Province of British Columbia
Ministry of Energy, Mines and
Petroleum Resources
Hon. Jack Davis, Minister

MINERAL RESOURCES DIVISION
Geological Survey Branch

EXPLORATION IN BRITISH COLUMBIA 1989

Part A - Overview of Exploration Activity

Part B - Geological Descriptions of Properties

Editors:
Brian Grant
John Newell
Formatting and Page Layout:
Janet Holland

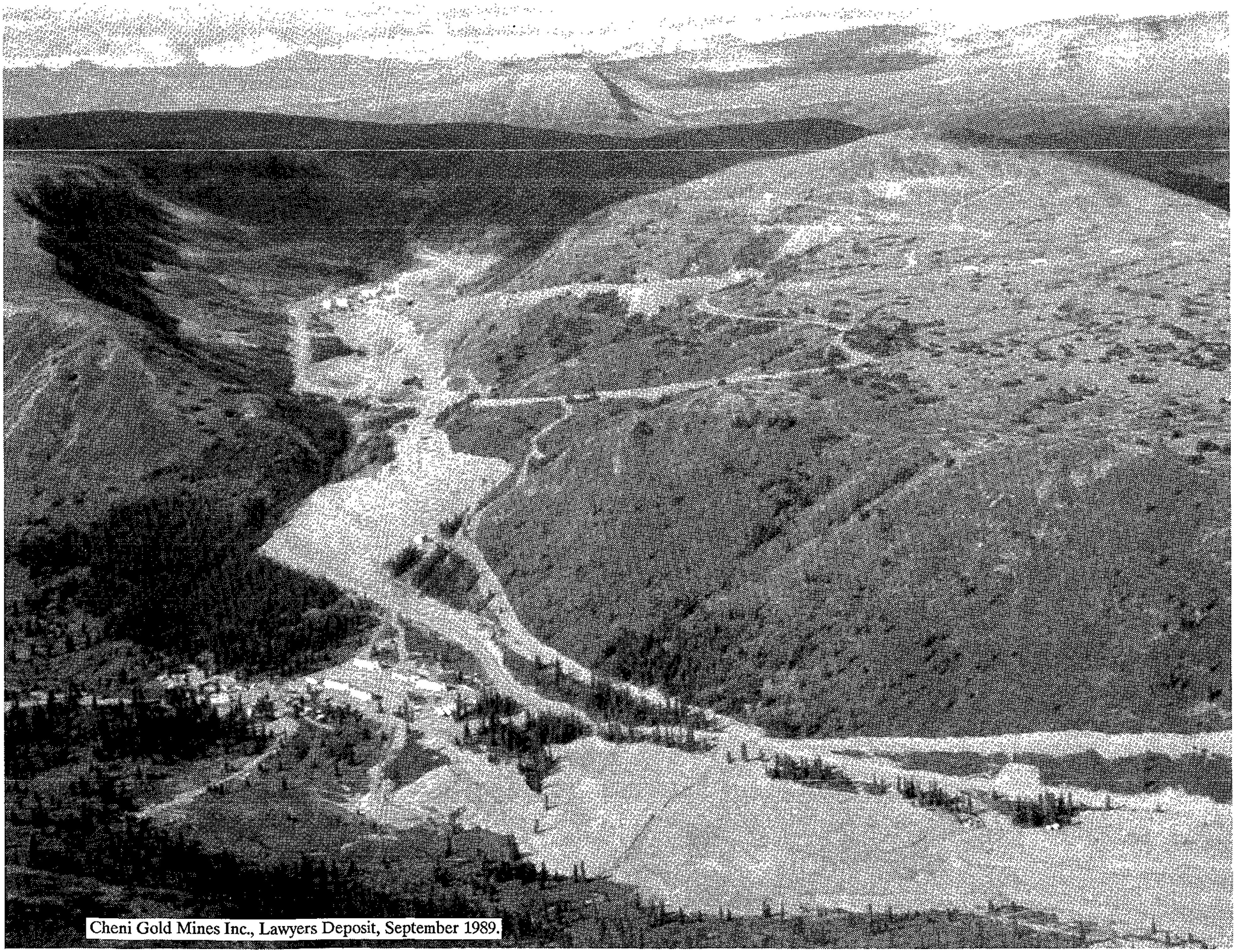
British Columbia Cataloguing in Publication Data
Main entry under title:
Exploration in British Columbia. - 1975-
Annual.
With: Geology in British Columbia, ISSN 0823-1257; and, Mining in British Columbia, ISSN 0823-1265, continues: Geology, exploration, and mining in British Columbia, ISSN 0085-1027.
1979 published in 1983.
Issuing body varies: 1975-1976, Ministry of Mines and Petroleum Resources; 1977-1985; Ministry of Energy, Mines and Petroleum Resources; 1986- , Geological Survey Branch.
ISSN 0823-2059 - Exploration in British Columbia.

1. Prospecting - British Columbia - Periodicals. 2. Geology, Economic - British Columbia - Periodicals. I. British Columbia. Ministry of Mines and Petroleum Resources. II. British Columbia. Ministry of Energy, Mines and Petroleum Resources. III. British Columbia. Geological Survey Branch.

TN270.E96 622.1'09711
Rev. April 1987

VICTORIA
BRITISH COLUMBIA
CANADA

JULY 1990



Cheni Gold Mines Inc., Lawyers Deposit, September 1989.

FOREWORD

1989 was an exciting year for the minerals industry in British Columbia. Five precious metal deposits, Lawyers (*see* Frontispiece), Silbak-Premier, Golden Bear, Shasta and Samatosum, went into production as well as one base metal deposit, the Ajax. Exploration had a record year for exciting developments led by the discovery of the Eskay Creek deposits and by significant encouragement from the Mount Milligan and Windy Craggy deposits.

In spite of a 25 per cent drop in exploration expenditures to $153 million, claim staking in the province increased by 8 per cent to 94 233 units, and this no doubt was a reflection of growing confidence in the mineral potential in B.C. in light of the new discoveries. Exploration continued to emphasize precious metals development but with improving international metal markets, particularly in copper and zinc, base metals have become the focus of renewed activity.

The publication series *Exploration in British Columbia* has also acquired a new focus and format commencing with this volume. Part C is discontinued and forms a separate publication, the *Assessment Report Index*. Part B takes on a new emphasis with this issue and includes more material on metallogenic research, in addition to the traditional property descriptions by Ministry staff, many of which this year are joint projects with industry geologists. New initiatives in surficial geology by the Geological Survey Branch and external researchers, is reflected in several interesting manuscripts on placer deposits. Part A is maintained as an overview of industry activity and includes a short review of the fieldwork of the Geological Survey Branch in 1989.

W.R. Smyth
Chief Geologist

PART A
OVERVIEW OF EXPLORATION ACTIVITIES

TABLE OF CONTENTS

PART B
GEOLOGICAL DESCRIPTIONS OF SELECTED PROPERTIES

PART A

OVERVIEW OF EXPLORATION ACTIVITIES

WHAT IS NEW IN BRITISH COLUMBIA? EXPLORATION AND DEVELOPMENT HIGHLIGHTS - 1989

By V.A. Preto
Manager, District Geology and Coal Resources

INTRODUCTION

1989 was a year of exciting new discoveries in British Columbia, and also a year of change for mineral exploration. Junior companies maintained a prominent role on the provincial stage, with exciting new precious metal discoveries such as **Eskay Creek** and continuing encouraging results from **Mount Milligan** and **Windy Craggy**. The year also saw a resurgence of exploration for base metals and the return of the major companies as the biggest spenders, prompted by stronger base metal prices, particularly for copper and zinc.

After reaching record levels of $192 million in 1987 and $206 million in 1988, exploration expenditures totalled $153 million in 1989 a drop of $53 million or 25.7 per cent from the previous year. This anticipated decrease is due to softening gold and silver prices through much of the year and the virtual demise of flow-through financing. Drastically reduced programs by junior companies totalled only 71 million, versus the $143 million spent in 1988. This drop was only partially offset by an increase in expenditures by major companies which reached $80 million versus the $63 million spent in 1988.

In contrast, mineral claim staking increased appreciably over 1988 and 1987 levels. By years end a total of 94 233 units had been staked, compared to 87 285 in 1988, an increase of 8 per cent (*see* Figure A-1). What little ground that was still open in the Iskut - Unuk River area was gobbled up after the **Eskay Creek** news releases in August, and a staking rush ensued on Vancouver Island

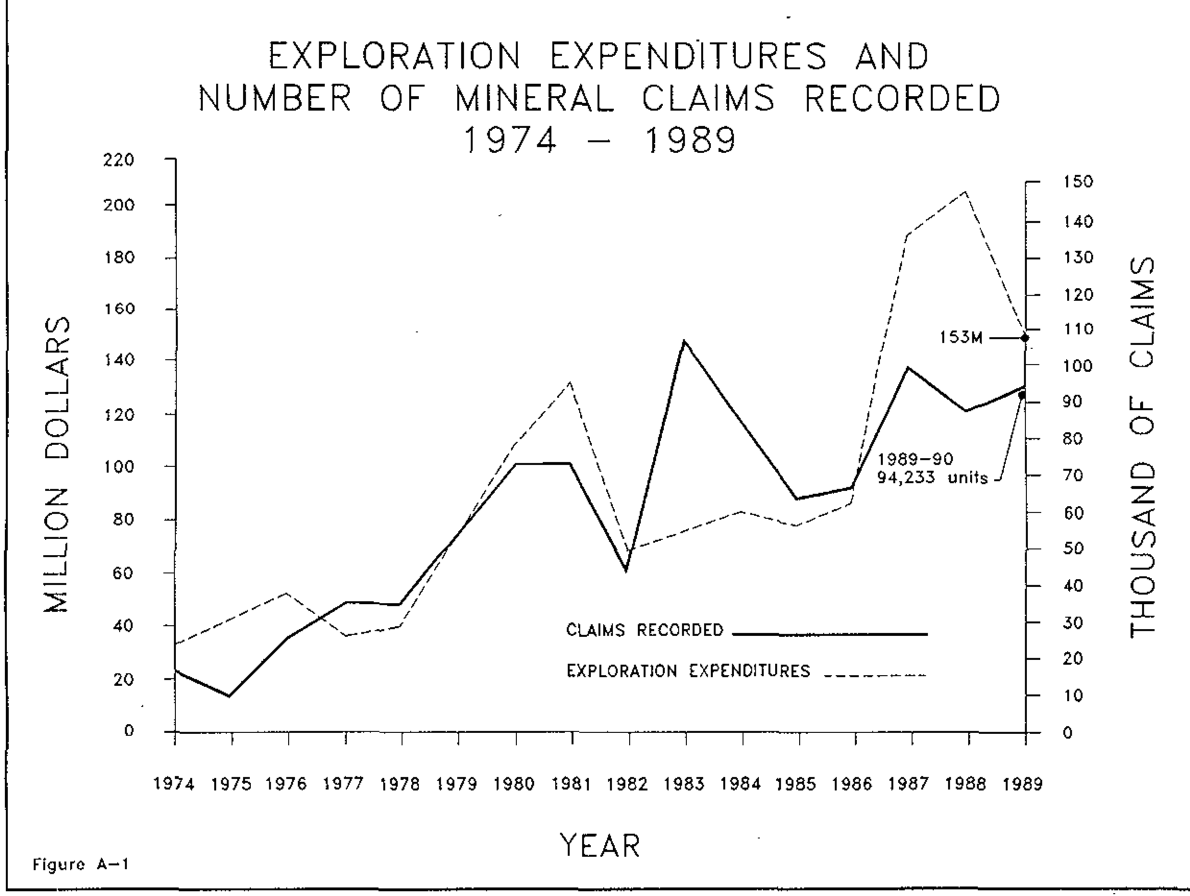


Figure A-1

after the Regional Geochemical Survey release on June 20. The busiest mining divisions were Liard, Omineca and Skeena, all good hunting grounds for base and precious metals.

Although interest in precious metals, and in the Vancouver Stock Exchange, was significantly buoyed in August by the spectacular drilling results from the **Eskay Creek** property of Calpine Resources Incorporated, the softer gold and silver prices took their toll on the number of mines that were expected to open during the year. Of the seven anticipated precious metal projects, only four have come on stream: **Lawyers**, **Samatosum**, **Silbak Premier - Big Missouri** and **Golden Bear**. **Snip** and **Spud** are still being evaluated and their development is on hold; **Tillicum Gold** was shut down indefinitely in early September. In contrast, the **Ajax** copper deposit of Afton Operating Corporation began production in July as planned, while other large base metal deposits such as **Windy Craggy**, **Mount Milligan**, **Mount Polley** and **Cirque** continued to be the object of very large surface drilling and underground exploration programs, and hold considerable promise of becoming large, company-sustaining producers.

Because of the renewed interest in base metals, exploration and development expenditures were distributed through several geologically distinct parts of the province, in contrast to 1988 when many large programs were in the rugged northwestern region and particularly in the Stewart - Iskut River - Unuk River Golden Triangle. Thus, of the major exploration plays in 1989, **Windy Craggy** (massive sulphide, Cu-Au-Co) is in the Insular Belt, **Eskay Creek** (epithermal Au-Ag) is in the Coast Belt, **Mount Milligan** and **Mount Polley** (alkalic Cu-Au porphyry) are in the Intermontane Belt, and **Cirque** (sediment-hosted Pb-Zn-Ag massive sulphide) is in the Foreland Belt.

In cooperation with several exploration companies active in the area, engineering studies to select a road corridor into the mineral-rich Iskut River and Unuk River areas have been funded by the Canada/British Columbia Mineral Development Agreement. The provincial government also removed two areas containing known mineral deposits at Lindquist Lake and Mount Alcock from Provincial Parks and established them as parts of new Recreation Areas, thereby allowing assessment of the two deposits.

As in previous years, the search for precious and base metals focused on five main geological settings which are briefly summarized below.

EPITHERMAL DEPOSITS

Classic epithermal systems in Mesozoic to Tertiary volcanic rocks continue to yield new important deposits. The **Lawyers** deposit of Cheni Gold Mines Inc., located in the Toodoggone River area 300 kilometres north of Smithers, began production early in the year (*see* Table A-1).

In late August, a spectacular intersection of 201.2 metres grading 30 grams per tonne gold from drill hole No. 109 on the Eskay Creek property of Calpine Resources Incorporated, located in the remote Unuk River area, catapulted the Vancouver Stock Exchange from a state of lethargy into a frenzy of trading which saw all records broken for volumes of shares traded at the exchange. What is known of the **Eskay Creek** deposit at this time points to a large and very rich high-level precious and base metal-bearing hydrothermal system which includes deposits that range from exhalative gold-enriched massive sulphides to high-level gold-silver epithermal systems. Mineralization is hosted partly in argillaceous sedimentary rocks of the Lower Jurassic Hazelton Group (Mount Dilworth or Betty Creek formation) and partly in a footwall sequence of felsic volcanics. Although still at an early stage of exploration because of its large size and complexity, the **Eskay Creek** 21 Zone has been calculated to contain probable geological reserves of 3.35 million tonnes grading 19.20 grams per tonne gold and 521.13 grams per tonne silver and an additional 1.68 million tonnes of possible geological reserves grading 8.57 grams per tonne gold and 281.14 grams per tonne silver. The above reserves were calculated using a 1.37 grams per tonne gold cut-off, are in good part open pittable and contain additional unspecified values of lead-gold-zinc. Although these calculated reserve estimates are considerably lower than earlier preliminary estimates, continuing favourable results from Eskay Creek indicate that this will likely become one of the most important precious metal deposits ever discovered in British Columbia

In late September, Bond Gold Canada Inc. announced significant gold-silver intersections from drilling on its Red Mountain property, located on the east side of Bromley Glacier, 15 kilometres east of Stewart. Although very little is known about the geological setting of this exciting new discovery at this time, it appears to occur in similar stratigraphy, and have other similarities to the **Eskay Creek** deposit. The **Red Mountain** discovery is the result of a land acquisition and exploration program launched by Bond Gold after optioning claims on **Willoughby Creek**, 6 kilometres to the east, from prospector Charles (Chuck) Kowall who discovered significant gold-silver mineralization in 1988 while prospecting with support from the provincially funded FAME program.

In the south-central part of the province Canadian Nickel Co. Ltd. continued drilling on its **Vault** property, a gold epithermal system in Eocene volcanic rocks, while Fairfield Minerals Ltd. and Placer Dome Inc. carried out trenching, sampling and other surface work with encouraging results on the **Elk** prospect, a quartz-sulphide vein system of possible Tertiary age, hosted in granitic rocks of the Jurassic Pennask batholith.

TABLE A-1
OPERATING MINES IN BRITISH COLUMBIA, 1989

MAP No. *Fig. 2*	MINE	OWNER	MINING DIVISION	TONNES MILLED (000's)	RATED CAPACITY (TPD)	% ANNUAL RATED CAPACITY	DEPOSIT TYPE	RESERVES/PRODUCTION
NORTHWESTERN DISTRICT								
11	Barrington River	Integrated Resources Ltd.	Liard				Placer Au	2574 m^3 mined; 3806 g Au recovered
18	Johnny Mountain (Reg)	Skyline Gold Corp.	Liard	90.93 (Jan/Oct)	270	99	Mesothermal Au-Ag-Cu Vein	Production: 1598 kg Au, 2688 kg Ag, 544 t Cu
27	Silbak Premier/Big Missouri	Westmin Mines Limited	Skeena	303.55	2000	96	Ag-Au Vein	Production: 359 kg Au, 5288 kg Ag (Jun/Oct)
46	Lawyers	Cheni Gold Mines Inc.	Omineca	151.59	500	92	Epithermal Au-Ag	Production: 1567 kg Au, 32044 kg Ag
47	Shasta	Sable Resources Ltd.	Omineca	12.25 (Oct/Dec)	180	77	Epithermal Ag-Au	Production: 30.9 kg Au, 2145 kg Ag
55	Bell	Noranda Minerals Inc.	Omineca	5500	15 400	98	Porphyry Cu-Au	Production: 18.5 kt Cu, 860 kg Au, 3149 kg Ag
69	Pine Creek	Queenstake Resources Ltd.	Atlin				Placer Au	764 554 m^3 mined; 233.1 kg fine Au recovered
70	Spruce Creek	Queenstake Resources Ltd.	Atlin				Placer Au	382 277 m^3 mined; 144.0 kg fine Au recovered
71	Golden Bear	Golden Bear Operating Co.	Atlin	1.62	360	Start-up	Replacement Au	41.19 kt mined open-pit; 3.86 kt mined u/g
72	Cassiar	Cassiar Mining Corp.	Liard	1165	3600	89	Asbestos	1.6 Mt stockpiled June '89
73	Equity Silver	Equity Silver Mines Ltd.	Omineca	3100	8500	100	Transitional Ag-Au-Cu	Production: 220 000 kg Ag, 1800 kg Au, 6300 t Cu
SOUTHWESTERN DISTRICT								
108	Myra Falls/ Lynx, H-W	Westmin Mines Ltd.	Alberni	4 000			Volcanogenic massive sulphides	Reserves (Jan. 1989): 12.1 Mt @ 2.34% Cu, 0.35% Pb, 5.19% Zn, 2.4g/t Au, 34.3 g/t Ag
109	Island Copper/ Bay, Road	BHP-Utah Mines Ltd.	Nanaimo	50 000			Porphyry	Reserves: ~ 53 Mt @ 0.48% Cu, 0.023% Mo, 0.24g/t Au
110	Quinsam	Brinco Coal Corp.	Nanaimo				Coal	Production: 200 kt thermal coal from open pit
SOUTH-CENTRAL DISTRICT								
163	Nickel Plate	Corona Corporation	Similkameen	936.4	2 903	88	Skarn Au-Ag	Reserves: 7.43 Mt @ 2.57 g/t Au
189	Copper Mountain	Similco Mines Ltd.	Similkameen	7 500	22 680	91	Porphyry Cu-Au-Ag	Reserves: proven; 36 Mt @ 0.45% Cu; probable, possible 81.6 Mt @ 0.43% Cu
190	Afton/Ajax	Afton Operating Corporation	Kamloops	2 597	7 112	100	Porphyry Cu-Au	Reserves: 23.15 Mt @ 0.46% Cu 0.34 g/t Au
191	Highland Valley Copper	Highland Valley Joint Venture	Kamloops	33 000	126 000	72	Porphyry Cu-Mo	Reserves: 736 Mt @ 0.4% Cu, 0.007% Mo
192	Samatosum	Minnova Inc.	Kamloops	102.8	454	62	Polymetallic massive sulphide	Reserves: 670.8 kt @ 834 g/t Ag 1.6 g/t Au, 1% Cu, 3% Zn, 1% Pb

193	Brenda	Brenda Mines Ltd.	Osoyoos	13 940	32 300	118	Porphyry Cu-Mo	Reserves: 7.5 Mt @ 0.17% Cu, 0.035% Mo
194	Highland Bell	Teck Corporation	Greenwood	36.3	100	100	Ag-Pb-Zn Vein	
195	Candorado	Candorado Mines Ltd.	Similkameen	97.3	0.8	0.33	Tailings recovery	Reserves: 1.3 Mt @ 1.37 g/t Au
KOOTENAY DISTRICT								
223	Fording River	Fording Coal Ltd.	Fort Steele	6 020.4	15 900	104	Coal	Production: 5.0 Mt metallurgical coal, 0.4 Mt thermal blend, 0.35 Mt thermal coal
224	Line Creek	Crows Nest Resources Ltd.	Fort Steele	2 094.9	10 400	55	Coal	Production: 1.26 Mt metallurgical coal, 0.65 Mt thermal coal, development drilling on Natal Ridge (2000 m) metallurgical coal, 80 kt thermal coal, 70 kt special blend
225	Balmer	Westar Mining Ltd.	Fort Steele	6 462.6	26 000	68	Coal	Production: 5.8 Mt metallurgical coal 75 kt thermal coal
226	Greenhills	Westar Mining Ltd.	Fort Steele	3 053.8	9 900	85	Coal	Production: 2.46 Mt metallurgical coal, 0.33 Mt thermal coal, 0.31 Mt special-blend coal
227	Coal Mountain	Byron Creek Collieries	Fort Steele	1 030.1	4 930	57	Coal	Production: 0.9 Mt thermal coal
228	Sullivan	Cominco Ltd.	Fort Steele	2 038.1	7 300	76	Sedex Zn-Pb-Ag	Reserves: 23 Mt @ 4.6% Pb, 7.1% Zn, 29 g/t Ag
229	Mt. Brussilof	Baymag Mines Ltd.	Fort Steele				Magnesite	pit development, 25 ddh
229A	Parson	Mountain Minerals Co. Ltd.	Golden	30.0			Fissue vein of barite	500 kt
230	O.B. - Skylark	Viscount Resources Ltd.	Greenwood	n/a	custom milled	n/a	Ag-Au vein	Reserves: 25.2 kt @ 687 g/t Ag, 3.1 g/t Au, closed April 89
231	Sylvester K	Kettle River Resources Ltd./ Skylark Resources Ltd.	Greenwood				Au massive sulphides	mined 8000 t
232	Silvana	Dickenson Mines Ltd.	Slocan	27.8	90	84	Ag-Pb-Zn-Cd vein	Milling rate:100 tpd; reserves: 29.1 kt @ 403 g/t Ag,4.4% Pb, 5.1% Zn 5.0% Pb, 5.8% Zn
CENTRAL DISTRICT								
270	Endako	Placer Dome Inc.	Cariboo	6900	29 600	63	Porphyry Mo	Reserves:109 Mt @ 0.081% Mo
271	Gibraltar	Gibraltar Mines Ltd.	Cariboo	13 245	38 100	75	Porphyry Cu-Mo	Reserves:185 Mt @ 0.31% Cu, 0.009% Mo Production:27 kt Cu in concentrates and 4.5 kt cathode Cu from electrowinning plant
272	Blackdome	Blackdome Mining Corp.	Clinton	80.5	200	115	Epithermal vein	Reserves:133 kt @ 20.2 g/t Au, 64.1 g/t Ag Production: 1555 Kg Au
273	Bullmoose	Bullmoose Operating Corp.	Liard	1800	6300	77	Coal	Reserves:66.5 Mt metallurgical coal Production: 1.8 Mt metallurgical coal
274	Quintette	Quintette Coal Ltd.	Liard	4200	17 260	67	Coal	Reserves: 226.8 Mt metallurgical coal 4.45 Mt thermal coal Production: 4.2 Mt metallurgical coal

• *Annual rated capacity = daily rated capacity x 365*

VOLCANOGENIC AND SEDIMENT-HOSTED MASSIVE SULPHIDE DEPOSITS

Paleozoic and Mesozoic submarine volcanic sequences continue to be intensively explored for various types of massive sulphide deposits while the strong price of zinc has renewed interest in lead-zinc-silver sediment-hosted deposits in Paleozoic sedimentary sequences. As expected, the **Samatosum** deposit of Minnova Inc. began production earlier in the year (*see* Table A-1). Although this deposit is considered by many to be a large quartz vein, its setting and stratabound nature suggest that it may have originally been a distal volcanogenic exhalative deposit that was later recrystallized.

In the rugged extreme northwest corner of the province the **Windy Craggy** deposit of Geddes Resources Ltd. was the target of $14.1 million program. This is a world class copper-gold-cobalt volcanogenic deposit with recently calculated probable and possible reserves of 118.8 million tonnes grading 1.89 per cent copper, 0.2 gram per tonne gold and 0.08 per cent cobalt at a 1 per cent copper cut off. The deposit is still open along strike and at depth, and is currently the object of engineering studies examining the feasibility of a 7 to 9 million tonne per year operation.

Also in the rugged northwestern part of the province and only 50 kilometres northeast of Juneau, Alaska, the **Tulsequah Chief** (Cu-Pb-Zn-Ag-Au) deposit of Cominco Ltd. and Redfern Resources Ltd. was the object of a $1.8 million program of underground drilling and exploration. The program is reported to have achieved its objective of increasing geologically indicated reserves beyond the 5 million tonne level.

In the northeastern part of the province, the **Cirque** sediment-hosted massive sulphide-barite deposit of Curragh Resources Inc. was the object of a $10 million advanced underground exploration program. The deposit is located 280 kilometres north of Mackenzie, the nearest railhead, and has geological reserves of 34.6 million tonnes averaging 2.1 per cent lead, 7.8 per cent zinc and 47.0 grams per tonne silver.

Triumph Resources Ltd. carried out surface exploration work, including diamond drilling, on the nearby **Mount Alcock** deposit, another sediment-hosted massive sulphide-barite deposit. In the south-central part of the province Bethlehem Resources Corporation acquired the **Goldstream** copper-zinc deposit from Noranda and is making preparations to resume production. Noranda operated the Goldstream mine from May, 1983 to April, 1984, and at shut down, left behind a mineral inventory that is calculated by Bethlehem to be 1.8 million tonnes grading 4.8 per cent copper, 2.7 per cent zinc and 20.6 grams per tonne silver, using a 3 per cent copper cutoff.

In the Adams Lake area, Homestake Mineral Development Company continued with surface exploration work at the **Kamad 7** deposit, also a former producer with reserves of 220 000 tonnes grading 7.36 grams per tonne gold, 69.2 grams per tonne silver, 7.32 per cent zinc, 6.19 per cent lead and 0.54 per cent copper. Forty kilometres to the north, Minnova Inc. completed a surface drilling program at the **Chu-Chua** volcanogenic massive sulphide deposit, under option from International Vestor Resources Inc., Pacific Cassiar Ltd. and Quinterra Resources Inc., and is considering the feasibility of an open-pit operation. Reserves are 1 043 000 tonnes grading 2.97 per cent copper and 1.0 gram per tonne gold.

On Vancouver Island ongoing exploration was successful in finding at least one more massive sulphide lens at the **Myra Falls** mine of Westmin Mines Limited, a major copper-zinc-gold-silver producer. In the Chemainus area Minnova Inc. and Laramide Resources Ltd. continued exploration at the **Lara** property where drill-indicated reserves stand at 530 000 tonnes grading 4.73 grams per tonne gold, 100.11 grams per tonne silver, 5.87 per cent zinc, 1.01 per cent copper and 1.22 per cent lead.

North of Revelstoke, Equinox Resources Ltd. continued its reassessment of the **J & L** deposit which has drill-indicated reserves of 808 000 tonnes grading 7.2 grams per tonne gold, 65.7 grams per tonne silver, 5.2 per cent zinc, 2.5 per cent lead and 4.7 per cent arsenic.

PORPHYRY DEPOSITS

Alkalic or syenitic porphyry copper-gold systems in Upper Triassic to Lower Jurassic volcanic sequences of the Intermontane Belt continue to be one of the hottest exploration targets in the province.

Near Kamloops the **Ajax** deposit of Afton Operating Corporation began production in July (*see* Table A-1). In the Quesnel trough south of Prince George the **Mount Polley** deposit of Imperial Metals Corporation and Corona Corporation is at the feasibility study stage. Estimated open-pit reserves are 48.6 million tonnes averaging 0.44 per cent copper and 0.61 gram per tonne gold. Nearby the **Q.R.** deposit of QPX Minerals Inc. is at the production decision stage with reserves of 814 000 tonnes averaging 4.5 grams of gold per tonne.

North of Prince George the Omineca region has been buzzing with activity driven by the continued success of a very large and on-going surface drilling program at the **Mount Milligan** deposit of Continental Gold Corporation and B.P. Resources Canada Ltd. To the end of 1989, in excess of $11 million had been spent on this property and a $2 million budget was recently secured for further work. A total of 96 389 metres had been drilled in 406 holes. Four diamond drills were on the property at year's end systematically testing a 15 square kilometre sulphide system and the current drilling rate was approximately 11 000 metres per month. Current preliminary calculations by Continental Gold Corporation indicate geological reserves of 265.5 million tonnes of probable ore grading 0.19 per cent copper and 0.56 grams per tonne gold for the Mount Milligan deposit, and 145.8 million tonnes of possible ore grading 0.23 per cent copper and 0.34 grams per tonne gold for the Southern Star deposit.

Current plans for Mount Milligan are to complete a bankable feasibility study by mid-1990. Production at 45 000 tonnes per day is contemplated by late 1992 to early 1993. If this is achieved, this deposit will produce 12.4 million grams (400 000 ounces) of gold and 45 000 tonnes of copper annually, thereby effectively doubling the current provincial gold production and significantly reducing the shortfall in copper production resulting from anticipated closure of a number of copper mines.

Success at **Mount Polley** and **Mount Milligan** has rekindled interest in the entire Intermontane tectonic belt, and particularly in the Omineca Belt north of Prince George. This has triggered extensive staking of any available prospective ground and the launching of several significant projects on properties such as **Tas** of Noranda Exploration Company, Limited and Black Swan Gold Mines Ltd., **Windy** of Placer Dome Inc., **Col** of Kookaburra Gold Corporation, **Cat** of B.P. Resources and Lysander Gold Corporation, and other very interesting properties, near Witch and Chuchi lakes, which are being explored by Noranda and Digger Resources Ltd.

In the rugged Unuk River – Stikine River region, work continued on the **Kerr** property of Sulphurets Gold Corporation, Placer Dome Inc. and Western Canadian Mining Corporation which has geological reserves of 60 million tonnes grading 0.86 per cent copper and 0.343 gram per tonne gold with excellent potential for expansion, while Mingold Resources Inc. carried out a major resampling program on the **Galore Creek** deposit which has been known since the 1950s to have drill-indicated reserves of 113 million tonnes grading 1.06 per cent copper, 0.445 gram per tonne gold and 8.57 grams per tonne silver. On Vancouver Island, Falconbridge Limited carried out a major resampling and drilling program at its **Catface** copper-gold property near Tofino.

TRANSITIONAL DEPOSITS

These deposits formed in a transitional setting between the classic epithermal environment and the deeper seated porphyry environment. Most of them are found in British Columbia's Golden Triangle and include one of the province's newest mines, the **Silbak-Premier** of Westmin Mines Limited, Canacord Resources Inc. and Pioneer Metals Corporation, with reserves of 7.5 million tonnes grading 2.4 grams per tonne gold and 69.60 grams per tonne silver. Some 40 kilometres to the northwest, the **Sulphurets** property of Newhawk Gold Mines Limited continued to be the target of a major underground exploration program. This property has drill-indicated reserves of 854 000 tonnes grading 11.99 grams per tonne gold and 785.12 grams per tonne silver. Another 50 kilometres farther to the northwest the **Snip** deposit of Cominco Ltd. and Prime Resources Ltd. continues to be explored on surface and underground, and has an inventory of 1.57 million tonnes grading 21.94 grams per tonne gold.

GOLD SKARNS

Although recent down-grading of reserves at the **Nickel Plate** mine of Corona Corporation and the early September closure of the **Tillicum Mountain** project of Esperanza Exploration Ltd. have cooled the interest in this type of precious metal target somewhat, interest continued in deposits of this type in the Insular and Omineca belts. South of Nelson at the **Second Relief** property, a past producer which has yielded 2.8 million grams of gold, Hawkeye Developments Ltd. intersected significant gold mineralization. In the Port McNeill area of Vancouver Island, Taywin Resources Ltd. successfully outlined areas of significant gold-copper mineralization at the **Merry Widow** mine, a former iron producer, while on Texada Island, Freeport-McMoRan Gold Company met with some success in outlining new areas of copper-gold mineralization at the **Little Billie** property, under option from Vananda Gold Ltd.; Echo Bay Mines Ltd. explored other skarn prospects at the north end of the island, optioned from Rhyolite Resources Inc.

OTHER SIGNIFICANT DEPOSITS

A number of other precious metal deposits, many of them mesothermal veins or replacements associated with major high-angle faults or thrust faults and commonly displaying listwanite alteration, are definitely highlights on the British Columbia scene.

The **Golden Bear** deposit of Golden Bear Operating Company and Homestake Mining (B.C.) Ltd., located west of Dease Lake, is British Columbia's newest gold mine with reserves of 1.63 million tonnes grading 11.0 grams per tonne gold. Mineralization at Golden Bear occurs in silicified and breccia zones along a major fault which juxtaposes Permian limestone and Upper Triassic andesites.

The **Debbie-Yellow** property of Westmin Mines Limited and Nexus Resources Ltd. located near Port Alberni on Vancouver Island has gold mineralization in veins and in extensive quartz-carbonate-pyrite alteration zones associated with major north-trending faults, as well as in a magnetite-jasper-sulphide-bearing chert with quartz-vein stockwork in a footwall basalt. Westmin completed a 2-kilometre tunnel in preparation for a major underground drilling and sampling program.

Major programs involving surface and underground drilling and sampling were carried out on a number of gold-bearing mesothermal vein systems including **Polaris Taku** of Suntac Minerals Corporation, **Erickson Gold/Cusac** of Total Energold Corporation, **Porcher Island** of Cathedral Gold Corporation, **Lindquist Lake** of Golden Knight Resources Inc., and **Dome Mountain** of Canadian United Minerals Inc. and Teeshin Resources Ltd. In the Iskut River area Gulf International Minerals Ltd. completed a major drilling program with encouraging results on its **McLymont Creek** property, a replacement deposit with skarn and porphyry affinities. In the southern part of the province Bethlehem Resources Corporation obtained encouraging results and discovered new zones of mineralized breccia on its **Giant Copper** property east of Hope. Results of this program should improve current reserves of the **AM** zone which are 2.45 million tonnes grading 1.25 per cent copper, 0.5 gram per tonne gold, and 22 grams per tonne silver. North of Nelson, Cominco Ltd. intersected significant lead-zinc mineralization on its Duncan Lake property, 2 kilometres north of the old **Duncan** mine, significantly increasing the reserve potential on this property. Near Burton, Greenstone Resources Ltd.completed an extensive drilling and mapping program at its **Millie Mac** property where gold mineralization occurs in quartz-graphite "augens" in a gently dipping graphitic fault zone.

Although coal exploration remains at a very low level and almost exclusively confined to operating mines, somewhat improved markets and a considerably improved outlook for thermal coal have prompted Crows Nest Resources Limited to shift its **Telkwa Coal** project into high gear. Current plans are to bring this large and strategically located deposit of thermal coal into production at 1.0 million tonnes of clean coal per year within two years.

OPERATING MINES

INTRODUCTION

Thirty eight mines operated in British Columbia in 1989 (*see* Table A-1) including three placer gold mines, fourteen precious metal mines, several of which also produced considerable base metals, ten base metal mines, several of which also recorded very significant precious metal production, eight coal mines, and three industrial minerals mines. Six of these are new operations and include five precious metal mines; **Lawyers**, **Premier** (Big Missouri), **Golden Bear**, **Shasta** and **Samatosum**, and one base metal mine, **Ajax**.

Operating mines ranged in throughput from less than 100 tonnes per day for some small precious metal mines to 126,000 tonnes per day for the Highland Valley Copper complex, and collectively contributed to a total mineral production for 1989 that is estimated at $3.218 billion, including $1.040 billion for coal. In the metal sector, the most valuable product was copper at $1.005 billion, followed by zinc at $264 million and gold at $228 million.

Looking ahead at 1990 (*see* Table A-2) three small new precious metals operations are expected to open: Goldwedge, Golden Crown and Canty, which will ship its relatively high-grade ore to the nearby Nickel Plate mill. In addition, the Snip project is expected to receive approval in principle early in 1990 and might begin production later in the year.

Looking beyond 1990, the Mount Polley copper-gold project of Imperial Metals and Corona Corporation, and the Q.R. gold deposit of QPX Minerals and Placer Dome are anticipated to begin production in 1991. Other possible new producers beyond 1990 are the Cirque lead-zinc-silver deposit of Curragh Resources, the Mount Milligan copper-gold deposit of Continental Gold and B.P. Resources, and the Windy Craggy copper-gold-cobalt deposit of Geddes Resources. These deposits and others such as Eskay Creek and Sulphurets, are still at the exploration or early development stage of assessment, and their likelihood of becoming producers still depends on the outcome of feasibility studies which are either in progress or have not yet been commissioned.

On the negative side of the ledger, operations at Brenda Mines Ltd. are expected to terminate in mid-1990 due to depleted ore reserves, while on January 31, 1990 the sudden closure of the Sullivan mine which had been continuous operation since 1909 brought sharply into focus the vulnerability of some of our major producers to fluctuating metal prices.

NORTHWESTERN DISTRICT

A total of eight mines operated in the Northwestern District during 1989 (Figure A-5). Collectively they employed more than 1050 workers and played a very important economic role. The base metal open-pit mines enjoyed continuing high prices for copper; however, the gold mines suffered from falling gold prices for most of the year.

Construction at the Golden Bear project (71) (*see* Plate A-1) was put on hold in late 1988 pending re-evaluation, because costs were higher than originally anticipated. In particular the 150-kilometre access road cost $17 million, almost twice the original estimate. In April, Chevron Canada Resources Ltd. and Homestake Mineral Development Company decided to proceed with mine construction. Open-pit mining started in the summer with some underground mining in the fall and enough ore was stockpiled to run the plant through the winter. Utilizing the latest technology, the plant uses dry grinding, fluidized-bed roasting and carbon-in-pulp leaching to recover the gold. At the end of the year the 360 tonne per day facility was in the start-up phase.

The Erickson gold mine (9) remained closed for the entire year although a very aggressive exploration program was completed. Drifting on the adit being driven to access the Michelle zone was stopped approximately half way to its target.

At Cassiar Asbestos (72) open-pit mining continued until June 1, 1989 when the danger of a potential pit-wall failure halted the mining operation. The pit still contains approximately 54 000 tonnes of ore which may be recovered in 1990. Cassiar stockpiled 1.6 million tonnes of ore as of June, to ensure sufficient feed for the mill until the McDame deposit starts to produce.

The Johnny Mountain mine (18) completed its first full year of operation with an output of 794 690 tonnes of ore grading 18.9 grams gold per tonne. The mill was simplified with the elimination of the cyanide circuit; the gold is now being recovered by both a gravity circuit and in a copper concentrate containing byproduct silver. Current throughput in the mill is 308 tonnes per day. Most of the production has come from the No. 16 vein with the reserves now extended to the 700 level.

The Premier Gold mine opened in May, 1989. Open-pit mining of low-grade deposits on the Silbak Premier and Big Missouri properties supplied the mill with ore. The mill initially operated with 234 894 tonnes of low-grade development-ore mined in 1988 from the Dago and Silbak Premier pits. As of the end of September, 159 899 tonnes of ore and 2.57 million tonnes of waste have been mined from the Premier, Dago and S-1 pits. The first doré bar was poured in early June. The mill approached its 2000 tonne per day capacity in October with a total of 59 660 tonnes processed at an average grade of 2.48 grams gold per tonne.

In the Toodoggone camp the Lawyers mine (46) overcame start up problems caused by bitterly cold weather in December and January and followed by labour unrest. All production was from the AGB zone. A total of 151 590 tonnes with an average grade of 10.42 grams gold and 241.4 grams silver per tonne was milled at a rate of 460 tonnes per day. Initial development work was started on the Cliff Creek zone and late in the year Cheni Gold Mines Inc. entered into agreement with Energex Minerals Ltd. to obtain the rights to mine several deposits on the Al property.

Sable Resources Ltd. started open-pit mining in the summer on the Creek and JM zones of the Shasta property (47). There had been no previous production from this property although several companies, including Newmont Exploration of Canada Ltd., Esso Minerals Canada and Homestake Mineral Development Company have completed extensive drill programs on the claims. A total of 36 300 tonnes was mined and stockpiled. The mill at the old Baker mine has been leased from Dupont of Canada Inc. and operated at the rate of 139 tonnes per day from September 27 to December 31, 1989 for a total of 12 247 tonnes. The ore averaged 8.91 grams gold and 34 grams silver per tonne milled.

Bell mine (55) on Babine Lake maintained its production levels at approximately 15 000 tons per day with an average grade of 0.41 per cent copper and 0.240 gram gold per tonne. The current pit has an anticipated life extending to 1992; a major exploration drilling program was completed around the pit and on the property looking for new ore reserves.

Southeast of Houston the Equity Silver mine (73) started mining from the Waterline zone, although the bulk of production came from the Main zone. Production levels were similar to 1988 with a daily mill throughput of 8 500 tonnes grading 113 grams per tonne silver, 1 gram per tonne gold and 0.3 per cent copper.

Central District

The five operating mines in the district continued production at close to previous year's levels (*see* Table A-1).

At the Endako mine (270) Endako Mines Division of Placer Dome Inc. continued work on the ultimate pit design.

At Gibraltar mine (271) the electrowinning plant continued to produce cathode copper at capacity, and another dump is to be prepared for leaching. Gibraltar Mines Ltd. began a recalculation of the ore reserves, prompted by the improved prices and outlook for copper.

Blackdome Mining Corporation produced more than 50 000 ounces of gold from the Blackdome mine (272), with ore coming mainly from the southern part of the No. 1 and No. 2 veins. A small tonnage of ore was also recovered from some narrower veins. A program of 2800 metres of decline and drifting from the 1870 level was completed to allow testing of deeper levels of the No. 1 and No. 2 vein systems.

In the northeast coalfield, Bullmoose Operating Corporation produced 1.8 million tonnes of clean coal from the Bullmoose mine (273), and Quintette Coal Ltd.produced 4.2 million tonnes of clean coal from the Quintette mine (274).

KOOTENAY DISTRICT

At the Silvana mine (232) efforts to access the old Carnation workings at different levels were only partly successful. Surface exploration this year was minimal. Underground development involved mostly drifting and clean-up following the change in ownership from Dickenson Mines Ltd. to Treminco Resources Ltd. Underground drilling at the beginning of the year totalled 3700 metres. Development drilling to the west (faulted extension) was not successful. Present reserves stand at about 29 100 tonnes at about 403 grams per tonne silver, 4 per cent lead and 5 per cent zinc.

In the Crowsnest coalfield Coal Mountain mine (227) underwent a significant expansion and increased output by 0.7 million tonne to 1.6 million tonnes with an approximate doubling of employment. At the Balmer operations (225) of Westar Mining Ltd. development drilling was conducted on Natal Ridge and the Baldy North pit came on stream. At Westar's Greenhills operations (226) 12 000 metres of reverse-circulation drilling were completed to help define coal structure and quality for the current short-range mine plan. At Fording Coal the main effort was consolidation of mining at Eagle Mountain (223).

At Mount Brussilof mine (229) 25 short diamond-drill holes were completed in peripheral areas of the pit. High-grade magnesite was confirmed in the north part of the pit, but not in the south.

SOUTH-CENTRAL DISTRICT

Mine production in south-central British Columbia during 1989 was affected by labour problems and a temporary slump in gold prices. However, a strong base metal market proved to be the industry's main strength. Two new mines were opened to improve the district's long-term outlook and provide continued incentive and support for a stable exploration environment.

Production at the Highland Valley Copper joint venture (191) totalled approximately 33 million tonnes grading 0.43 per cent copper and 0.01 per cent molybdenum, at an average milling rate of 126 000 tonnes per day. Operations were interupted by a 15-week strike from July 6 to October 21. Earlier in the year the Bethlehem mill was permanently shut down and the HVC milling complex was upgraded by the relocation of the two Highmont mills, bringing the design capacity of the operation to 131 000 tonnes per day.

Minnova's Samatosum mine (192) began full production on July 1 at 454 tonnes per day. Capital costs for construction and development amounted to $30.3 million. As of July 31 diluted reserves were 766 682 tonnes grading 833 grams per tonne silver, 1.6 grams per tonne gold, 1.1 per cent copper, 1.4 per cent lead and 3.0 per cent zinc. Operations are initially planned for a 5-year mine life, with 65 per cent of production from a two-phase pit at an 18.4:1 stripping ratio. The remainder of the ore is to be mined from underground.

Operations at Afton Operating Corporation's Ajax mine (190) began in mid-July following capital and development expenditures of $12 million. The deposit occurs in two zones and will be mined from the East and West pits. Initial reserves for the deposit were reported at 24.7 million tonnes grading 0.46 per cent copper and 0.343 gram per tonne gold. Production for the Afton operation during 1989 was approximately 7500 tonnes per day and totalled 2.6 million tonnes, grading 0.42 per cent copper and 0.21 gram per tonne gold. Approximately 1.28 million tonnes came from the Crescent orebody, which was completely mined out during the year.

The Similco Mines Ltd. Copper Mountain mine (189)operated throughout 1989 at a milling rate of 22 680 tonnes per day. Production for the year totalled 7.5 million tonnes grading 0.449 per cent copper. Current reserves are reported as : proven: 36.3 million tonnes grading 0.454 per cent copper; probable: 27.2 million tonnes grading 0.48 per cent copper and possible: 54.4 million tonnes grading 0.40 per cent copper.

At the Nickel Plate mine (163), Corona Corporation maintained production at 2900 tonnes per day for a total 1989 production of 936 396 tonnes grading 2.88 grams per tonne gold. Current reserves are estimated to be 7.43 million tonnes grading 2.57 grams per tonne gold. Lower than anticipated ore grades have resulted in higher stripping ratios and the recovery process has required higher cyanide and hydrogen peroxide consumption. The company has submitted plans to the Mine Development Steering Committee to place the Canty deposit (166), into production. Reserves for that deposit are 435 000 tonnes grading 3.4 grams per tonne gold, with a 7:1 stripping ratio.

Brenda Mines Ltd. (193) operated throughout the year milling 13.94 million tonnes of ore grading 0.170 per cent copper and 0.035 per cent molybdenum at a milling rate of 32 300 tonnes per day. The mine is scheduled to close in mid-1990.

Teck Corporation's Highland Bell mine (194) at Beaverdell milled 36 300 tonnes grading 308.5 grams per tonne silver, 0.103 gram per tonne gold and approximately 1 per cent combined lead-zinc.

At Hedley, Candorado Mines Ltd. began gold production from its tailings recovery operation (195). The company expected to produce 85 700 grams of gold in 1989 from its first leach pad. Four additional pads are planned for 1990. Reserves are reported to be 1.3 million tonnes grading 1.37 grams per tonne gold. Gold recoveries are approximately 62 per cent or 0.85 gram per tonne.

SOUTHWESTERN DISTRICT

There are currently three producing mines in the Southwest District and no new mines under development. There are also three producing limestone quarries on Texada Island and a few claystone and marl producers on Vancouver Island and in the Fraser Valley.

At Myra Falls (108) on Vancouver Island, Westmin Mines Limited continued in full production from the H-W and Lynx mines at a milling rate of approximately 4000 tonnes per day. Published reserves at the start of 1989, totalling all categories in all orebodies, were 12.1 million tonnes averaging 2.34 per cent copper, 0.35 per cent lead, 5.19 per cent zinc, 2.4 grams per tonne gold and 34.3 grams per tonne silver. Exploration drifting and underground drilling continued in various areas on the property with a 1989 exploration budget of $6.5 million. The current accelerated exploration program has resulted in the intersection of significant thicknesses of massive sulphide mineralization at the H-W horizon 300 metres below the Lynx workings. Exploration drifting to allow evaluation of this new discovery is now in progress.

BHP-Utah Mines Ltd. continued to mine and mill ore at a rate of approximately 50 000 tonnes per day from the Island Copper orebody (109) at Rupert Inlet near Port Hardy. An impermeable slurry wall has been completed as a first step in pushing back the south pit-wall toward Rupert Inlet, thereby adding about four additional years to the mine life. Current recoverable reserves, including those to be accessed by the south-wall push back, are estimated at about 53 million tonnes grading 0.48 per cent copper, 0.023 per cent molybdenum and 0.24 gram per tonne gold. These reserves will be exhausted by the late 1990s but the company is continuing an aggressive and systematic exploration program to firm up additional reserves on the mine property. The 1989 program included 36 diamond-drill holes, totalling 8621 metres, distributed among several zones.

At Middle Quinsam Lake near Campbell River, Brinco Coal Corporation operates the Quinsam open-pit coal mine (110). Total thermal coal production in 1989 is estimated at about 200 000 tonnes. Planning is currently underway to begin underground production during 1990.

SUMMARY AND A LOOK AT 1990

In summary, 1989 produced exciting new discoveries and developments which hold great promise for the future of mining in British Columbia. Four new precious metals mines began production. While **Eskay Creek** is still under assessment, it is undoubtedly a very significant discovery which produced one of the most spectacular gold-silver intersections ever drilled in the province.

On the base metal scene **Mount Milligan, Mount Polley, Windy Craggy** and **Cirque** all made very significant progress towards development and hold considerable promise of becoming large, company-sustaining producers.

Although exploration expenditures decreased by roughly one third from the 1988 record of $206 million, a firming of the price of gold and the outlook for continuing strong base metal prices should mean that exploration in 1990 will continue at least at current levels. Continued interest in base and precious metals will ensure that the search for a variety of mineral deposit types will continue strong throughout the province. The resurgence of base metal exploration will ensure that existing or anticipated road access will be an important factor in the choice of areas to explore while the considerable successes of 1988 will continue to attract exploration for precious metals in more remote areas.

