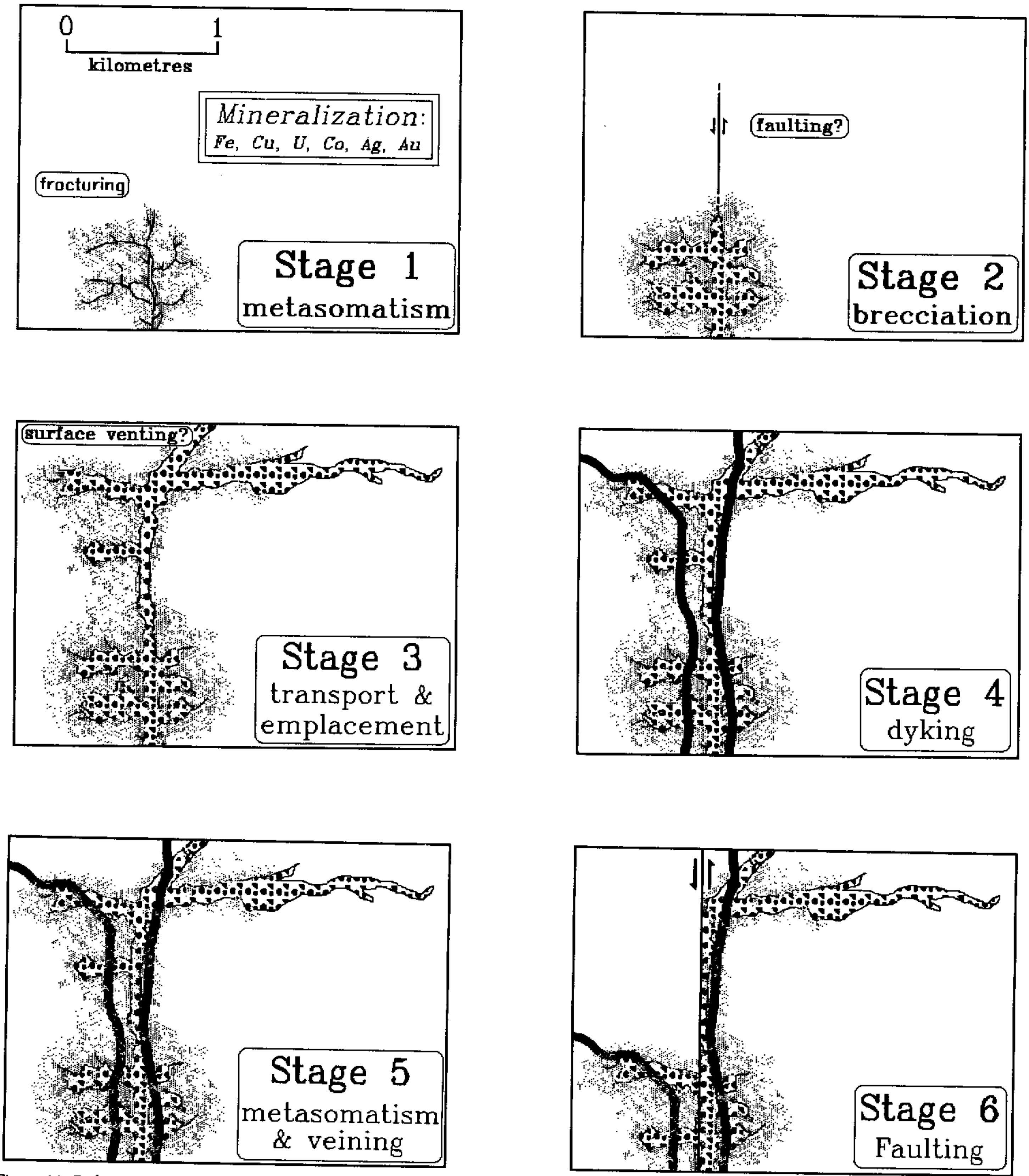

Figure 11. Preliminary model of Wernecke breccia genesis, showing six stages in breccia zone development. See text for details.