TABLE A-2
MINE DEVELOPMENT REVIEW PROCESS (MDRP) PROJECTS IN REVIEW, DECEMBER, 1989

Prospectus STAGE

PROJECT/COMPANY DEVELOPMENT REGION	COMMODITY/PRODUCTION RATE*/MINE LIFE	EMPLOYMENT (CONSTRUCTION/ OPERATION)/COMMUNITY	DEVELOPMENT SCHEDULE (STAGE/AIP**/PRODUCTION)
Crystal Peak/Polestar Exploration Inc. Thompson-Okanagan	Garnet 100 - 200 stpd for 20 yrs	Total: 6 Apex Village, Penticton	Prospectus - Sept 1989 Review on-going

STAGE I (or equivalent)

PROJECT/COMPANY DEVELOPMENT REGION	COMMODITY/PRODUCTION RATE*/MINE LIFE	EMPLOYMENT (CONSTRUCTION/ OPERATION)/COMMUNITY	DEVELOPMENT SCHEDULE (STAGE/AIP**/PRODUCTION)
Canty (Nickel Plate Extension)/Corona Corp., Golden North Resource Corp. Thompson - Okanagan	Au 907 tpd for 15 months	Existing employment Penticton	Focused Stage I - Nov 1989 Review on-going Prod. - 1990
Cirque/Curragh Resources Inc. Northeast	Pb, Zn, Ag 3500 tpd for 16+ yrs	Constr: 200 Op: 250 Fort St. John, Mackenzie, Prince George	Stage I - Spring 1990 Prod. - 1991
Equinox (J&L)/Equinox Resources Ltd., Pan American Minerals Corp. Thompson-Okanagan	Au, Ag, Pb, Zn 350 tpd for 10 yrs	Constr: 50 person yrs Op: 80 - 90 Revelstoke	Stage I - 1990 Prod. - 1991
Golden Crown/ Attwood Gold Corp. Kootenay	Au, Cu 200 stpd for 2 yrs	Op: 20-30 Grand Forks	Stage I - Early 1990 Prod. - 1990
Goldwedge/ Catear Resources Ltd. North Coast	Au, Ag 181 tpd for 6-10 yrs	Constr: 50 Op: 30 Campsite, Stewart	Stage I - July 1989 Review on-going Prod. - 1990
Mount Polley/Imperial Metals Corp., Corona Corp. Cariboo	Cu, Au 13 600 tpd for 10 yrs min	Constr: 250 person yrs Op: 250 Williams Lake	Stage I - Early 1990 Prod. - 1991
Quesnel River/QPX Minerals Inc., Placer Dome Inc. Cariboo	Au 400 tpd for 7 yrs	Constr: 42 Op: 28 Quesnel	Stage I - July 1989 Review on-going Prod. - 1991
Snip/Cominco Ltd., Prime Resources Corp. North Coast	Au, Ag 300 tpd for 13 yrs min	Constr: 120 Op: 165 Smithers, Vancouver	Stage I - Sept 1988 Review on-going Prod. - 1990
Spud/McAdam Resources Inc. Island-Coast	Au 90 - 185 tpd for 3 - 4 yrs	Constr: 15 - 20 Op: 20 - 25 Zeballos	Pilot plant - Fall 1989 Stage I - pending
Windy Craggy/ Geddes Resources Ltd. Nechako	Cu, Co, Au, Ag 15 000-25 000 tpd for 30+ yrs	Constr: 2000 person yrs Op: 600 Whitehorse	Access Assessment - In progress Stage I - Jan 1990

PROJECT/COMPANY DEVELOPMENT REGION	COMMODITY/PRODUCTION RATE*/MINE LIFE	EMPLOYMENT (CONSTRUCTION/ OPERATION)/COMMUNITY	DEVELOPMENT SCHEDULE (STAGE/AIP**/PRODUCTION)
Cinola/City Resources Canada Ltd. North Coast	Au, Ag 3500-6000 tpd for 9-15 yrs	Constr: 225 Op: 190 Port Clements, Skidegate, Massett	Stage II - June 1988 Review on-going
Hellroaring Feldspar/ Lumberton Mines Ltd. Kootenay	Feldspar 50 000 t bulk sample	Cranbrook, Kimberley	Stage III Permitting Kootenay Mine Development Review Committee review
Mount Klappan/Gulf Canada Resources Ltd. Nechako	Anthracite coal 1.5 million tpy for 20 yrs	Constr: 975 Op: 750 Stewart, Dease Lake, Terrace, Smithers	Stage II - Apr 1987 AIP - Uncertain Prod. - Uncertain
Nanaimo Coal/ G. Hoberstorfer Island-Coast	Thermal coal 365 000 - 450 000 tpy for 5 yrs	Total: 70 Nanaimo	Stage III Permitting Vancouver Island Mine Development Review Committee review
Shasta/Baker Gold, Sable Resources Ltd., International Shasta Resources Ltd. Northeast	Au 180 tpd for 2-3 yrs Reactivation of old mill	Op: 26 Smithers, Terrace	Prospectus - July 1989 AIP - Nov 1989
Silbak Premier Province Zone/ Westmin Resources Ltd. North Coast	Au, Ag 252 000 t total for 2 yrs Feed for existing mill	Existing employment Stewart	Stage II - Aug 1989 Prod. - 1991
Twin Lakes/ Brenna Resources Thompson-Okanagan	Au 200 000+ st total Reclamation of old gold tailings	Oliver, Okanagan Falls	Stage III - Permitting South Central Mine Development Review Committee review

* *Metric tonnes per day (tpd)*
Short tons per day (stpd)
** *Approval-In-Principle (AIP)*

SOURCE: Engineering and Inspection Branch, 01/01/90

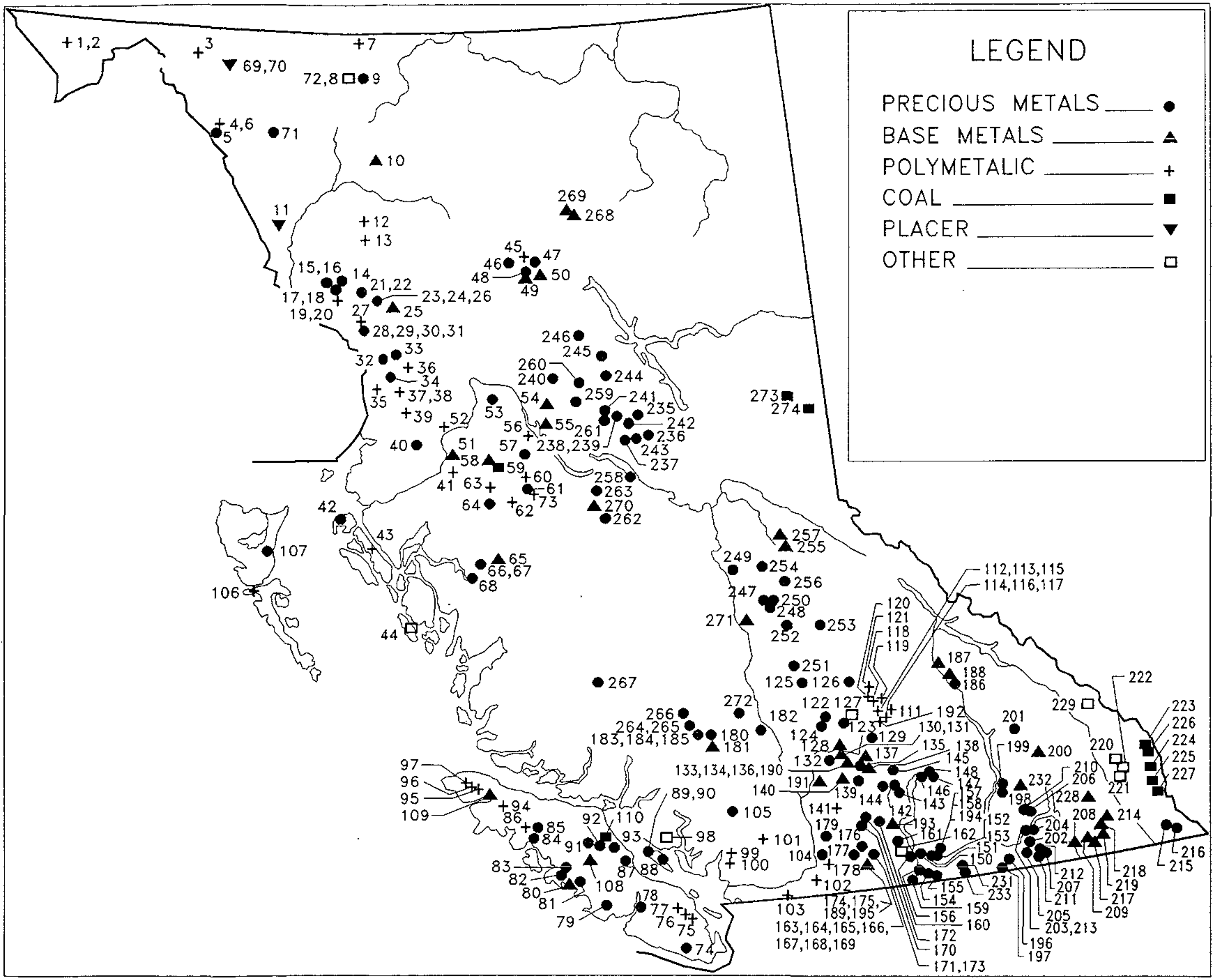


Figure A-2. Location of Active Properties in British Columbia during 1990. Numbers are keyed to Table A-3 and text.

NOTES

TABLE A-3
ACTIVE EXPLORATION PROPERTIES IN BRITISH COLUMBIA, 1989

MAP No.	PROPERTY/ (OWNER/OPERATOR)	MINFILE No.	MINING DIVISION	NTS	COMMODITY	DEPOSIT TYPE	WORK DONE
NORTHWESTERN DISTRICT							
1	Windy Craggy (Geddes Resources)	114P 002	Atlin	114P/12E	Cu, Co, Au, Ag, Zn	Volcanogenic massive sulphide	1362 m drifting; 700 m surface ddh; 23 500 m u/g ddh; bulk sampling
2	Rime (East Arm) (Bond Gold Canada)	114P 061	Atlin	114P/12E	Au, Ag, Cu Pb, Zn, Co	Volcanogenic massive sulphide	4 ddh, 1054 m; mag; UTEM
3	Teepee (Auspex Gold/Cyprus Gold)	104M 048	Atlin	104M/10E	Au, Ag, Pb Zn,	Vein	13 ddh, 1371 m; rock and soil geochem; VLF-EM; CEM
4	Tulsequah Chief (Redfern Resources/ Cominco)	104K 002	Atlin	104K/12E	Ag, Au, Pb Zn,Cu	Volcanogenic massive sulphide	174 m drifting; 10 u/g ddh, 4880 m
5	Polaris Taku (Rembrandt Gold Mines/ Suntac Minerals)	104K 003	Atlin	104K/12E	Au, Ag, Cu Sb	Vein	20 ddh 4575 m; geochem; u/g rehabilitation
6	Banker (Silver Talon Mines/ Sunport Metals)	104K 007	Atlin	104K/12E	Ag, Au, Pb Zn, Cu	Vein	5 ddh, 915 m
7	Midway (Regional Resources/ Strathcona Mineral Services)	104O 038	Liard	104O/16W	Ag, Pb, Zn Au, Sn, Cu	Manto	pumped out old workings; rehabilitated camp facilities
8	McDame (Cassiar Mining)	104P 084	Liard	104P/05E	Asbestos	Ultramafic	drift rehabilitation; 13 u/g ddh, 2480 m
9	Erickson (Total Energold/ Erickson Gold Mining)	104P 029	Liard	104P/04E	Au	Mesothermal vein	37 ddh, 4060 m; 1375 m drifting; VLF; mag
10	Gnat Pass (June-Stikine) (Integrated Resources)	104I 001	Liard	104I/05W	Cu, Au	Porphyry	8 ddh, 915 m; trenching
11	Barrington River (W. Eberg/Integrated Resources)	104G 008	Liard	104G/12W	Au	Placer	2574 m^3 gravel moved; 5 rdh, 140 m
12	Spectrum (Calnor Resources/Cominco)	104G 036	Liard	104G/09W	Au, Ag, Cu Pb, Zn	Vein	10 ddh, 1198 m; mapping
13	Hank (Lac Minerals)	104G107	Liard	104G/01W	Au, Ag, Zn Pb, Cu	Vein	11 ddh
14	McLymont (Gulf International Minerals)	104B 281	Liard	104B/15	Au, Cu, Ag	Replacement	ddh, 7165 m; mapping; VLF; mag

15	Iskut (Golden Band Resources, American Ore/Prime Resources)	104B 356	Liard	104B/11E	Au		10 ddh
16	Iskut River (Hughes-Lang)	104B 076	Liard	104B/11	Au, Cu, Mo	Porphyry ? vein?	33 ddh, 3136 m
17	Snip (Prime Resources/Cominco)	104B 250	Liard	104B/11E	Au	Mesothermal vein	489 ddh, 29 368 m; 2200 m drifting
18	Johnny Mountain (Reg) (Skyline Explorations)	104B 107	Liard	104B/11E	Au, Ag, Cu	Mesothermal vein	128 ddh, 16 460 m, surface; VLF; mag; EM; mapping; drift decline to 1035 m
19	Bronson Creek (Ecstall Mining/Cathedral Gold)	104B 131	Liard	104B/10W	Au, Ag, Pb Zn, Cu	Vein	26 ddh, 3245 m; soil geochem; UTEM; airborne mag, EM
20	Inel (Inel Resources)	104B 113	Liard	104B/10W	Au, Ag, Cu Pb, Zn	Vein	ddh, 7112 m surface; 1487 m u/g; 131 m drifting; VLF; mag; UTEM; mapping
21	Eskay Creek (Calpine Resources, Cons. Stikine Silver/Prime Explorations)	104B 008	Skeena	104B/09W	Au, Ag	Epithermal? massive sulphide	180 ddh, 11 278 m; mapping; VLF; IP; mag; airborne geophysics; soil geochem
22	Sib (American Fibre)		Skeena	104B/09W	Au, Ag, Pb Zn, Cu	Epithermal vein	13 ddh, 1830 m; geochem; IP; airborne geophysics
23	Goldwedge (Catear Resources)	104B 105	Skeena	104B/08E	Ag, Au	Vein	27 m drifting
24	Sulphurets (Granduc Mines/ Newhawk Gold Mines)	104B 193	Skeena	104B/08E	Ag, Au	Vein	79 ddh, 4094 m surface; 10 090 m u/g; 287 m drifting; 1061 m decline; 234 m raising; surface mapping; 408 m rocksaw trenching
25	Kerr (Placer Dome acquisition from/ Western Canadian Mining)	104B 191	Skeena	104B/08	Cu, Au	Porphyry	20 ddh, 4365 m; IP; mapping
26	Treaty Creek (Teuton Resources/ Orequest Consultants)	104B 078	Skeena	104B/09	Au, Ag	Vein	11 ddh, 1183 m; airborne mag, EM; silt, soil, rock geochem
27	Korri-Hill (Hi Ho) (J.B. Hill)	104B 140	Skeena	104B/01E	Ag, Pb, Au Cu, Zn	Vein	Headframe and hoist installed
28	Big Missouri (Premier Gold Joint Venture/ Westmin Mines)	104B 046	Skeena	104B/01	Ag, Au	Vein	15 ddh, 1758 m
29	Silver Butte (Tenajon Resources)	104B 150	Skeena	104B/01	Ag, Au	Vein	13 ddh, 1329 m u/g; 90 m drifting; 15 ddh, 2827 m surface; soil geochem; trenching; mapping
30	Indian (Caltech Data/Westmin Mines)	104B 031	Skeena	104B/01	Ag, Au, Pb Zn	Vein	17 ddh, 1593 m
31	Silbak Premier (Premier Gold Joint Venture/Westmin Mines	104B 054	Skeena	104B/01E	Ag, Au, Pb Zn, Cu	Vein	44 ddh, 3390 m

32	Red Mountain (Bond Gold Canada)		Skeena	103P/14W	Au, Ag		27 ddh, 4730 m; mapping; trenching; airborne geophysics
33	Willoughby Creek (Bond Gold Canada)		Skeena	103P/14E	Au, Ag		14 ddh, 1709 m; airborne geophysics
34	Homestake (Caulfield Resources, On Wah Resources, NDU Resources/ Noranda Exploration)	103P 216	Skeena	103P/13E	Au, Ag, Cu	Vein	2 ddh, 1450 m; rock and soil geochem; mag; IP
35	Georgia River (Cannon Resources/Avatar Resources)	103O 013	Skeena	103O/16W	Au, Ag, Pb Zn, Cu	Vein	8 ddh, 1525 m
36	Kits (Oliver Gold, Aber Resources/ Keewatin Engineering)	103P 245	Skeena	103P/14W	Ag, Pb, Zn Zn, Cu	Stratiform? massive sulphide,	5 ddh, 1000 m; silt, soil, rock geochem
37	Red Point (Dolly Varden Minerals)	103P 196	Skeena	103P/12E	Ag, Au, Cu Pb, Zn		25 ddh, 2260 m; soil geochem; mapping; trenching
38	North Star (Dolly Varden Minerals)	103P 189	Skeena	103P/12W	Ag, Au, Cu Pb, Zn	Massive sulphide	6 ddh, 2400 m; mapping
39	Illiance River (Monarch) (Great Northwest Resources)	103P 015	Skeena	103P/11E	Ag, Cu, Pb	Vein Zn	7 ddh, 685 m
40	Dick, Kit (Longreach Resources/ J. Paul Stevenson)	103I 215	Skeena	103I/14E	Au, Ag, Cu	Vein	3 ddh, 200 m
41	Lucky B (C. Watson)	103I 136	Skeena	103I/09W	Au, Ag, Cu W, Pb, Zn	Vein	46 m u/g rehabilitation; soil geochem
42	Porcher Island (Cathedral Gold)	103J 017	Skeena	103J/02E	Au, Ag, Cu	Vein	110 m raising; 100 m sub level drifting
43	Trinity-Gren (Fair Harbour Mining)	103H 066	Skeena	103H/12W	Cu, Zn, Pb Ag, Au	Massive sulphide	6 ddh, 450 m
44	Laredo Limestone	103A 001	Skeena	103A/11E	Limestone		11 ddh, 305 m; chip sampling
45	Moosehorn (Cassidy Resources, Imperial Metals/Cyprus Gold)	094E 086	Omineca	094E/06E	Ag, Au, Pb Zn, Ba	Epithermal	6 ddh, 745 m; mag
46	Lawyers (Cheni) (Cheni Gold Mines)	094E 066	Omineca	094E/06E	Ag, Au	Epithermal	100 m drifting; 915 m u/g drilling
47	Shasta (Homestake Mining (Canada)/ International Shasta Resources)	094E 050	Omineca	094E/02	Au, Ag	Epithermal	64 ddh, 5985 m; trenching
48	Grace (Asitka Resources/ Skylark Resources)		Omineca	094E/02	Au, Ag	Epithermal	92 pdh, 1975 m; geochem; prospecting
49	New Kemess (El Condor Resources/ D. Copeland)		Omineca	094E/02	Au, Cu	Porphyry	5 ddh, 782 m; IP; mag; VLF-EM; trenching; soil geochem; mapping
50	Mess (Western Premium Resources/Inco)		Omineca	094E/02E	Ag, Pb, Cu		7 ddh, 366 m
51	Usk (W.H. McRae, F. Loutitt/Falcon Drilling)	103I 183	Omineca	103I/09W	Cu		drilled

52	Morningstar (C. Carlson, J. Leblanc/ Equity Silver Mines)	103P 034	Omineca	103P/01E	Au, Ag, Pb Zn, As	Vein	4 ddh, 543 m
53	Rocher Déboulé (Canamin Resources/Southern Gold Resources)	093M 071	Omineca	093M/04E	Cu, Au, Ag	Vein	u/g rehabilitation; trenching
54	Hearne Hill (D. Chapman, P. Bland/ Noranda Exploration)		Omineca	093M/01E	Cu	Porphyry	6 ddh, 500 m; trenching; road; geochem
55	Bell mine (Noranda Minerals)	093M 001	Omineca	093M/01E	Cu, Au, Ag	Porphyry	ddh, 16460 m
56	Fireweed (Canadian-United Minerals)	093M 151	Omineca	093M/01W	Ag, Pb, Zn	Replacement? conformable mass. sulphide?	28 ddh, 5486 m; IP
57	Dome Mountain (Canadian-United Minerals/ Teeshin Resources)	093L 022	Omineca	093L/10, 15E	Au, Ag, Pb Zn	Vein	20 ddh; trenching; IP
58	Louise Lake (L. Warren, E. Shaede/Corona)	093L 079	Omineca	093L/13E	Cu, Mo, Au	Porphyry	5 ddh, 916 m
59	Telkwa Coal (Shell Canada/Crows Nest Resources)	093L 152	Omineca	093L/11E	Coal		18 rcd, 1486 m; 13 ddh, 1020 m; 4 (15 cm) ddh 262 m; resistivity
60	HD (J. Moll, D. & G. Merkley/ Equity Silver Mines)	093L 203	Omineca	093L/07E	Zn, Pb, Cu Ag, Au	Vein	6 ddh, 776 m
61	Bob Creek (Royal Star Resources/ Noramco Explorations)	093L 009	Omineca	093L/07	Au, Ag, Zn	Transitional	8 ddh, 1981 m; IP; mapping
62	Silver Queen (Pacific Houston Resources)	093L 002	Omineca	093L/02	Ag, Au, Pb Zn, Ga, Ge	Vein	945 m u/g ddh; 107 m drifting; surface mapping
63	Hagas (Progold Resources)	093L 221	Omineca	093L/03E	Cu, Ag, Pb Zn		4 ddh, 950 m
64	Hill (Swift Minerals)		Omineca	093E/14	Cu, Au	Porphyry	drilling
65	Ox (International Damascus/Granges)	093E 101	Omineca	093/11E	Ag, Pb, Zn	Shear, vein	8 ddh, 750 m
66	Wing (Equity Silver Mines)		Omineca	093E/11	Ag, Au		6 ddh, 485 m
67	Kate (Equity Silver Mines)		Omineca	093E/11	Ag, Au		4 ddh, 458 m
68	Deerhorn (Lindquist Lake) (Golden Knight Resources/ Teck Explorations)	093E 020	Omineca	093E/06W	Au, Ag, Cu W	Vein	2253 m surface ddh; u/g rehabilitation mapping; geochem; mag

SOUTHWESTERN DISTRICT

74	Valentine Mountain/Blaze (Beau Pré Explorations/ Noranda Exploration)	092B 108	Victoria	92B/12W	Au	Veins	5 ddh; mapping; geophys; geochem; trenching

75	Mount Sicker/Lenora, Tyee, Richard III, Copper Canyon (Minnova, Wind River Resources/Minnova)	092B 001, 2, 3, 4, 86, 89, 99	Victoria	92B/13E, 13W	Au, Ag, Cu, Pb, Zn	Volcanogenic massive sulphide	16 ddh, 3148 m; mapping
76	Lara/Coronation (Laramide Resources/ Minnova)	092B 110	Victoria	92B/13W	Au, Ag, Zn, Cu, Pb	Volcanogenic massive sulphide	44 ddh, 4253 m; geophys; mapping
77	Chemainus/Anita, Pauper (Falconbridge)	092B 037, 40	Victoria	92B/13W 92C/16E	Au, Ag, Zn, Cu, Pb	Volcanogenic massive sulphide	33 ddh, 11 500 m; geophys; geochem; mapping
78	Debbie, Yellow/Regina, Victoria (Westmin Mines, Nexus Resource)	092F 078, 79	Alberni	92F/2E 92F/7E	Au, Ag	Altered shear zone, auriferous chert, quartz vein stockwork	u/g drifting and sampling; trenching; u/g drilling, 13 ddh, approx. 5500 m; surface drilling, 20 ddh, approx. 1365 m
79	Lucky/Red Rover (Electrum Resource/ Freemont Gold)	092F 034	Alberni	92F/3W	Au	Vein	6 ddh, 914 m
80	Catface/ Irishman Creek (Falconbridge)	092F 120, 251	Alberni	92F/4W, 5W	Cu, Mo	Porphyry	4 ddh, 1625 m; u/g sampling; airborne & ground geophys; mapping
81	Ursus Creek/Thunderbird (Pacific Sentinel/Prime Resource Group)	092F 067	Alberni	92F/5E	Au	Shear zone, veins	5 ddh, 792.5 m
82	Cotter Creek (S. Craig/Stoney Creek Mines)		Alberni	92F/5W	Au, Ag	Veins	7 ddh
83	Abco/Mary McQuilton (S. Craig/Gold Parl Resources)	092F 122	Alberni	92F/5W	Au, Ag	Veins	2 ddh; geophys; geochem
84	Spud Valley/Goldfield (McAdam Resources)	092L 211	Alberni	92L/2W	Au, Ag	Veins	u/g drifting and sampling; bulk sampling; test milling
85	Central Zeballos (New Impact Resources/ CanAlaska Resources)	092L 212	Alberni	92L/2W	Au, Ag	Vein	u/g drilling, 21 ddh, 2195 m
86	Hiller-Churchill (Falconbridge/Footwall Explorations)	092L 031, 127, 154	Alberni	92L/2W	Au, Ag, Cu, Magnetite	Skarn, veins	u/g drilling, 16 ddh
87	CIH (B. Buskell)	092F 323	Nanaimo	92F/7W	Au, As	Vein stockwork in dike	2 ddh, 108 m
88	Angel (Rhyolite Resources/ Nexus Resource)	092F 327	Nanaimo	92F/9E	Au	Veins in altered shear zone	5 ddh, 540 m; geophys; geochem
89	Vananda Gold/Little Billie, Cornell, Copper Queen, Texada Iron (Vananda Gold/Freeport-McMoRan Gold)	092F 105, 106, 107, 112 257, 259	Nanaimo	92F/10E, 15E	Au, Ag, Cu, Zn, Magnetite	Skarn	2 2 ddh, 5208 m; geophys; geochem; mapping
90	North Texada/Paris, Loyal (Rhyolite Resources/ Echo Bay Mines)	092F 265, 266	Nanaimo	92F/15E	Au, Ag, Cu, Zn	Skarn	9 ddh, 248 8 m; trenching geophys; geochem; mapping
91	Mount Washington/ Domineer, Lakeview (Better Resources)	092F 116, 117, 330	Nanaimo	92F/11E,11W 92F/14E,14W	Au, Ag, Cu	Epithermal veins, breccias	17 ddh, 571.8 m; trenching
92	Murex (Better Resources/Noranda Exploration)	092F 206	Nanaimo	92F/11E,11W 92F/14E,14W	Au, Ag, Cu	Mineralized breccia	2 ddh, 80 m; rock & soil geochem

93	Dove (J. Paquet/Westmin Mines, Visible Gold)		Nanaimo	92F/11E 14E, W	Cu, Ag, Au, As	Epithermal veins	5 ddh, approx. 610 m; geochem; prospecting
94	Merry Widow/Raven, Kingfisher, Marten, Snowline (Taywin Resources)	092L 044, 45, 46, 50, 51	Nanaimo	92L/6E, 6W	Au, Ag, Co, Cu, Magnetite	Skarn, manto	43 ddh, 271 3 m; trenching; geophys
95	Quatse Lake/Caledonia (*Hisway Resources*)	092L 061, 209	Nanaimo	92L/12E	Cu, Zn, Ag	Skarn	1 ddh, 153 m; trenching
96	HPH/HPH, Ucan, Rain (Hisway Resources)	092L 069, 76, 241, 242 243, 253	Nanaimo	92L/12W	Ag, Pb, Zn, Au, Cu	Skarn, manto	6 ddh, 506 m; trenching; geophys; geochem; mill tests
97	Expo/Hep, Expo, Bowerman (BHP-Utah Mines/ Moraga Resources)	092L 078, 131, 240	Nanaimo	92L/12W	Cu, Mo, Au	Porphyry	7 ddh, 764.4 m; geochem; mapping
98	Lang Bay (Fargo Resources, Brenda Mines)	092F 137	Vancouver	92F/16W	Kaolin, Ge, Ga	Residual sedimentary	12 ddh; process & marketing studies
99	Fleck-Britannia/ *Victoria* (Minnova)	092GNW003	Vancouver	92G/10W, 11E	Cu, Zn, Pb, Ag,Au	Volcanogenic massive sulphide	10 ddh, 2372 m
100	International Maggie/ Indian River Copper, ABC, War Eagle (Minnova)	092GNW024, 28, 42,	Vancouver	92G/10W, 11E	Cu, Zn, Pb, Au, Ag	Volcanogenic massive sulphide	7 ddh, 2345 m
101	Easy & Jo/Mayflower (Hillside Energy, Corona/ Kali Venture)	092GNE010	New Westminster	92G/16W	Au, Ag, Pb, Zn	Shear zone	*5 ddh, approx. 400 m; trenching;* geochem; mapping
102	Giant Copper/AM (Bethlehem Resources)	092HSW001	New Westminster	92H/3E	Cu, Au, Ag, Mo	Mineralized breccias	23 rdh, 2544 m; trenching; mapping; geochem
103	Mount Foley/Lucky Four (McNellen Resources)	092HSW007, 079	New Westminster	92H/4E	Cu, Ag, Au, Mo	Skarn	29 u/g ddh, 1519 m
104	Ladner Creek/Aurum, Idaho, Montana, Pipestem (Anglo Swiss Mining)	092HNW003, 7, 8, 9, 11, 48	New Westminster	92H/11W	Au, Ag	Veins	12 u/g ddh, 610.5 m; 6 ddh, 417 m; mapping
105	Wren (J. MacDonald/ Castle Minerals)		Lillooet	92J/6E, 7W	Au	Altered shear *zone; veins*	5 ddh, 202 m; geochem; geophys; mapping; trenching
106	Cimadoro (Doromin Resources/Teck Explorations)		Skeena	103F/1E, 1W	Au, Ag, Cu, Zn	Massive sulphide	6 ddh, approx.1000 m; geophys; geochem; mapping
107	Cinola (City Resources Canada/ Barrack Mine Management)	103F 034	Skeena	103F/9E	Au, Ag	Epithermal veins; breccia	3 ddh, 320 m; metallurgical testing; feasibility study

SOUTH CENTRAL DISTRICT

111a	Samatosum (Minnova)	82M 244	Kamloops	82M/4W	Au, Ag, Cu Zn, Pb	Volcanogenic massive sulphide	57 ddh, 12426 geochem; geophys
111b	Victory (Minnova)		Kamloops	82M/4W	Ag, Au, Cu, Zn, Pb	Volcanogenic massive sulphide	7 ddh, 950 m, geochem
112	OK (Minnova)		Kamloops	82M/4W	Au, Ag, Cu Zn, Pb	Volcanic massive sulphide	3 ddh, 12 99 m
113	Dixie (Minnova)		Kamloops	82M/4W	Ag, Au, Cu, Zn, Pb	Volcanogenic massive sulphide	*2 ddh, 200 m, geochem;* geophys, 25 km

114	Kamad (Homestake Mineral Development)	082M 025	Kamloops	82M/4W	Zn, Cu, Ba, Au, Ag	Volcanogenic massive sulphide	25 ddh, 1515 m; 15 trenches; geophys, 21 km
115	Cana (Mingold Exploration/ Homestake Mineral Development)		Kamloops	82M/4W	Au, Ag, Cu Zn, Pb	Volcanogenic massive sulphide	2 ddh, 300 m;
116	Twin Mountain (Homestake Mineral Development)	082M 020	Kamloops	82M/4W	Au, Ag, Cu Zn, Pb	Volcanogenic massive sulphide	3 trenches, 200 m
117	Bay (Cominco/Falconbridge)	082M 053	Kamloops	82M/4E	Au, Ag, Zn, Cu, Pb	Vol;canogenic massive sulphide	9 ddh, 1333 m; geophys; road
118	FY 1-3, Anna (Bar) (Minnova)		Kamloops	82M/5W	Ag, Au, Cu, Pb, Zn	Volcanogenic massive sulphide	5 ddh, 530 m; geochem geophys, 87 km
119	Biere (National Resource Exploration/ Minnova)	082M 069	Kamloops	82M/5W	Au, Ag, Cu, Zn, Pb	Volcanogenic massive sulphide	5 ddh, 5 m; geophys, 3.9 km
120	CM (Chinook Mountain) (BP Minerals/Minnova)	092P 101	Kamloops	92P/8E	Au, Ag, Cu Zn, Pb	Volcanogenic massive sulphide	5 ddh, 585 m; geochem; geophys, 100 km
121	Chu Chua (Pacific Cassiar/Minnova)	092P 140	Kamloops	92P/8E	Cu, Au	Volcanogenic massive sulphide	21 ddh, 1663 m; geochem geophys, 25 km
122	Epi/Yard (Inco Gold Mgmt.)	092P 127	Clinton	92P/2W	Au	Epithermal	20 ddh, 3913 m; 4 km, road
123	Bonaparte (Centre) (Interpacific Resources/ QPX Minerals	092P 159	Kamloops	92I/16W	Au	Vein	9 ddh, 449.3 m
124	Arrowstone (MOW) (M. Dickens/Iron River Resources)		Kamloops	92P/2W	Au	Epithermal	5 ddh, 199 m; geochem; geophys
125	Rayfield (P. Ziebart/Brenda Mines)	092P 005	Clinton	92P/6E	Cu, Au	Porphyry	8 ddh, 1100 m; geophys, 36 km
126	Haida (Electrum Resources/ Teck Explorations)	092P 136	Kamloops	92P/9W	Au, Ag	Skarn	10 trenches, 1 km; geochem, 1500 samples
127	G claims (G. Wolanski/Michael Resources)		Kamloops	92P/1E	Feldspar	Intrusive	13 ddh, 582 m; trenching bulk sample
128	Iron Mask (North Eureka Resources/ Teck Explorations)	092INE031	Kamloops	92I/15E, 10E	Cu, Au	Porphyry	19 ddh, 1818 m
129	Morgan (Shepherd Insurance Group/R. Steiner)	092INE110	Kamloops	92I/16E	Ag, Cu, Au	Vein	4 ddh, 183 m; geochem; geophys
130	Maskam (Beaton) (V. Coucet/Boitard)		Kamloops	92I/10E	Cu, Au	Porphyry	3 ddh, 972 m; geochem; geophys, 20 km
131	Boy (Skyrocket Exploration and Resources)		Kamloops	92I/10E	Cu, Au	Porphyry	4 ddh, 1356 m
132	Model-Anne (Mad River Resources)	092INE039	Kamloops	92I/10W	Au, Ag	Vein	7 pcdh, 733 m; geophys, 15 km
133	Oz (J. Osterhagen/Brenda Mines)		Kamloops	92I/9W	Cu, Au	Porphyry	11 pcdh, 1006 m; geophys, 60 km
134	Edith (Cominco)	092INE101	Kamloops	92I/9W	Cu, Au	Porphyry	41 pcdh, 3507 m
135	Road (A. Babiy/Naxos Resources)		Kamloops	92I/9E	Au	Vein	18 ddh, 1700 m; 8 pcdh, 500 m; geochem,
136	JJ (J. John/Naxos Resources)		Kamloops	92I/9W	Cu, Au	Vein	4 ddh, 80 m; geochem
137	Vicars (L. Mear/A. Babiy)	092INE169	Kamloops	92I/9E	Cu, Au	Vein	1 ddh, 75 m; geochem

138	Powl (L. Mear/A. Babiy)		Kamloops	92I/8E, 9E	Cu, Au	Vein	1 ddh, 70 m; geochem
139	Mary Reynolds (Anglo American Resources)	092ISE115	Nicola	92I/8W	Au	Vein	6 ddh, 596 m; geophys
140	Des (C. Boitard/Menika Mining)		Kamloops	92I/7E	Cu, Au	Porphyry	7 ddh, 2046 m
141	Leadville Charmer (K. Livingstone/ Golden Dynasty Resources)	092ISE052	Nicola	92I/2W	Au	Vein	4 ddh, 456 m; geochem; geophys
142	Brett (Corona)	082LSW110	Vernon	82L/4E	Au	Epithermal	29 ddh, 4486 m, trenching; geochem
143	Miller (Eureka Resources)		Vernon	82L/4E	Au	Epithermal	2 ddh, 475 m; geophys, 8 km
144	CLF/Exam (Clifton Resources/ Spencer Engineering)		Nicola	82L/4W, 5W	Au	Vein	2 ddh, 124 m; geochem; geophys, 8 trenches, road
145	Jewel (Corona)		Kamloops	82L/5E, 12E	Au, Cu	Shear vein	9 ddh, 839 m; geochem; geophys
146	Lavington (BP Resources Canada)		Vernon	82L/6E	Au	Vein	5 ddh, 610 m; geochem, geophys
147	BS (Zicton Gold)		Vernon	82L/7W	Au	Shear	1 ddh, 209 m vein
148	OK (Lumby) (Zedco Petroleums/J. Hilton)		Vernon	82L/7W	Au	Vein	1 ddh, 61 m; trenching
149	Vault (7 Mile High Group/Inco Gold Mgmt)	082ESW173	Osoyoos	82E/5E	Au	Epithermal	75 ddh, 13 229 m
150	Dusty Mac (Dusty Mac Mines/Minnova)	082ESW078	Osoyoos	82E/5E	Au	Epithermal	13 ddh, 3244 m; geochem, geophys, 125 km
151	Allendale (Allendale Resources *et al.*/ Yukon Minerals)	082ESW060	Osoyoos	82E/6W	Cu, Au	Porphyry	4 ddh, 248 m geochem, geophys
152	Au (K. Daughtry/Inco Gold Mgmt)		Osoyoos	82E/6W	Au	Epithermal	8 ddh, 1637 m; geochem
153	Venner (Corona/Tigris Minerals)		Osoyoos	82E/6W	Au	Epithermal	1 ddh, 410 m
154	Cariboo-Amelia (W. McArthur/Ark Energy/Gold Power)	082ESW020	Greenwood	82E/3E	Au	Vein	12 ddh, 872 m; 3 trenches, 122
155	Jolly (Brican Resources/Minnova)	082ESW159	Osoyoos	82E/3E	Au	Vein	9 ddh, 1299 m; geochem; geophys, 18 km
156	LMS (F. Lalonde/Huntington Resources)		Osoyoos	82E/3W	Au, Ag	Vein	2 ddh, 237 m
157	Beaverdell (Del Norte Chrome)	082ESW031	Greenwood	82E/6E	Ag, Au	Vein	15 ddh, 1265 m
158	Dominion (Mad River Resources)	082ESW071	Greenwood	82E/6E	Au, Ag	Vein	8 pcdh, 701 m
159	Dividend-Lakeview (Rideau Resources/Battle Mountain (Canada)	082ESW001	Osoyoos	82E/3W, 4E	Au	Skarn	5 ddh, 777 m; geochem; geophys
160	Astro (QPX Minerals/ Minequest Expln. Associates)		Osoyoos	82E/5W	Au	Vein	5 pcdh, 248 m; trenching, 150 m
161	Vent (Zygote Resources)	082ENW071	Osoyoos	82E/12W	Au	Epithermal	8 pcdh, 492 m

162	Crystal Peak (Mt. Riordan) (Polestar Exploration Inc.)	082ESW107	Osoyoos	82E/5W	Industrial garnet	Skarn	23 ddh, 1011 m; geophys, road
163	Nickel Plate (Corona)	092HSE062	Osoyoos	92H/8E	Au	Skarn	2 ddh
164	John, Taurus (Nickel Plate) (K D'Angelo/Corona)		Osoyoos	82E/5W	Au	Skarn	6 ddh, 568.3 m
165	Rollo, Climax (Nickel Plate) (Corona)	092HSE049	Osoyoos	92H/8E	Au	Skarn	4 ddh, 1932 m
166	Canty, Good Hope, French (Golden North Resource/Corona)	092HSE064	Osoyoos	92H/8E	Au	Skarn	57 ddh, 6053 m; geochem
167	Pridge, Evening Star, Bullion (Hedley Pacific/Corona)		Osoyoos	92H/8E	Au	Skarn	11 ddh, 1706 m
168	Eagle's Nest (Agio Resource/ Corona)	092HSE036	Osoyoos	92H/8E	Au	Skarn	3 ddh, 408 m u/g
169	Golden Zone (Midland Energy Group/ Redding Gold)	082ESW042	Osoyoos	82E/5W	Au	Vein	4 ddh, 282 m; 3 trenches; geochem
170	Elk (Fairfield Minerals/Placer Dome)		Similkameen	92H/16W	Au	Epithermal	12 ddh, 754 m; 17 trenches; 2000 m; geochem, geophys, 50 km
171	Dill (Fairfield Minerals)		Similkameen	92H/9W, 16W	Au	Vein	12 trenches, 200 m; geochem, geophys, 6.3 km
172	Spring (Golden Pick Resources/ Placer Dome)	092HNE108	Similkameen	92H/16W	Au	Shear vein	20 trenches, 1200 m; geochem; geophys, 95 km
173	Gold Core (H. Adams)		Similkameen	92H/9W, 16W	Au	Vein	2 ddh, 152 m
174	Lost Horse Gulch (Similco Mines)	092HSE001	Similkameen	92H/7E	Cu, Au	Porphyry	ddh; geophys, 40 km; geol
175	Oriole (Similco Mines)	092HNE024	Similkameen	92H/7E	Cu, Au	Porphyry	6 ddh, 800 m; geochem, geophys, 40 km
176	Tor (E. Wedekind)		Similkameen	92H/10E	Au, Cu	Vein	5 pcdh, 305 m; 5 ddh, 305 m; geochem
177	Lodestone (Imperial Metals/ Tiffany Resources)	092HSE034	Similkameen	92H/7W	Fe, Au, PGE	Magmatic	6 ddh, 613 m; geochem, road
178	Treasure Mountain (Huldra Silver)	092HSW016	Similkameen	92H/6E	Ag,Pb,Zn	Vein	13 ddh, 1227 m; 10 pcdh, 575 m; geochem, 570 samples, geophys, 4.6 km
179	Keystone (Blue Gold Resources)	92HNW024	Nicola	92H/11E	Au, Ag	Intrusive breccia	4 ddh, 404.4 m
180	Spokane (J. Posnikoff/MacNeill Industrial)	92JNE 034	Lillooet	92J/16W	Au, Ag	Vein	37 ddh, 1586 m; 21 trenches, 420 m; geophys, 8.3 km, road
181	Cub 200 (MacNeill Industrial)		Lillooet	92J/16W	Cu, Mo	Porphyry	3 ddh, 547 m; geochem
182	Second (Cyprus Gold Canada)		Clinton	920/1E	Au	Vein	13 ddh, 1838 m; trenching, geochem; geophys
183	Minto Extension (Avino Mines & Resources)	092JNE075	Lillooet	92J/15W	Au	Vein	5 ddh, 610 m
184	Gun Creek (Mt. Allard Resources/ Hi-Tec Resource Management)		Lillooet	92J/15W	Au, Ag	Vein	3 ddh, 194 m; geochem
185	Love Oil/Cosmopolitan (Coral Gold)		Lillooet	92J/15W	Au, Ag	Vein	7 ddh, 914.4 m; 70 trenches, 1524 m

186	J & L (Pan American Minerals/ Equinox Resources)	082M 003	Revelstoke	82M/8E	Au, Zn, Pb, Ag	Sedex	32 ddh, 3000 m; bulk sample
187	Goldstream (Bethlehem Resources)	082M 141	Revelstoke	82M/9W	Cu, Zn	Massive sulphide(Besshi)	6 ddh, 255 m; geochem, 1476 samples u/g
188	Keystone (J. Leask/Bethlehem Resources)	082M 088	Revelstoke	82M/8W	Cu, Zn, Pb, Au, Ag	Massive sulphide	11 ddh, 1555 m

KOOTENAY DISTRICT

196	Rossland Claims (Bryndon Vent./Antelope Res.)		Trail Creek	82F/4W	Au	Vein	55 ddh, 8455 m; geophys
197	Velvet (Minnova)	082FSW162	Trail Creek	82F/4	Au	Vein	3 ddh, 750 m
198	Tillicum Mtn. (Esperanza Explorations)	082FNW234	Slocan	82F/13	Au, Ag	Quartz skarn	Grizzly, 4 ddh, 600 m; East Ridge, 10 ddh Arnie Flats, 5 ddh, 300 m
199	Millie Mack (Bapty Research)	082KSW051	Slocan	82K/4	Ag, Au, Pb	Shear	66 holes (3000 m pdh 175 m ddh); 100 trenches
200	Duncan Lake (Cominco)	082KSE023	Slocan	82K/7	Pb, Zn	Replacement	2 ddh, 1524 m
201	Red Elephant (Mikado Resources/Roper Resources)	082KNW056	Slocan	82K/11E	Au, Cu		48 ddh, 2750 m
202	Second Relief (Hawkeye Dev.)	082FSW187	Nelson	82F/6W	Au	Skarn	6 ddh & more; geophys; geochem
203	Great Western Star (Lectus Dev./Pacific Sentinel Gold)	082FSW083	Nelson	82F/6W	Au, Ag	Porphyry?	Trenching, drilling planned
204	Whitewater Group (Snowwater Resources)	082FSW222	Nelson	82F	Au	Vein, breccia?	15 (ddh & rdh)
205	Rely (Pegasus Gold)		Nelson	82F/3	Au, Zn		4 ddh, 850 m; geophys
206	Alpine Gold (Cove Resources)	082FNW127	Nelson	82F/11	Au	Vein	12 ddh; underground sampling
207	Sumit (Baloil Resources)	082FSW054	Nelson	82F/3	Au	Vein	10 ddh(?), 700 m;), trenching geophys
208	Liz, John, Bid, Rex, Tag (Legion Resources)	082FSE005	Nelson	82F/2	Zn	Stratabound	7 ddh
209	Star (Cominco)	082ESE089	Nelson	82F/1W	Ag, Pb, Zn	Sedex	1 ddh
210	For Sure (King Jack Resources)		Nelson	82F/11	Au	Breccia	4 ddh
211	Katie (Baloil Resources)		Nelson	82F/3	Cu, Au	Porphry	3 ddh, 300 m
212	Nugget (Gunsteel Resources)	082FSW040	Nelson	82F/3E	Au, Ag, Pb	Vein	Fawn x-cut extended,
213	Kenville Mine (Algoma Industries)	082FSW086	Nelson	82F/6W	Au	Vein	Mill tests

214	Vine (Cominco/Kokanee Exploration)	082GSW035	Fort Steele	82G/5W	Pb, Zn,Cu	Vein	trenching, 10 ddh, 1250 m
215	Howell 1-5, Howe 1-7 Cominco/Placer Dome		Fort Steele	82G/2	Au	Alkaline porphyry	7 ddh, 1095 m
216	Flathead Cominco/Placer Dome	082GSE026	Fort Steele	82G/2	Au	Alkaline porphyry	6 ddh, 866 m
217	Goatfell (Chevron Minerals)		Fort Steele	82F/1	Pb, Zn	Sedex, breccia	2 ddh, 1161 m; geochem
218	McNeil (Dragoon Resources)		Fort Steele	82G/5W	Pb, Zn	Sedex	7 ddh , 1250 m & 6 pending
219	Stoney (Minnova)	082GSW022	Fort Steele	82G/4	Pb, Zn	Sedex	2 ddh , 500 m
220	Domtar Gypsum (Kootenay Geo-Service)		Fort Steele	82J/4	Gy	Evaporite	11 rdh, 300 m
221	Denby (Westroc Resources)		Fort Steele	82G/14	Gy	Evaporite	New discovery, 3 to 5 million tonnes possible reserves;
222	Reserve (Westroc Resources)		Fort Steele	82G/14	Gy	Evaporite	trenching
223	Eagle Mt. (Fording Coal)		Fort Steele		Coal		5 ddh, 2428 m
223	Henrietta Creek (Fording Coal)		Fort Steele		Coal		30 rdh, 2859 m
223	Lake Mt. & Lake Pit (Fording Coal)		Fort Steele		Coal		8 rdh, 855 m, 4 rdh, 374 m
224	North Line Creek (Crows Nest Resources)		Fort Steele		Coal		45 dh, 8000 m
224	Teepee (Crows Nest Resources)		Fort Steele		Coal		1 dh, 150 m
224	Horseshoe Ridge (Crows Nest Resources)		Fort Steele	82G/15W	Coal		ddh, 495 m
224	3 & 4 Seam Area (Crows Nest Resources)		Fort Steele	82G/15	Coal		
224	Ewin Pass (Crows Nest Resources)		Fort Steele	82G/15	Coal		4 dh, 600 m
224	Mine Services Area (Crows Nest Resources)		Fort Steele	82G/15	Coal		12 dh, 1500 m
226	Cougar 6&7 (Greenhills) (Westar Mining)		Fort Steele		Coal		9 ddh, 930 m
233	Golden Crown (Cons. Boundary Exploration/ Altwood Gold)	082ESE032	Greenwood	82E/2E	Au, Ag	Vein	465 m drifting x-cut, raise, 42 ddh, 3230 m winter 88/89

CENTRAL DISTRICT

235	Mt. Milligan/Phil-Heidi (Continental Gold)	093N 194	Omineca	93N/1	Au, Cu	Alkali porphyry	406 ddh, 76 200 m; feasibility study
236	Windy (Big Bar Gold/Placer Dome)	093J 024	Cariboo	93J/13	Au	Alkali porphyry	37 ddh, 5500 m; 30 pdh; trenching
237	Tas (Noranda Exploration/ Black Swan Gold Mines)	093K 080	Cariboo	93K/16	Au	Porphyry	9 ddh, 1300 m; IP; trenching

238	Chuchi (Noranda Exploration)	093N 041	Omineca	93N/1, 2	Au, Cu	Alkali porphyry	29 ddh, 2750 m; geophys
239	Chuchi (BP Resources Canada/ Digger Resources)	093N 041	Omineca	93N/1, 2	Au, Cu	Alkali porphyry	9 ddh, 1300 m; geochem; geophys
240	Mt. Bodine (Noranda Exploration)		Omineca	093N/12W	Au, Cu	Porphyry	ddh; geochem; geophys
241	Col (C. Campbell/Kookaburra Gold)	093N 101	Omineca	93N/2E	Au, Cu	Alkali porphyry	geochem; geophys
242	Mitze/Buz (R. Haslinger/Noranda Exploration)	093N 096	Omineca	93N/1W	Au, Cu	Porphyry	geochem
243	Tsil (Noranda Exploration)		Omineca	93K/16E	Au, Cu	Porphyry	5 ddh, 500 m; geochem; geophys
244	Blackhawk (J. Hidber/Noranda Exploration)	093N 022	Omineca	93N/10E	Au	Porphyry related	4 ddh, 320 m
245	Nina Lake (Noranda Exploration)	093N 011	Omineca	93N/15	Au	Replacement?	4 ddh
246	Cat/Betty (BP Resources Canada/ Lysander Gold)	093C 069	Omineca	94C/3	Au, Cu	Porphyry	7 ddh, 910 m; geochem; mag, 7 trenches
247	Quesnel River/QR (QPX Minerals)	093A 040	Cariboo	93A/12	Au	Alkali porphyry	45 ddh, 800 m; geotechnical; MDRP Stage 1
248	Mt. Polley/Cariboo Bell (Imperial Metals)	093A 008	Cariboo	93A/12E	Au, Cu	Alkali porphyry	139 ddh, 18 700 m; geotechnical; MDRP pospectus
249	Mouse Moutain (Placer Dome)	093G 003	Cariboo	93G/1	Au, Cu	Porphyry	geochem, geophys
250	Cariboo (Corona)	093H 006	Cariboo	93A/12E	Au, Cu	Porphyry?	10 ddh, 1750 m; geochem
251	Miracle (GWR Resources)	093P 002	Clinton	92P/14W	Au, Cu	Porphyry	trenching, 1500 m
252	Redgold/C2 (J. Morton, R. Durfeld/ Phelphs Dodge Canada)	093A 069	Cariboo	93A/6W	Au, Cu	Porphyry	geochem
253	Frasergold (Eureka Resources)	094A 150	Cariboo	93A/7E	Au	Phyllite-hosted	heap leach test planned
254	Cariboo Gold Quartz (Mosquito Consol Gold/Pan Orvana Res.)	093H 019	Cariboo	93H/4E	Au, Ag	Vein	u/g drifting; pdh and ddh
255	Indian Lake (Noranda Exploration)		Cariboo	93H/6	Pb, Zn, Ag	Replacement	10 ddh, 900 m
256	Maybe (R. Keep/Sable Resources)		Cariboo	093A/14	Pb, Zn, Ag	Vein	10 ddh
257	WD (Kennco Exploration/ Comineca)	093H 072	Cariboo	93H/6	Pb, Zn, Ag	Replacement	3 ddh; geochem; geophys
258	Snowbird (Pipawa Exploration/X-Cal Resources)	093K 036	Omineca	93K/7, 8	Au	Vein trenching	20 ddh, 4000 m;
259	Indata (Eastfield Resources)	093N 192	Omineca	93N/6W	Au	Vein	13 ddh; 1795 m; 42 trenches; geochem; IP
260	Swan/Boom (Eastfied Resources/ Northair Mines)	093N 073	Omineca	93N/11W	Au, Cu	Porphyry	geochem; IP

261	Tchentlo Lake (Westmin Mines)		Omineca	93N/2E	Au	Vein	geochem; geophys
262	HC (Noranda Exploration)		Omineca	93G/15W	Au, Ag	Epithermal	pdh, 3000 m; trenching; geochem
263	Hanson Lake (Cazador Explorations)	093K 081	Omineca	93K/6	Au, Cu	Porphyry	30 pdh, 1000 m; geochem; geophys
264	Taseko (Westpine Metals)	092O 038	Clinton	92O/3W	Au, Cu	Porphyry	10 ddh, 2000 m
265	Spokane (Canmark International Resources)	093O 024	Clinton	92O/3W	Au, Cu	Porphyry related	6 ddh, 600 m
266	Fish Lake (Taseko Mines/Cominco)	093O 041	Clinton	92O/5E	Au, Cu	Porphyry	12 ddh, 1984 m; metallurgical tests
267	Perkins Peak (Kleena Kleene Gold Mines/ Hunter Point Expln.)	093N 010	Clinton	92N/14	Au	Epithermal	180 m u/g drifting
268	Cirque (Curragh Mining/ Canadian Mine Development)	094F 008	Omineca	94F/11	Pb, Zn, Ag	Sedex	decline; u/g development; geotech; MDRP prospectus
269	Mt Alcock (Triumph Resources)	094F 015	Omineca	94F/11W	Pb, Zn, Ag	Sedex	9 ddh, 1200 m; geochem; IP
274	Quintette (Quintette Coal)	093P 019	Liard	93P/2W, 3E	Coal	Sedimentary	5 ddh, 56 rdh, 7290 m

NOTES

NORTHWESTERN DISTRICT

By D.V. Lefebure and M.L. Malott
District Geology, Smithers

INTRODUCTION

In northwestern British Columbia four new gold mines opened in 1989. The Lawyers (Cheni) mine (*see* Frontispiece) in the Toodoggone went into production late in 1988 and became fully operational in January 1989. A small open-pit mining operation was started on the Shasta property and the ore trucked to the mill at the old Baker mine. In the Stewart area the Premier mine started up in May processing ore from the Big Missouri and Silbak Premier open pits. At the Golden Bear property mining started in the open pit in the summer and underground in the fall. The ore was stockpiled for winter milling.

The Johnny Mountain, Bell, Equity Silver and Endako mines continued normal operations throughout the year. Cassiar Asbestos Corporation halted open-pit mining at the beginning of June, due to limited asbestos reserves and the possibility of a pit-wall failure. The Erickson mine remained closed; drifting in the adit being driven to access the Michelle zone was stopped roughly one kilometre short of its target.

Currently under development, the McDame asbestos deposit in Cassiar should start producing asbestos fibre in April or May, 1990. At the end of the year the Sulphurets and Snip projects were at very advanced exploration stages with production decisions a possibility in 1990.

Exploration activity in the Northwestern District slowed from the record levels of 1987 and 1988. Expenditures for the Northwest were in excess of $61 million for the 68 major exploration projects, down $24 million from 1988. Over forty per cent of the 1989 exploration expenditures for British Columbia are estimated to have been spent in the Northwest (Figure A-3). The Stewart - Iskut River gold belt continued to be the busiest exploration and development area in the district, with expenditures in excess of $27 million on 17 major projects, including the Eskay Creek deposit.

An increase in the number of Notices of Work submitted to the government (Figure A-4) was due in part to a resurgence of reconnaissance prospecting programs throughout the district, particularly in the region extending from north of the Iskut River to the Tatsamenie Lake area. Several companies also showed renewed interest in the Kitsault Valley area. These two areas are underlain by rocks of the Stikine Terrane which also hosts the numerous gold deposits of the Iskut River - Stewart gold belt. Exploration companies examined a broader variety of mineral deposits in 1989 than in previous years, with veins, skarns, porphyries and volcanogenic massive sulphides the most frequent targets.

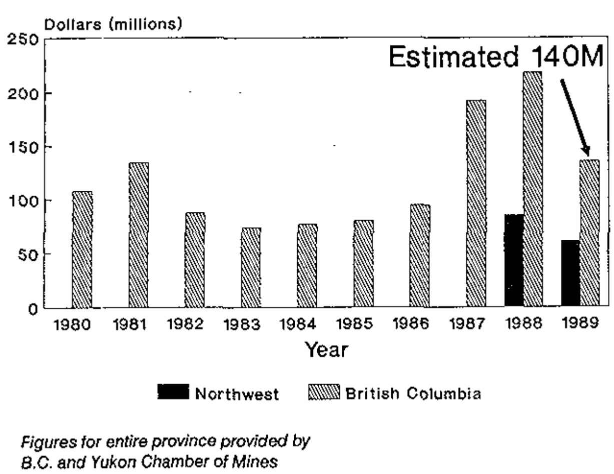


Figure A-3. Mineral exploration expenditures.

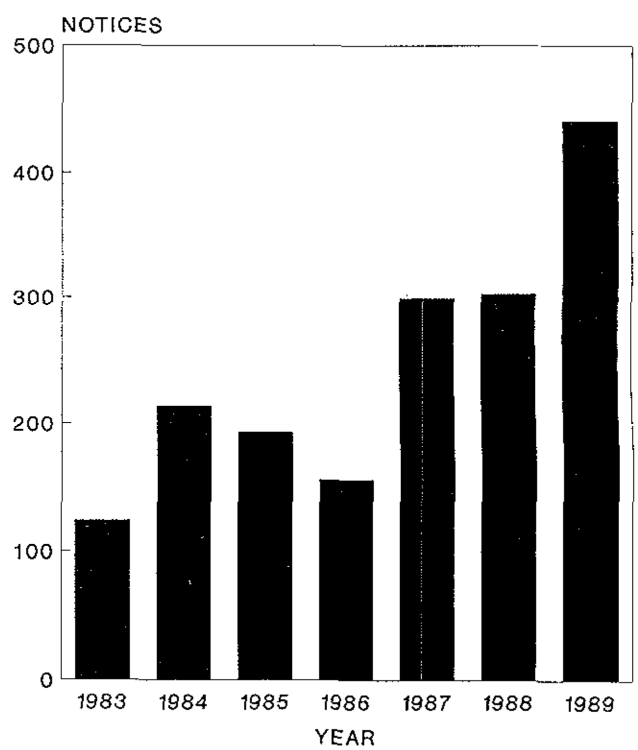


Figure A-4. Mineral notices of work, Northwestern British Columbia.

Plate A1. GOLDEN BEAR MINE (71) - The Golden Bear site in May, 1989. Note camp on shore of Muddy Lake and the road to the Bear zone portal behind it.

Coal exploration was limited to only one program on the North zone of the Telkwa property as Crows Nest Resources Limited prepared to submit a Stage 2 report in early 1990. The number of placer mining operations in the district declined 15 per cent from 1988. Queenstake Resources Ltd. produced a total of 377 kilograms of fine gold from two large operations in the Atlin area.

HIGHLIGHTS

- Intense exploration activity continued on the **Windy Craggy deposit** (1) with expenditures of $14.1 million
- Deep drilling on the **Tulsequah Chief property** (4) identified a new sulphide lens and increased ore reserves.
- At **Golden Bear** (71) (Plate A-1)construction and mine development was completed with open-pit and underground mining starting in the summer and fall, respectively.
- Underground development continued at the **McDame asbestos deposit** (8) with production planned for 1990.
- After 26 years of operation, the **Cassiar Asbestos** open pit (72) halted production in June. Ore stockpiles will feed the mill until the McDame deposit is developed.
- Underground exploration continued at the **Snip project** (17); no production decision has been announced.
- On the **Eskay Creek property** (21) the 21-zone has been traced along a strike length of 1300 metres and down dip 240 metres.
- The **Kerr porphyry copper-gold deposit** (25) (Plate A-2) reserves were doubled and the property was sold to Placer Dome Inc.
- The West, UTC and newly discovered R-8 Zones continued to be the focus of underground development on the **Sulphurets property** (24).
- Open pit mining started at the **Silbak Premier** (31) and **Big Missouri silver-gold deposits** (28).
- On the **Silver Butte property** (29) underground drilling delineated reserves on the Facecut 35 zone of 105 590 tonnes with cut grades of 10.6 grams gold and 39.7 grams silver per tonne.
- Bond Gold intersected gold mineralization in drilling at **Red Mountain** (32) and **Willoughby Creek** (33).

- The **Lawyers mine** (46) overcame initial start-up problems and the mill operated at the planned 460 tonnes per day.
- Crows Nest Resources Ltd. announced new plans to mine the **Telkwa coal deposit** (59); this time focusing on the North zone.

TRENDS AND OPPORTUNITIES

Exploration activity in the Northwestern District slowed from the record levels of 1987 and 1988, primarily due to difficulties in raising risk capital and falling gold prices. Numerous projects suffered from a late start (July or August) on fieldwork; some companies proposed major exploration programs only to be limited by funding to surface sampling and mapping. Major companies, such as Cominco Ltd., Placer Dome Inc. and Homestake Mineral Development Company, played a more active role in the Northwestern District than in recent years.

Exploration expenditures were most significant in known mining camps such as Stewart, Iskut River, Tulsequah, Toodoggone and Smithers (Figure A-5) or potential mining camps such as the Windy Craggy and Sulphurets areas (Figure A-6). However, exploration programs were more widespread than in 1987 or 1988 reflecting a greater willingness to explore on "grass roots" properties. In the region extending from north of the Iskut River to Tatsamenie Lake there were a large number of preliminary programs and for the first time in several years, several companies completed major exploration programs in the Kitsault valley.

The exciting drill intersections on the Eskay Creek property produced a late summer rush by a number of companies to explore for similar deposits in the general Sulphurets area. Much of the industry activity focused on a mineralized felsic volcaniclastic horizon identified by D. Alldrick and J. Britton of the British Columbia Geological Survey Branch during their mapping in 1988.

Areas with excellent exploration potential are still open for staking throughout the district. Some of the most attractive exploration targets are the porphyry copper-gold deposits within the Stikine Terrane. Examples of known deposits are the Bell orebody on Babine Lake and the Galore Creek deposit located south of Telegraph Creek. The Stikine Terrane north and west of the Bowser Basin is particularly prospective for these deposits. The Babine area also has considerable potential, although in

Plate A2. KERR (25) - A major drilling program on the Kerr porphyry copper-gold B zone, located to the right of the camp, increased ore reserves to more than 100 million tonnes.

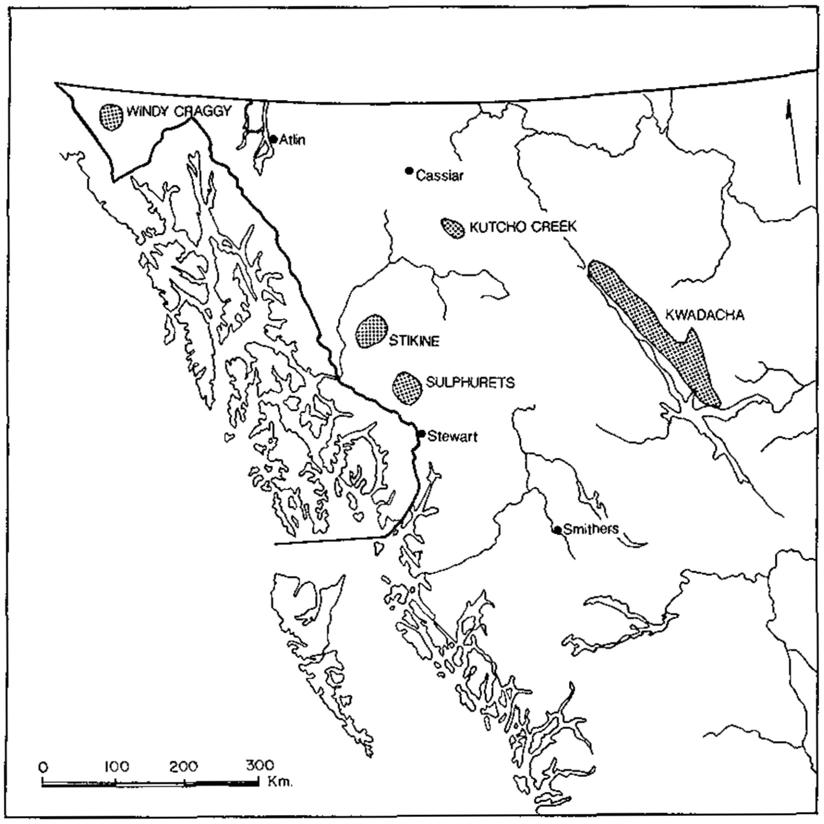


Figure A-5. Mining camps of N.W. British Columbia.

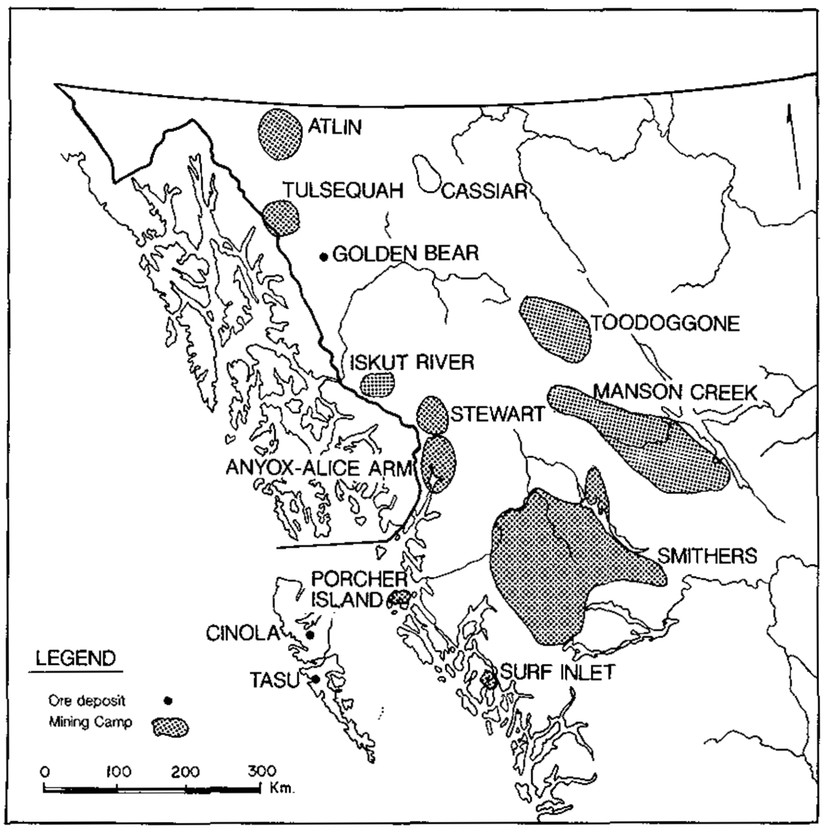


Figure A-6. Potential mining camps of N.W. British Columbia.

low-lying areas thick overburden increases the difficulty of exploration.

Recent exploration results at Windy Craggy and the Tulsequah Chief mine, as well as the new Greens Creek mine in Alaska, have generated more interest in volcanogenic massive sulphide deposits. There is still considerable open ground in areas with massive sulphide potential including the Tatshenshini River, Cry Lake and Prince Rupert areas.

The North Coast was one of the quietist areas in the province with respect to mineral exploration. This is surprising given the presence of several past producers, including the Surf Inlet (Plate A-3) and Pugsley gold mines which jointly produced 896 647 tonnes grading 13.4 grams gold and 7.2 grams silver per tonne with 0.32 per cent copper. Gold-bearing mesothermal veins and skarns are prospective targets, particularly if regional structures and known showings are used to pinpoint areas of special interest.

MINERAL EXPLORATION

A total of 441 Notices of Work were submitted in 1989 for mineral exploration, up 53 per cent from 1988 (Figure A-2). Some of these notices were to record program changes from earlier submissions. Expenditures per project varied from small amounts by individual prospectors up to $14.1 million. Ten properties are at an advanced stage (Table A-4); many of these show excellent potential to become mines in the 1990's. Table A-3 lists the 68 major projects in the Northwestern District with drilling, underground development or major surface exploration programs. The map numbers shown in the Tables and listed in brackets after property names in the following text are keyed to the location map (Figure A-6).

TATSHENSHINI RIVER AREA

In the extreme northwestern corner of the province, Geddes Resources Ltd. spent $14.1 million on the Windy Craggy (1) (Plate A-4) volcanogenic massive sulphide deposit. Extensive underground drifting included a crosscut through the North zone which encountered 223 metres of continuous massive sulphides. Detailed underground drilling increased the confidence level of the ore reserves, currently estimated at 118.1 million tonnes of 1.9 per cent copper and 0.1 per cent cobalt. Ore quality was studied through bulk sampling followed by bench and pilot plant metallurgical tests. Engineering and environmental studies are being completed for a Stage I submission to the British Columbia Mine Development Review Committee in early 1990. Initial surveying of part of the proposed route for the 100-140 kilometre access road was completed.

The Rime (East Arm) property (2) of Bond Gold Canada Inc. is located immediately to the east of Windy Craggy. UTEM and magnetic surveys defined an anomaly 2.3 kilometres long which is believed related to massive sulphide mineralization. Drilling through the East Arm glacier in 1988 was followed up in 1989 by drilling from the valley edge.

ATLIN VICINITY

West of Tagish Lake on the Teepee property (3) Cyprus Gold (Canada) Ltd. tested five different vein systems in Proterozoic-Paleozoic metamorphic rocks paralleling and close to the Llewellyn fault. A regional mapping program led by M. Mihalynuk of the British Columbia Geological Survey Branch has identified the Llewellyn fault as a major locus for precious metal mineralization.

TABLE A-4
ADVANCED EXPLORATION PROJECTS, NORTHWESTERN DISTRICT

	Project	Company	Ore Reserves
1	Windy Craggy	Geddes Resources Ltd.	118.8 Mt; 1.9% Cu, 0.08% Co, 0.2 g/t Au, 3.26 g/t Ag
4	Tulsequah	Cominco Ltd., Redfern Resources Ltd.	5.26 Mt; 1.6% Cu, 1.31% Pb, 7.03% Zn, 2.74 g/t Au, 100.5 g/t Ag
9	Erickson Gold	Total Energold Corporation	Erickson:18.3 kt; 14.1 g/t Au Cusac, Michelle Ext.: 25 kt; 34.29 g/t Au, 12.3 g/t Ag
21	Eskay Creek	Calpine Resources Incorporated, Consolidated Stikine Silver Ltd.	21 Zone: Probable 3.35 Mg; 19.20 g/t Au, 521.3 g/t Ag Possible 1.68 Mt; 8.57 g/t Au, 281.14 g/t Ag
25	Kerr	Western Canadian Mining Corp., Sulphurets Gold Corporation	114.3 Mt (drill inferred); 0.61% Cu, 0.27 g/t Au, 1.71 g/t Ag
29	Silver Butte	Tenajon Resources Corporation, Westmin Resources Limited	279.4 kt; 17.31 g/t Au 36.68 g/t Ag
	Mt Klappan	Gulf Canada Corporation	231 Mt, anthracite
57	Dome Mountain	Teeshin Resources Ltd. Canadian-United Minerals Inc.	270.9 kt; 12.17 g/t Au 36.68 g/t Ag
59	Telkwa Coal	Shell Canada Ltd.	South Telkwa: 23.4 Mt bituminous coal
62	Silver Queen	Pacific Houston Resources Inc.	1.73 Mt; 327.76 g/t Ag,6.19% Zn, 2.74 g/t Au, Ge, Cd, In, Ga, Pb, Hg

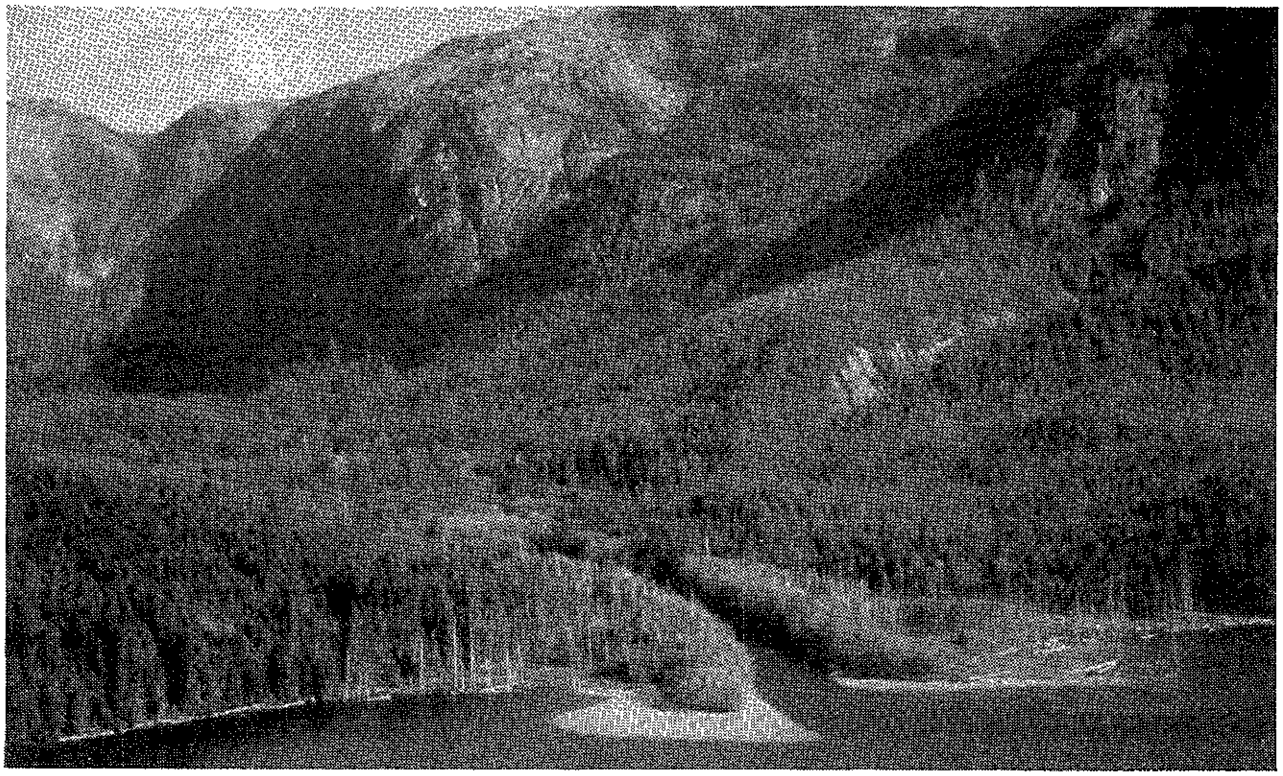


Plate A3. SURF INLET - Numerous exploration opportunities exist in British Columbia, including mesothermal gold vein targets on the North Coast. The Surf Inlet and Pugsley mines, located in the valley (centre of the photograph), produced more than 890 000 tonnes grading 13.4 grams per tonne between 1917-1926 and 1936-1942.

Plate A4. WINDY CRAGGY (1) - The North Zone of the copper-bearing massive sulphide deposit is exposed on the north flank of Windy Craggy peak.

In the immediate Atlin area, there was no major exploration activity for Motherlode-style gold deposits, although placer operations are ongoing.

TULSEQUAH RIVER - TATSAMENIE LAKE AREA

Redfern Resources Ltd. announced that Cominco Ltd.'s underground drilling program on the Tulsequah Chief (4) delineated additional reserves bringing the total to 5.3 million tonnes of 1.6 per cent copper, 1.31 per cent lead, 7.03 per cent zinc, 2.74 grams per tonne gold and 100.46 grams per tonne silver. A sulphide lens was discovered down dip from known zones and indications are that the individual upper lenses may be coalescing at depth, into a single large zone open in all directions. Nearby, in a geologically similar setting to the Tulsequah Chief, Sunport Metals Corporation completed a drill program on the brecciated sulphide mineralization of the Banker (6). Across the Tulsequah river on the old Polaris-Taku mine site (5), Suntac Minerals Corporation drilled a number of gold-bearing mesothermal vein systems. In one hole the drilling intersected 8.5 metres (true width) grading 23.5 grams per tonne gold. Results to date suggest gold grades and widths are increasing with depth.

CASSIAR MINING CAMP

At the Erickson gold mine (9), in the Cusac area, the exploration adit being driven to access the Michelle zone was halted in the fall. The adit is 1375 metres long and approximately half-way to its target. Elsewhere on the Cusac option, limited open-pit tonnage was outlined on the Heather vein and the Bain vein was discovered. The latter was traced along strike by drilling for 200 metres with widths of 0.5 to 1.7 metres containing high gold values.

On the McDame property (8) of Cassiar Mining Corporation some drifts were rehabilitated and underground diamond drilling defined further reserves.

North of Cassiar, near the British Columbia - Yukon boundary, Strathcona Mineral Services Ltd. pumped out the workings and rehabilitated the camp at Midway (7) preparatory to a major exploration program in 1990.

DEASE LAKE - MOUNT EDZIZA AREA

On the Gnat Pass property (10) of Integrated Resources Ltd., located immediately southeast of Dease Lake, it is expected that the results of a drilling and trenching program will increase both the known tonnage and grade on this copper porphyry deposit.

To the west of Mount Edziza Park, Integrated Resources drove a number of rotary drill holes into the Barrington River placer lease (11) testing the two gold-bearing pay zones. Close to the eastern boundary of the park, Cominco Ltd. drilled on the Spectrum property (12). The holes were to test strike length and down-dip extensions of previously drilled high-grade gold intersections in an Upper Triassic to Lower Jurassic volcanic-sedimentary sequence which is crosscut by Jurassic to Cretaceous diorite to quartz monzonite dikes. South and east of Mount Edziza Park the Hank claims (13) of Lac Minerals Ltd. cover altered Upper Triassic andesites cut by quartz-carbonate-barite veins. Drilling intersected several-high grade gold and silver sections with associated zinc, lead and copper mineralization.

ISKUT RIVER AREA

The Iskut River area was again a hot spot of activity. Triassic Stuhini or Jurassic Hazelton Group volcanics and sediments were the focus of exploration for gold hosted in veins or shears and associated with quartz, carbonate, sulphides and chlorite.

A study jointly funded by government and industry identified the best route for a future access road to the Bronson Creek airstrip. The cost of building the all-weather industrial road is estimated to be $12.5 million and construction could start as early as spring 1990.

Gulf International Minerals Ltd. concentrated on drilling the Northwestern zone on the McLymont property (14). The mineralization is along a northeast-trending shear and replaces the limy siltstones of a Mississpian sequence of cherts and siltstones. Drilling for an extension of the Northwestern zone, as well as on two adjacent geophysical targets, expanded the potential size of the deposit.

On the Iskut joint venture project (15), drilling by Prime Resources Corporation tested a strong soil geochemical anomaly and coincident weak geophysical trends on an interpreted strike extension of the Gorge showing.

Hughes-Lang Corporation drilled 33 holes testing four sub-parallel zones on the Iskut River property (16). The northwestern portion of the property contains semimassive to massive sulphide mineralization and quartz-carbonate veins within Hazelton Group sediments. Gold values range between 2.81 grams per tonne gold over 2.7 metres, and 44.6 grams per tonne gold over 1.4 metres. A second style of mineralization, a gold-copper-molybdenum porphyry, is found in sericitized, feldspathized and biotized greywacke in the southeast corner of the claims.

Cominco Ltd. spent $2.3 million on an extensive underground drilling and drifting program on the Twin zone at the Snip site (17). The Twin zone is a shear vein averaging 4.3 metres in width cutting greywackes and siltstones. After the completion of 489 holes in 1989 the current reserves are 934 395 tonnes containing 30.0 grams per ton gold. Testing of a bulk sample indicated that average recoveries would be 90 per cent.

At Johnny Mountain (18) Skyline Gold Corporation drilled 19 holes in the Johnny Flats area and concentrated on testing three locations; the Windsock, the C-3 and the Bronson Slope anomalies. Another 109 drill holes were completed in the vicinity of the mine to better define the Pick Axe zone and increase the reserves. Prospecting discovered the Homestake vein, which trends parallel to, and is located to the north of the Discovery vein.

Two mineralized structures on the Bronson Creek property (19), the S and T zones, were drilled by Cathedral Gold Corporation. The claims, underlain by Mesozoic siltstone, sandstone and volcanics, are intruded by granitic stocks and dikes. Hole 89-9 on the S zone cut a 4.6-metre intercept grading of 15.77 grams gold per tonne. Other holes on the zone returned values between 0.79 and 33.08 grams per tonne gold over widths of 0.6 and 1.4 metres respectively.

Inel Resources Ltd. tested the AK zone on the Inel property (20). The zone is a mineralized breccia in the footwall of a porphyry dike and has a known strike length of 76 metres, a width of 6.1 metres and is open in all directions. The newly discovered Ninety-Eight zone is located 183 metres southwest of the AK zone along a porphyry dike contact and contains visible gold.

SULPHURETS AREA

The Sulphurets area became the focus of attention in mid-August when Calpine Resources Incorporated and Consolidated Stikine Silver Ltd. announced spectacular results from Hole 89-109 on the Eskay Creek property (21). Following the announcement there was a flurry of exploration activity in the area. The principal targets were gold-silver deposits found in quartz veins and siliceous breccias hosted by the volcanic and sedimentary rocks of the Jurassic Hazelton Group. Many companies keyed on the mineralized felsic volcaniclastic horizon identified by D. Alldrick and J. Britton of the British Columbia Geological Survey Branch during their 1988 mapping.

At Eskay Creek, Calpine Resources Incorporated spent $12 million on an extensive drilling program on the new 21 zone discovery. This zone has a strike length of 1300 metres, has been tested over 240 metres down dip and is open along strike and to depth. Mineralogy changes within the South, Central and North sub-zones of the 21 zone; generally base metals become more abundant and stibnite, realgar and orpiment less significant to the north. The gold mineralization is generally hosted by the transitional argillite unit, although it occurs in both the hangingwall andesite and the footwall rhyolite. To the north the mineralization is more abundant in the footwall rhyolite. A recent estimate by Roscoe Postle and Associates indicates that the 21 Zone of the Eskay Creek deposit contain probable geological reserves of 3.35 milion tonnes grading 19.20 grams per tonne gold and 521.3 grams per tonne silver and gold additional 1.68 million tonnes of possible geological reserves grading 8.57 grams per tonne gold and 281.14 grams per tonne silver at a 1.37 grams per tonne gold cut off.

On the Sib property (22) of American Fibre Corporation, the emphasis has been on defining near-surface mineralization. Drilling has indicated that the gold is not in veins but associated with sulphides in a brecciated unit.

On the Sulphurets property (24), Newhawk Gold Mines Ltd. continued delineating the West and R-8 zones through underground drilling and drifting. The recently discovered R-8 zone varies from 1.2 to 11.6 metres in width. It is a quartz-orthoclase vein and stockwork containing electrum and visible gold with tetrahedrite, silver sulphosalts, sphalerite and some chalcopyrite. The R-8 zone, a target of ongoing drilling, is open to depth but cut off at the top by a fault.

On the Treaty Creek claims (26) Teuton Resources Corporation was encouraged by drill results. Limited underground development was done on the Goldwedge property (23)of Catear Resources Ltd.

Copper-gold mineralization was the focus of attention on the Kerr prospect (25). Western Canadian Mining Corporation completed a drilling and geophysical program and has estimated drill-inferred reserves of 114.3 million tonnes of 0.61 per cent copper, 0.27 gram per tonne gold and 1.71 grams per tonne silver. This copper-gold porphyry deposit is open along strike and to depth. It is hosted by a sequence of sericitic and silicified felsic volcaniclastics. In October, Placer Dome Inc. acquired a controlling interest in the property by purchasing all the common shares in Sulphurets Gold Corporation from Western Canadian Mining.

STEWART MINING CAMP

Activity in the Stewart mining camp was centred around the start up of the Premier Gold mine (*see* Operating Mines, Table A-1). Westmin Mines Limited continued to actively explore both the Silbak Premier (31) and Big Missouri (28) properties. At Premier underground drilling on the Power, 4G and 609 zones delineated additional reserves. On the Day zone, at Big Missouri, the drill-holes were a follow-up of significant intersections found in 1988. The drilling was to determine if the lower and middle mineralized horizons contain open-pit reserves. Westmin Mines also worked on the Myrtle and East Myrtle veins, an extension of the main Indian vein on the Indian (30) claims.

With the demise of Esso Minerals Canada, Tenajon Resources Corporation became sole owner of the Silver Butte property (29) situated slightly southwest of the Big

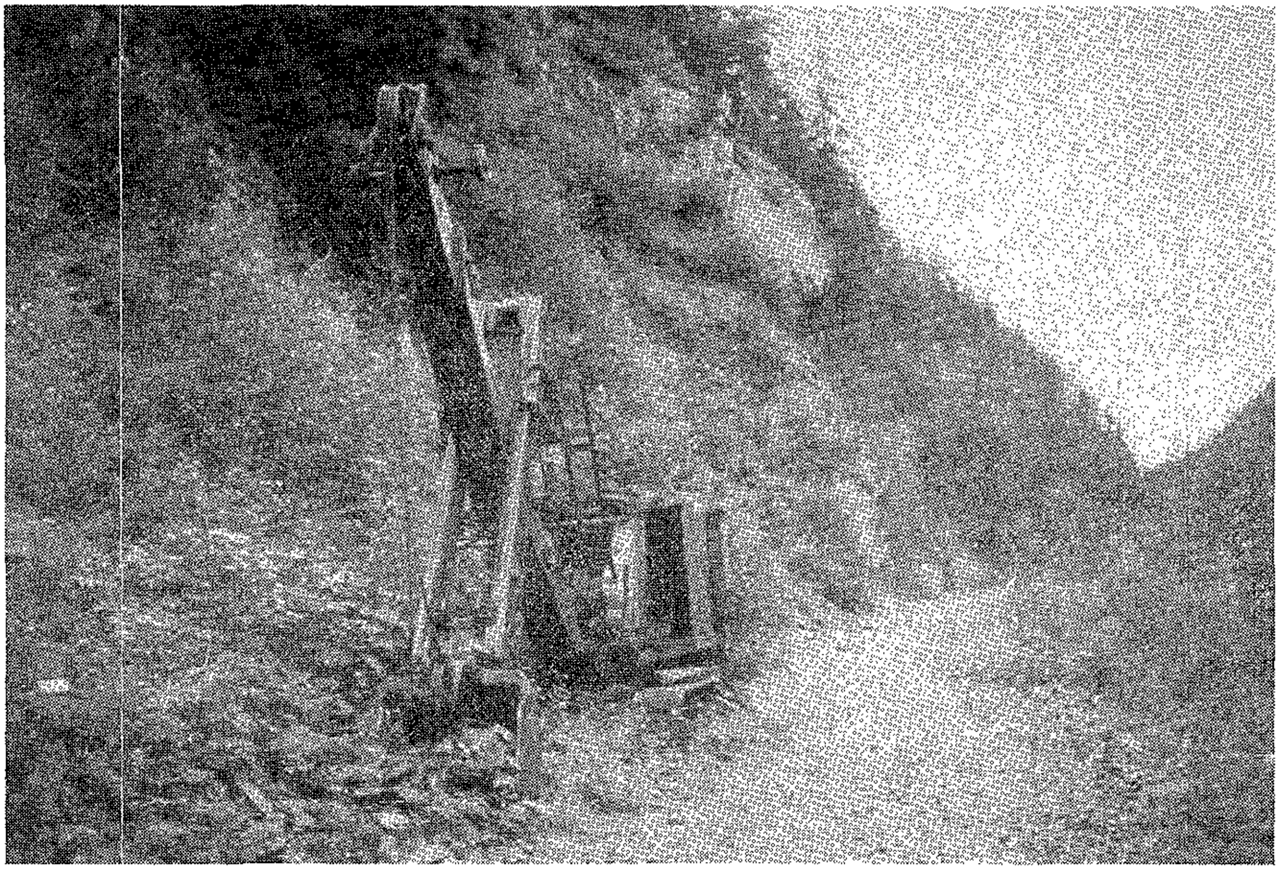


Plate A5. ALICE ARM AREA - This old steam shovel from the Dolly Varden mine is a reminder that the renewed exploration interest in the Kitsault valley is based in part on past production.

Missouri mine site. Exploration drilling and drifting further defined the 35, West Kansas and Kansas zones.

Farther north, on the Korri-Hill property (27) a headframe and hoist have been installed in preparation for sinking a shaft to trace several veins and two zones of massive sulphide mineralization.

East of Stewart, Bond Gold Canada Inc. made significant discoveries on the Red Mountain property (32) and at Willoughby Creek (33). Both discoveries are hosted in pyroclastics and sediments of the Lower Jurassic Hazelton Group. At Red Mountain there are two intersecting, steeply dipping zones, the Marc and the Brad, which contain disseminated sulphide mineralization, mainly pyrite with some pyrrhotite and sphalerite. Drill intersections on the Marc zone varied between 1.16 grams per tonne gold over 142.5 metres and 23.35 grams per tonne gold over 16.5 metres with silver to gold ratios of 2:1 to 5:1.

South of Stewart Avatar Resources Corporation drilled on the Georgia River site (35) with the intention of extending the known reserves.

ALICE ARM AREA

Extending southward from the Stewart region into the Alice Arm area (Plate A-5) favorable Hazelton Group lithologies are again the target of exploration with the focus on gold-bearing veins and silicified zones, and conformable sulphide horizons. Immediately south of the Cambria Icefield, Noranda Exploration Company, Limited tested three zones within a large area of hydrothermally altered volcanics and sediments on the Homestake claims (34).

In the Kitsault Lake area Aber Resources Ltd. was active on the Kits property (36). A mineralized horizon with galena, sphalerite, barite and celestite is believed to be syngenetic and has been traced for over 5 kilometres.

Dolly Varden Minerals Inc. drilled on the Red Point (37) and North Star (38) properties which are located approximately 25 kilometres up the Kitsault River from the head of Alice Arm. On the Red Point three zones were drilled to confirm the grade and continuity of gold-copper mineralization. On the North Star the drilling intersected

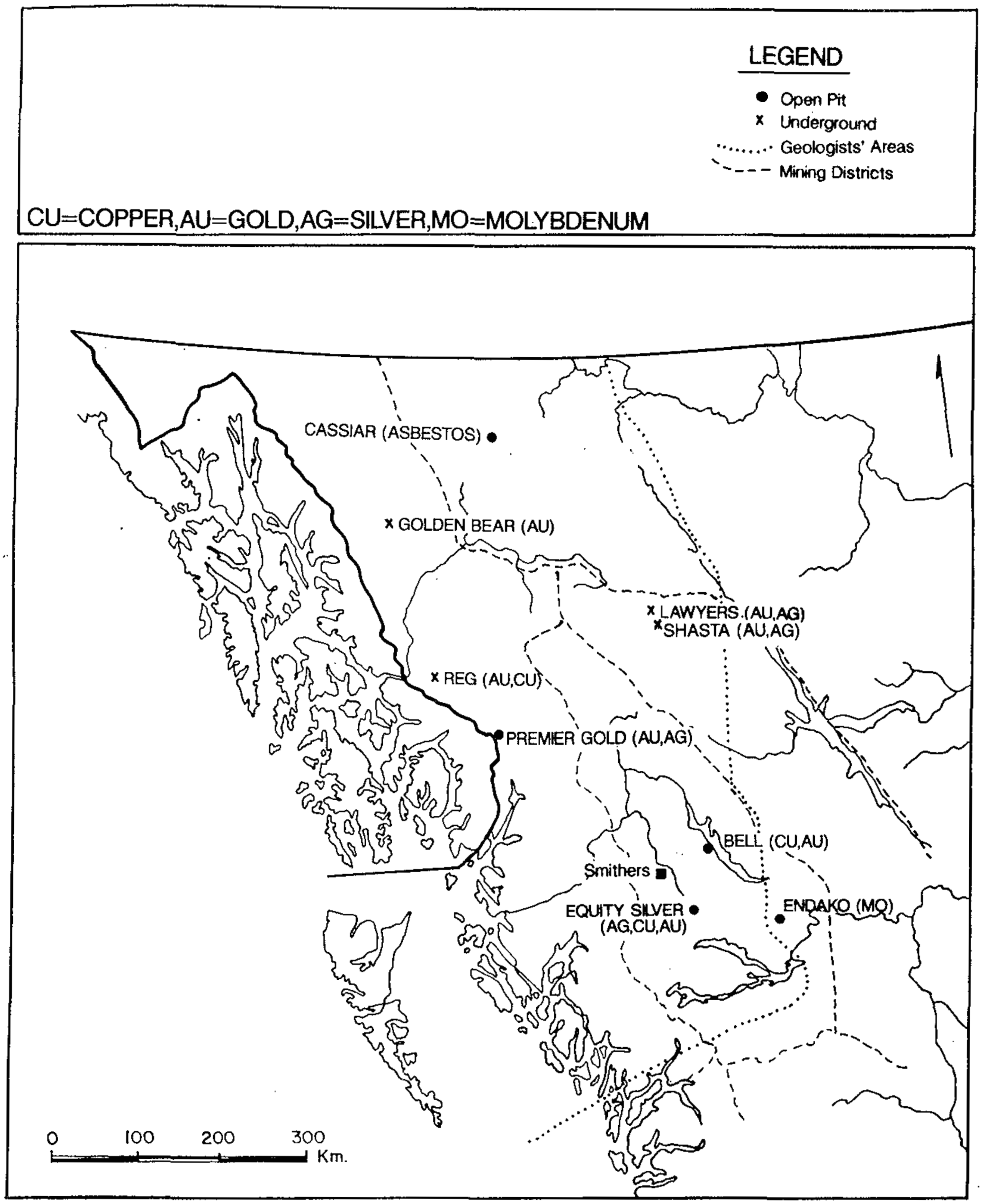


Figure A-7. Operating mines in N.W. British Columbia 1989.

sphalerite, galena and barite mineralization with associated calcite and chert(?) which included 4.1 metres of 4.46 per cent zinc, 0.45 per cent lead, 0.1 per cent copper, 0.34 gram gold and 17.1 grams silver per tonne. The drilling confirmed the down-dip extension of the zinc-silver zone.

Northeast of Alice Arm, Great Northwest Resources Corporation completed work on three zones on the Illiance River property (39). Mineralization is disseminated or associated with quartz veinlets in altered volcanics cut by a number of parallel dikes.

TERRACE AREA

Quartz veins with associated sulphides and gold, silver, copper values were the target of drilling programs on the Dick/Kit (40) and Usk (51) properties as well as the underground rehabilitation on the Lucky B property (41).

NORTH COAST

There was scattered activity on the coastal islands south of Prince Rupert. On the Porcher Island property (42) of Cathedral Gold Corporation a quartz diorite intrusion is cut by mesothermal subvertical quartz veins and shears containing gold in pyrite. Sublevel drifting and raising to test the No. 4 vein for grade and structural continuity confirmed the structure previously interpreted from diamond drilling.

On the east side of Pitt Island, Fairharbour Mining Corporation drilled a polymetallic massive sulphide zone within a highly deformed volcanic-sedimentary sequence on the Trinity property (43). The mineralization is hosted by felsic schists near the contact with mafic schists.

Laredo Limestone Ltd. carried out a drilling and chip sampling program in the Laredo quarry (44) on Aristazabal Island. Proven and probable reserves of limestone are 60.7 million tonnes.

TOODOGGONE RIVER AREA

Exploration activity in the Toodoggone River area was quieter this year than for the past number of years. The majority of programs were directed toward gold-silver epithermal veins hosted by Triassic Takla Group and Early Jurassic Toodoggone volcanics (equivalent to the Hazelton Group).

In the northern part of the camp, Cyprus Gold (Canada) Ltd. carried out a program on the Moosehorn property (45). The Moosehorn East zone and coincident induced polarization and geochemical anomalies south of the Toodoggone River were both tested by drilling.

Cheni Gold Mines Inc. was active in searching for further reserves at the Lawyers mine site (46). Crosscut drifting and underground drilling defined additional reserves in a brecciated zone below the 1700 level currently being mined.

Homestake Mining Canada Ltd. conducted an extensive exploration program on the Creek, JM, O and Far East zones on the Shasta property (47). Detailed drilling increased the quantity and quality of reserves on the JD and Creek zones. Sable Resources Ltd., International Shasta Resources Ltd. and International Taurus Resources Inc. mined two small open pits on the JM and Creek zones (*see* Operating Mines, Table A-1).

In the Finlay River area the Grace claims (48) were percussion drilled by Skylark Resources Ltd. A number of holes were for deep overburden sampling and the remainder tested the strike extension of the Electrum zone and other newly discovered zones. The gold-silver mineralization is generally found within propyllitic and argillically altered Toodoggone volcanics.

Two companies were working on porphyry-style mineralization south of the Finlay River and to the east of Thutade Lake. Drilling on the New Kemess claims (49) of El Condor Resources Ltd. intersected wide zones of anomalous copper-gold values such as 0.15 per cent copper and 0.34 gram per tonne gold over 57 metres. On the Mess property (50) Inco Gold Company encountered weak copper, zinc, lead and silver mineralization within shallow dipping, silicified zones in altered mafic volcanics.

HAZELTON-SMITHERS AREA

The Morningstar property (52), within the Skeena river drainage west of Hazelton, was drilled by Equity Silver Mines Ltd. At the contact between a granodioritic intrusion and sedimentary rocks, a hornfelsic argillite contains small veinlets of pyrite and arsenopyrite with minor sphalerite and chalcopyrite.

Southwest of New Hazelton, Southern Gold Resources Ltd. worked on the old Rocher Déboulé mine (53), a past producer of copper, gold and silver. Southern Gold rehabilitated the 300 level on the No. 4 vein and trenched on the newly discovered 2A vein.

Noranda Exploration Company Limited explored both on the mine site at Bell (55) and approximately 25 kilometres northeast at Hearne Hill (54). Drilling at Hearne Hill concentrated on the definition of a small mineralized breccia pipe containing significant chalcopyrite mineralization. At the Bell mine site an extensive drilling program was undertaken outside the present pit boundaries with the hope of finding reserves which would extend the mine life beyond the present 1992 projection. Mineralization was encountered at depth and a follow-up program is anticipated.

The Fireweed property (56) of Canadian-United Minerals Inc. is on the south side of the Northwest Arm of Babine Lake. The silver-zinc-lead mineralization is

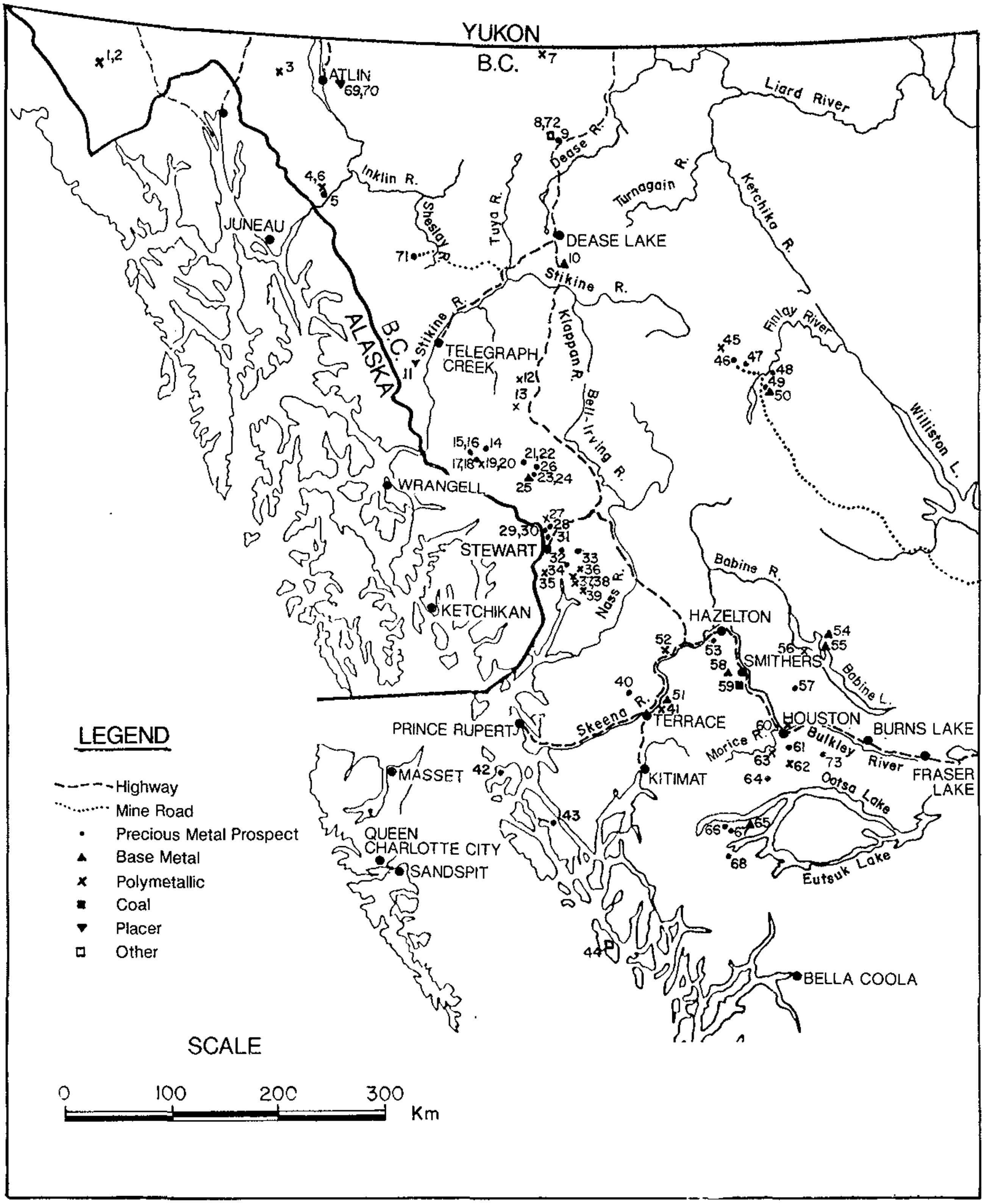


Figure A-8. Exploration, development and mine sites 1989, N.W. British Columbia.

within Cretaceous Skeena Group sandstones. Six zones are known on the property and drilling in 1989 concentrated on the Jan, the 1600 and the East zones. Drill-indicated reserves on the West zone are 580 600 tonnes of 341.8 grams per tonne silver, 2.22 per cent zinc and 1.34 per cent lead.