Metasomatic aureoles generally increased in size and intensity; economic minerals continued to be deposited. The causes of open space development are unknown, but may be linked to extensional faulting (Roots and Thompson, 1992) or rapid expansion and upflow of volatile-rich fluids.

In Stage 3, some of the breccia was transported from its site of origin and emplaced elsewhere in the crust. Locally, clasts were rounded or aligned by flowage. In most places, metasomatizing fluids continued to flow through the breccia zones, increasing the region of host rock alteration. In others, however, metasomatism did not continue after emplacement, and blocks of unaltered country rock which were incorporated into the breccia during emplacement remained unaltered; the surrounding country rock was not metasomatised. Faulting may have occurred during emplacement. Whether breccias or metasomatizing fluids reached the surface during this or any other stage is unknown.

Many of the breccia zones were affected by subsequent igneous, metasomatic and structural events. In Stage 4, dykes of mainly mafic and less commonly intermediate to felsic compositions intruded the crust, particularly in zones of Wernecke breccia. The striking spatial relationship between breccia and crosscutting igneous rocks indicates that breccia zones were preferred conduits for magmatic intrusion, and infers that breccia zones or their controlling structures had deep-seated roots. In Stage 5, metasomatism continued after intrusion, producing alteration of breccia, dykes, and presumably host rock. Metal-poor dolomite and quartz veins are generally the last manifestations of this hydrothermal activity. Faulting (Stage 6) within or near many of the breccia zones occurred after cessation of most of the metasomatism, juxtaposing relatively unaltered strata with metasomatized country rock or breccia. These late-stage displacements may represent the last in a series of protracted crustal movements along and within zones of breccia, outlasting hydrothermal activity and mineralization.

Wernecke breccia developed in fully lithified strata which had undergone contractional deformation leading to cleavage development and kink banding. Slaty or phyllitic cleavage is well developed in many parts of the study area, including country rock adjacent to zones of breccia. Locally, clasts of kinked phyllite resembling country rock are included within breccia. In contrast, cleavage was not observed in any of the breccia bodies. Breccia development is therefore considered to have occurred after Middle Proterozoic Racklan orogeny, consistent with observations and interpretations of Roots and Thompson (1992). A model of breccia development appealing to uprise of mud diapirs from unconsolidated Wernecke Supergoup strata (Lane, 1990) is therefore rejected. A model of breccia formation as collapse structures related to dissolution of evaporite diapirs (Bell, 1989) is considered unlikely because: (1) evaporite source horizons have not been recognized; (2) relics of evaporite in breccia zones have not been identified; (3) metallic mineralization is typical of the breccia zones, whereas evaporite diapirs are commonly barren; and (4) the preponderance of dykes and small stocks within breccia zones infers a deep crustal or mantle connection, rather than genesis soley within supracrustal strata. Ongoing studies of these enigmatic rocks will hopefully permit sophistication of our preliminary model, perhaps linking breccia genesis to magmatism.

CONCLUSIONS

1) Zones of Wernecke breccia in the study area, developed within and intruded Middle Proterozoic strata of Wernecke Supergroup, and possibly Pinguicula group.

2) Brecciation occurred in fully lithified rock after folding, formation of cleavage, and kink banding during Middle Proterozoic Racklan orogeny.

3) Breccia development began with fracturing and metasomatism, continued with fragmentation into open spaces, followed by breccia transport and emplacement, subsequent intrusion of small igneous bodies, and faulting.

4) Protracted iron, carbonate and silica metasomatism affected both breccia and adjacent country rock.

5) Mineralization of Cu, U, Co, Ag, and Au accompanied the metasomatism.

6) Concentration of igneous intrusions in breccia zones suggests an igneous influence in breccia genesis; metasomatizing fluids may have been derived in part from tholeiitic igneous sources, and transported upward along deep-seated structures.

7) Fragmentation and generation of open spaces in country rock may have been produced by rapid expansion of volatile-rich fluids, and/or extensional faulting.

8) Breccia genesis as evaporite or mud diapirs is rejected.

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