Situated 25 kilometres east of Smithers the Dome Mountain project (57) has been beset for several years by litigation and dispute. Teeshin Resources Ltd. and Canadian-United Minerals Inc. conducted a drilling program to test three new anomalies and a mineralized outcrop area with the intent of expanding the known reserves. The ore reserves of the Boulder and Argillite zones are in quartz-carbonate veins within a major shear.

Thirty-three kilometers west of Smithers, Corona Corporation drilled a highly altered feldspar porphyry intrusion on the Louise Lake property (58). Low-grade copper, gold and molybdenum were found in the core.

HOUSTON-WHITESAIL LAKE AREA

Mount Harry Davis, several kilometres northeast of Houston, is the site of the HD claims (60) drilled by Equity Silver Mines Ltd. Zinc, lead, copper, silver and gold mineralization occur in veins associated with red and green intermediate to rhyolitic tuffs cut by small andesitic dikes.

Noramco Explorations Inc. conducted a drilling program at the Bob Creek site (61), 10 kilometres south of Houston. Located on the west edge of the Buck Creek caldera, the property is considered to have potential for a low-grade large-tonnage gold-silver-zinc-copper deposit.

At the old Silver Queen (Nadina) mine site (62), 35 kilometres south of Houston, Pacific Houston Resources Inc. completed an underground drilling and drifting program. Surface mapping, stratigraphic correlation, radiometric dating and petrographic studies were undertaken by a team of researchers from The University of British Columbia. Objectives of the 1989 program were to gain a detailed understanding of the mineralogy and to develop an ore deposit model to assist exploration for additional reserves. The deposit is an epithermal gold, silver, zinc, lead and copper vein system hosted by Tip Top Hill volcanics which are believed to belong to the Upper Cretaceous Kasalka Group.

On the Hagas property (63), on the south side of the Morice River southwest of Houston, Progold Resources tested three mineralized zones containing pyrite and associated copper, silver, lead, zinc and gold mineralization.

At the end of the year Swift Minerals Ltd. was drilling the Hill prospect (64) near Nadina Lake.

On the south side of Tahtsa Lake, on the Ox property (65), Granges Inc. completed six holes on the Damascus zone, a small mineralized shear and vein containing silver, lead and zinc.

Equity Silver Mines Ltd. conducted drilling programs on the Wing (66) and Kate (67) properties located approximately 10 kilometres to the west of Troitsa Lake. Gold and silver mineralization was the target of exploration within the ash to lapilli tuffs containing thin interbedded polymictic conglomerates on the Wing and minor siltstone and andesitic dikes on the Kate.

Golden Knight Resources Inc. was successful in its bid to the British Columbia Ministry of Energy, Mines and Petroleum Resources for a lease on the Deerhorn property (68) in the Tweedsmuir Recreation Area. A $900 000 program was carried out with surface mapping and drilling together with underground rehabilitation and mapping. The drilling program tested and delineated the strike length of the three known veins carrying gold and silver.

COAL

There was only one coal exploration program in northwestern British Columbia in 1989. Crows Nest Resources Ltd. continued its drilling program on the Telkwa coal project (59). Working on the north side of the Telkwa River, the intent of the program was to confirm the structural interpretation, improve coal quality information and obtain large cores for bulk samples to test the coal washability characteristics. Resistivity surveys were useful in delineating shallow coal reserves. The bituminous coal measures in the vicinity of Pine Creek on the north side of the Telkwa River are found within Cretaceous Skeena Group sediments and are fault bounded or subcrop to the west, south and east and are truncated on the north by an intrusion.

Gulf Canada Corporation was not active in the field on the Mount Klappan anthracite coal deposit, however, feasibility and marketing studies are ongoing.

PLACER

During 1989, 85 Notices of Work were filed for placer operations in northwestern British Columbia. Of these 39 were for the Atlin area. Queenstake Resources Ltd. was active on both Spruce and Pine Creeks just east of Atlin. At the Pine Creek site (69) twenty-five men were employed processing 229 366 cubic metres of pay gravel with production estimated at 233 138 fine grams of gold. Thirty men processed 99 392 cubic metres of pay gravel producing 143 997 fine grams of gold from Spruce Creek (70).

In the Liard Mining Division 38 Notices of Work were submitted. Integrated Resources Ltd. washed 4175 cubic metres of gravel producing 3806 grams of gold from the Barrington River (11).

TABLE A-5
DEVELOPMENT STAGE PROJECTS, NORTHWESTERN DISTRICT

Project		Company	Ore Reserves
8	McDame	Cassiar Mining Corporation	16 Mt; 5.6% asbestos
17	Snip	Cominco Ltd., Prime Resources	782.4 kt; 30.4 g/t Au
23	Goldwedge	Catear Resources Ltd .	Golden Rocket Zone: 290 kt; 26.4 g/t Au, 230.7 g/t Ag
24	Sulphurets	Newhawk Gold Mines Ltd., Granduc Mines Limited 786.5 g/t Ag	West Zone 7.7 kt; 12.14 g/t Au,

DEVELOPMENT PROJECTS

With the opening of new mines in the district, the number of projects in the development stage is reduced from last year. Current projects judged to be at the development stage are listed in Table A-5.

In the Cassiar mining camp a $50 million development program on the McDame asbestos deposit (8) is ahead of schedule with the start-up date projected to be April 1990 at a daily production of 340 tonnes. There are now a total of 6 kilometres of underground workings at McDame. Underground diamond drilling has increased ore reserves (*see* Table A-3) and potentially extended the mine life from 10 to 13 years. Block caving methods will be used to mine the ore.

Development work slowed down on the Snip project, as Cominco focused on refining its ore reserve calculations by completing 489 underground drill holes on the Twin zone. Further improvements were made to the Bronson Creek airstrip and the camp. A feasibility study was in progress at the end of the year with the possibility of a production decision in 1990. Completion of the Iskut access road would definitely improve the economic viability of this project.

On the Sulphurets property underground development and drilling were focused on the West, UTC and newly discovered R-8 zones. A total of 79 surface and underground drill holes and 1582 metres of underground development were completed to increase the ore reserves. The first 39.6 metres of drifting on the R-8 zone on the 1200 level averaged 51.8 grams gold and 588.3 grams silver per tonne across a true width of 2.5 metres. In early 1989 Newhawk Gold Mines Ltd. submitted its Stage 1 report. A full-scale production feasibility report is scheduled for completion early in 1990.

Catear Resources Ltd. submitted a Stage 1 report in 1989 on the nearby Goldwedge property (23) and completed minor underground development on the project.

SOUTHWESTERN DISTRICT

By H.P. Wilton and S.N. Pfuetzenreuter, District Geology, Victoria

INTRODUCTION

The Southwestern District experienced a significant reduction in exploration activity in 1989. The number of advanced projects, defined as those which involved drilling, large-scale trenching or underground exploration (*see* Table A-3), was only two-thirds of the 1988 total. Most of the more advanced projects, particularly those operated by major companies, had the funding necessary to maintain activity at or above the level of previous years. However, many less advanced properties, or those operated by junior mining companies, remained relatively inactive through 1989, mainly due to the inability of the operator to raise funding necessary to carry out the planned programs. The continuing low gold price was a major contributing factor, as indicated by the fact that some very promising, advanced gold projects were dormant in 1989 (*e.g.* Abo, Ashlu and Kennedy River/Bear) and others were scaled back (*e.g.* Mount Washington and Spud Valley). In contrast, there was increased interest in deposit types such as skarns, porphyries and volcanogenic massive sulphides which are characterized by significant base metals enhanced with precious metal values. For instance, interest remained high in the gold-bearing skarns of Texada Island and northern Vancouver Island and in the polymetallic massive sulphides of the Sicker belt and the Britannia - Indian River pendant. Falconbridge Limited re-investigated its Catface porphyry copper property for the first time since 1972. Although activity remained subdued in the epithermal gold belt of the Queen Charlotte Islands, Cimadoro a newly discovered polymetallic massive sulphide occurrence on northern Moresby Island directed new interest toward the Queen Charlottes late in the year.

The most promising new exploration projects in the Southwest District in 1989 have been the Merry Widow south of Port McNeill, where Taywin Resources Ltd. has discovered widespread gold values associated with base metal sulphide zones in skarn, and the Giant Copper property southeast of Hope, where Bethlehem Resources Corporation is exploring gold-silver-copper mineralization in intrusive breccia zones.

Only one industrial mineral project, Lang Bay 'kaolin', underwent any significant exploration in 1989 although it had also become dormant by year-end. An important change, however, in the industrial minerals area has been the renewed interest in dimension stone quarrying. Several small granite quarries on the mainland coast, and marble quarries on Vancouver Island, are being developed or have been proposed. No coal exploration is known to have been carried out except for some development drilling at the producing Quinsam mine. Placer activity has been minor and intermittent on the Fraser River and in the Leechtown area but a large placer gold surface mine and processing plant are being planned for a site on the Lilloet River north of Harrison Lake.

A significant event in the Southwest District in 1989 was the release in June of Regional Geochemical Survey data for NTS sheets 92E, L and K. It generated increased staking activity both prior to and immediately following the release, particularly in the under-explored areas of 92E and 92K. Time will tell how much of the new staking will lead to significant new discoveries, but it is fortuitous that the data release coincided with a period of renewed interest in polymetallic massive sulphides, skarns and porphyries, all of which are important target types in the area. Data for the remainder of Vancouver Island and the Vancouver sheet (92G) will be released in 1990.

MINERAL EXPLORATION

Table A-3 lists all those exploration projects in the Southwest District on which some significant amount of drilling or underground exploration is known to have been done in 1989. The map numbers listed in the table and shown in brackets after property names in the following text are keyed to the location map, Figure A-2.

VANCOUVER ISLAND

As in the past several years, the greatest concentration of exploration expenditure on Vancouver Island, outside of the two producing metal mines, was at the Chemainus end of the Cowichan uplift of Sicker Group rocks, where two major companies continued to explore for new reserves of polymetallic massive sulphides in sheared felsic volcanics of the Paleozoic McLaughlin Ridge Formation. Minnova Inc. drilled 4253 metres in 44 holes at the Lara property (76) optioned from Laramide Resources Limited. Some of the drilling was directed at increasing reserves in the Coronation zone where the previous operator, Abermin Corporation, had estimated drill-indicated reserves of 529 000 tonnes averaging 1.01 per cent copper, 1.22 per cent lead, 5.87 per cent zinc, 100.1 grams per tonne silver and 4.73 grams per tonne gold. However, most of the 1989 drilling tested other anomalous zones on the property. Minnova also drilled 3148 metres in 16 holes on its adjoining Mount Sicker property (75), part of which has been optioned from Wind River Resources Ltd. (formerly Canamera Explorations Inc.). Falconbridge Limited drilled a total of 11 500 metres in 33 holes distributed among various zones on its large Chemainus property (77) which adjoins the Lara property on the east and west. Falconbridge exercised its right of first refusal to purchase the 50 per cent ownership of the property offered for sale by Esso Minerals Canada and is now the sole owner and operator.

The only other major project undertaken within the Sicker rocks in 1989 was the ongoing Debbie/Yellow project (78) which is a joint venture of Westmin Mines Limited and Nexus Resource Corporation, with Westmin as operator, By early February, the 2-kilometre-long tunnel through McLaughlin Ridge was complete with two crosscuts and some raises into the Mineral Creek zone. Chip sampling across the zone where exposed in a crosscut on the Yellow claim indicated an average grade of 6.2 grams per tonne gold over 9.5 metres, a grade significantly higher than averages projected from previous drill intersections. Underground drilling from stations within the tunnel was carried out immediately following completion of mining (four holes) and resumed in a second phase of drilling late in the year (nine more holes), the objective being to test deeper levels within the Mineral Creek zone, a steeply inclined, quartz-carbonate-altered regional fault. Trenching of the Linda zone, a quartz-veined shear zone in the hangingwall of the Mineral Creek fault, exposed impressive gold mineralization. An average of 42.2 grams per tonne gold over a 15-metre strike length and an average true width of 1.86 metres was reported. A fall program of surface drilling totalled 850 metres in twelve holes on the Linda zone and approximately 515 metres in eight holes on the 900 zone which consists of a high-grade gold-quartz stockwork superimposed on an auriferous chert horizon located 1.6 kilometres southwest of the Mineral Creek zone. A preliminary mineral inventory for the three zones combined has been published by Westmin and totalled 243 130 tonnes probable, averaging 5.15 grams per tonne gold with an additional 518 000 tonnes possible of unspecified grade.

A promising new project which has attracted considerable attention is the Merry Widow (94) of Taywin Resources Ltd. located in the Benson Lake skarn camp south of Port McNeill. Approximately 3.4 million tonnes of magnetite iron ore were produced from the Merry Widow mine and adjacent Kingfisher and Raven pits during the 1950s and 1960s. Taywin discovered that significant areas of gold-rich, skarn-hosted sulphide mineralization are exposed in the walls of the Merry Widow pit and several surface showings to the north and south. The company spent about $450 000 in 1989 to explore the gold potential with 43 drill holes totalling 2713 metres as well as trenching and geophysical surveys. The gold-bearing sulphides appear to be structurally controlled and distributed in three or four parallel zones over a strike length of at least 400 metres. Typical drill intersections average 5 to 9 grams per tonne gold with up to 1 per cent copper over widths of 15 to 30 metres.

Another skarn-hosted, gold-rich sulphide occurrence explored in 1989 is the Hiller-Churchill property (86) northwest of Zeballos, owned by Falconbridge Limited and held under option by Footwall Explorations Ltd. which drilled underground from an adit completed in 1988 on the Hiller 25 zone. Hisway Resources Corporation explored two skarn-related prospects at the north end of Vancouver Island. The HPH property (96) west of Port Hardy and southeast of Nahwitti Lake covers several showings, most of which are manto or replacement-type massive silver-lead-zinc sulphide zones. Hisway drilled six holes totalling 506 metres on the HPH and has begun exploration, with one hole drilled so far, on a property at Quatse Lake (95) which includes the Caledonia copper-zinc-silver skarn deposit. Although the project is not yet at the drilling stage, encouraging trench assays were reported by Battle Mountain (Canada) Inc. from its preliminary program on the Beano property located just south of Zeballos and optioned from Billikin Resources Inc. The mineralization is described as massive pyrrhotite zones in actinolite skarn. One of the better trench samples to be reported this year assayed 71.2 grams per tonne gold over 5 metres.

Symptomatic of the revived interest in base metal exploration is the fact that Falconbridge Limited mounted a program to re-examine and resample its Catface porphyry copper-molybdenum prospect (80) located 10 kilometres northwest of Tofino. Exploration prior to 1972 had outlined a main zone containing a drill-indicated reserve of 181 400 tonnes averaging about 0.35 per cent copper. The company resampled the old workings on the main zone, completed extensive air and ground geophysical surveys, drilled three other anomalous zones, and is optimistic about the potential for increased reserves. The mineralization is directly associated with porphyritic quartz diorite intrusions of Tertiary age. In the porphyry belt extending northwest from the Island Copper mine, Moraga Resources Limited drilled seven holes totalling 764.4 metres on the Expo property (97) optioned from BHP-Utah Mines Ltd. The drilling was done adjacent to the Red Dog porphyry copper-molybdenum-gold deposit recently under option to Crew Natural Resources Ltd. and reported to contain reserves in excess of 45 million tonnes.

On the Red Dog property itself, Crew National Resources conducted detailed geological studies but did no further physical work in 1989.

Among the strictly gold-oriented projects on Vancouver Island, the most advanced is the Spud Valley project of McAdam Resources Inc. at Zeballos (84). Underground exploration drifting continued on several gold-bearing vein structures with particularly interesting results reported from the 7A sublevel on the Linton North vein, where continuous panel samples from 14 metres of drift averaged 26 grams per tonne gold over a 1.2-metre mining width. A small test mill was completed on the property by early October and has been processing ore recovered from the exploration drifts and from a stockpile on surface. The most recent reserve figures published by the company were 220 000 tonnes averaging 10.8 grams per tonne gold. Also at Zeballos, a 50/50 joint venture between CanAlaska Resources Ltd. and New Impact Resources Inc. completed 21 underground drill holes totalling 2195 metres, at the former-producing Central Zeballos mine (85). They are attempting to increase the proven and possible reserves beyond the presently reported 68 000 tonnes at 12.0 grams per tonne gold. The targets on both of these Zeballos projects are mesothermal quartz-sulphide veins in shear zones cutting the Tertiary Zeballos quartz diorite stock.

At the Mount Washington epithermal gold-silver-copper camp west of Courtenay, exploration activity was scaled down in 1989 as Better Resources Ltd. completed only minor trenching and 17 short drill holes in the Lakeview zone at the Mount Washington property (91). Published reserves remain at 550 300 tonnes of drill-indicated ore averaging 6.75 grams per tonne gold and 32.2 grams per tonne silver. On the east side of the mountain, Noranda Exploration Company, Limited drilled two very short holes into the Murex breccia zone (92), optioned from Better Resources, where locally gold-rich massive copper mineralization occurs in the matrix of an extensive, tabular breccia zone. On the CIH claim (87) near Fanny Bay, prospector Bert Buskell drilled two short holes to test the subsurface character of an arsenopyrite-rich quartz-vein stockwork with low gold values hosted by a large felsite dike. This occurrence is believed to be of Tertiary age and related to the gold mineralizing event at Mount Washington.

Other gold projects of note on Vancouver Island include the Lucky property (79) north of Toquart Bay where Freemont Gold Corporation and partners, under an option agreement with Electrum Resource Corporation, drilled six holes to further test locally high-grade gold in a quartz vein. On Ursus Creek west of Sproat Lake (81), the Prime Resources Group drilled five holes totalling 792.5 metres on a property owned by Pacific Sentinel Gold Corporation. The target is gold in quartz veins localized within a major east-striking shear zone. On Cotter Creek near the head of Herbert Inlet (82), Stoney Creek Mines Ltd. and Gold Parl Resources Ltd. cooperated on the staging of small drilling programs on adjoining claim groups both optioned from prospector Sam Craig. Included within one of the groups is the former Mary McQuilton or Abco gold mine which is reported to have produced 78 tonnes yielding more than 7200 grams of gold and minor amounts of silver and copper.

Finally, the only major exploration project south of Cowichan Lake continued to be the Valentine Mountain property (74) of Beau Pré Explorations Ltd. north of Sooke, where erratic high gold values are found in a persistent system of narrow quartz veins in the axis of a major anticlinorium within the Leech River metamorphic complex. Noranda Exploration Company, Limited explored the property under option from Beau Pré and carried out extensive surface surveys and mapping followed by five diamond-drill holes.

TEXADA ISLAND

Freeport-McMoRan Gold Company, encouraged by several wide intersections of high-grade skarn-hosted gold-silver-copper mineralization encountered in late 1988 drilling below the Little Billie mine workings, continued comprehensive work on the extensive holdings of Vananda Gold Limited which extend across the island from Vananda to Gillies Bay (89). The program culminated with the drilling of 5208 metres in 22 holes distributed among several zones. Echo Bay Mines Ltd., which had, in 1988, systematically surveyed most of the large North Texada property (90) optioned from Rhyolite Resources Limited, focused its exploration activity in 1989 at the extreme north tip of the island where trenching, drilling, and detailed mapping of skarn mineralization was carried out at the Paris showing and adjacent to a small diorite stock east of Blubber Bay. Drilling totalled 2488 metres in nine holes. At the Angel showing (88) in central Texada Island, where erratic gold values occur in narrow quartz veins associated with the strongly ferrocarbonate-altered hangingwall of a regional fault, Nexus Resource Corporation completed I.P. surveys and drilled 540 metres in five holes. The property was optioned by Nexus from Rhyolite Resources Limited.

SOUTHWESTERN MAINLAND

The highlight project in the mainland part of the district was the Giant Copper property (102) of Bethlehem Resources Corporation, located at high elevation between Manning Park and the Skagit Recreation Area southeast of Hope. Several mineralized intrusive breccia zones occur on the property, the best known being the AM breccia pipe. Recalculated reserves based on pre-1989 data and limited mainly to the northern end of the breccia pipe are 3.355 million tonnes of underground reserves grading 1.17 per cent copper, 0.51 gram per tonne gold and 20.6 grams per tonne silver. Potential open-pit reserves have been calculated at 20.7 million tonnes grading 0.75 per cent copper, 0.41 gram per tonne gold and 12.0 grams per tonne silver. Rotary drilling in 1989 focused on the relatively untested south and central parts of the breccia zone and has demonstrated that significant additional reserves exist in these areas. For example, one drill intersection graded 1.15 per cent copper over 50.3 metres. A newly discovered breccia zone containing comparable copper and gold values, with locally high silver-lead-zinc, lies about 330 metres northeast of the AM zone and was extensively trenched and drilled in 1989. Other mineralized breccias occur on the property, most notably the Invermay breccia, but have yet to be explored in detail.

In the Britannia - Indian River roof pendant of Early Cretaceous Gambier Group volcanic rocks southeast of Squamish, Minnova Inc. continued systematic exploration by drilling on two separate optioned properties. At the divide between the headwaters of the Stawamus and Indian rivers, on a property optioned from International Maggie Mines Ltd. (100), Minnova drilled 2345 metres in seven holes in an ongoing search for volcanogenic massive sulphides in the "Slumach rhyolite". The Slumach rhyolite is an altered rhyolite fragmental unit with widespread low-grade zinc mineralization that stratigraphically overlies the Slumach polymetallic sulphide vein previously explored underground by International Maggie. In the Furry Creek valley (99), Minnova drilled 2372 metres in ten holes as part of an ongoing search for mineralization associated with the southeasterly extension of the Britannia mineralized "shear zone". This property is part of the former Anaconda holdings optioned by Minnova from Fleck Resources Ltd.

On a property called Easy and Jo (101), located on the Lillooet River opposite Skookumchuk and owned jointly by Hillside Energy Corporation and Corona Corporation, Kali Venture Corporation financed the drilling of a locally gold-bearing zone of strong shearing which is conformable with bedding in felsic tuffs of the Fire Lake volcanics. A similar gold-bearing, silicified and pyritized shear zone in carbonaceous argillites was drilled by Castle Minerals Inc. at the Wren property (105) on Rutherford Creek south of Pemberton.

A new project in 1989 was the underground drilling program carried out by McNellen Resources Inc. at Mount Foley (103), 24 kilometres east of Chilliwack. A total of 1519 metres of drilling was completed in 29 holes to test mineralization in the Lucky Four showing which consists of massive copper-molybdenum-gold-silver sulphides in garnetite skarn at the contact between a granodiorite intrusion and an argillite-greywacke assemblage, probably of the Chilliwack Group.

On Ladner Creek (104) near Hope, Anglo Swiss Mining Corporation (formerly Carolin Mines Ltd.) completed six surface drill holes on the McMaster zone and twelve underground drill holes on the Idaho zone. The company is optimistic about the potential for increased reserves and a substantially improved milling process which will enable it to justify re-opening the Ladner Creek gold mine. Existing proven and probable reserves are reported to be 816 500 tonnes grading about 4.1 grams per tonne gold.

QUEEN CHARLOTTE ISLANDS

Exploration remained low key on the Queen Charlotte Islands through 1989 but received a minor spurt of interest late in the year as a result of the activity of Teck Explorations Ltd. on the Cimadoro property (106) optioned from Doromin Resources Ltd. The property is located at the north end of Moresby Island, about 35 kilometres west of Sandspit. The mineralization of interest consists of two massive sulphide lenses, with variable amounts of precious and base metals, apparently stratabound within a chert-argillite package immediately below the base of the Late Triassic Karmutsen Formation. Teck drilled six holes totalling about 1000 metres to test the assumed mineralized horizon, potentially a new stratigraphic target for the Queen Charlottes.

At the Cinola gold property (107) on Graham Island, Barrack Mine Management Inc. took over as operator from City Resources (Canada) Ltd. and is still waiting for completion of a feasibility study. Meanwhile environmental reviews are ongoing and public meetings are proposed for early 1990. The only physical work carried out in 1989 consisted of three drill holes totalling 320 metres to recover HQ core from the orebody for metallurgical testing.

INDUSTRIAL MINERALS

At the Lang Bay kaolin project (98) south of Powell River, the joint venture of Fargo Resources Ltd. and Brenda Mines Ltd. completed a diamond-drilling project which had begun in late 1988 to further delineate the primary (residual) kaolin reserves. The most recent published reserve is 6 million tonnes. Upon completion of prefeasibility studies in May, Brenda Mines announced that it was withdrawing from the project and no further exploration has been done since that date.

No other industrial minerals properties are currently being explored in the district, but there has been a significant increase in interest in dimension stone quarrying in 1989. Small amounts of granite tile have been produced from a quarry on Fox Island and quarry development is proposed at Sechelt, near Squamish, and at the former producing quarry on Knight Inlet. A new marble quarry at Bonanza Lake on Vancouver Island has also been proposed for development.

PLACER

Platinate Minerals and Industries Ltd. (affiliated with Metals Research, S.A.) which owns and has been systematically testing 104 placer leases along the Lillooet River and its tributaries north of Harrison Lake since 1975, successfully completed a series of test runs in 1989 on material mined from placer lease 9790 near Douglas. Large-scale production at a rate of as much as 9000 tonnes per day is proposed in a larger plant currently being designed.

Other gold placer activity consisted of a few minor and intermittent operations on the Fraser River north of Hope and in the Leechtown area of Vancouver Island.

COAL

No coal exploration is known to have occurred on Vancouver Island or elsewhere in the Southwest District in 1989, except for some development drilling at the producing Quinsam mine.

NOTES

SOUTH-CENTRAL DISTRICT

R.E. Meyers and T.B. Hubner, District Geology, Kamloops

INTRODUCTION

The overall level of mineral exploration and development in south-central British Columbia was slightly lower during 1989 than in the previous two years, when record levels were attained. Although the total number of exploration projects was approximately the same as 1988, there was about a 25 per cent reduction in the number of major projects (*i.e.* project expenditures of $250 000 or more). This downturn can be attributed primarily to reduced funding levels for junior exploration companies and secondly, to the attraction of the bulk of the province's market-based funding to high-profile projects in remote areas of northwestern British Columbia.

Despite these factors, and because of the long term commitment to the region by several major mining and exploration companies, an estimated $20 million was spent on surface and underground exploration and drilling projects. An additional $50 million is estimated to have been spent on development at mining and milling operations in the district, bringing the total estimated 1989 exploration and development budget for south-central British Columbia to the order of $70 million.

HIGHLIGHTS

A new mining camp was established during 1989 in the Adams Lake area with the official opening of the Minnova Inc. Samatosum mine in October. In just three years since its discovery, this high-grade silver-rich deposit has been developed into one of the most profitable mining operations in the province.

The district's second new mine to be brought into production during the year was the Afton Operating Corporation Ajax porphyry copper-gold deposit. This deposit, together with the others in the Iron Mask batholith, has provided British Columbia with an important exploration model that has accelerated the discovery and advanced exploration of such notable projects as Mount Polley, Mount Milligan and others in the Intermontane Upper Triassic island arc volcanic belt.

New potential has also been established for intrusive-hosted epithermal lode gold deposits with the discovery of the Elk prospect at Siwash Lake by Fairfield Minerals Ltd. This discovery is less than 2 kilometres from Phase 3 of the Coquihalla Highway and may well contribute to maintaining a strong mining industry in the Okanagan-Similkameen region after the Brenda mine, 20 kilometres to the east, ceases operations in 1990.

Exploration in the Okanagan region was maintained despite a scarcity of funding for several current projects. A new higher grade gold zone was outlined by Inco Gold Management Inc. on the Vault deposit, which has substantially enhanced the project's outlook and the epithermal potential of the area in general.

Two areas in the district experienced reduced levels of exploration and development during 1989. A 15-week strike at the Highland Valley Copper operations greatly reduced copper production and profitability of the region. In the Bridge River gold camp the absence of exploration funding for several major projects has seriously affected the area's economy and left important mineral potential under developed.

MINERAL EXPLORATION

ADAMS LAKE AREA

The search for stratiform polymetallic sulphide deposits continued throughout the Eagle Bay assemblage and Fennell Formation. Minnova Inc. was the main operator in the area, with two-thirds of all exploration projects. Much of its effort was concentrated on claim groups in the Samatosum mine area, on properties including the Victory (111), OK (112) and Dixie (113). Immediately southeast of the mine, Homestake Mineral Development Company operated drilling programs on the Kamad (114) and Cana (115) properties and surface exploration on the Twin Mountain (116) prospect. These properties were recently acquired by Homestake from Esso Minerals Canada. Farther southeast, Falconbridge Limited completed a drilling program on the Bay claims (117), exploring the same mafic volcaniclastic sequence that hosts the Samatosum deposit.

North of the Barriere River, Minnova operated drilling programs on FY/Anna (118) and Biere (119) claim groups in Eagle Bay rocks and on the Chinook Mountain (120) and Chu Chua (121) properties in the Fennell Formation. The Chu Chua property is a joint venture with International Vestor Resources Ltd., Quinterra Resources Inc. and Pacific Cassiar Limited. Recently published geological reserves in the deposit are approximately 1.04

million tonnes, grading 2.97 per cent copper, using a 1 per cent copper cut-off grade.

KAMLOOPS - BONAPARTE AREA

In the Vidette Lake area Inco Gold Management Inc. completed a two-phase drilling program on the Epi/Yard claim (122), where the target is epithermal precious metals related to presumed Tertiary structures cutting Nicola volcanic rocks. Similar lode gold targets were drilled by QPX Minerals Inc. to the southeast on the Bonaparte property (123). To the southwest at the Arrowstone property (124), Iron River Resources Ltd. tested epithermal base and precious metals mineralization associated with chalcedonic quartz veins. Brenda Mines Ltd. drilled geophysical anomalies associated with copper-gold porphyry mineralization on the Rayfield River property (125) southeast of Green Lake. Northwest of Little Fort, Teck Explorations Ltd. completed a comprehensive surface program on a gold-bearing skarn prospect on the Haida claims (126). To the south, near Barriere, Michael Resources Ltd. initiated a drilling and sampling program for industrial feldspar on the G-Claims (127). Teck Explorations Ltd. also drilled a copper-gold porphyry target in the north extension of the Iron Mask batholith, on the Iron Mask property (128) near Kamloops Lake. To the northeast of Kamloops, R. Steiner drilled the Morgan prospect (129), where precious metals values are associated with copper and arsenopyrite.

South of Kamloops Lake and west of the Afton mine, Menika Mining Ltd. completed geophysical work and drilling on the Maskam (Beaton) property (130). Skyrocket Exploration and Resources Inc. drilled four holes on the Boy claim (131) to the southeast. Farther to the west, Mad River Resources Inc. drilled the Model-Anne prospect (132), where anomalous mercury values occur in Tertiary Kamloops Group volcanic rocks.

On the south side of the Iron Mask batholith, exploration continued near the Ajax mine for alkaline porphyry copper-gold mineralization. Brenda Mines Ltd. undertook surface mapping, geophysical surveys and subsequently drilled the Oz claims (133), while to the east, Cominco Ltd. completed an extensive rotary percussion drilling program on the Edith property (134).

NICOLA BELT

In the central Nicola belt, between Kamloops and Merritt, several lode gold-silver targets were explored. Naxos Resources Ltd. completed first-phase diamond and rotary percussion drilling programs in mafic rocks of the Nicola sequence on the Road 4 (135) and JJ (136) properties north of Shumway Lake. To the north and east A. Babiy drill-tested the Vicars (137) and Powl (138) copper-gold prospects. East of Stump Lake, Anglo American Resources Inc. drilled several geophysical targets on the Mary Reynolds gold prospect (139). Farther west near Desmond Lake, Menika Mining Ltd. intersected copper mineralization in Nicola basaltic rocks on the Des property (140). South of Merritt, at Iron Mountain, Golden Dynasty Resources Ltd. drill-tested polymetallic sulphide targets on the Leadville and Charmer prospects (141), where barite, gold and base metals occur in steeply dipping veins hosted in Nicola mafic tuffs.

OKANAGAN

Exploration activity in the northern Okanagan region was lower in 1989 than in 1988. The Brett project (142), at Whiteman Creek, was again the most active property in the area. Corona Corporation and Huntington Resources Inc. have completed a three-phase drilling program on the Brett which extended the known epithermal mineralization of the main shear zone farther to the north. As operator, Corona plans to re-evaluate results accumulated to date before planning further work. South of Whiteman Creek Eureka Resources Inc. intersected anomalous precious metals values in Eocene basaltic tuffs on the Miller property (143) north of Terrace Mountain. To the west, Clifton Resources Ltd. drilled the CLF/Exam claims (144) for epithermal precious metals in the Tertiary volcanic sequence. To the north near Westwold, Corona Corporation also drilled the Jewel property (145), a copper-gold prospect associated with Tertiary structures.

East of Vernon, BP Resources Canada Ltd. completed a drilling and sampling program on the Lavington property (146). At Lumby, Zicton Gold Limited drilled the BS claim (147) and J. Hilton drilled the OK property (148). In this area, gold mineralization is associated with quartz veins in sheared graphitic sedimentary rocks correlative with the Nicola Group.

In the southern Okanagan region, much of the exploration activity was focused on Eocene volcanic rocks centred around Okanagan Falls. Inco Gold Management completed its third major program on the Vault (149) epithermal gold project. Its efforts were divided between the "Main Zone", a deep, structurally complex epithermal vein system and the "North Vein", a shallower mineralized structure which extends to surface and is reported to have higher average gold grades than the Main Zone. To the east, Minnova Inc. completed a second comprehensive program on the Dusty Mac property (150). Farther east, Yukon Minerals Corporation drilled a porphyry copper-gold target on the Allendale property (151). At Venner Meadows, Inco Gold and Tigris Minerals Corporation completed drilling programs on gold-bearing epithermal quartz-carbonate mineralization in a trachytic volcaniclastic sequence similar to that of the Okanagan Falls area. At both localities (Inco's Au claims (152), Tigris'

Venner (153) property), the Eocene volcanic sequence is being explored down to the basement gneiss complex.

In the Camp McKinney area, Ark Energy Ltd. and Gold Power Corporation completed a joint venture drilling program on the Cariboo-Amelia property (154). Their efforts were oriented toward tracing a faulted extension of the historic main gold vein system. To the southeast Minnova Inc. continued drilling the Jolly gold prospect (155). Farther to the west Huntington Resources Inc. initiated gold exploration in foliated granitic rocks on the LMS claims (156). In the Beaverdell camp, Del Norte Chrome Corporation drilled several holes in a highly faulted silver-rich vein system on its Beaverdell property (157). To the south, on the Dominion property (158), Mad River Resources Inc. completed a drilling program for precious metals in Paleozoic Wallace Formation sediments. Battle Mountain (Canada) Inc. drilled several holes on the historic Dividend-Lakeview gold skarn property (159) near Osoyoos.

In the Marron Valley area, north of Olalla, Minequest Exploration Associates Ltd. completed a second-phase percussion drilling and trenching program on the Astro claims (160). West of Penticton, near Riddle Creek, drilling on the Vent (161) epithermal gold prospect was begun by Zygote Resources Ltd. Initial work is focused on pyritic tuffs cut by chalcedonic quartz veins. To the south, near Apex Mountain, Polestar Exploration Inc. began testing the industrial garnet potential on its Crystal Peak (Mount Riordan) property (162), in an area underlain by widespread skarn mineralization. The company has submitted a prospectus to develop a quarry for garnet production and is reviewing the requirements for Stage I of the Mine Development Review Process. Immediately to the west, at the Nickel Plate mine (163) and adjacent areas, Corona Corporation drilled several gold-bearing skarn occurrences. Some of these projects are joint ventures or option agreements with various partners and include the Nickel Plate, John/Taurus (164), Rollo Climax (165), Canty (166), Pride/Bullion (167) and Eagle's Nest (168). Corona has submitted a prospectus to the Mine Development Steering Committee to develop the Canty deposit. North of this area Redding Gold Corporation carried out a limited drilling program in a north-trending pyritic quartz vein system on the Golden Zone claims (169).

PRINCETON - TULAMEEN

There was a notable increase in exploration activity in this region during 1989, due in part to the announcement by Fairfield Minerals Ltd. of its gold discovery on the Elk property (170) near Siwash Lake. This project, which is under option to Placer Dome Inc., focused on a system of epithermal-style quartz veins in the Jurassic Pennask granodiorite. This discovery reflects new and important potential for intrusive-hosted gold mineralization in the area. Fairfield also completed an extensive surface program on the nearby Dill property (171). In the same area Placer Dome operated a major trenching and sampling project on the Spring claims (172) and H. Adams drilled a sulphide-bearing zone on the Gold Core claims (173).

South of Princeton, Similco Mines Ltd. continued a program of exploration drilling at various localities near the Copper Mountain mine, including the Lost Horse Gulch (174) area and the Oriole claims (175). Northwest of Princeton, E. Wedekind and partners drilled the Tor copper-gold prospect (176). Farther west, in the Tulameen ultramafic complex, Tiffany Resources Inc. explored the Lodestone Mountain property (177) for its gold-platinum-iron potential.

At Treasure Mountain (178), near the headwaters of the Tulameen River, Huldra Silver Inc. has continued to evaluate the silver-lead-zinc vein potential. A limited program of underground and surface drilling was carried out in conjuction with geophysical surveys. To the north, in the Coquihalla Lakes area, Blue Gold Resources Ltd. drilled the Keystone prospect (179), a gold-silver occurrence associated with an intrusive breccia.

BRIDGE RIVER - YALAKOM AREA

The traditionally active Bridge River district was noticeably quieter in 1989, as a number of recent major projects were not funded.

The main area of interest moved from the Bralorne-Gold Bridge camp eastward to the Shulaps Range, where MacNeill Industrial Inc. operated a major trenching and drilling program on the Spokane property (180), a gold vein system in the Tertiary Rexmount porphyry flanking the Shulaps ultramafic complex. MacNeill also drilled the Cub 200 copper-molybdenum property (181) to the south. This prospect was discovered during regional mapping in the area by Geological Survey Branch geologists and is also associated with the Rexmount porphyry.

North of the Yalakom River, near Watson Bar Creek, Cyprus Gold Canada Ltd. continued its work on the Second claims (182), where base and precious metals mineralization is hosted in Cretaceous Jackass Mountain Group sedementary rocks.

In the Gold Bridge area the Minto Extension property (183) was drilled by Avino Mines and Resources Ltd. to test gold geochemical anomalies. Farther west, the Gun Creek claims (184) were drill-tested by Hi Tec Resource Management Ltd. At Bralorne, Coral Gold Corporation continued a drilling and trenching program on the Love Oil (Cosmopolitan, 185) property, near the old King mine.

Further work on this vein system may be undertaken from underground workings in the Bralorne mine.

REVELSTOKE AREA

A minor surge of activity took place in the Revelstoke area stimulated by the work of Equinox Resources Ltd. on the J&L deposit (186) and by the announcement that Bethlehem Resources Corporation and partners have acquired the Goldstream mine (187). Equinox completed a major underground exploration program early in the year and submitted a prospectus to enter the Mine Development Review Process. Later in the year Placer Dome Inc. became associated with the project by funding pilot metallurgical tests. At Goldstream, Bethlehem Resources completed a limited drilling and sampling program. The company also drilled the Keystone massive sulphide prospect (188) to the south, near Downie Creek.

KOOTENAY DISTRICT

By A. Legun, District Geology, Nelson

INTRODUCTION

The year saw a broad spectrum of exploration activity directed toward precious and base metals, industrial minerals and coal.

In the search for precious metals major companies took the lead from juniors which experienced difficulties in adjusting to the end of flow-through funding and the softening in gold and silver prices. The continued strength in base metal prices slowly translated itself into increased base metal exploration in the Kootenay District. To December 31 there were 262 mineral Notices of Work submitted and 42 placer. This is an increase from 1988 but reflects new regulations where Notices of Work are required for programs of minimal surface disturbance. As in 1988 the activity was concentrated in the Nelson area (82F), but all areas show an increase in Notices of Work with the Cranbrook area proportionally the most significant. Statistics from the government agent indicate 2021 mineral and 104 placer claims were staked in the district.

A number of small industrial mineral projects were undertaken in contrast with nominal activity last year. There were several coal exploration programs with the largest by Crows Nest Resources Limited in the vicinity of the Line Creek mine (224).

One project, the Golden Crown (233) entered the Mine Development Review Process, one seasonally operating mine, Skylark (230) closed and Silvana (232) changed ownership.

TRENDS

The last year or so has seen a substantial increase in staking of areas underlain by Rossland volcanic rocks. Current studies, particularly by Trygve Höy and Kathryn Andrew of the Geological Survey Branch, suggest intrusions which are bracketed in age by the Rossland volcanics and the major granitoid bodies such as the Nelson batholith, have metallogenic significance. The intrusions may be coeval with the volcanics or younger - perhaps precursors to the Nelson intrusions. A substantial number of properties are associated with such intrusive rocks, including Great Western Star (203), Shaft, Rossland claims (196), Katie (211), Kenville (213), Tillicum (198), Second Relief (202) and the inactive Willa. Geologic models being pursued include intermediate subalkalic copper-gold porphyries, skarn, vein and "conformable gold". This latter type has been defined by Höy and Andrew as gold mineralization which is conformable with its sheared and stratabound subvolcanic host. Some of the models have overlapping characteristics. For example the currently inactive but well-researched Willa deposit has been described as a porphyry deposit with a late-stage skarn overprint.

The improvement in zinc prices in 1989 has encouraged evaluation of known low-grade carbonate-hosted lead-zinc deposits such as Duncan Lake (200).

In the Cranbrook area there is further potential for discovering fault-controlled mineralization such as the Bar and Vine (214). Deep-seated fault structures have not been thoroughly prospected. Possible extensions to previously exploited vein structures (*e.g.* St. Eugene) were discovered in 1989.

In the search for another Sullivan deposit, mapping by industry in the last few years has led to the recognition that the favourable stratigraphy (*i.e.* the Lower/Middle Aldridge contact) extends to the southwest toward Creston.

A number of new industrial minerals (magnetite, gypsum, phosphate, fluorite) prospects have recently been discovered. The Kootenays have an abundance of industrial mineral deposits, including the inactive dimension stone quarries, but require the development of effective marketing strategies for their development.

MINERAL EXPLORATION

NELSON AREA (82F)

Antelope Resources Inc. continued its substantial drilling program on the outskirts of the town of Rossland. Work in 1989 focused on the North Belt claim group within the Rossland claims (196) near Monte Cristo Mountain. Massive pyrite-pyrrhotite lenses lie along the sheared intertonguing contact of Rossland monzonite and Rossland volcanics and sediments.

Southwest of Rossland, Minnova Inc. reopened and sampled the Velvet mine (197), and drilled three holes targeting gold-copper-silver replacement veins.

At Tillicum Mountain (198) Esperanza Exploration Ltd. evaluated three different areas: Grizzly, Silver Queen and Arnie Flats. The Grizzly zone was shown to be a skarn hosted by rocks very similar to those at East Ridge. Surface showings suggest lead-zinc and tungsten potential but drilling indicated encouraging values in gold.

Across the valley from Tillicum, at Blue Grouse Mountain, Mike Bapty Research Ltd. oversaw an extensive program of trenching, percussion drilling and bulk sampling at the Millie Mack property (199) of Dragoon Resources Ltd. and Greenstone Resources Ltd. Silver-lead mineralization is associated with several quartz-calcite-graphite zones of cataclasis at the base of a gently dipping tectonic zone of uncertain origin. Gold values are associated with detached and carbonatized bodies of feldspar porphyry within the tectonic zone. The base of the tectonic zone is exposed on the entire periphery of the mountain.

There were a number of exploration programs in the immediate Nelson area. To the south, at Erie, Hawkeye Development Ltd. assessed four additional vein structures near the Second Relief prospect (202), a major past producer of skarn-related gold. At the Great Western Star (203) Pacific Sentinel Gold Corporation is evaluating intrusive and conformable felsic rocks within Rossland volcanics in a heavily drift covered area. At Snowwater Creek on the Whitewater property (204) Teck Corporation is evaluating several targets including a breccia near the contact of Rossland volcanics and Nelson granitic rocks.

To the southwest of Nelson, on the Rely property (205), Pegasus Gold Inc. completed geochemical surveys and drilled a gold-zinc target associated with a felsic intrusion into the basal tuffite of the Elise Formation.

To the north, within the Nelson batholith, step-out drilling by Cove Resources Corporation early in the year indicated remarkable continuity of the Alpine quartz vein (206) and considerable tonnage potential (1 Mt). Subsequent drilling suggested economic grades are localized and Cominco Ltd. did not pursue its option on the property. Nevertheless the vein presents a dip-slope drilling situation and a large target within which higher grade zones may be delineated. Proven reserves were established at about 210 000 tonnes grading 13.7 grams per tonne gold.

East of Salmo on the Sumit property (207) Baloil Resources Inc. intersected gold mineralization within limestones in an area where gold-bearing quartz veins have been previously mined. The property straddles the Salmo lead-zinc and Sheep Creek gold belts and is prospective for base metals as well.

North of Wyndell on the Liz, John, Bid and Rex claims (208) Legion Resources Ltd. explored lead-zinc mineralization in the Proterozoic Kitchener-Siyeh Formation and drilled a soil geochemical anomaly northwest of known showings.

CRANBROOK AREA (82G, 82J)

The search for "sedex" lead-zinc deposits in the Aldridge Formation continued, led by Cominco Ltd. Cominco used mapping, soil geochemistry and an emphasis on deep-probing UTEM geophysics on five claim groups, the largest program being the Kid/Star (209). Other companies actively looking for another Sullivan orebody and focusing on the Lower/Middle Aldridge contact included Chevron Minerals Ltd. (Goatfell, 217), Minnova Inc. (Stoney, 219) and Dragoon Resources Ltd. (McNeil, 218). Chevron has been drilling tourmaline-bearing targets including a breccia (pipe?).

On the Vine property (214) Kokanee Exploration Ltd. trenched and drilled a fault zone containing base metal sulphides in veins and matrix to a breccia. Mineralization is preferentially developed where the fault intersects a more quartzitic unit of the Aldridge Formation. Mineralization consists of sphalerite, galena, chalcopyrite and arsenopyrite. There is exploration activity on the trace of the fault for several kilometres toward the northwest.

In the Flathead area (215, 216) Placer Dome Inc. drilled three different targets in its pursuit of gold associated with Cretaceous alkalic intrusives.

LARDEAU AREA (82K)

On the Duncan Lake property (200) Cominco Ltd. drilled two holes and proved that lead-zinc mineralization exists on the east limb of the Duncan anticline 2 kilometres north of the old Duncan mine adit. Primary mineralization occurs at the contact between Badshot Formation and lower argillites of the Lardeau Group. Ore zones are lenticular and tend to thin down the limb to the east.

Roper Resources drilled on the Red Elephant prospect (201) near Hall Creek. This prospect, known from the turn of the century, has high gold values in a surface zone of oxidized pyritic phyllite and irregular quartz veining. Massive pyrite-pyrrhotite with stringers of chalcopyrite was intersected in a deeper hole below the zone but returned disappointing values in gold. The prospect is near a major fault and there are other showings (lead-zinc in quartz) nearby, suggesting untested targets remain to be evaluated.

GREENWOOD AREA (82E)

The Skylark mine (230), rejuvenated in 1988, closed in April as a result of declining silver prices. Skylark Resources Ltd. also mined about 8000 tonnes from the Sylvester

K (231) massive sulphide deposit nearby with an average grade less than expected.

Early in the year Attwood Gold Corporation completed the second phase of underground development on the Golden Crown property (233), hosted by the same Triassic greenstones as at the Skylark mine. Some spectacular gold grades were intersected in quartz veins.

INDUSTRIAL MINERALS

A number of small exploration programs were conducted for industrial minerals including gypsum in the Devonian Burnais Formation of the Stanford Range and phosphate in the basal beds of the Fernie Formation in the Flathead area.

Formosa Resources Corporation trenched and sampled the phosphatic intervals on several claim groups (Hunger Lake, Five Cabin) paying particular attention to their potential for rare earths. Yttrium values of over 1000 ppm were identified.

Domtar Construction Materials Ltd. drilled its South Quarry gypsum deposit (220), an area of limited production 1 kilometre south of its active quarry at Lussier River. Westroc discovered a potentially high quality deposit in the Lussier valley (221) and trenched the deposit discovered by Steve Butrenchuk, of the Geological Survey Branch, at Coyote Creek (222).

COAL

Three coal companies in southwestern British Columbia had significant exploration programs. Fording Coal Ltd. drilled deep holes at Eagle Mountain (223) seeking reserves below the Ewin Pass fault. At the Lake pit four rotary-drill holes demonstrated limits of the pit could not be pushed back. Rotary drill programs at Lake Mountain and Henrietta Creek were designed to determine potential pit limits.

Crows Nest Resources Limited conducted six exploration programs in the vicinity of the Line Creek mine (224). Four were within Coal Lease 4 and there were single programs immediately to the north (Ewin Pass) and south (Teepee). The exploration area covered the east limb and axial region of the Alexander Creek syncline.

Westar Mining Ltd. explored the north end of the Greenhills property in the Cougar 6 & 7 areas (226). Drilling helped define detailed structural geology associated with 16 seam.

NOTES

CENTRAL DISTRICT

By E.L. Faulkner, District Geology, Prince George

INTRODUCTION

Exploration activity in the Central District reached record levels, with expenditures of more than $40 million. The number of mineral Notices of Work was up sharply from 1988. Placer Notices of Work, however, were down slightly. Interest in alkali porphyry and porphyry-related copper-gold deposits, and major companies with large exploration budgets, were the reasons for the increase in exploration activity. Junior companies were still very active, despite increasing difficulty in raising risk capital.

As in previous years, precious metals dominated exploration targets in the district. Interest in base metals with gold or silver values increased, but was mostly confined to a few major companies.

Once again, there was little interest in industrial minerals, and coal exploration was confined to producing areas or immediately adjacent ground.

HIGHLIGHTS

- Continued exploration success at Mount Milligan, one of Canada's most extensive surface exploration projects.
- The Cirque deposit (lead, zinc, silver) and Mount Polley deposit (copper,gold) entered the Mine Development Review Process.
- Continued strong interest in alkali porphyry and porphyry-related copper-gold targets, especially in the northern Quesnel trough.

TRENDS AND OPPORTUNITIES

Many major companies reported their largest exploration budgets of the decade, and major companies are expected to lead exploration activity in the next few years. Junior companies continue to have funding difficulties, with some choosing to spend limited funds in the district, rather than in more costly frontier areas. However, participation through option agreements or with small programs was the rule.

Interest in alkali porphyry copper-gold targets continued to grow, with exploration activity in the Omineca matching that in the Cariboo. A notable trend in the Omineca was the large number of reconnaissance or initial surface programs on properties staked or acquired by major companies in 1987. To date, follow-up work is planned on a gratifying one-third of these. Encouraging results have also been reported from several projects in Takla volcanics adjacent to the Hogem batholith, and especially in the Witch Lake - Chuchi Lake area. This area has the potential to become a major copper-gold camp.

Another trend has been the re-examination of some older porphyry properties many of which have extensive exploration histories. Work by Imperial Metals Corporation at the Mount Polley copper-gold deposit (formerly the Cariboo Bell) is expected to result in a production decision this spring. Other companies were active on the Fish Lake deposit, the Hanson Lake prospect and on properties in the upper Taseko River area.

Interest in base metal deposits with some precious metal values has been slow to respond to improved base metal prices and the better long-term outlook. Opportunities exist for exploration in the Gataga - Muskwa Ranges and Barkerville - Cariboo Mountains areas. In the Muskwa Ranges, for example, despite improving logistics and known potential, much ground in this Devonian shale belt remains open, and only two major projects were carried out in the area in 1989. Although limited exploration in the Barkerville - Cariboo Mountains area has so far failed to develop economic tonnages, the potential of this region remains high.

MINERAL EXPLORATION

Mineral Notices of Work received were up 31 per cent from 1988 to a total of 215, setting records for all Mining Divisions. There were 68 drilling or underground projects this year, up slightly from 1988. More than half of the drilling programs were for 10 holes or more. Placer Notices of Work were down 10 per cent from 1988 to a total of 412. Details of selected exploration programs in the district are given in Table A-3.

QUESNEL TROUGH

Alkali porphyry or porphyry-related copper-gold targets dominated activity in the Quesnel trough. In the

Omineca, despite rapidly improving access, ongoing success at the Mount Milligan deposit and encouraging results from other properties, much ground has remained open until recently. As a result, the majority of projects were at an early stage of exploration. Target areas were usually selected on the basis of aeromagnetic signatures attributed to intrusions in the host Takla volcanics, with follow-up geochemical work and induced polarization surveys being used to define trench or drill targets.

Exploration has been hampered by lack of outcrop, thick drift cover in places, and the fact, exemplified by Mount Milligan, that alkali porphyry targets may be large and costly to explore. Bulk drift-sample geochemistry and float mapping have been used with some success in areas of thick glacial overburden.

At Mount Milligan (235) Continental Gold Corp. conducted Canada's largest surface exploration project with a budget of $11 million. More than 400 holes were drilled and about 100 kilometres of core recovered. Gold occurs with pyrite and chalcopyrite in potassically altered latites and related volcanic and volcaniclastic rocks of the Takla Group, and in the brecciated contact zone of a monzonite intrusion that appears to underlie much of the mineralized area and subcrops as a small pluton west of the MBX deposit.

More than 180 million tonnes of probable ore grading 0.3 per cent copper and 0.68 gram per tonne gold have been outlined in the MBX and adjacent zones, and more than 90 million tonnes of possible ore of similar grades has been outlined to date in the newly discovered Southern Star deposit south of the MBX zone. Metallurgical and other studies on the property are expected to lead to a feasibility decision for a major open-pit operation, by mid-1990.

At the Windy property (236), south of Mount Milligan, Placer Dome Inc. drilled and trenched a large altered and sheared diorite target, with mixed results. Other targets in the intrusion and host volcanic rocks will be drill-tested.

Black Swan Gold Mines Ltd. conducted a major program of induced polarization surveys, trenching and drilling at the Tas property (237), concentrating on five mineralized shear zones where gold occurs associated with pyrite and magnetite in cherty metasediments and augite porphyry flows adjacent to a diorite stock. An inventory of 25 000 tonnes grading 10 grams per tonne gold or more, with some significant copper values, was outlined in vein widths up to 7 metres.

In the Chuchi Lake area, Noranda Exploration Company, Limited (238) and Digger Resources Inc. (239) explored part of the Chuchi Mountain stock and adjacent andesitic flows at the southeast margin of the Hogem batholith. Digger Resources reported intersections grading from 0.14 to 0.71 per cent copper and 0.27 to 1.34 grams per tonne gold from three holes in altered volcanics. Noranda Exploration reported intersections up to 10 metres with significant copper mineralization and anomalous gold values, mostly in the intrusion. Both companies plan additional drilling.

Major companies active with initial exploration programs on alkali porphyry targets in the northern Quesnel trough included Cominco Ltd. with seven properties north of Prince George, Placer Dome Inc. with five properties, mostly in the Fort St. James area, Rio Algom Exploration Inc. with two properties in the Witch Lake area, and BP Resources Canada Ltd. on properties near or adjacent to Mount Milligan. Noranda Exploration was particularly active, with 17 properties in early exploration stages. Single test holes were drilled on four of six properties in the Mount Bodine area (240), with encouraging results from two of them. Follow-up work is also planned on four other properties.

Best initial results were reported by companies in the Witch Lake - Chuchi Lake area. On the Mitze property (242), for example, Noranda Exploration identified coincident magnetic and soil geochemical anomalies, and found mineralized float with significant copper and gold mineralization.

Noranda Exploration also conducted a late-season drilling program on the Tsil property (243), and drilled the Blackhawk (244) and Nina Lake (245) properties, with mixed to poor results.

Surface work by Kookaburra Gold Corporation at the Col property (241) established the potential for an alkali porphyry deposit, while north of Manson Creek, Lysander Gold Corporation identified another promising alkali porphyry target at the Cat property (246), with an extensive surface exploration program and initial drilling. Significant widths of copper-gold mineralization occur in silicified magnetite-bearing zones in altered volcanics, with grades up to 1.9 per cent copper and 1.7 grams per tonne gold.

In the southern Quesnel trough, exploration work was mostly confined to established properties. Final geotechnical and environmental studies were completed by QPX Minerals Inc. at the Quesnel River gold deposit (247) with a construction start scheduled for late this year. The planned workforce is 26.

At the nearby Mount Polley copper-gold deposit (248), Imperial Metals Corporation completed bulk sampling and geotechnical work. Reserves of 48 million tonnes grading 0.44 per cent copper and 0.58 gram per tonne gold have been outlined in five skarn-like zones of orthoclase-magnetite-chalcopyrite rock in the Mount Polley intrusive stock. Production is planned to start in 1992, at 13 500 tonnes per day, with a workforce of 200.

At other porphyry prospects, Placer Dome Inc. was unable to outline any large targets with surface work at the Mouse Mountain property (249) near Quesnel. Corona Corporation drilled targets at the Cariboo property (250) near Likely and reported some gold mineralization in silicified andesites that is probably not of porphyry origin.

There was little work done on porphyry targets in the Canim Lake area, as junior companies holding the more promising properties had funding difficulties. GWR Resources Inc. continued to find low-grade copper-gold mineralization in a major trenching program at the Miracle property (251). Other companies active in the Likely-Horsefly area included Brooks Resources Ltd. and Phelps Dodge Corporation Canada Ltd. at the Redgold property (252) where a fragmented land position previously hindered exploration of a promising property.

Elsewhere in the southern Quesnel trough, Eureka Resources Inc. resumed work on the Frasergold basal phyllite hosted gold property (253), with plans for a pilot leach test of a bulk sample.

BARKERVILLE - CARIBOO MOUNTAINS

Mosquito Consolidated Gold Mines Ltd. completed a major program of underground drifting and drilling at the old Island Mountain mine (254). Gold-bearing pyrite replacement ore was found in both the Main Band and Aurum limestones, but insufficient tonnages were found to reopen the mill. Surface work on the adjacent Cariboo Gold Quartz mine, however, identified low-grade gold mineralization in a possible bulk-tonnage target.

In the Cariboo Mountains, Noranda Exploration Company, Limited continued drilling base metal sulphide targets at Indian Lake (255) with mixed results. On other base metal targets, Sable Resources Ltd. planned further drilling at the Maybe property (256) where earlier drilling had failed to find either the vein width or silver values found in outcrop. Cominco Ltd. reported some shallow base metal sulphide replacement mineralization in dolomite in an initial drilling program at the WD property (257). Further work is planned.

PINCHI FAULT TREND

There was increased activity along the Pinchi fault trend, with the attraction of both vein-hosted gold targets in Cache Creek Group sediments and the possibility of alkali porphyry targets in the Takla Group volcanics east of the fault. Listwanite-gold targets, however, have so far proved disappointing.

At the Snowbird property (258) X-Cal Resources Ltd. found that the gold mineralization is associated with arsenopyrite in shear zones in Cache Creek Group sediments, with little in listwanite alteration zones. A drill-indicated inventory of 225 000 tonnes grading 6 grams per tonne gold or better was established and additional ground staked.

Eastfield Resources Limited drilled several talc-carbonate and listwanite alteration zones at the Indata property (259) with mixed to poor results. Surface work however discovered five new quartz-arsenopyrite veins, with some gold grades of more than 10 grams per tonne, and outlined a promising porphyry target.

On the nearby Swan property (260), Northair Mines Ltd. re-examined an old porphyry copper prospect and established drill targets with copper-gold potential. Other companies active in this area with initial programs included Placer Dome Inc. and Westmin Mines Limited in the Tchentlo Lake area (261).

OTHER AREAS

There was some work on the Fraser Plateau, with targets being bulk-tonnage low-grade epithermal mineralization in fractured and silicified Ootsa Lake Group volcanics. Noranda Exploration reported widespread anomalous and low-grade gold mineralization associated with minor pyrite at the HC property (262) but not yet in economic tonnages.

Other companies active on the Fraser Plateau included Westfield Minerals Ltd. in the Gaspard Lake area, BSA Investors Ltd. in the Empire Valley and Blackdome Mining Corporation near Blackdome mine.

A number of porphyry copper deposits or targets in the Fraser Plateau and Coast Range marginal belt received attention. Cazador Explorations Ltd. explored the Hanson Lake prospect (263) and found widespread precious metal and minor base metal mineralization with a percussion drill program. Grades of up to 1.8 grams gold and 80 grams silver per tonne over 2-metre widths were reported, with lower but encouraging grades over longer intersections.

Mixed to encouraging results were reported by Westpine Metals Ltd. from drilling at the Taseko property (264) and by Canmark International Resources Inc. at the nearby Spokane property (265). Westpine Metals Ltd. reported some intersections up to 35 metres grading more than 0.5 per cent copper and up to 1 gram gold per tonne. Cominco Ltd. drilled the Fish Lake copper-gold deposit (266) to obtain fresh core for metallurgical tests.

On other properties, Kleena Kleene Gold Mines Ltd. continued underground drifting on a quartz-arsenopyrite vein system at the Perkins Peak property (267).

In the Muskwa Ranges, Curragh Mining Corporation began a program of underground development and bulk testing at the Cirque property (268) with a mining decision expected this year. Reserves are 18.9 million tonnes grading 2.7 per cent lead, 9.2 per cent zinc and 57 grams silver per tonne from an inventory of more than 50 million tonnes. Production is planned for late 1991 at a rate of 3500 tonnes per day with a workforce of approximately 250.

At the nearby Mount Alcock property (269), Triumph Resources Ltd. reported economic lead-zinc-silver mineralization with barite in shales over a 300-metre strike length and with widths up to 20 metres. The zone is open at the depth drilled to date.

PLACER

The decline in placer mining in the district was mostly in the smaller operations, which have been most affected by rising costs and stricter reclamation requirements. This trend is expected to continue if the gold price remains stable.

COAL

Despite changes in the royalty provisions for coal production, coal exploration was again confined to production areas or immediately adjacent ground. This situation is unlikely to change until the current arbitration proceedings to determine the price to be paid to northeast coal producers are settled. Quintette Coal Ltd. (274) in a program of diamond and rotary drilling, showed that the Mesa North deposit extends north into the Wolverine River valley.

FAME - FINANCIAL ASSISTANCE FOR MINERAL EXPLORATION PROSPECTORS ASSISTANCE PROGRAM

By J. Pardy, Prospectors Assistance and Training Officer

INTRODUCTION

The 1989-90 Prospectors Assistance Program is a FAME (Financial Assistance for Mineral Exploration) funded $500 000 one-year program to promote prospecting activity in the province by providing training and financial and technical assistance to prospectors. Financial and technical assistance is available through the prospector grant program which is designed to provide part of the risk capital required by prospectors in their search for mineral deposits. Sound, well-conceived prospecting projects are supported with financial assistance up to a maximum of $7500 per year. Prospecting targets eligible for assistance include lode and placer deposits of metallic and industrial minerals (except sand and gravel), and coal deposits. Prospectors have access to technical assistance in the field from ministry personnel active throughout the province. Training consists of the annual Advanced Prospecting Course held at Cowichan Lake, B.C. and several basic courses in centres across the province.

TRAINING

The Advanced Prospecting Course is an 18-day, live-in, field-oriented course comprising practical instruction in geological, geochemical and geophysical prospecting methods. Other topics include law, metallurgy and provincial government acts and regulations. In-class instruction and accommodation are provided at the Ministry of Forests' Cowichan Lake Research Station. The class is limited to a maximum of 32 students - the fee is $425. Applicants must demonstrate basic skills in rock and mineral identification and should have prospecting experience.

The majority of the basic courses offered each year are sponsored by the Ministry of Energy, Mines and Petroleum Resources, the British Columbia and Yukon Chamber of Mines and prospector associations, and are delivered through community colleges. Courses are also sponsored and delivered by the colleges themselves. Cities where courses are available annually include: Victoria, Nanaimo, Vancouver, Chilliwack, Nelson, Kelowna, Prince George and Smithers. Other basic courses are offered at selected times and locations on a cyclical or as-needed basis.

FINANCIAL ASSISTANCE

For the 1989-90 Prospectors Assistance Program applications received by April 7, 1989 were considered for the initial allotment of funds; grants were awarded starting April 20.

Applications received	233
Grants awarded	84
Maximum grant	$7500
Average grant	$4879

The 233 applications received are up 14 per cent and the 84 grants awarded are down 39 per cent from 1988-89 levels, whereas the average grant of $4879 is up 57 per cent from the average of $3109 last year. The trend over the past two years has been a reduction in the number of grants awarded and a substantial increase in the size of the average grant.

Maximum assistance is $7500 per prospector for a pre-approved prospecting project. Fifty per cent of the grant awarded is payable on approval of the application, with the remainder on receipt of a satisfactory prospecting report. Applications for assistance are evaluated on the basis of points awarded for each of the following selection criteria:

Quality and documentation of proposal	45%
Experience and training of applicant	20%
References and recommendations	20%
Financial commitment of applicant	15%

Grantee prospectors are required to submit a prospecting report consisting of two parts, Part A, a summary of prospecting activities and expenditures and Part B, a technical report of activities, to qualify for final

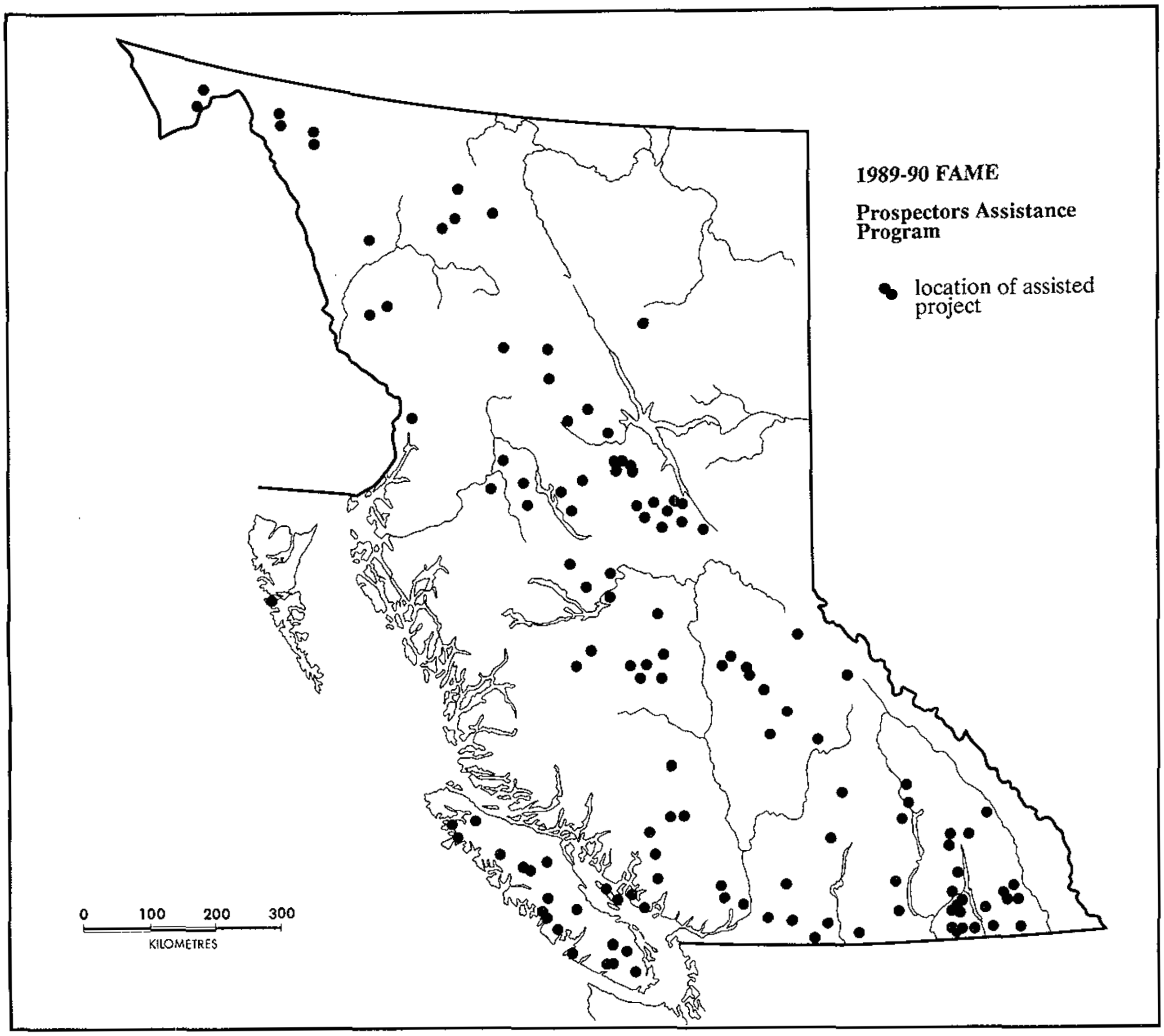


Figure A-9. Location of assisted projects, Prospector's Assistance Program.

payment. Final payment of the grant is made upon approval of the report. The technical reports received will be released to the public domain five years after receipt.

Seventy-seven grantees remain active under the program after seven of the initial 84 successful applicants declined their grants. The 77 active prospectors have a combined total of 129 projects. Most of these projects are located in areas of active exploration and good access. The projects are more evenly distributed in the province as compared to those funded under the 1988-89 program and there has been a significant northward shift in the location of projects (Figure A-7).

The percentage of assisted projects by primary target commodity is as follows:

1989-90	
Base metals	4%
Industrial minerals	9%
Placer gold	9%
Precious metals	39%
Base/precious metals	39%
TOTAL	100%

Changes in primary target commodity from the 1988-89 program include decreases in placer gold projects (17.5 per cent to 9 per cent) and hardrock precious metal projects (47.5 per cent to 39 per cent) and increases in base metal projects (1.5 per cent to 4 per cent), industrial mineral projects (4.5 per cent to 9 per cent) and base/precious metal projects (29 per cent to 39 per cent). The trend over the past two years has been significant reduction in the number of precious metal projects and an increase in base/precious metal projects.

RESULTS TO DATE

Twenty-eight summary prospecting reports, representing 36 per cent of the total number of active grants, had been received by December 31, 1989. Many of the prospectors have completed prospecting projects and hold tenure to property which should be evaluated further. Fewer prospectors report option agreements made this year compared to last - this probably reflects a reduced presence of the junior companies on the exploration scene.

Selected data compiled from the reports noted above are summarized below:

Total prospecting expenditures	$192 850
Average expenditure/prospector	$ 6 888
Grant funds approved	$135 700
Average grant	$ 4 843
Total prospecting days in the field	409
Average prospecting days/prospector	50
Claim units staked	403

The above summary can be used as a measure of the amount of prospecting activity under the grant program, but the effectiveness of the prospecting activity can only be measured by future developments of properties and projects generated under the program. Examples include the Fireweed silver-lead-zinc-copper-gold occurrence (MINFILE 093M 151) located on the west side of Babine Lake which was discovered under the 1987-88 program; in excess of $1 million has been spent on the property and interesting targets have been defined. Under the 1988-89 program a prospector discovered significant gold-silver mineralization on Willoughby Creek east of Stewart and optioned the property to Bond International Gold Inc. The company subsequently acquired additional claims and conducted an exploration program which resulted in a drill intersection of 20.5 metres averaging 24.98 grams gold and 184.21 grams silver per tonne at the Willoughby gossan and a drill intersection of 66 metres averaging 9.88 grams gold and 49.29 grams silver per tonne 6 kilometres to the west at Red Mountain.

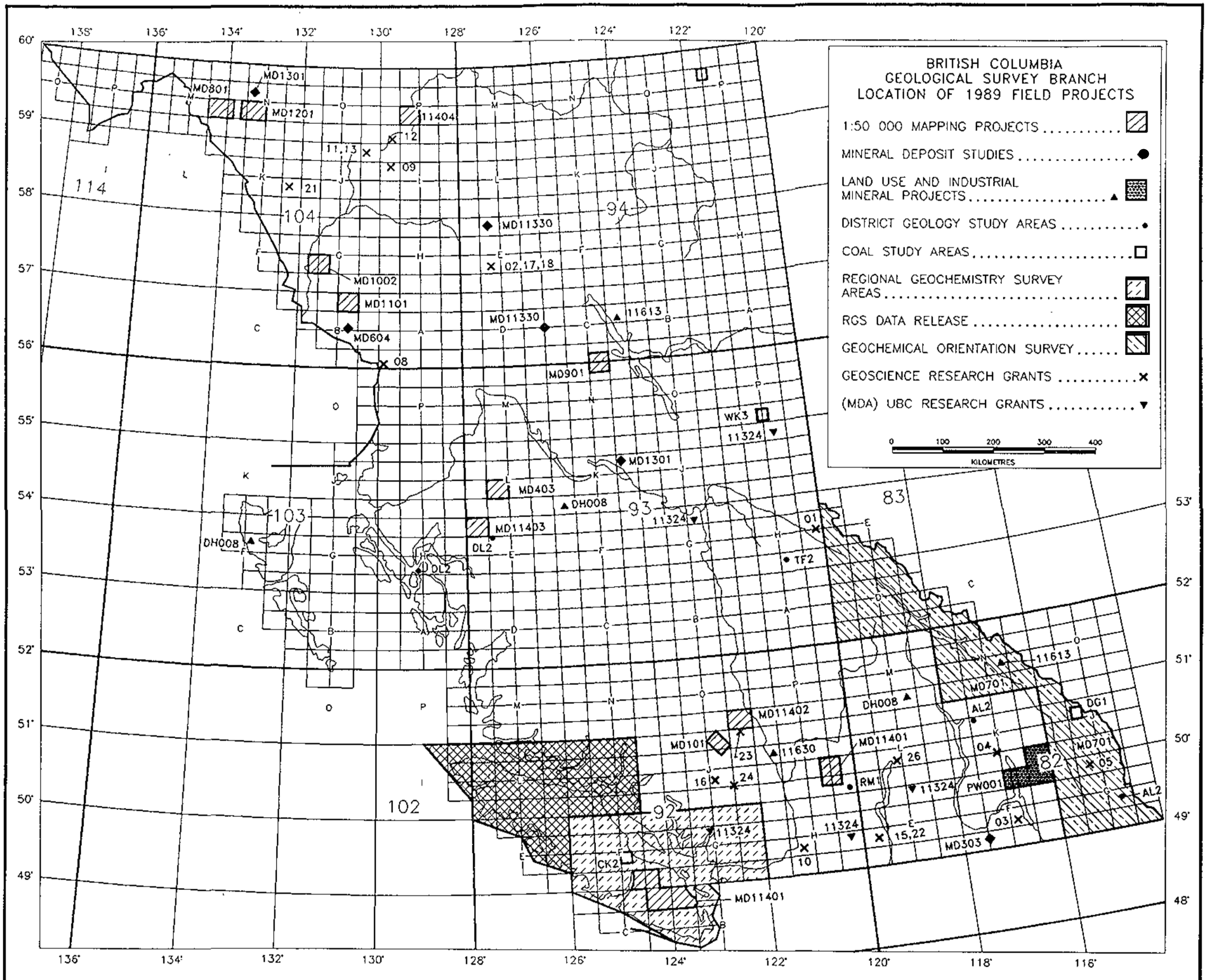


Figure A-10. Location of 1989 field projects, Geological Survey Branch.

1989 FIELD SEASON GEOLOGICAL SURVEY BRANCH

Part of the Branch mandate is to produce and interpret geological data that will aid government policy decision making, and encourage and guide private sector exploration to the ultimate benefit of all the citizens of British Columbia. Activities in support of this mandate during 1989 are briefly described in this report.

MINERAL DEPOSITS AND REGIONAL MAPPING

Mineral deposits studies and regional mapping projects are on-going throughout the province. They focus on districts of known high mineral potential and areas that we feel are under-explored. Each project updates MINFILE for mineral showings visited. Mapping projects also include the collection of stream silt samples to integrate with and augment the Regional Geochemical Survey (RGS) program. Mineral deposits projects concentrate on the geologic setting and controls of mineralization to produce widely applicable genetic models.

Following are brief descriptions of the projects and summaries of their achievements during the 1989 season. Ongoing projects extended work begun in previous years. Two, the Rossland and Taseko - Bridge River projects will be highlighted to give the flavour of our studies; results from the remainder are briefly summarized.

A new study of **precious and base metal skarns** was started by Gerry Ray and Ian Webster. Initial work during a shortened field season was on Texada Island, examining the geologic setting of copper and iron skarns. These deposits provide examples of typical Insular Belt skarns related to the Jurassic Island plutonic suite.

The new **Listwanite project** is investigating the relationship between this type of carbonate-mariposite alteration, ultramafic rocks and gold mineralization in rocks of the Cache Creek Group. It will also study the tie, if any, with faults and granitic intrusions that are commonly spatially associated with listwanite alteration zones. Areas near Atlin, Cassiar and Fort St. James have been examined in the field and samples collected will be studied petrologically, geochemically and radiometrically.

In the **Rossland project** Trygve Höy and Kathryn Andrew are studying the volcanic, plutonic and sedimentary rocks of the Late Triassic to Early Jurassic Rossland Group. This work will determine the structural and stratigraphic setting and controls of shear-related gold, alkali gold-copper porphyry, skarn and vein mineralization in the Nelson-Rossland area. The Rossland camp has produced more than 84 000 kilograms of gold and 105 000 kilograms of silver; in British Columbia, this precious metal production is second only to that from the Bralorne camp. Elsewhere in the Rossland Group, recovery from the combined Nelson and Ymir camps was more than 16 750 kilograms of gold and 190 000 kilograms of silver.

Mapping documents dramatic thickness and facies changes in the Archibald Formation, the basal succession of the Rossland Group, that indicate an evolving tectonic high in the area underlying Trail and Rossland. This Pennsylvanian or Permian Mount Roberts Formation high influenced deposition of overlying volcanic rocks of the Elise Formation, which formed in a complex island arc and basin environment. In the Nelson area, effusive volcanism occurred in the west and local volcanic islands shed debris southward. Near Salmo, epiclastic deposits near the middle of the formation record a hiatus in the volcanic activity.

Mineral deposits in the area are structurally and lithologically controlled. Key elements are proximity to comagmatic or later intrusions, host lithology (volcanic rocks host copper-gold deposits, sedimentary rocks host lead-zinc deposits) and previously unrecognized structures.

In the **Taseko - Bridge River project** Paul Schiarizza and Bob Gaba are mapping to provide 1:50 000-scale geological maps for the northeastern side of the Coast Range from Taseko Lakes to the Bridge River area. The geological data will be used to assess the mineral potential, especially for precious metal mesothermal to epithermal veins, porphyry copper-gold or copper-molybdenum and skarn deposits. Also important is the goal of interpreting the tectonic evolution and faulting history, particularly as it relates to mineralization.

The geological framework of the area consists of:

- Bridge River complex: oceanic volcanic and associated intrusive rocks, cherts and argillites imbricated on all scales; includes limestone layers and olistoliths, clastic rocks and, locally, blueschists
- Cadwallader "terrane": Upper Triassic arc-related volcanic and sedimentary rocks of the Cadwallader and Tyaughton Groups and overlying Lower to Middle Jurassic shale

- Shulaps ultramafic complex: a dismembered ophiolite suite with harzburgite mantle tectonites capping the Shulaps Range and structurally underlain by serpentinite mélange derived from ultramafic cumulates, gabbros, mafic to intermediate dikes and pillowed greenstones
- Middle Jurassic to Upper Cretaceous marine sediments to nonmarine sediments and volcanics of the Tyaughton basin and Battlement Ridge Group respectively
- Tertiary volcanic and intrusive rocks

The Cadwallader fault system and mesothermal gold mineralization in the Bralorne camp are probably related to development of mid-Cretaceous transpressional faults with sinistral offsets. Thrusts, folds and steep faults formed throughout the region at this time. These were later cut by Late Cretaceous(?) to Eocene dextral strike-slip faults. Important low and high-angle normal faults in the southeastern part of the area were synchronous with and/or later than the strike-slip faulting.

During mapping this summer our crews found molybdenite mineralization in and adjacent to the Eocene Mission Ridge pluton leading to a drilling program by the property owners.

Farther north, two regional mapping projects are underway south of Smithers. Don MacIntyre and Pat Desjardins extended coverage southward in the Telkwa Range and Larry Diakow and Jay Timmerman extended mapping northward along the eastern side of the Coast Range complex into the Morice Lake area. Stratabound sulphides, epithermal veins and porphyry copper-molybdenum deposits are exploration targets in the area.

The **Telkwa project** has completed four 1:50 000-scale map sheets in the Smithers-Telkwa area. In 1989 mapping was completed on NTS sheet 93L/6, selected, in part, because stream sediments in this map area are anomalous in gold. Additional silt geochemistry and mapping were required to better define the areas of highest mineral potential. The area is part of the Stikine Terrane and includes calcalkalic island arc volcanic and sedimentary rocks of the Jurassic Hazelton Group and Jurassic and Early Cretaceous successor basin sediments of the Bowser and Skeena Groups, which contain important coal measures. The mapping allowed more detailed subdivision of the Lower Jurassic Telkwa Formation in its type area and located volcanic and plutonic centres which are areas of higher than average mineral potential.

The **Whitesail project** has covered the equivalent of three 1:50 000-scale map sheets. In 1989, mapping in NTS 93E/13 and 93E/14 was designed to extend coverage northward and to tie on to mapping published in Bulletin 75 by D.G. MacIntyre (1985). This area is along the eastern edge of the Coast plutonic complex and has precious and base metal potential.

Hazelton Group strata in the area form a thick, easterly facing homocline. The succession thickens from southeast to northwest and is thickest in the Nanika Lake area, where there is a large volume of mafic and felsic volcanic rocks. Plutonic and metamorphic rocks of the Gamsby complex were thrust eastward over the Hazelton rocks in Late Jurassic time. These thrusts were reactivated during the Late Cretaceous and Eocene. The area is also intruded by Middle Jurassic, Late Cretaceous and Tertiary granitic plutons and has potential for copper-molybdenum porphyries like the Berg deposit, stratabound sulphide and skarn deposits like the Boulder occurrence, and epithermal gold deposits like the New Moon prospect.

In the Johanson Lake to Manson Creek area, in the north-central part of the province, two projects are in progress. Fil Ferri and Dave Melville extended 1:50 000-scale mapping northward from Germansen Lake. Graham Nixon and Jan Hammmack completed the field component of a study of the mineral potential of Alaskan-type ultramafic bodies in British Columbia.

Mapping at 1:50 000 scale in the Manson Creek area, along the boundary between the allochthonous Intermontane Belt and the North American Omineca Belt, is to understand the area's geologic, tectonic and metallogenic history. The area has known placer and lode gold, porphyry copper-gold and rare-earth element deposits, and potential for base metal deposits.

It was found that late Proterozoic to middle Paleozoic carbonates and siliciclastic rocks of the Slide Mountain Group correlate well with units exposed in the Sylvester allochthon well to the north, near Cassiar. Late Triassic Takla volcanics and sediments, which underly the southwest edge of the 1989 map-area, have porphyry potential. Base metal possibilities are indicated by lead-zinc-barite-silver mineralization found by the crew near the top of the "Echo Bay group", a carbonate package 1000 metres thick, conformably overlying the Cambrian Atan Group.

The **Ultramafic project** is designed to evaluate the potential of mafic and ultramafic rocks in the province for economic concentrations of platinum group elements and other commodities. Work to date has concentrated on Alaskan-type ultramafic bodies. Fieldwork was completed on the Lunar Creek, Polaris, Wrede Creek and Johanson Lake complexes. Locally, Lunar Creek has spectacular layering like that seen on Duke Island in Alaska. The Polaris complex is interpreted to be a thick mafic-ultramafic sill. Lithogeochemical results from five samples from chromitite layers in the Wrede body show anomalous concentrations of PGEs - from 120 up to 2300 ppb platinum. A preliminary interpretation of these ultramafic rocks is that they represent cumulate piles below island arc volcanoes, some of which appear to have been shoshonitic.

Two mapping projects and the new listwanite mineral deposits project were active in the Atlin - Tagish Lakes area of northernmost British Columbia. The mapping projects are producing 1:50 000-scale geological coverage in this area of placer and lode gold potential. They have spurred mineral exploration along the Llewellyn and Nahlin faults and in the Proterozoic(?) to Paleozoic "Boundary Ranges metamorphic suite".

The **Tagish project** is being undertaken by Mitch Mihalynuk and Keith Mountjoy. This anomalous arsenic-antimony province contains several known gold-silver deposits, including the old Engineer mine. Mapping in NTS sheets 104M/8 and 104M/9E attempts to define metallotects and evaluate resource potential through mapping geological units and structures, and conducting lithogeochemical amd moss-mat geochemical surveys.

Mesozoic stratigraphic units of the Stuhini and Laberge Groups were subdivided and traced throughout the map area. Attention was also given to Proterozoic(?) to Paleozoic, mainly metasedimentary, rocks of the Nisling Terrane and intrusive rocks of the Coast plutonic complex. Within the metamorphic rocks, pre-Triassic granodiorites are deformed by ductile, top-to-the-south shears that are offset by brittle, dextral and down-to-the-east faults that are probably related to the Llewellyn fault system. The Llewellyn fault is a long-lived and deep-seated structure. The latest movements created a zone of brittle deformation that hosts synkinematic mineralized veins. The fault is a metallotect of interest. A major zircon-based dating study of the Mesozoic rocks will attempt to better constrain rock ages and timing of fault movements and mineralization.

The focus of the **Atlin project** by Mary Anne Bloodgood and Kim Bellefontaine is the Cache Creek Group. Imbricate slices of a dismembered ophiolite suite within the Cache Creek rocks are the apparent source of placers in the Atlin camp and may host lode gold deposits. Mapping south from Atlin revealed southeasterly directed thrust faults and associated north-trending tear faults in the Cache Creek Group. These major structures, and the Nahlin fault, are metallotects for precious metals. Late northeast-striking faults that cut the Tertiary Sloko volcanics and older rocks may be targets for epithermal gold exploration. The Cache Creek Group is a mélange complex, but local coherent, fault-bounded stratigraphic blocks have been mapped.

The **Listwanite project**, with Chris Ash and Ron Arksey, will map and sample known and suspected listwanite occurrences in oceanic terranes in the province. The purpose is to develop a model to explain their origin(s) and tectonic settings, and to determine their relationship to precious metal and possibly PGE mineralization.

Formation of listwanite involves carbonatization of serpentinized ultramafic rocks generally in and above faults. During the field season, work was carried out in the Atlin, Cassiar and Fort St. James areas. In Atlin, allochthonous residual upper mantle rocks rest above thrusts that dip northwest. Bedrock exposed by placer operations shows tectonic mélange zones and the effects of faulting and alteration. Cassiar listwanites are interpreted to be derived from serpentinites strung out along thrust faults. Near Fort St. James, the targets are thrust faults with carbonate alteration and quartz veins with associated antimony and gold. The project will investigate timing of mineralization and alteration, lithotectonic setting and environment of formation of associated ultramafic rocks and basalts, timing and relationships of spatially associated granitic rocks, and fluid inclusions in included quartz veins.

Three projects are continuing in the exciting "Golden Triangle" of northwestern British Columbia.

In the **Stikine project** Derek Brown and Charlie Greig traced stratigraphic units mapped in 1988 northward, to resolve internal stratigraphy and contact relationships between Triassic, Jurassic and Upper Cretaceous to Tertiary rocks that underlie the area and to evaluate their mineral potential. Regional unconformities have been documented at the base of Lower Jurassic volcanic rocks and Upper Cretaceous to Tertiary sedimentary rocks. Radiometric dating and fossils should further constrain the ages of Lower to Middle Jurassic volcanics and sediments, and the timing of deformation in the area. Several narrow, volcanic-hosted base metal veins were discovered; some are related to Tertiary dikes in limy host rocks.

In the **Iskut North project** Jim Logan and Victor Koyanagi mapped southeastward to the Forrest Kerr area and extended their coverage as far south as the Iskut River to tie onto the Iskut-Sulphurets project. The Forrest Kerr area includes the McLymont Creek gold prospect, where mineralization is semiconformable and structurally controlled. Mapping defined an Early Jurassic volcanic package that apparently correlates with the Betty Creek/Spatsizi Group; similar rocks host the Eskay Creek deposit. The area contains a western package of relatively undeformed Paleozoic rocks separated from a penetratively deformed eastern package by a composite Jura-Cretaceous pluton.

The objective of the **Iskut-Sulphurets project** is to provide an up-to-date geological and mineral deposit database for the Iskut-Sulphurets gold belt that will lead to development of ore deposit models to aid exploration and resource potential assessment. Dani Alldrick, Jim Britton, Mary MacLean and Kirk Hancock extended coverage westward to cover Johnny Mountain and the Snip area. Detailed mapping was completed on the Eskay Creek, Johnny Mountain, Inel and Nickel Mountain deposits and on the Colagh prospect. Interaction with industry geologists in the area was extensive and helpful.

A provisional stratigraphic column derived from work in the Snippaker sheet has been established and correlated with rocks to the east and south. The Jurassic stratigraphic column established differs from that in the Sulphurets and Stewart areas, although the key Mount Dilworth felsic volcanic unit continues. The spectacular drill results on Calpine's Eskay Creek property sparked a flurry of company activity late in the season. Open File maps from last year's work on the project were in wide use and a map of the Johnny Mountain area by Dave Lefebure and Mike Gunning (OF 1989-28) was released at the Bronson "symposium" held in August.

Several projects are now in the write-up phase, with little or no fieldwork undertaken this season. These are:

Bridge River	Neil Church
Quesnel	Andre Panteleyev
Hedley	Gerry Ray
Sicker	Nick Massey
Midway-Cassiar	JoAnne Nelson

DISTRICT GEOLOGY

The District Geologists maintain an up-to-date inventory of mineral deposits and monitor exploration trends and development in their districts, promote the mineral potential of their districts, provide input to the Mine Development Review Process and the Land Use Review Process, offer advice to explorationists, other government agencies and the general public, and assist in the administration and delivery of the Prospectors Assistance and Training Program. All District Geologists are also involved in specific field studies aimed at augmenting and improving the provincial geoscientific database.

In the Northwestern District, Dave Lefebure in cooperation with Alan Campbell, began a study of gold deposits on Porcher Island and nearby areas, and of the applicability of computer-based expert systems to the understanding and discovery of these deposits. Dave also continued with metallogenic studies of volcanogenic massive sulphide deposits and, in cooperation with Mary Lou Malott, continued studies of precious metal deposits in the Tertiary Ootsa Lake volcanic rocks of the Nechako Plateau. All of these activities will produce mineral deposit descriptions and compilation maps to be used in developing ore deposit models.

Ted Faulkner initiated a compilation of geological, geophysical and geochemical data and a description of copper-gold porphyry-type deposits in the Omineca Belt between Fort St. James and Germansen Landing.

Rick Meyers continued his study of the distribution, setting and character of precious metal lode deposits in the Okanagan-Kamloops region. This study will result in a regional compilation of geochemical, petrographic and geological information for the deposits studied.

For the Kootenay region Andrew Legun, assisted by Andrew Skupinski, completed his study of the Cretaceous alkalic intrusions and associated gold deposits of the Twenty-nine Mile Creek area. Andrew also carried out detailed mapping and a study of gold mineralization at the Millie Mac property east of Burton.

Paul Wilton continued his studies of lode gold deposits in the southern Coast Mountains and on Vancouver Island, with emphasis on the relationships between mineralization and Tertiary volcanism, tectonics and alteration zones.

COAL RESOURCES

1989 was an active year for the Coal Subsection. Major activities included field mapping, coal-quality surveys, drilling and coalbed methane investigations.

Field mapping at a scale of 1:50 000 was carried out in the Tumbler Ridge area by Ward Kilby and Jim Hunter. This season's effort completes the mapping for this multi-year project. Barry Ryan and Henry Kucera conducted a regional survey of the Upper Cretaceous coal potential in the outer foothills and plains of northeastern British Columbia. At Telkwa, Regan Palsgrove and Marc Bustin investigated the stratigraphy and structure of the deposit. On Vancouver Island, Corilane Bickford and Candace Kenyon expanded the mapping of the Comox coalfield.

Studies of the coal quality of the province's coal resources remained our major effort. To this end Dave Grieve and Brad Van Den Bussche sampled all the producing mines in the Rocky Mountain region. Alex Matheson directed a small-diameter drill sampling program in the Telkwa area. Vitrinite reflectance analyses using the Crossplot method revealed that the vast majority of our coals have biaxial reflectance characteristics.

During the year the search for coalbed methane became a major industry initiative. To address the void of knowledge in this field in Canada, we sponsored a short course on the subject. In addition, Henry Kucera started a multiyear study of the coalbed methane potential of northeastern British Columbia through an M.Sc. program at the University of Victoria. The strong interest in this resource on Vancouver Island continues and is being addressed by Candace Kenyon.

A *Coal Quality Catalogue* and a *Coal Quality Brochure* were released during the year. These publications are directed to the international market and have been distributed around the world. Dave Grieve neared the end of his work on a bulletin on the Elk Valley coalfield. Paper 1989-2 *Stratigraphy of the Elk Formation in the Fernie Basin,* by Dave Grieve and Neil Ollerenshaw (GSC) was also released. Alex Matheson is compiling a publication on the thermal coal resources of British Columbia.

INDUSTRIAL MINERALS

The Industrial Minerals unit carries out both field and office based studies that range from regional geological studies to site-specific studies. All of these contribute to one or more of the following strategies:

- To encourage replacement of industrial minerals imported to British Columbia.
- To develop new export markets for these minerals.
- To encourage increased value added mineral processing within British Columbia.
- To identify opportunities for development of or substitution by environmentally friendly minerals.

The assessment of perlite and vermiculite occurrences for their development potential was conducted by Gary White. The project involved mapping, sampling and testing of nine occurrences of perlite and two of vermiculite. Nine bulk samples were shipped to CANMET, Ottawa, for laboratory testing to assess whether commercial product specifications can be met from these occurrences.

In addition to the Frenier deposit, which saw production from 1983 through 1985, perlite from Uncha Lake and Francois Lake, as well as from two sites near Port Clements on Graham Island, exhibited expanding properties during blow-torch tests in the field. Vermiculite showings near Sawchea Creek and Joseph Lake occur within major intrusive bodies. If the laboratory tests indicate that commercial product specifications can be obtained then the Fraser Lake area may have significant potential to host major deposits of vermiculite.

As a part of barite inventory project, Steve Butrenchuk investigated the Wigwam River, Larrabee, Brisco and Fireside occurrences in the field. The former two are potential prospects while Brisco and Fireside are past producers.

MINERAL INVENTORY

MINFILE, the Branch computer mineral inventory database, published 27 map sheets in 1989. These releases contain descriptions of 2399 occurrences or 23.6 per cent of the total database of 10 168 occurrences. At this time about 40 per cent of the entire database has been released in the new MINFILE format and a further 20 per cent is being prepared for release. The data are published as hardcopy printouts, floppy diskettes and mineral inventory maps. During the year 560 occurrences were coded for release in 1990. In addition an upgraded version (2.13) of MINFILE/pc was released. A report generation module was added to the basic search program routines.

MINERAL LAND USE

The Land Use unit provides a centralized and co-ordinated response to all land use planning and policy issues facing the Ministry. This includes field studies to estimate the mineral potential of large areas proposed for withdrawal from mineral exploration and mining, to office based reviews.

In the Mineral Land Use unit, a mineral potential study of the Purcell Wilderness Conservancy and the surrounding area was begun in 1989 by Graeme McLaren and Gregg Stewart. The conservancy is underlain by Proterozoic rocks of the Purcell and Windermere Supergroups in the east and by Paleozoic rocks of the Kootenay arc in the west; these are intruded by two Cretaceous batholiths and numerous minor stocks. The Sullivan silver-lead-zinc orebodies are located just to the south and the Mineral King mine, a past producer of lead, zinc, silver and barite, lies on the northern boundary of the study area. Other vein and skarn occurrences are also known. The information gained in this study will aid in determining the ultimate boundaries of a provincial park in the area.

Mapping this year was undertaken in the eastern half of the study area in conjunction with a stream sediment geochemical survey and a prospecting and lithogeochemical sampling program. Hostrocks for the Sullivan mine underlie the southeast corner of the study area. Similarities with the Sullivan environment and the presence of small lead-zinc vein occurrences indicate that this area warrants continued exploration. Vein occurrences with tin and tungsten mineralization also occur near the contact with the White Creek batholith in this southeast part of the area. Initial results in the north show a more complex structural setting than previously recognized. Extensive zones of asymmetric folding and thrust faulting repeat stratigraphy and, in places, have been invaded by quartz-barite veins carrying copper, lead or zinc mineralization. Following compilation of geochemical and stratigraphic data further mapping and prospecting will be undertaken in this northern part of the study area. In 1990 all surveys will be extended to cover the western half of the conservancy and surrounding areas of interest.

APPLIED GEOCHEMISTRY

Data released through the Applied Geochemistry Subsection in June, 1989, from samples collected in 1988 on northern Vancouver Island and the adjacent mainland stimulated considerable exploration interest and activity. Over 125 copies of the dataset were sold on release day; to date sales total in excess of 200 sets and 80 floppy diskettes.

In the summer of 1989, Regional Geochemical Surveys covering southern Vancouver Island and the Lower Mainland were conducted. Approximately 2430 sediment and water samples were collected over 25 000 square kilometres at an average density of one site every 10.5 square kilometres. As in 1988, moss-mat sediments samples were collected on Vancouver Island (1397 sites) and stream sediments were collected on the mainland (1033). The release of the results is scheduled for June 1990, with release centres in Nanaimo and Vancouver. The 1989 RGS orientation surveys were conducted in the eastern Rocky Mountains in preparation for next year's RGS sampling program.

The subsection is additionally involved in producing a report on the stream sediment geochemistry of the Purcell Wilderness Conservancy. The report includes data from sediment samples collected during the 1989 field season and archived RGS sediment samples collected in 1977. The samples have been analyzed for gold plus 33 other elements by neutron activation analysis. The samples were also analyzed for copper, lead and zinc using atomic absorption.

QUATERNARY GEOLOGY

After a hiatus of several years, the Ministry of Energy, Mines and Petroleum Resources has reinstated a program in Quaternary geology, under the aegis of the Geological Survey Branch. The newly created Surficial Geology Subsection forms part of the restructured Applied Geochemistry and Surficial Geology Section. The Subsection will address public, industry, and government needs related to Quaternary geology in the province.

Several geologic themes currently comprise the terms of reference for the subsection: placer, drift exploration, sand and gravel assessments, geological hazards, and surficial mapping. It will attempt to stimulate both placer and mineral exploration in areas of thick or geologically misunderstood drift cover by providing useable base data compilations and information case studies. Moreover, the implementation and coordination of a Geological Hazards Program will answer industry needs for a provincially based advisory (non-policy making) group, and public needs for a government-sponsored source of hazard information. Sand and gravel resource location and management will be an important function.

Field research in 1989 centred primarily on placer deposits in the Cariboo district of central British Columbia. Detailed sedimentological and stratigraphic mapping of freshly exposed sections at active placer operations provided a base for modelling preglacial placer occurrences in the province. Additionally, an integrated drift-exploration case study was started in north-central British Columbia. Initial field reconnaissance was undertaken in late October. Several case studies in differing glaciated environments are planned to provide industry with examples illustrating the use of varied Quaternary geological techniques for drift exploration. The Subsection is actively participating in fieldwork on neotectonics on southern Vancouver Island. Identification and sampling of buried and exhumed Holocene peat bodies provide data for a regional sea-level history compilation.

PART B

GEOLOGICAL DESCRIPTION
OF
SELECTED PROPERTIES

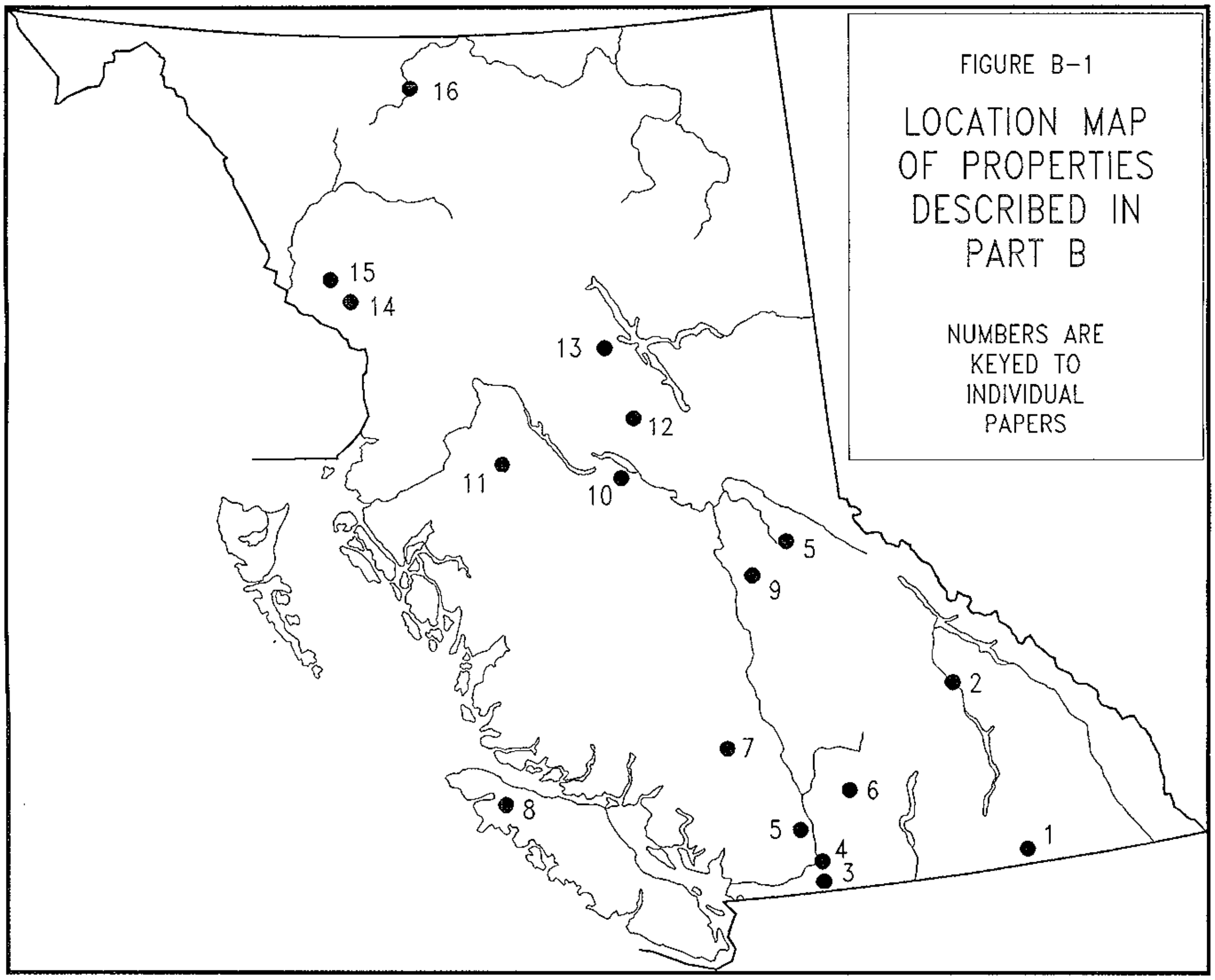


FIGURE B-1
LOCATION MAP OF PROPERTIES DESCRIBED IN PART B
NUMBERS ARE KEYED TO INDIVIDUAL PAPERS
16
15
14
13
12
11
10
5
9
2
7
6
8
5
4
3
1

SWIFT CREEK

(Fig. B1, No. 1)

By Kathryn P.E. Andrew and Trygve Höy

LOCATION:	Lat. 49°05'00"–49°08'30" Long. 117°18'7"–117°22'00" (82F/3W) NELSON MINING DIVISION. Approximately 8 kilometres southwest of Salmo at the headwaters of Swift Creek.
CLAIMS:	GUS 1-13, SWIFT 1-6, ELISE 9, 10, 16, 24, 25, 35, 36, 58-60, LISA 1-8.
ACCESS:	The area is reached from Salmo by paved Highway 3 and 6 (2 km south) and Hellroaring Creek gravel road (8 km).
COMMODITIES:	Gold.

GEOLOGY AND EXPLORATION OF THE ROSSLAND GROUP IN THE SWIFT CREEK AREA

INTRODUCTION

Gold mineralization in the Swift Creek area occurs within foliated and sheared mafic volcanic rocks of the Lower Jurassic Elise Formation. Shear zones are typified by intense carbonate-sericite-silica alteration exposed on surface and in a number of trenches at the headwaters of Swift Creek.

EXPLORATION HISTORY

Several collapsed trenches and pits in the area date back to the early 1900s, excavated during the Rossland mining boom. In 1980, Amoco Canada outlined a zone of anomalous copper in soils on the Katie claims (formerly the Jim group) just north of the Swift Creek area. Duval International Corporation undertook a geochemical sampling program on the Till 1 claims just west of the Swift Creek area in 1982 (McKillop, 1983). Further reconnaissance geochemical surveys were conducted by Anginel Resources Ltd. on the Ginny group of claims (now Elise group) near Salmo in 1983 (Santos, 1984a, b). Both these surveys and a regional reconnaissance lithogeochemical survey of the Elise Formation in 1984 by Falconbridge Limited indicated that these volcanic rocks are enriched in base and precious metals

Trenching in Archibald Formation argillites and siltstones was carried out west of the Swift Creek area on the Nova claims by Billiton Canada Ltd. in 1985. Noranda Exploration Company Limited carried out geophysical surveys immediately to the south and east of the area in 1986.

A rock sampling program in the Swift Creek area was conducted on the Swift, Gus and Ace in the Hole claims by Falconbridge Limited and Kidd Creek Mines Limited between 1985 and 1987 (Burge, 1986; von Ferson, 1986; Bakker, 1987). Trenched areas were tested in 1987 by diamond drilling totalling 892 metres in eight holes (Clemmer, 1988). Current activity includes substantial geophysical and geochemical surveys and selected mapping by Corona Corporation on the Elise claims southwest of Salmo (D. Gaunt, personal communication).

REGIONAL SETTING

The Swift Creek area lies just north of the closure of the Hellroaring Creek syncline, a tight northeast-plunging and locally overturned fold (Figure B-1-1; Fitzpatrick, 1985). The Hellroaring Creek syncline may be the continuation the Hall Creek syncline which dominates the structure of the Nelson map area (Höy and Andrew, 1989b, 1990a; Little, 1960, 1964). It is the earliest structure recognized in the area and is associated with a penetrative mineral foliation and intense shearing.

The intensity of compressive strain increases with proximity to the Waneta fault (Figure B-1-1), a steeply dipping, west-directed thrust fault that marks the boundary of Quesnellia with continental North America. Detailed structural mapping in the vicinity of the Waneta fault forms the basis of a thesis by Einerson (personal communication, 1989).

A second generation of thrust faults and associated open folds, such as the Mount Kelly syncline, postdates shearing associated with the Waneta fault. These thrust faults are east-directed and predate intrusion of Middle Jurassic plutons and later normal faulting.

Two generations of extensional tectonics occur in the vicinity of Swift Creek. North to northeast-trending, west-dipping normal faults offset early folds but are cut and sealed by Middle Jurassic plutons. These faults may be southern extensions of the Red Mountain fault in the Nelson area (Höy and Andrew, 1989a, b; 1990a). Northwest-trending, northeast-dipping normal faults offset all earlier structures and are probably related to the Middle Eocene extensional event in southern British Columbia (Parrish *et al.*, 1988; Corbett and Simony, 1984; Höy and Andrew, 1990a).

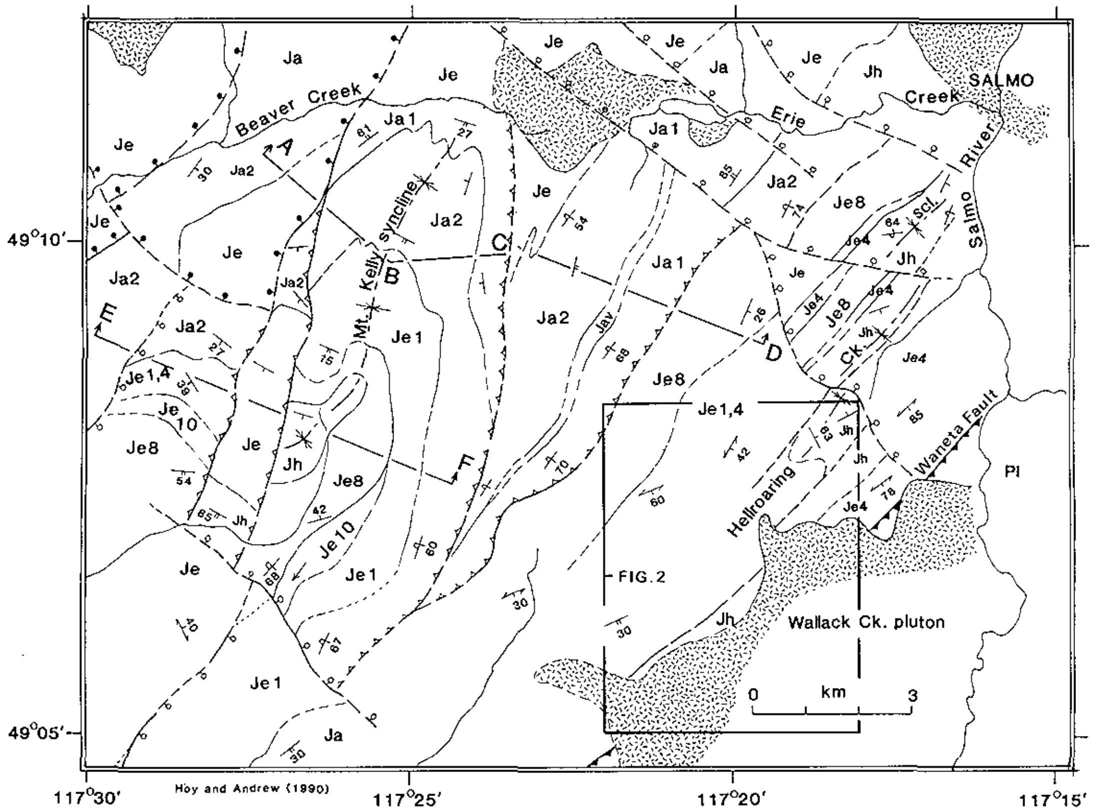


Figure B-1-1. Geology of the Mount-Kelly-Hellroaring Creek area (from Höy and Andrew, 1990a). Location of Figure B-1-2 shown by outline.

LEGEND

JURASSIC-CRETACEOUS

granite, granodiorite

LOWER JURASSIC

ROSSLAND GROUP

Jh	HALL FORMATION: argillite, siltstone
Je	ELISE FORMATION
Je10	siltstone, argillite
Je8	intermediate to mafic tuff
Jes	siltstone
Je2	mafic pyroclastic breccia
Je1,4	mafic flows, tuff
Ja	ARCHIBALD FORMATION
Ja2	siltstone, conglomerate

PALEOZOIC

Tgn	TRAIL GNEISS

SYMBOLS

bedding; tops known, overturned, unknown

foliation, cleavage

minor fold

normal fault; early, late

syncline

REGIONAL STRATIGRAPHY

The Rossland Group in the Swift Creek area comprises fine-grained sedimentary rocks and turbidites of the Archibald Formation, dominantly mafic to intermediate volcanic and epiclastic rocks of the Elise Formation and typically very fine-grained sedimentary rocks of the Hall Formation. The group is Lower Jurassic, bracketed by Sinemurian fossils in the Archibald Formation and Pleinsbachian and Toarcian fossils in the Hall Formation. The Rossland Group is intruded by Middle Jurassic Nelson intrusions which range from granites to quartz monzonites and by several Middle Eocene syenite stocks and rhyolite dikes.

The Elise Formation is exposed in the limbs of the Hellroaring Creek and Mount Kelly synclines. It is characterized by a thick succession of mafic flows, flow breccias and tuffs with some epiclastic deposits and minor interbedded siltstone and argillite sequences. The distinction between dominantly mafic flows and flow breccias in the lower Elise Formation and thick pyroclastic accumulations in the upper Elise is apparent in the Salmo area in the east limb and hinge zone of the Mount Kelly syncline as well as in the west limb of the Hellroaring Creek syncline (Figure B-1-1).

LOCAL GEOLOGY

Much of the Swift Creek area is underlain by augite porphyry flows and augite and plagioclase-phyric lapilli tuffs of the lower Elise Formation, and black fissile argillite of the Hall Formation (Figure B-1-2). These rocks occur in the limbs and hinge of the Hellroaring Creek syncline. The s-shape of the syncline closure, shown in the northwest part of Figure B-1-2, is schematic, based on the distribution of limited exposures of Hall and Elise formations. The axial trace of the syncline is projected from bedding-cleavage intersections exposed to the northeast. Elise volcanics in the area appear as schistose green rocks. Occasionally fragmental textures, pillows or amygdules are preserved. Distinction between lapilli tuffs and flows or flow breccias is often difficult in hand sample or outcrop exposures because of intense alteration and shearing, over one kilometre wide, in the limbs of the Hellroaring Creek syncline. Although the relict outlines of augite and plagioclase crystals remain, they have been variably replaced by chlorite, epidote and carbonate (Plate B-1-1). This alteration is attributed to regional lower greenschist grade metamorphism typical of the Rossland Group in much of the Nelson and Salmo areas (Beddoe-Stephens and Lambert, 1981).

The Wallack Creek stock, a Middle Jurassic pluton, intrudes the Rossland Group in the southeastern part of the area (Figure B-1-2). The stock is leucocratic, equigranular and lineated, ranging in composition from granodiorite to granite. Although it postdates the intense regional deformation, it is locally sheared along its margins.

Plate B-1-1. Relict outlines of augite and plagioclase crystals variably replaced by chlorite, epidote and carbonate.

The structural level of the Swift Creek area is similar to that adjacent to the closure of the Hall Creek syncline in the Nelson map area. The wide zone of shearing in the limbs of the Hellroaring Creek syncline at the headwaters of Swift Creek is comparable with the Silver King shear zone in the core and limbs of the Hall Creek syncline (Höy and Andrew, 1989b) and is characterized by intense zones of foliation (Plate B-1-2), commonly tens to hundreds of metres wide, separated by less-deformed schistose rocks.

ALTERATION

Pervasive alteration is spatially associated with shearing. The zones are characterized by bleached, brown to buff-coloured rocks. Weak to moderately altered samples retain original volcanic textures (Plate B-1-3a). Alteration is dominantly a fine-grained carbonate, probably ankerite (von Ferson, 1986), combined with sericite and locally silica (Plate B-1-3b) or zones of quartz vein stockwork. Areas of soft, white argillic alteration characterized by kaolinite after feldspar (Bakker, 1987) vary in intensity over a few metres. Some of the clay alteration may be supergene. Potassic alteration or development of secondary potassium feldspar similar to that in the Great Western - Star area (D. Forster, person-

LEGEND

CENOZOIC

QUATERNARY

Qal — *UNCONSOLIDATED DEPOSITS: TILL, SAND, GRAVEL, SILT*

TERTIARY OR OLDER (?)

KTr — *RHYOLITE DIKES*

MIDDLE EOCENE

Ec — *CORYELL INTRUSIONS: BIOTITE MONZONITE, BIOTITE-AUGITE MONZONITE*

MESOZOIC

JURASSIC

Jn — *NELSON INTRUSIONS: GRANODIORITE, QUARTZ MONZONITE*

LOWER AND MIDDLE(?) JURASSIC

ROSSLAND GROUP

Jh — *HALL FORMATION: SILTSTONE, SANDSTONE, CONGLOMERATE, ARGILLITE; MINOR LIMEY UNITS*

Jh1 — *ARGILLITE, RUSTY WEATHERING; MINOR SILTSTONE*

Je — *ELISE FORMATION: MAFIC TO INTERMEDIATE FLOWS, TUFFS, EPICLASTIC DEPOSITS AND SUBVOLCANIC INTRUSIONS*

pyroclastic units

Je8 — *ANDESITE TUFF, MINOR BASALTIC TUFF: Je8l, LAPILLI TUFF WITH PLAGIOCLASE + AUGITE-BEARING VOLCANIC CLASTS; Je8x, PLAGIOCLASE + AUGITE CRYSTAL TUFF*

Je7 — *BASALTIC TUFF: Je7l, AUGITE-PHYRIC LAPILLI TUFF, PYROCLASTIC BRECCIA; Je7f, MAFIC, FINE TUFF*

flow units

Je4 — *AUGITE + PLAGIOCLASE BASALT FLOWS, FLOW BRECCIAS*

Legend for Figure B-1-2.

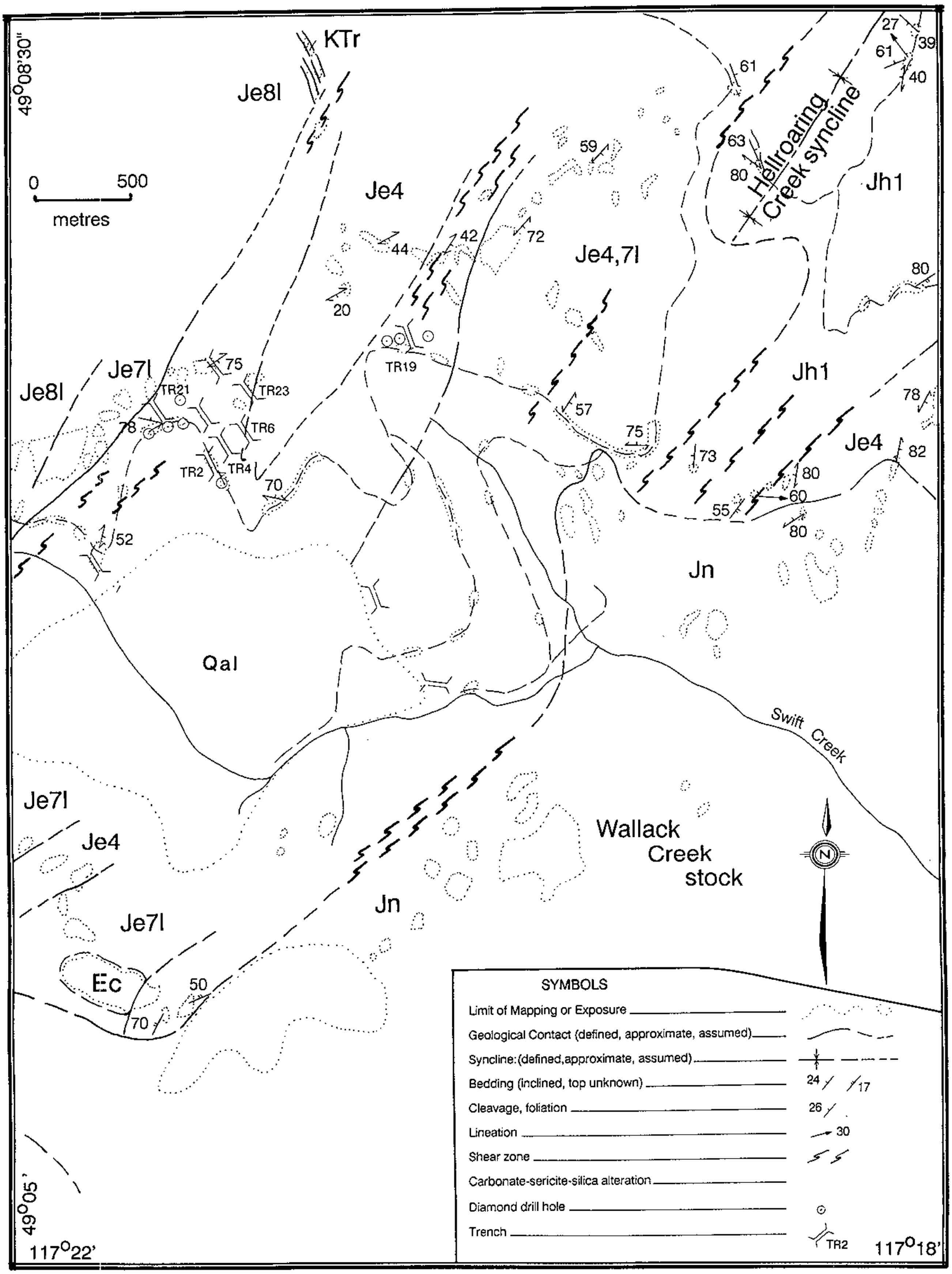


Figure B-1-2. Geology of the Swift Creek area (after Höy and Andrew, 1990b; Little, 1964; Bakker, 1987, von Fersen, 1986, Burge, 1986).

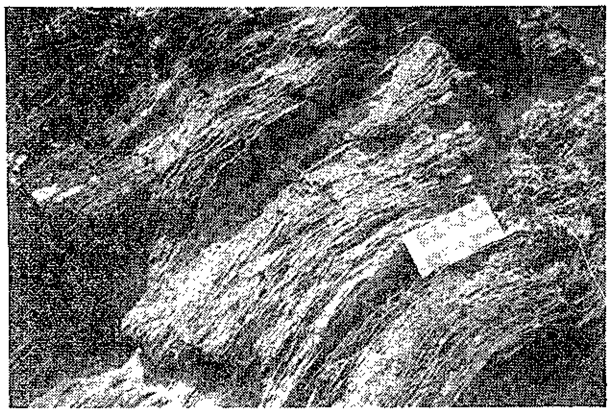


Plate B-1-2. Intense foliation in shear zones associated with carbonate-sericite-silica alteration.

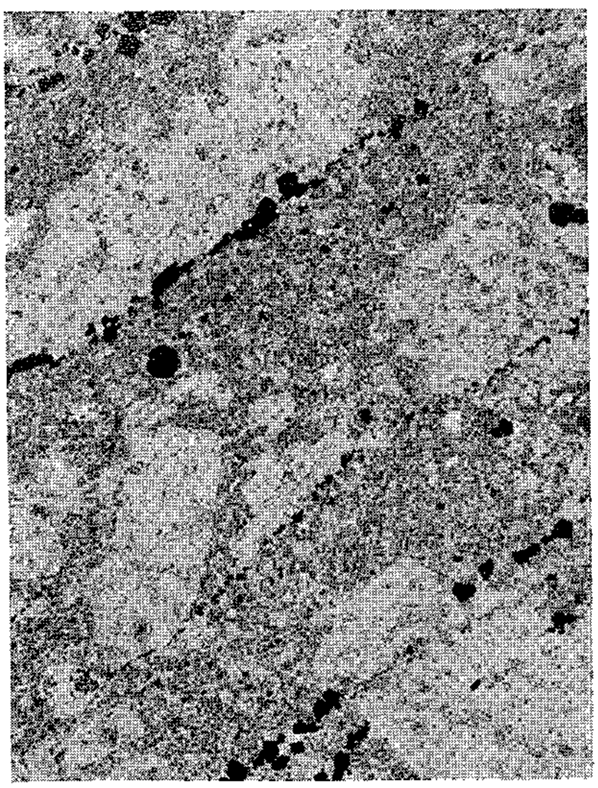


Plate B-1-4. Disseminations and stringers of pyrite parallel to the foliation.

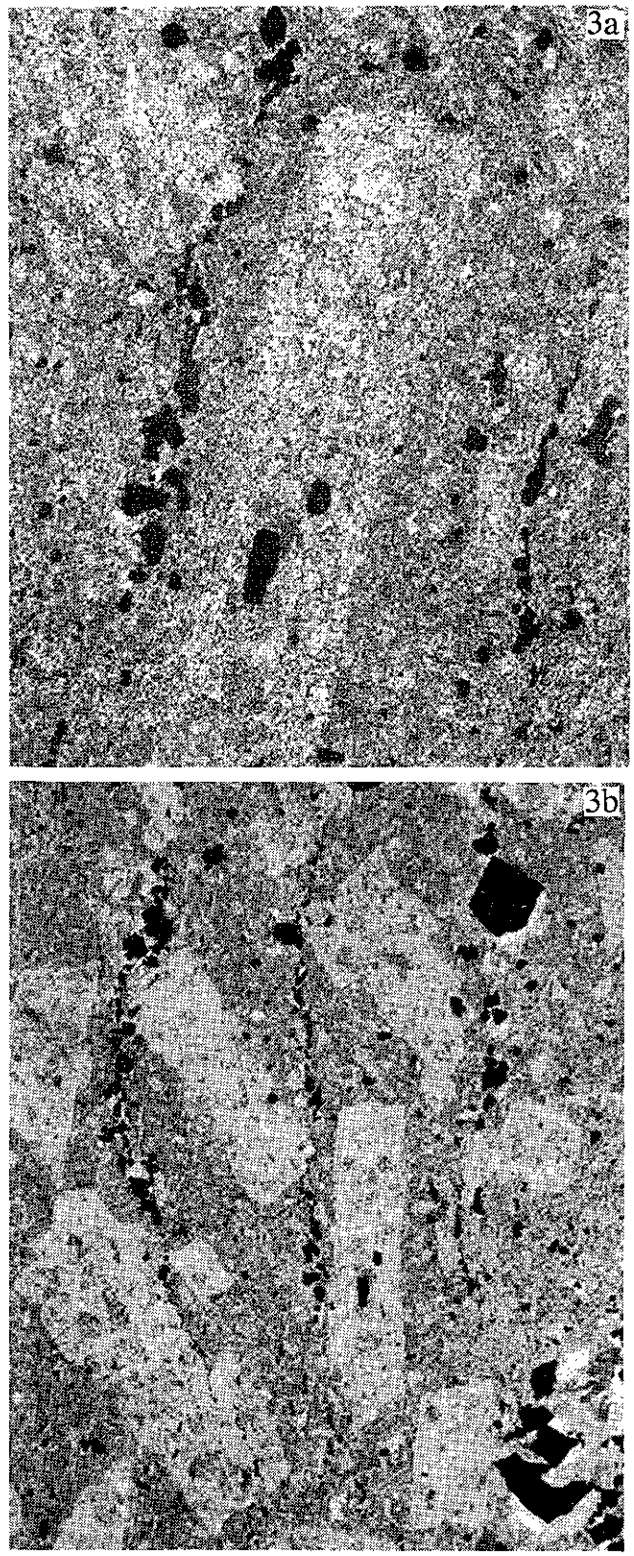


Plate B-1-3. Original volcanic texture of augite-plagioclase-phyric flow (3a) preserved in weak to moderately carbonate-sericite-silica altered sample (3b).

nal commumication) is minimal in volcanic rocks in the Swift Creek area.

MINERALIZATION

Gold mineralization is associated with zones of intense carbonate-sericite-silica alteration and shearing. Pyrite is the most visible metallic mineral in these zones occuring as disseminations or stringers parallel to the foliation (Plate B-1-4). It comprises from 1 to 5 per cent and locally up to 20 per cent of the rock. Chalcopyrite, sphalerite, trace galena and hematite-bearing quartz-carbonate veins (less than 1 centimetre wide) occur locally in areas of carbonatization but rarely constitute more than 1 per cent of the rock (Bakker, 1987).

Trenching by Falconbridge and Kidd Creek Mines between 1985 and 1987 encountered five areas of significant gold values (greater than 1000 ppb gold over 2 metres) within the alteration zones. A 2-metre section of carbonate-altered tuff that included a 40-centimetre quartz vein with 10 per cent sulphide content assayed 100.2 grams per tonne gold. The best results are summarized in Table B-1-1 (Clemmer, 1987). Diamond drilling by Falconbridge (Figure B-1-2) indicated that the best gold values are associated with zones of silicification within broader areas of carbonatization. Best drill intersections were beneath Trench 19 where 5.4 metres containing 1.45 grams per tonne gold and 10.1 metres containing 1.83 grams per tonne gold were intersected (Figure B-1-3).

Results of a detailed lithogeochemical study of the area by Falconbridge in 1985 indicate that gold content does not correlate with copper or other base metals. Furthermore, gold and lead do not show simple lognormal or normal distribution whereas barium and zinc are normally distributed and copper and silver display lognormal distributions (Burge, 1986).

TABLE B-1-1
BEST ASSAYS FOR GOLD IN SWIFT CREEK AREA (FROM CLEMMER, 1988)

Trench No.	ppb Au	Interval (m)	Comments
2	1270	0.1	Adj. 2.0 m of 220 ppb
4	1270	2.0	
4	1050	2.0	
6	427	6.0	Incl. 4 cm qtz vn 6420 ppb
19	535	12.0	Incl. 2.0 m of 2020 ppb
19	865	14.0	Incl. 2.0 m of 2160 ppb
19	760	16.0	Incl. 2.0 m of 1650 ppb
21	100	2.0	Adj. 2.0 m of 1010 ppb
21	8500	2.0	Adj. 2.0 m of 960 ppb
23	1430	6.0	Incl. 2.0 m of 2850 ppb

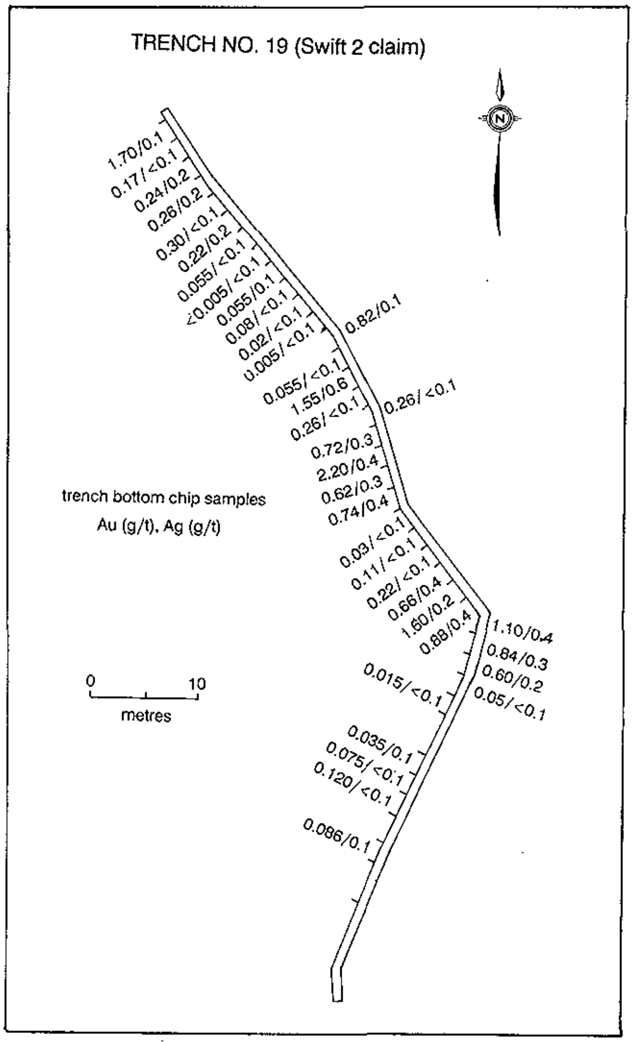


Figure B-1-3. Assay data from Trench 19, Swift 2 claim (from Bakker, 1987).

SUMMARY AND DISCUSSION

Mineralization in the Swift Creek area is in lower Jurassic Elise Formation augite and plagioclase-phyric flows, flow breccias and lapilli tuffs. Intense shearing, carbonate-sericite-silica alteration and gold mineralization appear to be spatially associated with the limbs of the Hellroaring Creek syncline. This area is in the same structural setting as the Toad Mountain - Morning Mountain area southwest of Nelson area, in the hinge zone of the Hall Creek syncline. There, a wide zone of shearing, the Silver King shear zone, alteration and gold-copper mineral occurrences appear to be associated with synvolcanic intrusions.

In summary, detailed mapping in the Swift Creek area indicates structural controls on mineralization. Zones of carbonate-sericite-silica alteration are aligned northeast in a zone of intense shearing parallel to the regional foliation, the limbs of the Hellroaring Creek syncline and the Waneta fault.

The similarity between this area and the area southwest of Nelson (Andrew and Höy, 1989; Höy and Andrew, 1989a, c) both in structural style, mineralization and alteration types makes shear-related gold deposits a viable new target for exploration in the Rossland Group. Similar structures and structural repetitions of the Hall and Hellroaring Creek synclines occur throughout the Rossland Group in the Nelson, Salmo and Rossland areas.

ACKNOWLEDGMENTS

We would like to acknowledge the able and cheerful field assistance of Heather Blyth and Darryl Lindsay. Discussions with Nils von Fersen and Ken Murray were very helpful. The editorial comments by John Newell are appreciated.

REFERENCES

Andrew, K.P.E. and Höy, T. (1989): The Shaft Showing, Elise Formation, Rossland Group; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1988, pages B21-B28.

Bakker, E. (1987): Report on Trenching, Mapping and Sampling on the Swift and Gus Claims; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 16901.

Beddoe-Stephens, B. and Lambert, R. St. J. (1981): Geochemical, Mineralogical, and Isotopic Data Relating to the Origin and Tectonic Setting of the Rossland Volcanic Rocks, Southern British Columbia; *Canadian Journal of Earth Sciences*, Volume 18, pages 858-868.

Burge, C.M. (1986): Geology, Lithogeochemistry and Economic Potential of the Swift Group Area, Rossland-Salmo, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 14933.

Clemmer, S.G. (1988): Diamond Drilling Assessment Report on the Swift and Gus Claims; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 17296.

Corbett, C.R. and Simony, P.S. (1984): The Champion Lake Fault in the Trail-Castlegar Area of Southeastern British Columbia; *in* Current Research, Part A, *Geological Survey of Canada*, Paper 84-1a, pages 103-104.

Fitzpatrick, M. (1985): The Geology of the Rossland Group in the Beaver Valley Area, Southeastern British Columbia; unpublished M.Sc. thesis, *University of Calgary*, 150 pages.

Höy, T. and Andrew, K.P.E. (1989a): The Rossland Group, Nelson Map Area, Southeastern British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 33-43.

______ (1989b): Geology of the Rossland Group, Nelson Map Area, Southeastern British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-1.

______ (1989c): The Great Western Group, Elise Formation, Rossland Group; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1988, pages B15-B20.

______ (1990a): Structure and Tectonic Setting of the Rossland Group, Mount Kelly - Hellroaring Creek Area, Southeastern British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 11-17.

______ (1990b): Geology of the Mount Kelly - Hellroaring Creek Area, Salmo Map Sheet (82F/3), Southeastern British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1990-8.

Little, H.W. (1960): Nelson Map-area, West-half, British Columbia; *Geological Survey of Canada*, Memoir 308, 205 pages.

______ (1964): Salmo Map-area, British Columbia; *Geological Survey of Canada*, Map 1145A.

McKillop, G.R. (1983): Report on the Reconnaissance Geology and Geochemistry of the Till 1 Claim; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 11227.

Parrish, R.R., Carr, S.D. and Parkinson, D.L. (1988): Eocene Extensional Tectonics and Geochronology of the Southern Omineca Belt, British Coumba and Washington; *Tectonics*, Volume 7, pages 181-212.

Santos, P.J. (1984a): Geochemical Report on the Ginny Group of Claims, Salmo Area, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 12244.

______ (1984b): Geochemical Report on the Ginny-2 and Ginny-3 Claims, Salmo Area, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 13371.

von Fersen, N. (1986): Geochemical Report on the Swift and Gus Claims; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 15561.

J & L

By R.E. Meyers and T.B. Hubner

(Fig. B1, No. 2)

LOCATION:	Lat. 51° 17′ Long. 118° 08′ (82M/8E) REVELSTOKE MINING DIVISION. At the confluence of Carnes and McKinnon creeks, approximately 32 kilometres north of the town of Revelstoke.
CLAIMS:	Crown Grants: Lots 14821-14829, Lot 7408. STAKED CLAIMS: MARY NO. 4-6, G.D., MIN, KIRK, TOM, SHANNON 100-1100, ARTY NO. 1-4, BURKE NO. 1-3, SAM, SAM NO. 1: TOTAL 357 UNITS IN 32 CLAIMS.
ACCESS:	North of the town of Revelstoke via highway 23 for 35 kilometres and then east onto a 10 kilometre gravel road to the property.
OWNER/OPERATOR:	EQUINOX RESOURCES LTD., PAN AMERICAN MINERALS LTD.
COMMODITY:	Gold, Silver, Lead, Zinc, Arsenic.

AN UPDATE ON THE J & L GOLD-BEARING POLYMETALLIC SULPHIDE DEPOSIT

INTRODUCTION

During its long history as an exploration prospect, the J & L property has been subject to several major phases of advanced exploration. Because of its geological setting, structure and unusual arsenic-gold association, the genesis of the deposit has been in dispute for as long as geologists have worked on it. Recently it has been the focus of exploration by Equinox Resources Ltd. and is at Stage I in the B.C. Mine Development Review Process. If the project goes ahead, it will be subjected to further and more detailed geological scrutiny that will undoubtedly cast new light on earlier and current ideas.

This article summarizes the main geological features of the J & L deposit. It attempts to draw together some of the geological evidence and perspectives that argue for, or against the various possible origins for the deposit and, hopefully, will stimulate further discussion.

EXPLORATION HISTORY

The J & L area has undergone a long history of exploration dating back to 1865 when placer gold was discovered in Cairnes Creek. Base and precious metal surface showings were subsequently discovered and the J & L claims, named for two prospectors "Jim" and "Lee", were staked in 1896 for Roseberry Consolidated Mines. Continued prospecting located the Roseberry Group 5 kilometres to the northwest, where significant underground and surface exploration took place. The main J & L zone was discovered in 1912 and early development included a 91-metre adit (986 level) and two 46-metre shafts (Coursier, 1899; Squarebriggs, 1915; O'-Grady, 1922). By 1924 metallurgical tests were attempting to resolve problems due to the high arsenical content of the ore. During 1924-27 Porcupine Goldfields Development and Finance Co. completed 43 metres of underground drifting on two levels. By 1934 significant development was completed on the A & E prospect, to the northwest. In 1934 the J & L property was acquired by T.E. Arnold and optioned to Raindor Gold Mines. That company extended the 986 Level by 152 metres of drifting and sank two shallow shafts.

The property was apparently dormant until 1962 when Westairs Mines Ltd. optioned the J & L, A & E and Roseberry prospects and carried out extensive work on all three zones. They completed helicopter supported surface sampling and mapping, 272 metres of drifting on the J & L Main zone (on the 830 level), 183 metres of undergound drilling and built 12.4 kilometres of road from the Columbia River highway (Hwy. 23)

In 1980 Pan American Minerals leased the property from T. Arnold. Selco Inc. (subsequently BP Canada Ltd., Selco Division) optioned the ground in 1981, and from 1982 to 1985 carried out road construction, 1095 kilometres of airborne geophysics, extensive surface surveys, 1183 metres of underground drifting and cross-cutting on the 830 level and 2640 metres of underground diamond drilling in 64 holes. Selco's program established lateral continuity on the Main zone and the potential for a mineable deposit of substantial proportion. During 1983 and 1984 Selco discovered more than 40 new sulphide occurrences on the north side of McKinnon Creek. They contain arsenopyrite and pyrite, with variable amounts of zinc and lead, and form the North zone in 4 parallel subzones. This zone was traced 1.54 kilometres along strike northwest of the Main zone (R. Pegg, personal communication, 1990). In 1986-87 Noranda Inc. optioned the property, completed extensive metallurgical tests on bulk samples and re-evaluated ore reserves. In 1987-88 Pan American Minerals Corp. drilled an additional 1904 metres and excavated four 30-metre raises for bulk sampling and additional metallurgical testing.

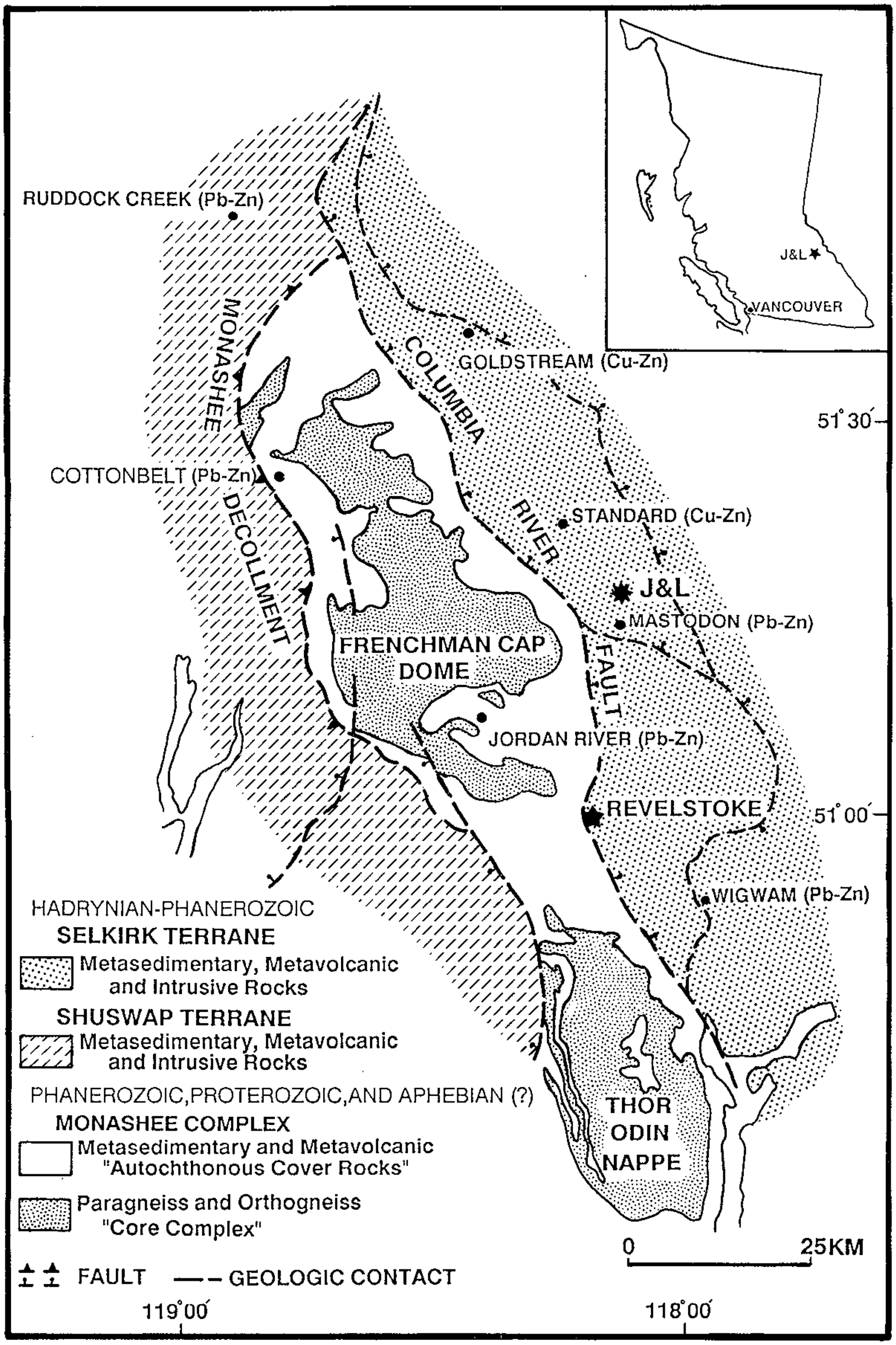


Figure B-2-1. Regional geology and location of the J & L property in southeastern B.C. Selkirk Terrane includes the northern Kootenay Arc; modified from Höy and Godwin (1988).

CURRENT WORK

Equinox Resources Ltd. optioned the J & L property from Pan American Minerals Corp. in 1988 and in 1988-89 undertook an aggressive program to re-evaluate the deposit. To date the company has completed 3000 metres of underground drilling in 32 holes and has extracted 270 tonnes of material for metallurgical tests. Late in 1989 the company collaborated with Placer Dome Inc. to carry out a pilot milling program on the bulk sample material.

Equinox has submitted a prospectus to the Mine Development Steering Committee and are involved in Stage I studies. Current undiluted proven and probable reserves are 808 100 tonnes grading 7.2 grams per tonne gold, 66 grams per tonne silver, 5.2 per cent zinc, 2.6 per cent lead and 4.9 per cent arsenic. Calculations which include material 50 metres beyond the probable ore blocks result in additional possible reserves of 669 000 tonnes with comparable grades, for a total reserve in all categories of 1 477 900 tonnes grading 7.9 grams per tonne gold, 62.2 grams per tonne silver, 4.7 per cent zinc, 2.3 per cent lead and 4.5 per cent arsenic (Wright and Weicker, 1989).

REGIONAL GEOLOGY

The J & L property (Figure B-2-1) lies near the north end of the Kootenay Arc, a northerly trending belt of Late Proterozoic to Late Paleozoic metasedimentary and metavolcanic rocks that are characterized by tight to isoclinal folds and generally west verging thrust faults (Brown *et al.*, 1978; Höy, 1979, 1980). The assemblage is bound to the east by the northern extension of the Purcell anticlinorium and the Rocky Mountain thrust belt, and to the west it is in contact with the Shuswap metamorphic complex, where it forms the hanging wall of the east-dipping Columbia River fault. Lowermost within the assemblage (Wheeler, 1965) is the Hadrynian Horsethief Creek Group (Windermere Supergroup), which is overlain by a Hadrynian to Lower Cambrian succession that includes the Hamill Group, the Mohican Formation, the Badshot Formation and the Lower Cambrian and younger Lardeau Group. The Hamill Group is the host to sulphide mineralization on the J & L property and to the Goldstream copper-zinc deposit to the north (Höy, 1979, 1985), whereas the overlying Badshot Formation contains most other stratiform base metal-bearing deposits (*e.g.* Mastodon) in the Kootenay Arc.

Structurally, the area has undergone at least two phases of folding (Brown *et al.*, 1978; Höy, 1979). The earliest phase was pre to synregional metamorphism and formed large nappe-like structures overturned to the southwest, with second phase tight to isoclinal folds developed in the overturned limbs.

The Hamill Group comprises impure quartzites, phyllites, limestone, quartz-mica schists and greenstone mafic metavolcanic rocks. Although no metavolcanic rocks have been recognized in the J & L sequence Brown *et al.* (1978) described the Hamill Group rocks as being more pelitic in composition from east to west, with an increasing metavolcanic component, and Höy (1979), interpreted the depositional environment in the Goldstream River area, immediately north of the J & L property, as transitional from stable shelf to deepening, restricted basin conditions. Recently Devlin (1989) has concluded that the introduction of mafic volcanic rocks into the arenaceous and pelitic shallow marine sequences of the Hamill Group are likely indicative of rifting in a Late Proterozoic to Early Cambrian extensional tectonic environment.

PROPERTY GEOLOGY

The main zones of mineralization on the J & L property are hosted by Hamill Group metasedimentary and metavolcanic rocks (Figure B-2-2). These rocks are interlayered, or in possible fault contact elsewhere on the property, with the Early Cambrian Mohican and Badshot formations and the Lower and Upper Index formations of the Cambrian and younger Lardeau Group (Pegg, 1985). Minor diorite, lamprophyre and amphibolite intrusive rocks are also present, but have not been described in detail.

The Hamill Group consists of impure quartzites, limestone, phyllites, chloritic and sericitic quartz-mica schists, minor chert and graphitic schists. Chloritic and sericitic phyllites are developed throughout the sequence and constitute the bulk of the lithologic sequence hosting the deposit. They are gradational in composition both laterally and vertically from chlorite-rich to sericite-rich, making subdivision difficult. Quartz-rich and quartz-poor mica schists are also highly variable in composition and are prominent in the hanging wall. Sericite and quartz-sericite schists are associated with most mineralized zones.

Quartzites vary from relatively "clean" to carbonaceous, fine to medium grained, buff white to grey and massive to weakly banded, commonly with a cherty texture. Iron staining is common in sections adjacent to mineralization and forms a narrow alteration envelope with sericite, chlorite and sulphides. The same assemblage is developed along fractures and shear planes. Carbonaceous grey and black limestone forms the footwall and, in places, the hanging wall for much of the main mineralized zone (Figure B-2-3). This unit is well jointed and variable in thickness. Some sections of limestone are silicified and "shot through" with calcite veinlets and minor quartz stringers.

A typical section in the footwall of the main sulphide zone comprises quartz-chlorite and quartz-sericite phyllites and schists, quartzites and limestone. The quartzite-phyllite-schist assemblage has been described as a

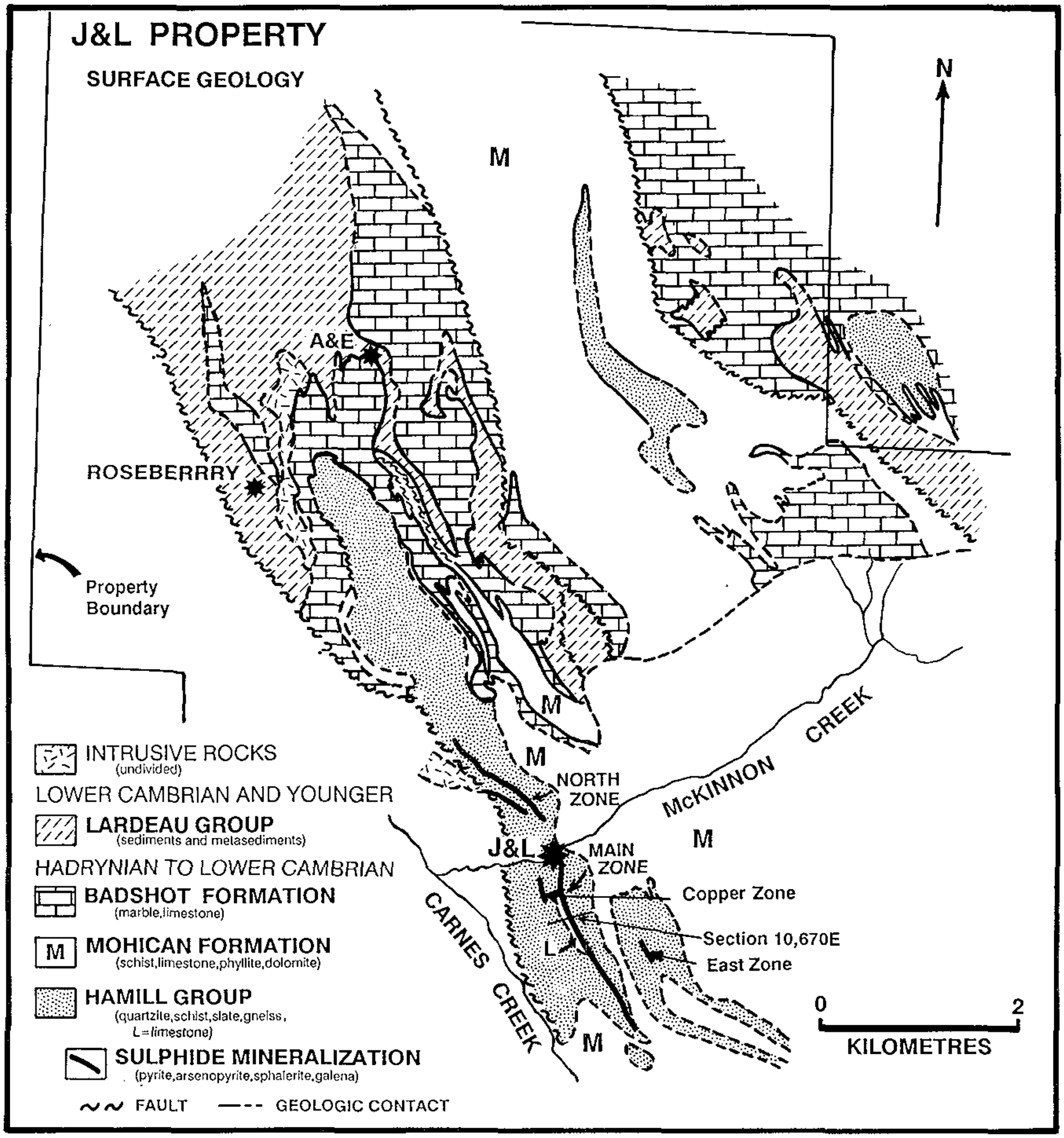


Figure B-2-2. J & L property surface geology, showing distribution of the main sulphide deposits and prospects; simplified from Pegg and Grant (1983, 1984) and Pegg (1985).

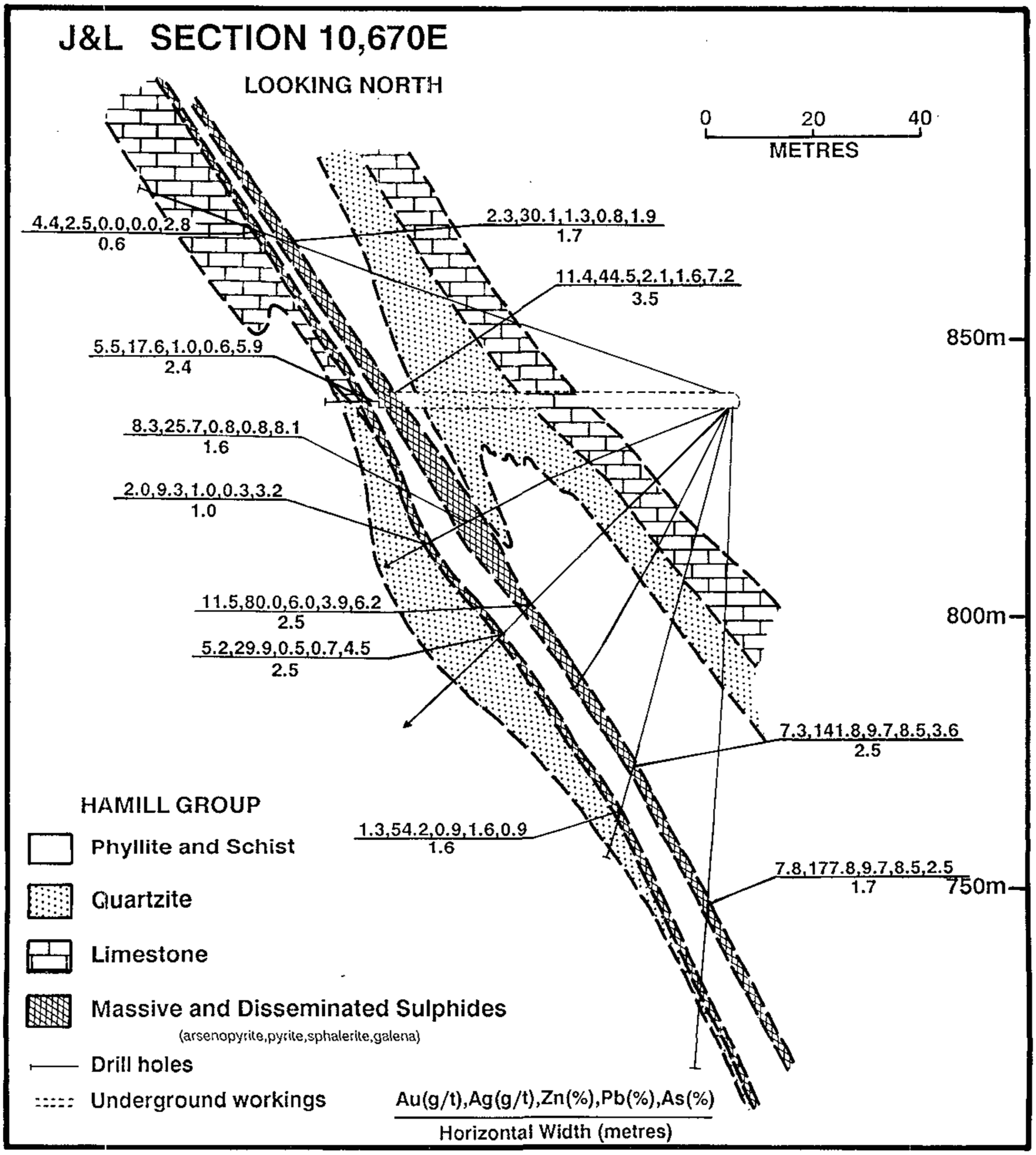


Figure B-2-3. J & L Section 10,670 East, showing main lithological units, diamond drill intersections and underground workings; from Pegg and Grant (1984) and Wright and Weicker (1989).

cyclical, upward-fining sequence, containing abundant carbonaceous material (Pegg, 1982; Grant, 1984b; Höy, 1985). Within a typical cycle, from the inferred stratigraphic bottom to top, the rocks tend to increase in alumina and decrease in silica. In the immediate footwall of the massive sulphides, the quartzites and pelitic rocks are usually overlain by two distinct carbonate units. The lower unit is a massive banded medium to dark grey limestone, which ranges in thickness from a few metres to more than 20 metres and contains little or no mineralization. It is overlain by a dark grey graphitic or carbonaceous limestone, which averages between 1 and 2 metres in thickness and contains discontinuous wispy laminations of yellowish-brown crystalline sphalerite. This unit is locally silicified, has a cherty texture and is commonly cut by irregular and deformed carbonate veins (Plate B-2-1) and minor quartz veinlets, which may also transect the adjacent massive sulphides.

In the hanging wall, the sulphide body is normally in contact with sulphide-rich sericitic schists or phyllites of variable thickness; locally it may contact sphalerite-pyrite bearing carbonaceous limestone. Further into the hanging wall, quartzite or micaceous rocks may be interlayered with minor limestone and disseminated sulphides, which gradually decrease in abundance, giving way to phyllitic rocks with only trace amounts of disseminated pyrite.

STRUCTURE

The rocks within the main zone of the deposit are extensively deformed. They generally trend northwesterly 320-325 degrees, with an average dip of about 55 degrees to the northeast. The entire sequence is strongly to intensely sheared (Plate B-2-2) and most individual units are transposed. Sulphides exhibit sheared, cataclastic and weak mylonitic textures (Plate B-2-3). Regional work by Höy (1979) and others has indicated polyphase deformation with at least two phases of folding. However, detailed underground work suggested that four and possibly five phases of deformation have affected the main zone sulphide sequence (McClay, 1984). The most prominent folds are tight to isoclinal, generally upright, with variable plunges trending northwesterly, parallel to regional structural trends. Stratigraphic and structural studies of the Main zone suggest that the deposit has a moderate plunge to the southeast. Recent workers (Wright and Weicker, 1989) have described the deposit as contained within a sericitically altered shear or deformation zone, oriented more or less parallel with the main lithological contacts.

MINERALIZATION

The J & L deposit is stratiform and generally conforms to the host stratigraphy, which strikes northwest and dips about 55 degrees east (Figure B-2-3). The "Main Zone", which lies south of McKinnon Creek, has been traced on surface for about 1.85 kilometres and over 800 metres underground, and has an average true width of 1.6 metres. Several other mineral occurrences are found on the property, east and west of the Main zone and to the north, across McKinnon Creek. Two of these, the Roseberry and A&E prospects, are about 5 kilometres to the northwest.

The Main zone is a complex tabular or sheet-like body that tends to follow the limestone-phyllite/schist contact and, in places, splits into multiple semiparallel sheets or branches (Pegg, 1982, 1985; Pegg and Grant, 1983, 1984; Höy, 1985; Wright and Weicker, 1989). The most abundant metallic minerals in the zone include pyrite, arsenopyrite, sphalerite and galena, with lesser amounts of chalcopyrite, pyrrhotite, tetrahedrite, silver-lead-antimony sulphosalts and lead-antimony sulphosalts. Gold and zinc are the most important economic minerals given current market conditions.

The deposit consists of nearly continuous, but structurally deformed zones of massive sulphides, flanked or locally enveloped by disseminated and stringer sulphide zones, which are most prominent in the hangingwall. The lowermost section of sulphides usually forms a sharp contact with the footwall limestone. Massive sulphide sections vary, from pyrite and arsenopyrite rich (Plate B-2-4) to sphalerite±galena rich. Increasing sphalerite usually coincides with a notable decrease in arsenopyrite. Sphalerite may be iron rich or iron poor but is normally accompanied by an increase in lead content. Sulphide content and composition is highly variable laterally and vertically, with massive, banded and disseminated zones of contrasting composition being complexly interleaved or interfingered, possibly due to shearing. The overall thickness of the sulphide zone tends to follow the thickness of the footwall carbonaceous limestone, such that the thickness of the zone increases with increased thickness of the limestone and is usually accompanied with increases in sphalerite and galena content.

Detailed descriptions from various workers (Pegg, 1982; Grant, 1984a, b; Pegg and Grant, 1983, 1984; Höy, 1985) generally indicate that the lowermost massive zone tends to be pyrite-rich, with or without arsenopyrite and sphalerite, and has a weakly to moderately developed banded texture. It is overlain by a gold-rich arsenopyrite-pyrite zone, with laminated sphalerite±galena, progressing upwards to a "disseminated" sulphide zone with laminated or intrafolial sphalerite and arsenopyrite. Hanging wall sulphides tend to be more arsenical, with arsenopyrite±pyrite exhibiting a coarse grained, "milled", mylonitic texture near the zone margins (Plate B-2-5). Laterally, some zones are sphalerite-rich, arsenopyrite (and gold)-poor and vice-versa. In sections where there are overlying massive sulphide layers, they are commonly separated by up to 10 metres of sericitic schist, that is rich in disseminated sulphides. Although they tend to be

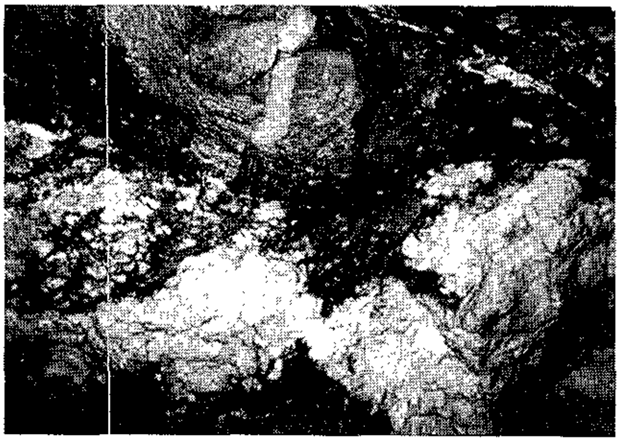


Plate B-2-1: Upper: Massive arsenopyrite and pyrite with minor carbonate veining. Lower: Deformed massive carbonate-quartz veins in footwall rocks. Dark areas in veins are sphalerite, pyrite and arsenopyrite veins. Width of view top to bottom is about 1 metre. J & L 830 Level.

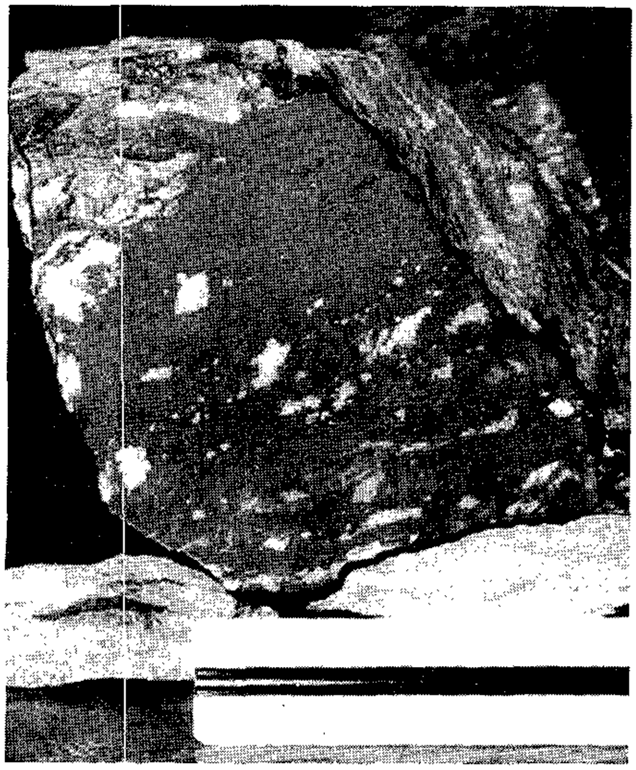


Plate B-2-3. Cataclastic carbonate, quartz and chert fragments in thinly laminated, contorted sphalerite. From J & L 830 level.

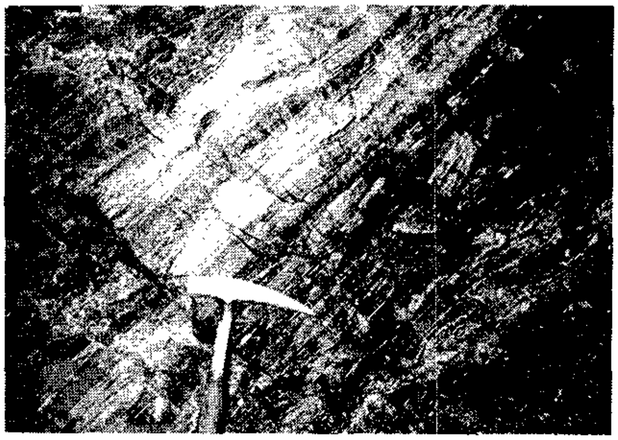


Plate B-2-2. Sheared and mylonitic wall rocks with intrafolial carbonate and quartz, J & L 830 Level. Lower right is carbonaceous limestone; Upper left is iron stained quartzitic sericite phyllite.

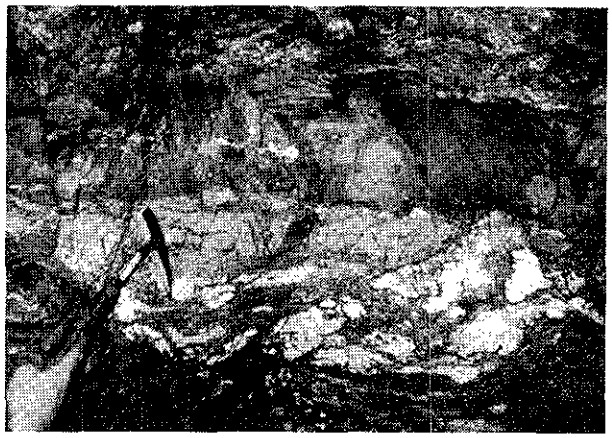


Plate B-2-4. Massive arsenopyrite and pyrite (central, above hammer). Above is contorted quartz-sericite schist, below is quartzite and sericite schist with disseminated sulphides and carbonate-quartz veins and lowermost (dark) is deformed carbonaceous limestone. J & L 830 level.

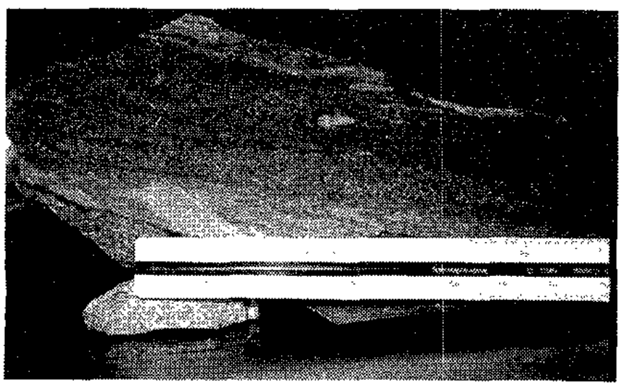


Plate B-2-5. Tectonic pyrite and sphalerite banding in quartz-sericite schist. From J & L 830 level.

restricted in size, some hangingwall disseminated zones are zinc-rich, low in arsenopyrite and may be sufficiently concentrated, in places, to be classed as ore grade material (Wright and Weicker, 1989).

Analytical data from Selco Inc. (Pegg, 1982; Grant, 1984a, b; Höy, 1985) indicate that gold is most strongly associated with arsenopyrite and silver occurs with galena. The footwall carbonaceous limestone is locally anomalous in antimony (1100ppm), and molybdenum (15ppm) is weakly anomalous in the immediate hanging wall sericite schists. The most dramatic changes are in arsenic, which averages about 10ppm in footwall rocks and about 4.7% overall in the ore zone, and in gold which, occurs in parts per billion in footwall rocks and averages 7.2 grams per tonne in the ore zone.

DISCUSSION

Extensive and intense deformation of the J & L deposit has distorted or destroyed most original ore textures and ore-wallrock relationships. Most textures now observed result from an overprinted tectonic fabric, making interpretation of the timing and environment of deposition difficult, at best. Early interpretations classed the deposit as an epigenetic shear zone replacement, or vein deposit (Gunning, 1928; Wheeler, 1965). Subsequent work in the region by Höy (1979, 1982, 1985) and others, established a volcanogenic setting for the Goldstream and Standard copper-zinc deposits to the north, within the Kootenay Terrane and a syn-sedimentary origin for lead-zinc deposits in the adjacent Monashee complex to the west (Cottonbelt; Höy and Godwin, 1988).

Some recent workers have returned to an epigenetic model, arguing that there is no concrete evidence to support a sedimentary-exhalative origin for the deposit and that the present structural relationships, cataclastic textures and the assemblage of arsenopyrite, gold, calcite and quartz fragments within the massive sulphide body point to a vein-replacement origin (McClay, 1984). McKinlay (1987) argued that sulphide banding and variations in thickness of the deposit are structurally developed features. In the same study, lead isotope data is interpreted to indicate a crustal origin for metals, and a depositional temperature range of 285° to 350°C is inferred from geothermometric characteristics of arsenopyrite. McKinlay concluded that the deposit formed during Early to Mid-Paleozoic compressional tectonics. This interpretation of origin has generally been adopted, with variations, by the current operators of the property (Wright and Weicker, 1989) and by others.

In support of a sedimentary-exhalative origin, Grant (1984a, 1984b) interpreted many of the ore and wall rock textures and stratigraphic features, such as intricate sulphide banding, the close correlation of thickness variations of the carbonaceous limestone unit with sulphide thickness, and the cyclical nature of the wholerock geochemistry and hostrock stratigraphy, as resulting from, or contributing to syngenetic sea-floor ore deposition.

One may further argue that the depositional and tectonic setting of the Hamill Group as a quartzite-pelite-carbonate platformal sedimentary assemblage, with attendant mafic volcanism, was a favourable site for the formation of the Goldstream Besshi-type massive sulphide deposit (Höy *et al.*, 1984). It follows that, during this Early Cambrian extensional (Devlin, 1989) and potentially basin-forming regime, virtually all of the requirements for "sedex" deposits to form, could be met.

Most proponents of a syngenetic model accept that there is a strong tectonic overprint on the deposit. There is, however, no concrete evidence that the Main zone was not formed by sedimentary-exhalative processes. Regardless of its origin, the J & L deposit is stratiform and in its present state of deformation, it does resemble a complex vein system within a shear zone and it is unusual in its high arsenic and gold content.

Most importantly, the deposit retains the potential to become an important gold producer. Only a small portion of the Main zone has been explored in detail, yet it has been traced on surface for at least 1.8 kilometres allowing potential for additional inferred reserves of 5.6 million tonnes (Equinox Resources Ltd. 1988). North of McKinnon Creek, the North zone (Figure B-2-3) is possibly an extension of the Main zone and has been explored only on surface. It has been traced discontinuously for more than 1.5 kilometres and is an important prospect for future exploration.

ACKNOWLEDGMENTS

We wish to acknowledge the cooperation of Equinox Resources Ltd. for providing access to underground workings, drill core and to company data. This report has also benefited from fruitful discussions, critical review and volunteered data from Rex Pegg and Brian Grant, both formerly of Selco Inc.

REFERENCES

Brown, R.L., Tippett, C.R. and Lane, L.S. (1978): Stratigraphy, Facies Changes, and Correlations in the Northern Selkirk Mountains, Southern Canadian Cordillera; *Canadian Journal of Earth Sciences*, Volume 15, pages 1129-1140.

Coursier. H.N. (1899): Carnes Creek; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Annual Report, 1899 page 671.

Devlin, W.J. (1989): Stratigraphy and Sedimentology of the Hamill Group in the Northern Selkirk Mountains, British Columbia: Evidence for Latest Proterozoic - Early Cambrian Extensional Tectonism; *Canadian Journal of Earth Sciences*, Volume 26, pages 515-533.

Equinox Resouces Ltd. (1988): The J & L Property, Prospectus to the Mine Development Steering Committee; *Ministry of Energy, Mines and Petroleum Resources*.

Fyles, J.T. and Waterland, T.M. (1966): J & L; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Annual Report, 1966, pages 227-228.

Grant, B. (1984a): The J & L Deposit, MEG Meeting, March 21, 1984, Vancouver, B.C.

______ (1984b): Geological Setting and Genesis of the J & L Deposit; *BP Canada Ltd.*, Selco Division, private company report.

Gunning, H.C. (1929): Geology and Mineral Deposits of the Big Bend Map-area, British Columbia; *Geological Survey of Canada*, Summary Report 1928, Part A, pages 136-193.

Höy, T. (1979): Geology of the Goldstream Area; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 71.

______ (1980): Geology of the Riondel Area Central Kootenay Arc Southeastern British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 73.

______ (1982): Stratigraphic and Structural Setting of Stratabound Lead-Zinc Deposits in Southeastern B.C.; *Canadian Institute of Mining and Metallurgy*, Bulletin 75, pages 114-134.

______ (1984): J & L, A Stratabound Gold-Arsenic Deposit, Southeastern British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1984, Paper 1985-1.

Höy, T., Gibson, G. and Berg, N.W. (1984): Copper-Zinc Deposits Associated with Basic Volcanism, Goldstream Area, Southeastern British Columbia; *Economic Geology*, Volume 79, pages 789-814.

Höy, T. and Godwin, C.I. (1988): Significance of a Cambrian Date From Galena Lead-isotope Data for the Stratiform Cottonbelt Deposit in the Monashee Complex, Southeastern British Columbia.

McClay, K.R. (1984): The Structure of the J & L Polymetallic Sulphide Deposit, British Columbia, Private Report for BP Canada Ltd., Selco Division..

Mitchell, J.A. (1946): Carnes Creek, B.C. Ministry of Energy, Mines and Petroleum Resources Annual Report, 1946, pages 174-175.

O'Grady, B.T. (1922): J & L Group; *B.C. Ministry of Energy, Mines and Petroleum Rresources*, Annual Report, 1922, pages 215-217.

Pegg, R.S. (1982): Geological, Geochemical & Physical Work Report On The J&L Prospect; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 10939.

Pegg, R.S. and Grant, B. (1983): A Summary Report on the J & L Mineral Option; *BP Canada Ltd.*, Selco Division, Private Company Report.

______ (1984): A Summary Report on the J & L Mineral Option; *BP Canada Ltd.*, Selco Division, Private Company Report.

Pegg, R.S. (1985): The J & L Project; *BP Canada Ltd.*, Selco Division, private company report.

Squarebriggs. R.S. (1915): Carnes Creek; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Annual Report, 1915, page 117.

Wheeler, J.O. (1965): Big Bend Map Area, British Columbia; *Geological Survey of Canada*, Paper 64-32.

Wright, J.H., Weicker. B.F. (1989): Completion Report On Phase 1 Exploration Program J & L Property; *Equinox Resources Ltd.*

Wright, J.H., Weicker. B.F., Taal, T. (1989): Report On Diamond Drill Program and Metallurgical Testwork J & L Property; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 19469.

NOTES

GIANT COPPER (092HSW001, 002)

(Fig. B1. No. 3)

By H. Paul Wilton and Shielagh Pfuetzenreuter

LOCATION:	Lat. 49°10" Long. 121°01" (92H/3E) NEW WESTMINSTER MINING DIVISION. 42 kilometres southeast of Hope at the head of Silver Daisy Creek.
CLAIMS:	A.M. #5 CG, A.M. CG, A.M. #1 CG, JET 1 FR., 2 FR., 26 MILE FR., LOIS FR., LOIS 1-14, VERNON 1-8, LORNA FR., LESLIE, LESLIE 1-5, GE 1-12, GM 27-32, IP 1 FR., 2 FR., IP 4 FR., -9 FR., JOHN 1-4, RED 1-4, REX 11-22, AXE 2, 10 FR., RAN FR., MISTY, MISTY 1-3, MAY FR., MAY 1-11, 16, BROWN 1-4, GC 35-68, PEG 1, 2, RIDGE 1-3 FR., REX 22 FR., INVERMAY 1-3, CAMBORNE 1, 2, SABRE 1, HANK 1 FR., HANK 2-8, SLIDE FR.
ACCESS:	42 kilometres east along Highway 3 from Hope, then south along a gravel road for 5 kilometres to the 15 level portal. Mine roads lead to the AM and Invermay showings from there.
OWNER/OPERATOR:	BETHLEHEM RESOURCES CORPORATION.
COMMODITIES:	Copper, gold, silver, molybdenum.

INTRODUCTION

The Giant Copper property was discovered in the 1930s. Underground exploration and drilling began in 1950, and has continued intermittently ever since under a variety of operators. To date over 5800 metres of underground drifting and raising, and over 15 250 metres of drilling have been completed. Bethlehem Resources is the present owner and operator and is conducting extensive surface and underground drilling programs.

EXPLORATION HISTORY

The Giant Copper prospect originally consisted of two separate showings, the AM which was discovered in 1930 by The Consolidated Mining and Smelting Company of Canada Limited (now Cominco Limited) and the Invermay, then known as the Norwegian claim group, discovered in 1933 by Invermay Annex Mining Company (Figure B-3-1).

The AM property was worked on by Cominco from 1930 to 1938. Open-cuts and six adits were driven by hand, totalling about 760 metres. No further activity is reported until 1944 when Canam Amalgamated Mines and its successor, Canam Mining Corporation acquired the property. Intense underground exploration began in 1950. The various companies working on the property have been:

1944-53:	Canam Mining Corporation
1954:	American Metal Company Limited
1955-57:	Mogul Mining Company
1958-59:	The Consolidated Mining and Smelting Company of Canada, Limited
1960-61:	Intermountain Construction Limited
1962-63:	Canam Mining Corporation
1964-72:	Giant Mascot Mines Limited (now GM Resources)
1966:	Property purchased by Giant Mascot Mines Limited)
1973-78:	No work done
1979-80:	GM Resources Limited
1988:	Bethlehem Resources Corporation

Little is documented on the Invermay group. It was staked in 1933. By 1947 some 22.5 tonnes of ore had been

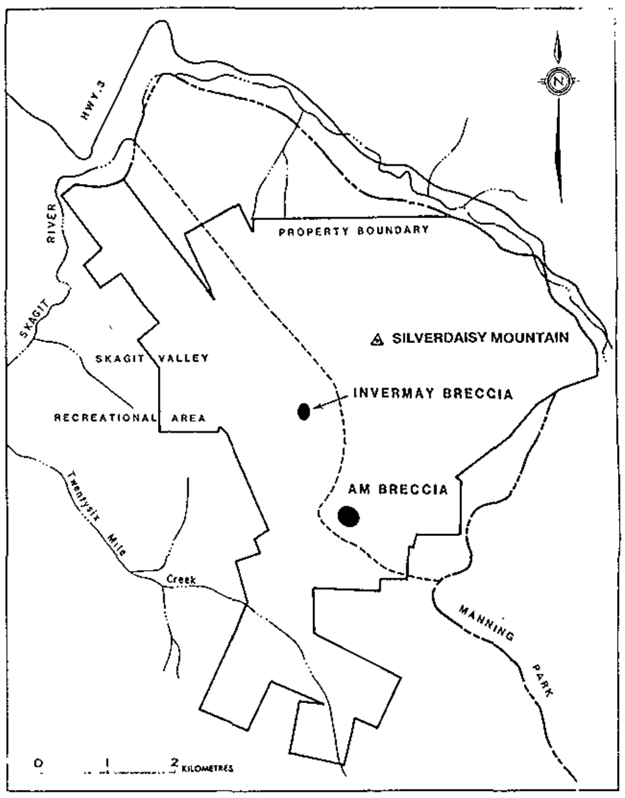


Figure B-3-1. Location of Giant Copper property and Main mineralized zones (modified from Hicks, 1989).

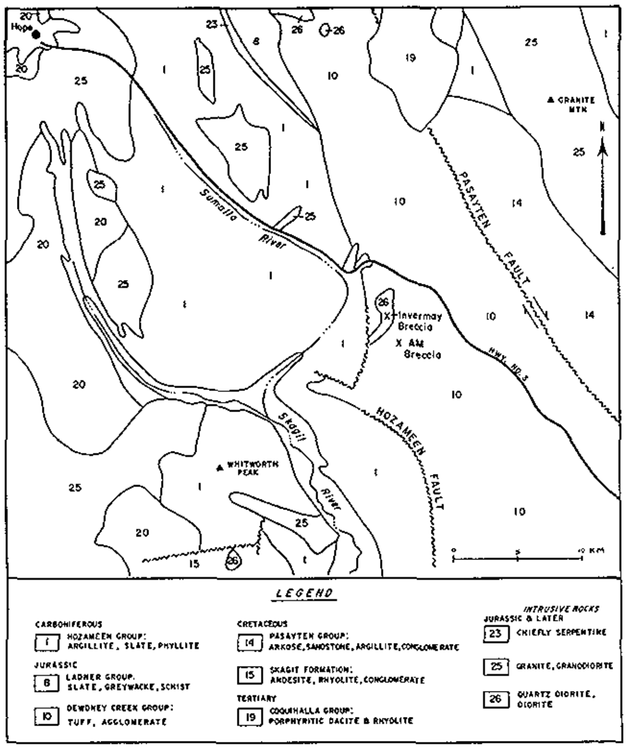


Figure B-3-2. Regional geology (modified from Hicks, 1989).

shipped to the Trail smelter. It was worked on by the Invermay Annex Mining Company, and then the Skagit River Development Company. In 1949 the Invermay was acquired by the Canam Mining Corporation.

CURRENT ACTIVITY

In 1989, 23 rotary-drill holes totalling 2544 metres were completed. Other work included mapping, trenching and geochemistry. A new mineralized breccia zone known as the No. 1 Anomaly was discovered. It is located about 330 metres northeast of the AM breccia. Also, extensive work in the south and central parts of the AM breccia delineated additional reserves.

GEOLOGY

Regional Setting

The Giant Copper property is located in the northern part of the Cascade Mountains and straddles the Hozameen fault. West of the fault the property is underlain by mafic volcanics and lesser sedimentary rocks of the Late Paleozoic to Early Mesozoic Hozameen complex. East of the fault it is underlain by younger sedimentary rocks of the Early to Middle Jurassic Ladner Group (Monger, 1989). Both stratigraphic packages have been intruded by numerous plutons of Early to Middle Tertiary age (Figure B-2-2).

Property Geology

Hostrocks to the mineralized zones are steeply dipping and tightly folded metasedimentary rocks consisting primarily of argillites and siltstones with minor greywacke and felsic tuff. These rocks have been interpreted previously as belonging to the Dewdney Creek Formation of the Ladner Group but have been most recently mapped as undivided Ladner Group (Monger, 1989). Numerous dikes and sills, ranging from diorite to pyroxenite composition, intrude the metasedimentary rocks and appear to pre-date the regional deformation and metamorphism. The Ladner Group beds trend north-northwest and dip steeply to the northeast. Large but tight fold noses occur locally; most notably the nose of a major syncline is exposed on the south spur of Silverdaisy Mountain and is reported to have involved three of the mafic sills (Payne, 1989).

Central to the area of economic interest on the property is the Invermay stock of medium-grained diorite to granodiorite. The stock has intruded the Ladner Group stratigraphy east of the Hozameen fault with its long axis parallel to the regional strike. Monger (1989) has suggested an Oligocene age but the stock has apparently not been dated. Deuteric alteration of the feldspars, hornblende and biotite is moderate to strong and accessory tourmaline is abundant. The adjacent argillites and siltstones have been strongly altered to pyritic biotite hornfels over an area several hundred metres wide surrounding the stock. The hornfels contains local concentrations of thin tourmaline veinlets containing minor pyrite and chalcopyrite.

The AM breccia zone is an oval-shaped, subvertical diatreme 400 metres long by about 150 metres wide, with a northwest elongation and bounded by steeply dipping faults (Payne, 1989). It outcrops a few hundred metres southeast of the Invermay stock and within the contact metamorphic halo. It and most of the smaller breccia zones are interpreted as explosive diatreme breccias related to the intrusion of the stock. It is mainly matrix-supported but contains zones near the contact where the country rock has been shattered with very little movement of the fragments. The clasts are angular to subrounded and consist mainly of intensely hornfelsed and silicified sedimentary rocks with only minor fragments of silicified mafic sills. The matrix is composed predominantly of chlorite with lesser amounts of sericite, epidote, tourmaline, and actinolite. Economic mineralization in the AM breccia zone consists of patches and blebs of sulphides within the matrix. The dominant sulphides are pyrite and chalcopyrite with minor concentrations of arsenopyrite, pyrrhotite, and sphalerite. Minor molybdenite, galena, magnetite and scheelite are also reported (Hicks, 1989). The timing of mineralization in the AM zone is uncertain but is interpreted to be due to partial hydrothermal replacement of the matrix of the breccia

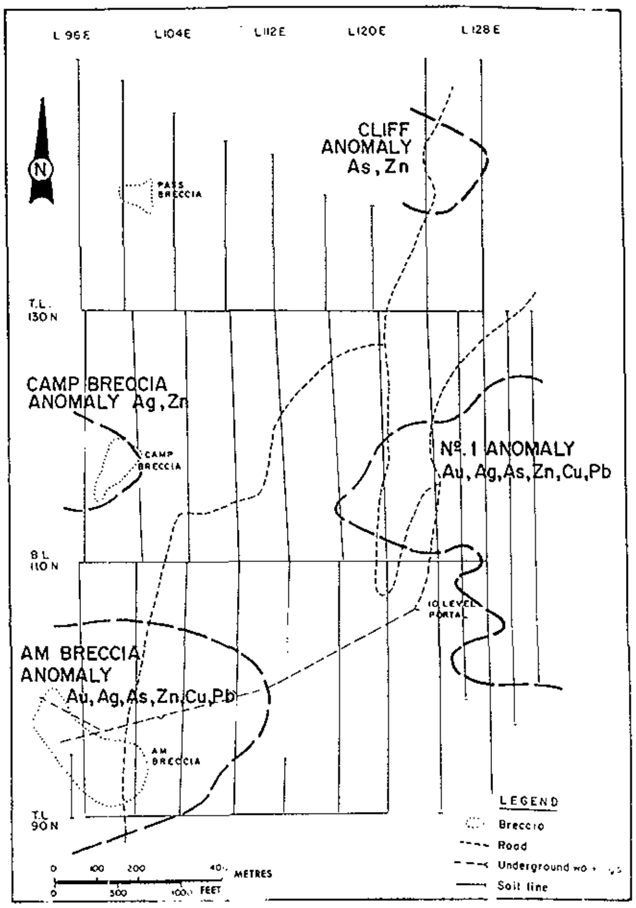


Figure B-3-3. Soil geochemistry Anomaly map (modified from Hicks, 1989).

by analogy with the Invermay showing where replacement textures have been observed (Payne, 1989). The mineralization appears to be concentrated mainly near the north and south ends of the breccia zone although the 1989 exploration drilling demonstrated that significant reserves also occur in the central parts of the zone. A somewhat younger mineralizing event has produced veins of sphalerite and galena with high silver content which occur within the AM breccia, at the new No. 1 Anomaly zone and elsewhere.

The No. 1 Anomaly zone (*see* Figure B-3-3) is a newly discovered breccia occurring about 330 metres northeast of the AM zone. It has very similar mineralization, hostrock lithology and geochemical signature to the AM breccia and probably represents a segment of the AM zone which has been offset by left-lateral movement on a northeast-trending fault (Figure B-3-2).

The authors did not visit the Invermay breccia zone but it has been described as a potentially significant mineral deposit occurring within a brecciated and hornfelsed pendant in the Invermay stock.

ECONOMIC POTENTIAL

Underground reserves in the AM breccia have been calculated at 3.35 million tonnes grading 1.17 per cent copper, 0.51 gram per tonne gold and 20.6 grams per tonne silver. This tonnage is limited to the northern end of the AM breccia. Potential open-pit reserves have been estimated at 20.7 million tonnes grading 0.75 per cent copper, 0.41 gram per tonne gold and 12.0 grams per tonne silver.

REFERENCES

Hicks, K. (1989): Drilling, Geochemical and Geophysical Assessment Report on the Giant Copper Property; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 18340.

Payne, J.G. (1989): Geological Report on the Giant Copper Property; private report, *Bethlehem Resources Corporation*.

Monger, J.W.H. (1989): Geology, Hope, British Columbia; *Geological Survey of Canada*, Map 41-1989, Sheet 1, scale 1:250 000.

NOTES

TREASURE MOUNTAIN

By R.E. Meyers and T.B. Hubner

(Fig. B1. No. 4)

LOCATION:	Lat. 49° 25′ Long. 121° 04′ (92H/6E) Similkameen Mining Division 27 km ENE of Hope.
CLAIMS:	REVERTED CROWN GRANTS: WHYNOT FR., WHYNOT FR.#3, EUREKA FR., TAMARACK, TAMARACK#2, LAKEVIEW, WHYNOT#2, EUREKA, TAMARACK FR. MINERAL CLAIMS: HEIDI 1-6, JOHN, HILL, VALE, BILL 1-6, SUMMIT FR., THUNDER, TUSSA, TUSSEN, HULDRA, TROLL 3, SKATT 3-12, HULDER.
ACCESS:	Via a 38 km logging road, southwest from the Coquihalla Highway toll gates, which are 52 km north of Hope. Alternate access is from the village of Tulameen via the Tulameen river road.
OWNER:	Huldra Silver Inc.
OPERATOR:	Huldra Silver Inc.
COMMODITIES:	Silver, lead, zinc.

PRELIMINARY GEOLOGY OF THE TREASURE MOUNTAIN SILVER-LEAD-ZINC VEIN DEPOSIT

INTRODUCTION

The Treasure Mountain silver-lead-zinc deposit lies at the southwest corner of the Tulameen district in the Cascade Mountains, near the headwaters of the Tulameen River (Figure B-4-1, Plate B-4-1). It is the largest and most important of a number of historic silver-rich deposits and prospects in an area known as the Summit Camp, which lies between Sutter, Vuich and Amberty Creeks (Figure B-4-2). Like most other small mining camps in southern British Columbia, this area has been the focus of intermittent exploration and development activity during the past century. Since 1980 Huldra Silver Inc. have carried out a comprehensive program of surface and underground work and has developed the potential for a small tonnage but high-grade silver-lead-zinc producer. Huldra is a Scandinavian female leprechaun who hoards silver in her burrows in the hills (Livgard, 1990).

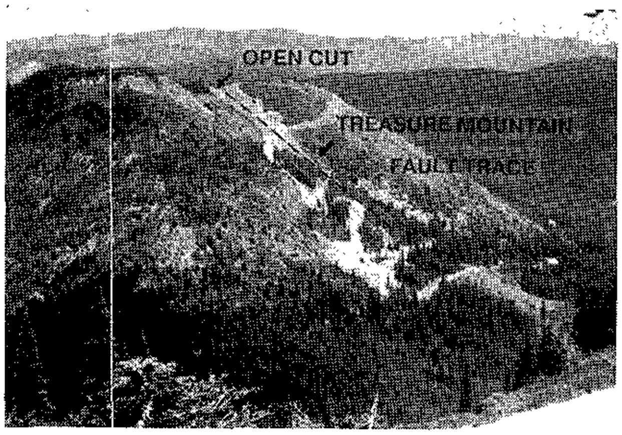


Plate B-4-1: View of Treasure Mountain, looking southeast.

EXPLORATION HISTORY

The earliest known work in the Treasure Mountain area took place in the late 1800s and was directed toward locating the source of gold and platinum-bearing placers in the Tulameen River system (Cairnes, 1924). The first claim to be staked was the Eureka in 1894, when prospectors reported the discovery of silver-bearing galena veins in the Sutter Creek area. In 1906 Andrew Jenson discovered the Silver Chief lode on Treasure Mountain and in 1911 the Treasure Mountain Mining Company purchased the property and began exploration and development. Between 1912 and 1926 a 20-metre shaft and three adits were developed near the summit of Treasure Mountain. Exploration continued intermittently and the property went through a number of name changes, including Silver Chief, Mary E, Silver King and Old Dornberg. During the same period on the adjoining Eureka claim, Jenson supervised the development of three adits and eventually 21 tonnes of high-grade ore were shipped (Freeland, 1926). In 1929 the Silver King Mining Company mined and shipped three railcar loads of sorted ore to the Trail smelter. A small mill was built in 1930 and was operated at intervals until 1934. The property was then dormant from 1935 until 1951. Silver Hill Mines Ltd. took over the property, optioned the Eureka claim and carried out further exploration. A 45 tonne per day mill was built during the 1953-56 period and a small shipment of zinc concentrate was sent to Trail (James, 1957). However, in 1957 the mill was dismantled and the property again lay dormant until 1979-80, when Magnus Bratlien negotiated an option from one of the

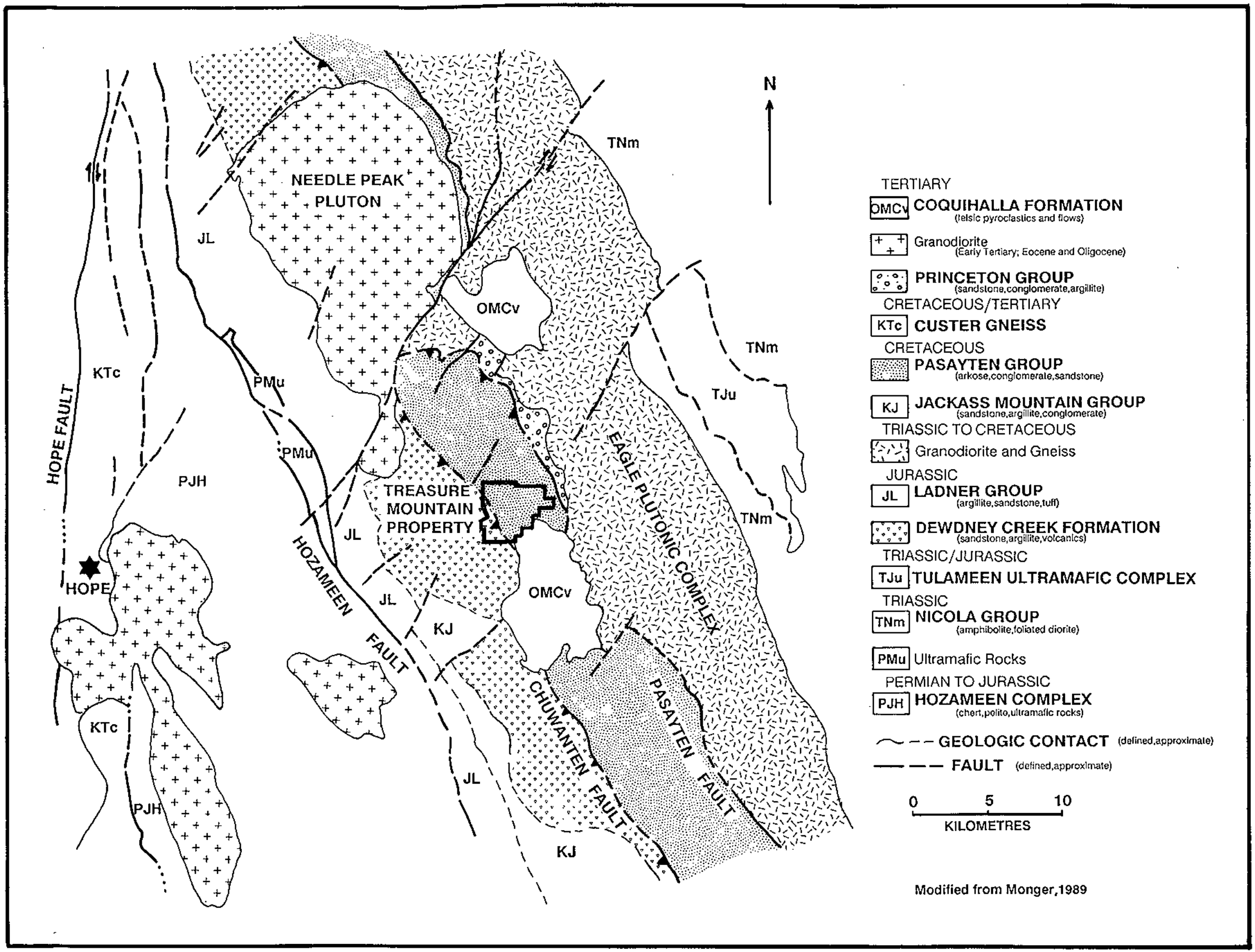


Figure B-4-1: Regional geology and location of the Treasure Mountain property, simplified from Monger (1989). The Methow-Tyaughton Terrane lies between the Pasayten and Hozameen faults and includes the Pasayten, Jackass Mountain and Ladner groups and the Dewdney Creek Formation and Spider Creek Formation (not shown).

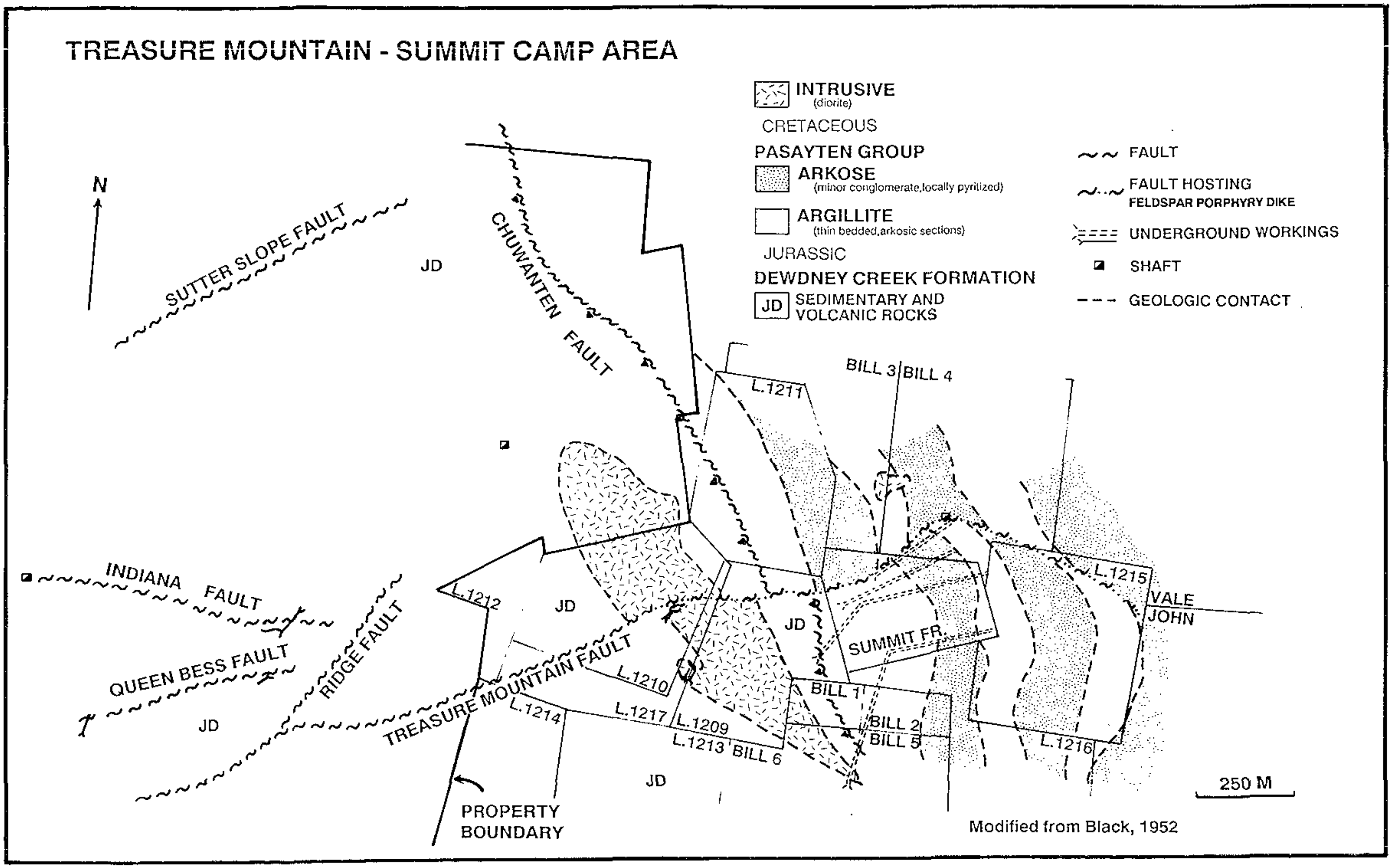


Figure B-4-2: General geology of the Treasure Mountain - Summit Camp area, modified from Black (1952). Only a portion of the Treasure Mountain claims (right) are shown, east of the property boundary.

Silver Hill Mines owners, E. Borup, and formed Huldra Silver Inc.

CURRENT WORK

During the 1980-85 period Huldra Silver Inc. carried out various surface exploration programs, including geochemical (soil) and geophysical (VLF-EM) surveys (Livgard, 1990). Diamond drilling was also completed, but with only limited success. Previous data and experience had indicated the close relationship between mineralization and a prominent feldspar porphyry dike that occupies the Treasure Mountain fault, a major east-trending structure on the property. Applying this knowledge a 1985 trenching program exposed a sulphide-rich vein which averaged about 2194 grams per tonne silver and 12 per cent combined lead-zinc over a 0.68 metre width and along a vein length of 150 metres. This vein became the main mineralized zone and was designated the "C-Vein". Further trenching in 1986 extended the zone to 250 metres length and exposed a second, parallel structure, named the "D-Vein".

In 1987-88 the company undertook a major development and bulk sampling program. A large open cut was excavated and approximately 4500 tonnes of silver-lead-zinc ore was mined, of which 363 tonnes, grading about 5150 grams per tonne silver was shipped to Asarco and Cominco smelters for test-milling. The remaining ore was stockpiled. Subsequently, underground exploration was initiated by rehabillitating and drifting on the old first and second level adits, for a total of 650 metres, using trackless mining methods. A third level was driven for 450 metres, between the first and second level adits, and raises were established from the third level (old No. 2 level) to surface. Later a fourth level was driven, expanding the former third level crosscut, plus additional drifting for a total of 700 metres on that level. In all more than 1800 metres of rehabillitation and new drifting were completed during the program. Underground diamond and percussion drilling completed during this time and early in 1989 intersected vein mineralization in structures parallel to the main zone, which indicate further potential. Drilling and raising between the fourth and third levels has encountered a zone containing ruby silver and freibergite.

In 1988-89 the company commissioned metallurgical testing by Bacon Donaldson Ltd. and a prefeasibility study by Entech Ltd. The metallurgical tests indicated approximate recoveries as follows: Silver,95 per cent, lead, 85-90 per cent, zinc, 80 per cent with a concentration ratio of 1:5. A lead concentrate would contain about 6850 grams per tonne silver and 65 to 75 per cent lead. The antimony and arsenic contents, are 1.0 per cent and 0.1 per cent respectively. A one-year baseline environmental study shows that water run-off from old underground workings has a high pH, probably due to the carbonate content of veins and hostrocks.

The company submitted a prospectus to the Mine Development Steering Committee in 1989, with the objective of placing the property into production (Entech, 1988). The current exploration program and related studies have outlined geological reserves of 147 000 tonnes grading 960 grams per tonne silver and about 11 per cent combined lead-zinc. Within the mine workings there are potential reserves of approximately 150 000 tonnes at comparable grades.

REGIONAL GEOLOGY

The Treasure Mountain property (Figure B-4-1) lies near the eastern edge of the Coast-Cascade belt within the Methow-Tyaughton Terrane (Monger, 1989). The Methow trough is a northwest-trending Jura-Cretaceous sedimentary-volcanic basin bounded on the east by the Pasayten fault, where it contacts the Jura-Cretaceous Eagle plutonic complex (Greig, 1989) and on the west by the Hozameen fault, which separates the terrane from the Permian to Jurassic Hozameen complex.

Rocks within the area include volcanic rocks and volcanic-derived sediments of the Early to mid-Jurassic Dewdney Creek Formation (Ladner Group) and arkosic and argillaceous sedimentary rocks of the Early to mid-Cretaceous Pasayten Group. Monger (1989) describes the Dewdney Creek Formation as a volcanic-rich marine facies of the Ladner Group, and the Pasayten Group sediments as a nonmarine succession derived from both the Nicola volcanic arc complex to the east and the Hozameen oceanic sedimentary succession to the west. They are in fault contact with each other, separated by the northwest-trending Chuwanten thrust, which extends the full length of the belt and verges east. Northwest of the Treasure Mountain area the succession is intruded by the Eocene Needle Peak granodiorite (48 Ma), which truncates the Chuwanten fault. South of the area the Jura-Cretaceous rocks are unconformably overlain by felsic to intermediate volcanic rocks of the Oligocene Coquihalla Formation and to the east, a narrow belt of Eocene Princeton Group sediments flanks the eastern side of the Pasayten fault, unconformably overlying the Eagle plutonic complex. A number of Paleogene to Neogene faults trend northeast and are believed to result from transform or transtensional movement in a Tertiary extensional environment (Monger, 1989).

PROPERTY GEOLOGY

Fine to coarse clastic sedimentary rocks of the Cretaceous Pasayten Group underlie most of the Treasure Mountain property. South and west of the mine area (Figure B-4-2), the Pasayten rocks are in thrust-fault contact with the Jurassic Dewdney Creek Formation, a volcano-sedimentary sequence composed of volcaniclastic and sedimentary clastic rocks and andesitic flows, which lies structurally above the Pasayten. The Dewdney

Creek Formation is the host assemblage for a number of mineral occurrences on the Summit Camp group of claims immediately to the west of the Treasure Mountain property (Dewonck, 1987). The entire stratigraphic sequence is intruded by dikes and sills of diorite, feldspar porphyry and quartz feldspar porphyry and is transected by east to northeast-trending faults, the largest of which offsets the sequence and is the main structural host to mineralization (Figure B-4-3). Deformation is weak within the local stratigraphic section and there is no penetrative fabric. The rocks are generally unmetamorphosed.

The Dewdney Creek Formation includes volcanic breccia, volcanic conglomerate, tuff, minor intermediate to mafic flows, sandstone and thin bedded argillite. The conglomerate occurs mainly near the fault contact with the Pasayten Group. Pebbles and cobbles of tuff, intermediate flow and fine-grained intrusive rock are supported in a tuffaceous matrix.

Pasayten rocks near Treasure Mountain are part of the Virginian Ridge facies (Monger, 1989) and are interpreted to have formed as alluvial fan deposits (MacLean, 1986). They comprise interbedded argillite, arkose, arkosic sandstone and conglomerate (Plate B-4-2), which trend north to northwest and dip steeply to the southeast. Argillite is generally fine grained, thin bedded and weathers light grey. Arkosic rocks are brownish weathering, with light-coloured feldspar clasts up to about 3 millimetres across in an impure sandy matrix (Plate B-4-3). The Pasayten conglomerates contrasts with the Dewdney Creek conglomerates in that they contain rounded granitic cobbles and boulders up to 0.5 metre in diameter, with only a minor pebble-sized fraction, in a sandy arkosic matrix.

The most prominent intrusion on the property is an easterly to northeasterly trending feldspar porphyry dike, termed the "mine dike" because of its close spatial association with mineralization (Figure B-4-4). The dike is

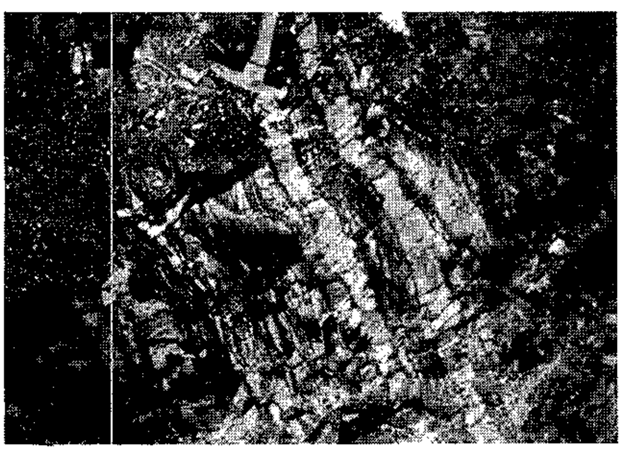


Plate B-4-2: Pasayten Group: massive arkosic sandstone (light) interlayered with argillite bands (dark).

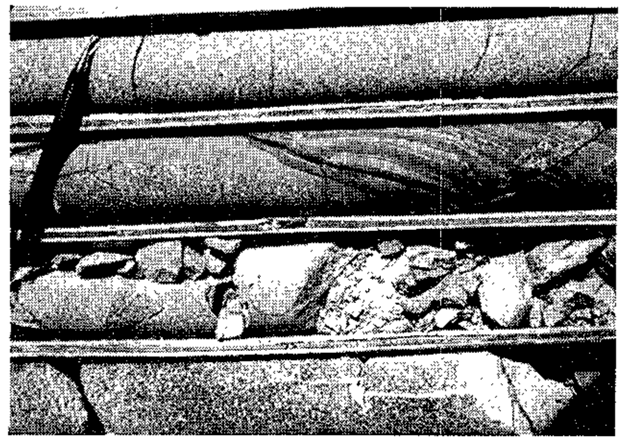


Plate B-4-3: Pasayten Group: laminated, pyritic argillite and massive arkose with abundant white feldspar clasts.

parallel to, and in places coincident with, the "Treasure Mountain fault" and is presumed to be of Tertiary age. Both features are arcuate in plan, exaggerated by topography and dip 55° to 65° to the southeast. The feldspar porphyry is massive, grey-green with cream-coloured plagioclase phenocrysts. It is generally undeformed, but shearing is developed locally along the hangingwall and footwall. Alteration in the dike appears as weakly developed sericitic and chloritic green discolouration, or lighter coloured carbonate bleaching, the latter being confined mainly to the dike margins and most intensely developed adjacent to zones of mineralization. Because of its proximity to mineralization, the dike has been a useful exploration and development guide. Minor whitish coloured quartz feldspar porphyries have also been intersected in drill core. Similar dikes have been noted elsewhere in the region and commonly fill fault structures (MacLean, 1986).

Elsewhere on the property, the stratigraphic sequence is intruded by medium-grained diorite. The largest body occurs southwest of the mine area and is entirely within the Dewdney Creek Formation (Figure B-4-2). It is about 1000 metres long, 250 metres in width, trends northwesterly subparallel to stratigraphy and may a sill (Black, 1952, pages 119-130). The intrusion is transected and offset by the Treasure Mountain fault.

STRUCTURE

Regional mapping by Monger (1989) and earlier by Cairnes (1924) infers that the Dewdney Creek rocks have been overthrust onto the Pasayten Group along the northwest-trending Chuwanten thrust. This contact passes through Treasure Mountain, just southeast of the workings. Black (1952) argued that structural observations near the mine might also be explained by an overturned, northwest-trending anticline. The Treasure Mountain fault offsets the contact with an apparant sinistral displacement. Slickensides (Plate B-4-4) ob-

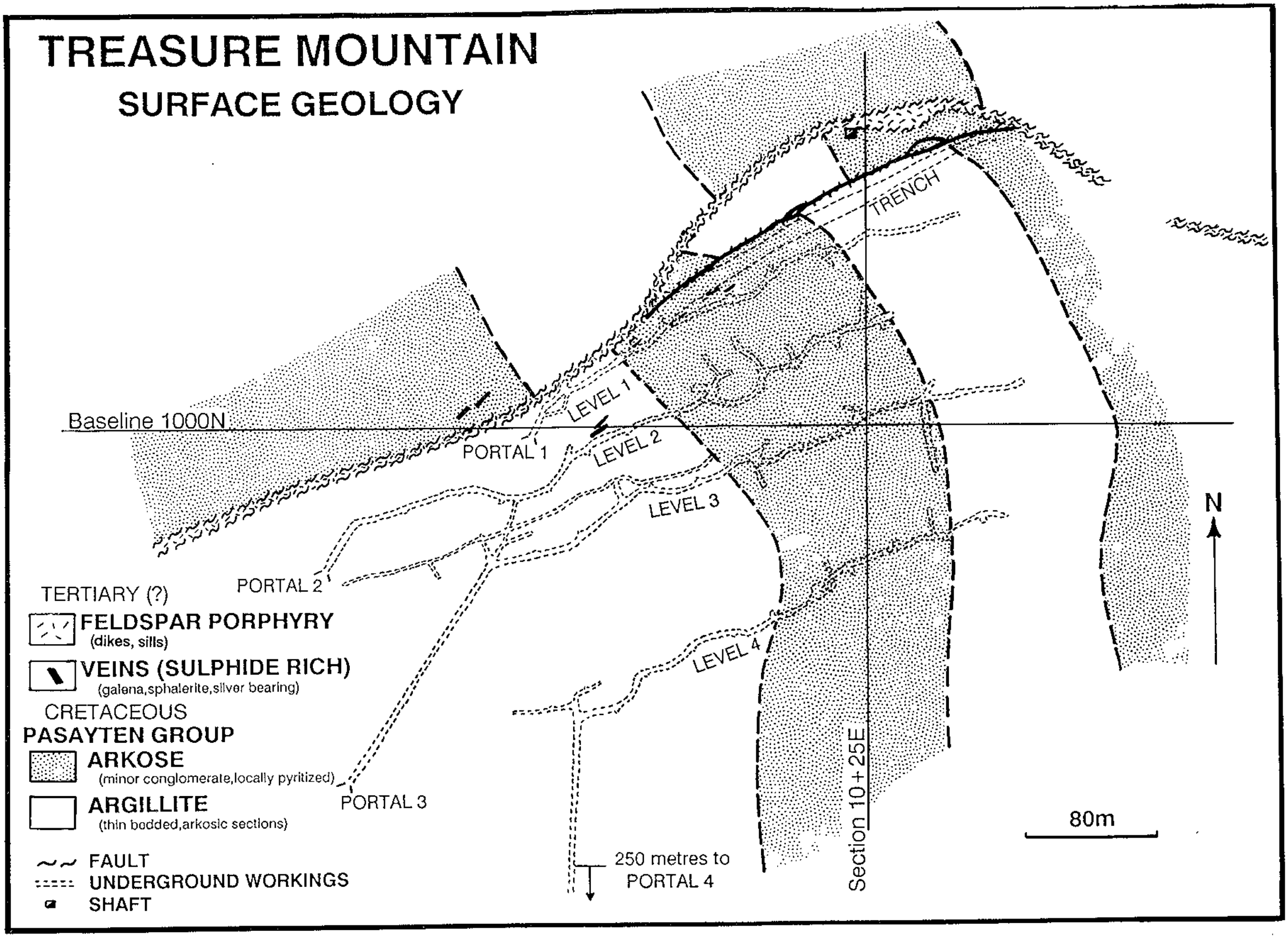


Figure B-4-3: Surface geology of the southeastern part of the Treasure Mountain property, showing the mine workings and the main geological features (from Huldra Silver Inc. company reports).

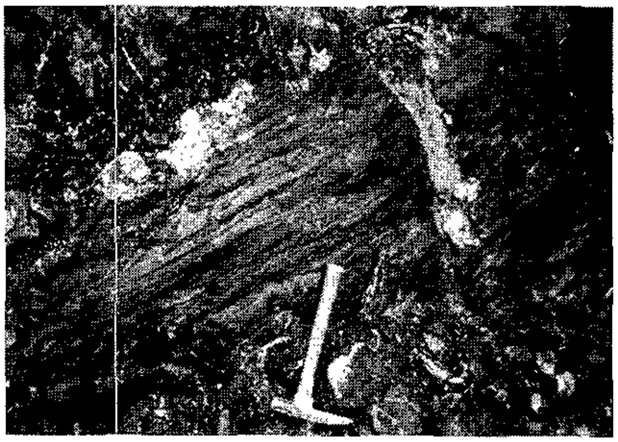


Plate B-4-4: *Slickenside development in altered argillite* wallrock on the Treasure Mountain fault; open cut, south wall.

served in the Treasure Mountain pit suggest that the major movement is down and to the east, however, there are multiple sets of slickensides, indicating more than one episode of movement along the structure. McDougall (1987) estimated a possible 305-metre displacement on the fault. Underground mapping indicates that the fault zone may be up to 9 metres wide, but averages between 1 and 5 metres. At several locations along the fault the wallrocks are strongly brecciated, truncated (Plate B-4-5), recemented with carbonate, quartz and contain weak mineralization (Livgard, 1990).

MINERALIZATION

The main zone of mineralization, known as the "C-vein", is a steeply dipping, discontinuous sheet-like or tabular system of sulphide-rich veins that are hosted primarily within the Treasure Mountain fault. The veins tend to follow the hangingwall and footwall contacts of the feldspar porphyry dike (Figure B-4-4), or are contained within the fault. A few veins have been intersected entirely within the dike, while others occur in subsidiary or parallel zones along sedimentary contacts and within brecciated zones. Vein widths of a few centimetres up to substantially more than one metre have been reported (McDougall, 1987; Beaton, 1987). The average width of massive vein mineralization is likely about 0.25 metre, but disseminated mineralization may extend locally for a metre or two into the wallrocks.

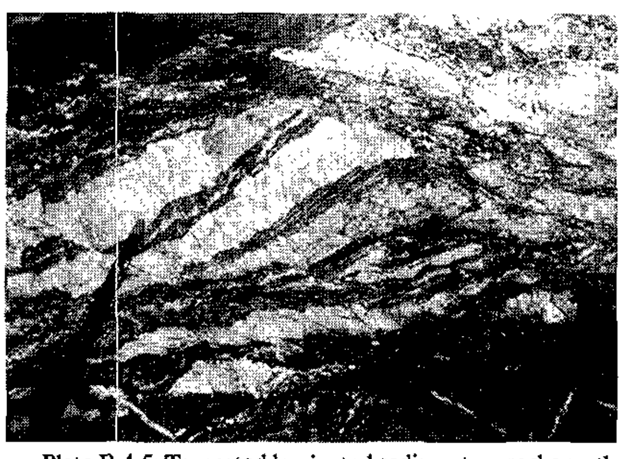


Plate B-4-5: Truncated laminated sedimentary rocks on the main branch of the Treasure Mountain fault.

The main ore minerals are silver-bearing galena and sphalerite, with pyrite, accessory chalcopyrite, tetrahedrite, boulangerite, bournonite and minor to trace amounts of stibnite, pyrrhotite and native silver (Downing, 1970; Harris, 1988). Iron and manganese oxides are also present near surface. Silver occurs within the galena as exsolved argentite and native silver. Veins typically vary from massive, very coarse grained galena, with only minor sphalerite and gangue minerals (Plate B-4-6), to sections with abundant sphalerite and ankerite, with a much lower proportion of galena (Plate B-4-7). Small vein offshoots extend for short distances into the wallrocks, which are commonly mineralized with disseminated sulphides. Recent exploration drilling between the third and fourth levels has intersected high-grade zones containing ruby silver (proustite, pyrargyrite).

Gangue minerals in the veins include ankerite, calcite, quartz and minor rhodocrosite(?). Carbonate and quartz may account for up to 70 per cent of vein material, with 20 per cent rock fragments and about 10 per cent sulphides and oxides (mainly magnetite, E. Livgard, personal communication, 1990). Manganese occurs as oxides, manganiferous ankerite or siderite (McDougall, 1987).

EXPLORATION POTENTIAL

The Treasure Mountain vein has "open" exploration potential laterally, to the east and west and at depth. To the east, a number of linear geophysical targets have been outlined along strike from, and parallel to the C-vein and the Treasure Mountain fault. Preliminary trenching and drilling in this area has exposed intermittent zones of siver-lead-zinc mineralization with carbonate veining and

Plate B-4-6: Massive-coarse grained galena vein, "C-Vein", Level 2.

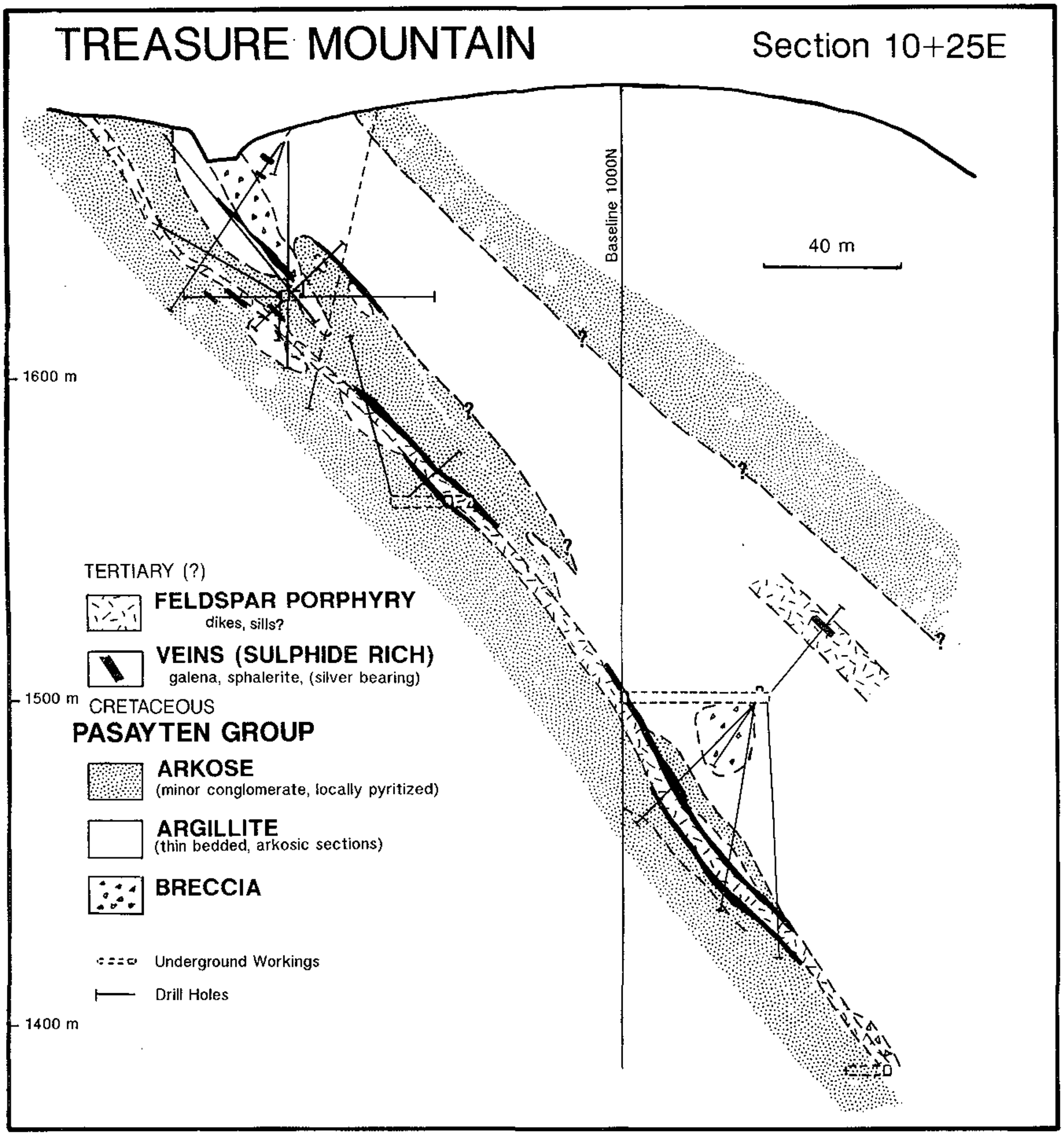


Figure B-4-4: Treasure Mountain Section 10+25 East, showing main geological features, underground workings and diamond-drill holes (from Huldra Silver Inc. company reports).

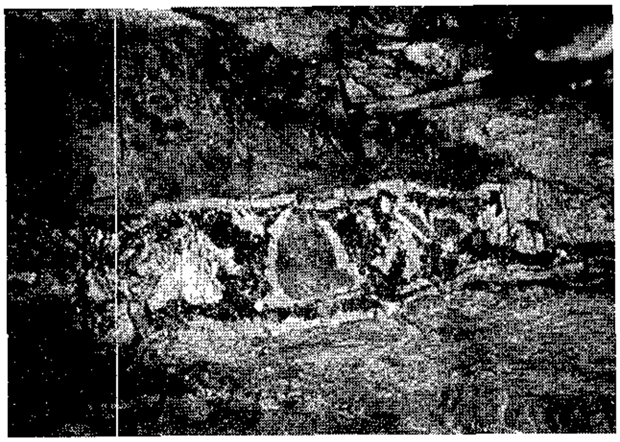


Plate B-4-7: Sphalerite-rich vein with abundant ankeritic carbonate and galena.

alteration comparable to that related to the C-vein. To the west, a large geochemical anomaly in soils has been outlined with metal values higher than previously encountered elsewhere on the property. Drilling below the third level has encountered a ruby silver zone that is generally sulphide-poor and may represent another type of mineralization that has not been recognized or encountered at higher levels in the workings. In addition, there are large sections within the presently developed mine workings which are outside the calculated ore-reserve blocks and have not been drilled off. These areas, in particular, probably represent the best potential for additional reserves.

ACKNOWLEDGMENTS

We acknowledge the cooperation and assistance of Magnus Bratlien and Egil Livgard of Huldra Silver Inc., for permission to visit the property, for the use of company data freely offered, information and for their generous hospitality at the project site.

REFERENCES

Beaton, A.J. (1987): A Review Report on the Feasibility of Open Pit Mining on the Silver-lead-zinc "C" Vein at Treasure Mountain in the Hope-Princeton Area, British Columbia; Private Report for *Huldra Silver Inc.*

Black, J.M. (1952): "Summit Camp" B.C.; *Ministry of Mines,* Annual Report 1952, pages 119-130.

Cairnes, C.E. (1924): Coquihalla Area, British Columbia; *Geological Survey of Canada*, Memoir 139.

Dewonck, B. (1987): Report on the Summit Camp Property for Harrisburg Dayton Resource Corp.; prospectus, *Vancouver Stock Exchange.*

Downing, B.W. (1970): Geology and Ore Metal Distribution of the Silver Hill Lode, B.C.; unpublished B.Sc. thesis; *Queen's University*, 72 pages.

Entech (1988): Treasure Mountain, Prospectus Submitted to the B.C. Mine Development Steering Committee, Huldra Silver Inc.

Freeland, P.B. (1926): Summit Camp, Tulameen; *B.C. Minister of Mines*, Annual Report 1926, pages 223-227.

Grieg, C.J. (1989): Geology and Geochronometry of the Eagle Plutonic Complex, Coquihalla Area, Southwestern British Columbia; unpublished M.Sc. thesis; *The University of British Columbia*, 423 pages.

Harris, J.F. (1988): Petrographic Report to Huldra Silver Inc.; private company report.

James, A.R.C. (1957): Summit Camp, B.C.; *Minister of Mines*, Annual Report 1957, page 32.

Livgard, E. (1990): The Treasure Mountain Project; paper presented at the Third Annual Kamloops Exploration Conference, Kamloops, B.C., March 29, 1990.

MacLean, M. (1986): Provenance and Depositional Setting of the Pasayten Group, Treasure Mountain, Southwestern British Columbia; unpublished B.Sc. thesis, *The University of British Columbia*, 68 pages.

McDougall, J.J. (1987): Report on Treasure Mountain Mineral Claims Tulammeen River Area; Huldra Silver Inc.

Monger, J.W.H. (1989): Geology, Hope, British Columbia; *Geological Survey of Canada*, Map 41-1989.

NOTES

LODE AND PLACER GOLD OF THE COQUIHALLA AND WELLS AREAS, BRITISH COLUMBIA (92H, 93H)

(Fig. B1, No. 5)

By J. Knight and K.C. McTaggart

INTRODUCTION

This report provides new data on the composition of gold from various lodes and placers in the Coquihalla and Cariboo areas, southern British Columbia. This material is a continuation of research reported previously (Knight and McTaggart, 1986, 1989). Some introductory material from earlier papers is repeated to clarify the present account.

It should be noted that the authors have not attempted a stratigraphic study of the Cariboo placer deposits. This aspect has been described by Johnson and Uglow (1923), Clague (1987), Levson *et al.* (1990), Eyles and Kocsis (1989), and Rouse *et al.* (1990).

Because more samples and analyses are needed, the present work must be considered only a progress report. New data and analyses from new localities will no doubt demand modification of the conclusions reached below.

A major objective of this work is to characterize gold by its suite of minor elements. With gold from different sources thus fingerprinted, one can attempt to trace the path of gold from lode to placer. In addition, the composition of lode gold is a parameter used in the genetic classification of gold deposits. In general, gold from epithermal lodes has a lower fineness and a wider range than gold from mesothermal lodes. The study of textures of placer gold yields information on conditions and distance of travel.

Placer and lode gold are rarely pure but are alloyed with other elements such as silver, copper and mercury. Early studies on the composition of gold were made before the electron microprobe was developed and Boyle (1979) provides an exhaustive summary of this research. One of the early studies is that of Warren and Thompson (1944) who analyzed gold from many areas, mainly British Columbia, by spectrographic techniques. Holland (1950) lists gold-silver ratios for many placers in British Columbia. Microprobe studies include those of Desborough (1970) who has studied placer gold from many localities in the United States and Giusti (1983) who reported on the compositions of placer gold from Alberta, Canada.

This report presents new compositional data on lode and placer deposits from the Coquihalla serpentine belt and from the Cariboo area and the reader may find it useful to compare these results with earlier work (Knight, 1985; Knight and McTaggart, 1986, 1989).

SAMPLE PREPARATION

Gold samples (for locations *see* Figures B-5-1 to B-5-4) were either donated or collected in the field by the authors (Table B-5-1). Vein quartz was crushed and the gold recovered by panning. Experience has shown that placer samples should contain at least 100 gold particles.

TABLE B-5-1

COQUIHALLA AREA			
LODE SAMPLES (FIGURE B-5-1)	**SAMPLE NO.**	**SOURCE**	**NO. OF PARTICLES**
Aurum	417	some donated some collected	40
Caroline	84	donated	3
Emancipation	466	collected at workings	18
Fifteen Mile Creek	506	panned from crusher floor	33
Murphy	352	donated	13
Pipestem	354	donated	2
PLACER SAMPLES (FIGURE B-5-2)			
Coquihalla River	349	panned	83
Fifteen Mile Creek	514	panned	74
Fifteen Mile Creek	515	panned	64
Ladner Creek	363	panned	71
Upper Ladner Creek	412	panned	36
Peers Creek	513	panned	48
Siwash Creek	418	panned	108
Sowaqua Creek	419	panned	54
CARIBOO AREA			
LODE SAMPLES (FIGURE B-5-3)			
Burns Mountain	502	donated	25
Burns Mountain	523	donated	1
Cariboo Gold Quartz Mine	402 to 404 & 17	donated	10
Cow Mountain	547 to 551	donated	89
Foster's Ledge	493	quartz from dump	5
Mosquito Creek mine	497, 499	donated	8
PLACER SAMPLES (FIGURE B-5-4)			
Ballarat-St.George's	500	donated	81
Burns Creek	494	donated	80
Dragon Creek	107	donated	89
Eight-mile Lake	123	donated	99
Mosquito Creek fan	518, 519	donated	86
Oregon Gulch	471	donated	73
Slough Bench	228	donated	97

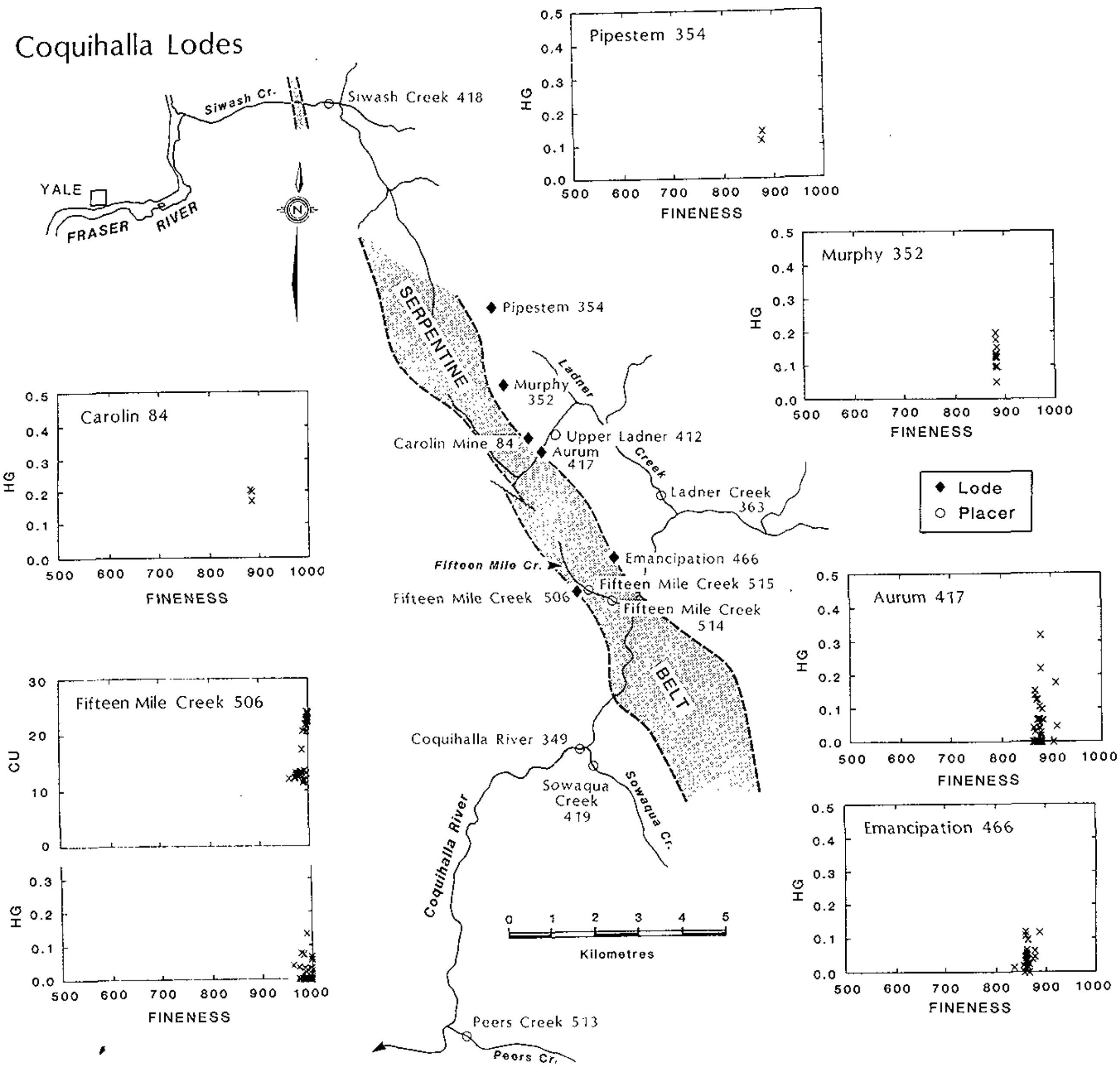


Figure B-5-1. Locations and analyses of lode gold samples from the Coquihalla gold belt. Scatter plots show fineness versus per cent mercury and fineness versus per cent copper.

All placer and some lode particles are photographed so that textural features can be related to composition. Gold particles which are to be photographed, numbered, analyzed and subsequently identified must be large enough to be manipulated by needle or tweezers: the practical lower size limit is about 0.2 millimetre although particles as small as 60 microns have been mounted.

Particles are embedded in plastic cylinders, ground and polished. The gold is examined with a reflecting microsope for contamination, inclusions and heterogeneities before being carbon-coated.

ANALYTICAL TECHNIQUES

Analyses were made using a SX-50 Cameca microprobe at 100 nano amperes (spot size 2 microns), 20 kilovolts using gold M alpha, silver L alpha, copper K alpha, mercury M beta lines and a counting time of 30 seconds. The practical detection limit for most elements is about 0.05 per cent. The detection limit for mercury is taken as 0.06 per cent and for copper, 0.025 per cent at 99 per cent confidence (3x sigma of background counts). All analyses are reported in weight per cent.

Preliminary testing of gold from British Columbia suggests that only three elements, silver, copper, and mercury occur at greater than detection limits. For this reason testing for other elements is not done routinely. Early, pre-microprobe studies suggested that gold commonly contains a large variety of elements in easily measureable amounts but that work, mainly spectroscopic, was done necessarily on large specimens that held inclusions of other minerals. In more recent studies, in which the microprobe is used, the investigator can examine gold under high magnification and thus avoid mineral inclusions.

The analytical results are displayed on scatter plots (Figures B-5-1 to B-5-4) on which weight per cent of mercury or copper is plotted against fineness and on which each cross represents the composition of a single gold particle. Separate diagrams for fineness vs per cent mercury and fineness versus per cent copper are used in this report, rather than three-parameter diagrams (Knight and McTaggart, 1989) because copper is absent in many of the samples. "Fineness", a term commonly used to represent the proportion of gold to silver in alloys of those metals, is calculated in this way:

$$\text{fineness} = 1000 \times \%\text{Au} / (\%\text{Au} + \%\text{Ag}).$$

Thus a nugget that is 90 per cent gold and 10 per cent silver is said to have a fineness of 900 or to be 900 fine.

TEXTURAL FEATURES OF GOLD PARTICLES

Gold grains show much variety in shape. Gold freed from lodes is extremely irregular, consisting of aggregates of blebs, intersecting flakes, crystals and wires.

Many placer gold particles from the Coquihalla and Wells areas are relatively thick and show rough rather than smooth surfaces. Many are irregular in outline. Some particles are slightly deformed or abraded crystals, other particles are thin, with intermediate dimension up to 10 times the least dimension. Many particles have smooth surfaces but some are wrinkled, folded or torn. In many placer samples most of these textural types and others intermediate to them can be found.

These modifications of the original particles derived from lodes are the result of river and glacial transport and can be used in estimating the relative distance of transport of gold particles in the surficial environment.

GOLD RIMS

Nearly all placer samples studied included gold grains with complete or partial rims of high fineness gold. Previous research (Knight and McTaggart, 1986) reported that rimming was not found in Bridge River or Cariboo district samples, however, new samples from the Cariboo show rimming and, after careful repolishing of original samples, rimming and partial rimming were found in nearly all placer samples. Rims consist of zones of nearly pure gold forming the outer coat of the placer grain. They range in thickness from a few microns to 20 microns or more, are invariably of high fineness (970-999) and are devoid of copper and mercury.

There has been much discussion on the origin of rimming of placer gold. Two main hypotheses are: formation of rims by accretion as a coat or outer zone of new gold on the original gold grains; or secondly, formation of rims by removal of silver from the outer part of the gold-silver alloy grains by solution or by a complex replacement process. The second hypothesis is favoured and is supported by the following evidence.

Some 30 placer particles from British Columbia and Yukon show multiple cores (Figure B-5-5) surrounded by continuous or partial rims. The polished surfaces shown in the figure are sections through the middle parts of the grains and thus expose separate cores rather than different parts of the same core. The compositions of the several cores of each grain are identical. The chances of agglomerating several grains of identical composition in a placer where there is great compositional variation from placer grain to placer grain, are very small. It is more likely that silver has been removed from a single grain, leaving only the isolated cores with their original compositions.

It has been argued that if the rims were formed by simple solution of silver from the gold, the rim-core contact would be gradual rather than sharp. To test this argument, gold of fineness 400 was subjected to hot nitric acid for short periods to produce artificial rims. A microprobe traverse across a core-rim boundary on such an artificially rimmed particle (Figure B-5-5f), is com-

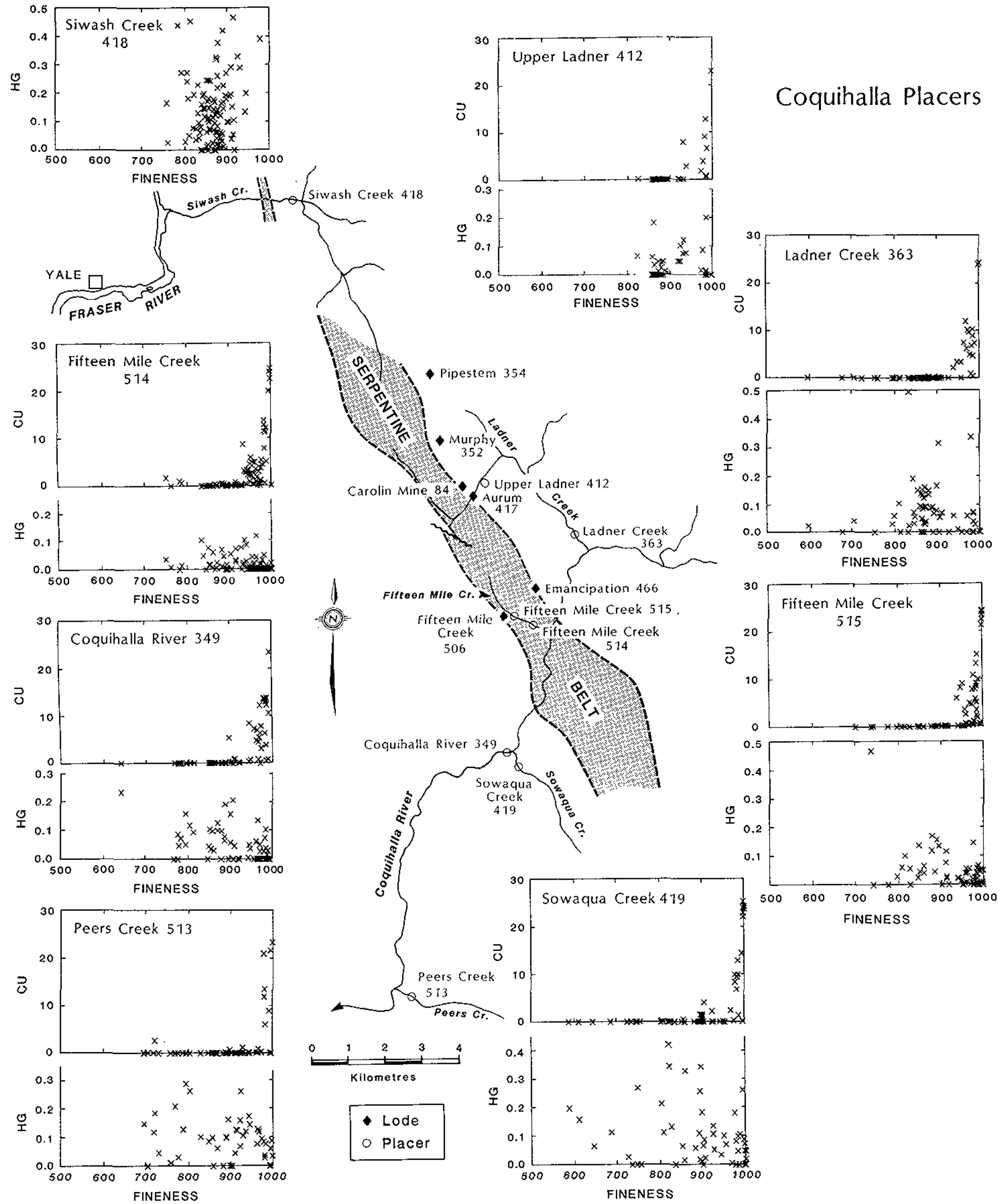


Figure B-5-2. Locations and analyses of placer gold samples from the Coquihalla gold belt. Scatter plots show fineness versus per cent mercury and fineness versus per cent copper.

pared with one made on a naturally rimmed grain (Figure B-5-5e). The boundaries appear to be equally sharp. It should be noted that the synthetic rim shows a microscopic porosity due to the attack of the acid and removal of silver. Such porosity is not commonly observed but has been reported by Colin *et al.* (1989) in gold from a laterite in Gabon. Porosity was not observed in natural rims from placers in British Columbia, perhaps for two reasons. The experimental rims were made on gold with a higher percentage of silver (40% gold, 60% silver) than nearly all of the natural gold examined to date. The porosity therefore, would be expected to be greater than in leached natural gold of higher fineness. Secondly, it is probable that most naturally rimmed gold, judged by its shape, has been severely hammered in the fluvial environment and any porosity reduced or destroyed, especially as the pure and porous gold rim is more malleable than the gold-silver core.

It is concluded that rims from this region probably result from removal of silver and other metals from the margins of the placer grains.

'NEW' GOLD

Gold found in certain gravel deposits has been interpreted to be not of detrital origin but rather formed by precipitation from groundwater or low temperature hydrothermal solutions at that site. This gold is referred to as "new" gold.

Gold deposited from solutions within a limited space where environmental factors such as pressure and temperature are uniform, should, in theory, all have the same composition. The only gold considered by the present authors to have formed in equilibrium with surface, low-temperature, low-pressure conditions, forms the rims described previously: the composition of these approach pure gold. It is significant that new gold from other areas (*e.g.* Nesterenko *et al.*, 1982; Mann, 1984) has been determined to be, almost without exception, nearly pure gold. No placer deposit has been sampled during this research in which all of the gold is of high fineness or of uniform composition. In addition, most of the gold has the form of clastic grains which have been abraded, flattened or otherwise modified during water transport. Furthermore, inclusions in placer gold are mainly angular quartz and pyrite and sedimentary-looking inclusions were not found. For these reasons it is believed that the placer gold described in this work is not "new" gold, but has been derived from lodes or pre-existing placers and has, in the surficial environment, undergone natural leaching or replacement to produce rims.

A few particles, much less than 0.5 per cent of the placer grains, show a thin coating of microcrystalline gold or are agglomerations of particles cemented by coatings of finely crystalline gold. These rare coatings were previously considered by the authors to be "new" gold precipitated on detrital gold. They are now, however, considered to be the effects of contamination by mercury introduced into gravels during early mining (*see* 'Mercury in Gold') because experiments involving removal of mercury films from gold particles by nitric acid result in the formation of similar coatings of finely crystalline gold. Energy dispersive analysis of such coatings invariably show the presence of mercury.

Although new gold does not seem important in the formation of placers, the authors have identified spongy gold of high fineness in a lode at the Blackdome mine which formed apparently by the breakdown of a rare gold-silver sulphide. Almost all examples of new gold from other parts of the world occur as spongy gold or as plates or films less than 0.1 millimetre across, associated with strongly oxidized zones (Vasconcelos and Kyle, 1989). The authors have not recognized such gold in placer samples from British Columbia.

MERCURY IN GOLD

Many of the placer gold particles contain mercury up to a maximum of about 10 per cent. It is believed that the mercury in placer gold reported here (with the exceptions noted below) is primary and is not the result of contamination. Mercury contained in lode gold that has not been exposed to contamination (Knight and McTaggart, 1986) demonstrates that mercury in placer gold derived from lodes may also be primary.

Samples from certain placers in the Coquihalla and the Cariboo areas are obviously contaminated with mercury as many of the particles have thin, white mercury-rich rims or fractures and some are agglomerated into silvery, heterogeneous pellets. Such material was not ordinarily analyzed but laboratory tests suggest that mercury slowly penetrates to the interior of gold particles and that the compositions of the cores of mercury-coated grains are not contaminated (except during polishing).

It was found during preparation of polished sections of gold which contain more than small amounts of mercury, that polishing laps became contaminated with mercury. If mercury-free gold is polished on that same lap gold may become contaminated with up to 1 per cent mercury. A useful test for such contamination is that gold rims described above are free from mercury. If rims on placer grains are found to contain mercury, repolishing on clean laps and re-analysis have invariably shown that the grains had been contaminated.

COPPER IN GOLD

All placer gold examined in this study contained at least trace amounts of copper and it was noted of copper increases with fineness to a maximum of about 0.025 per cent at a fineness of 700 and of about 0.15 per cent at a fineness of 900. High-copper gold, such as is found in the Coquihalla area and in Relay Creek, Bridge River, Fraser

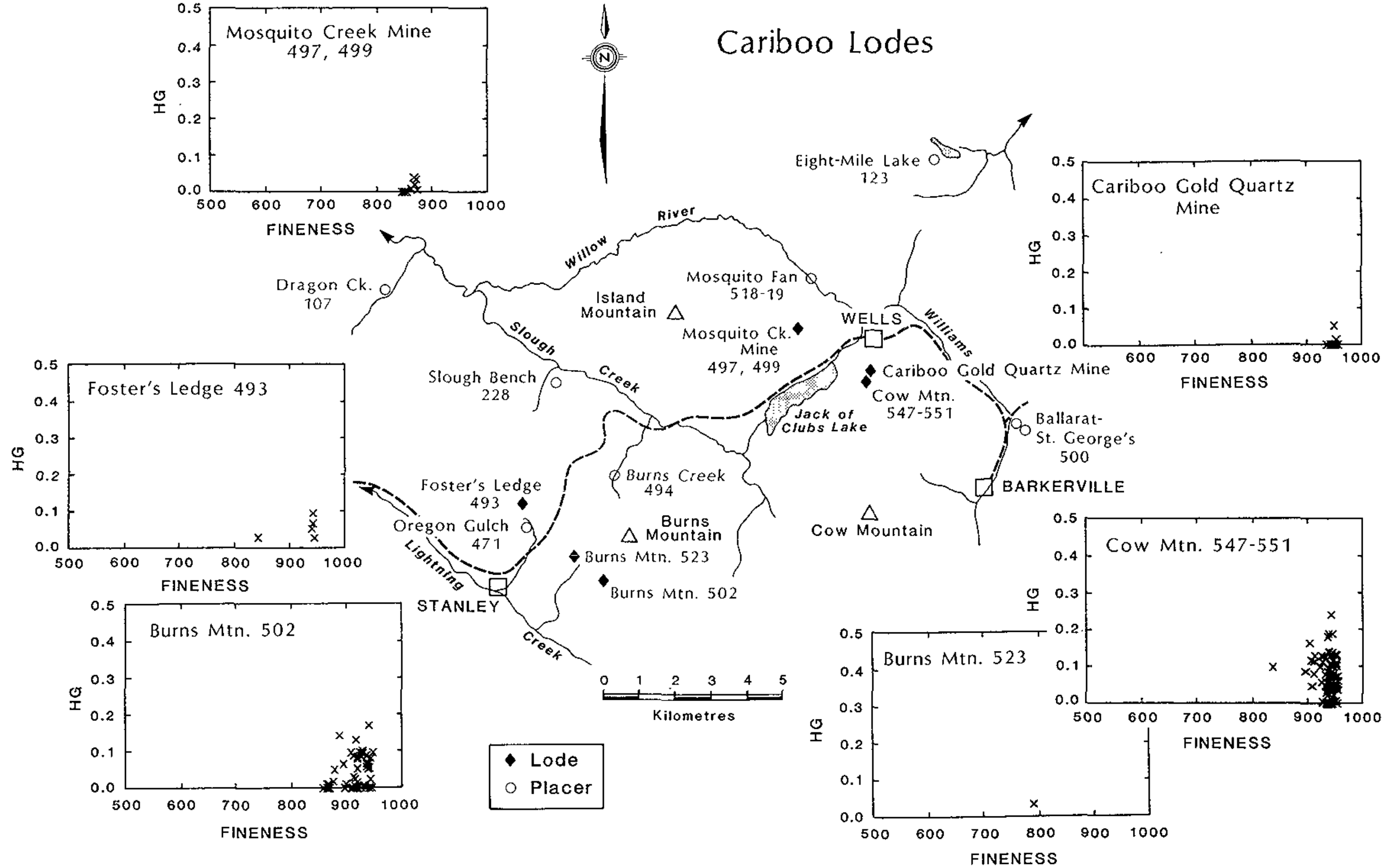


Figure B-5-3. Locations and analyses of lode gold samples from the Wells Area. Scatter plots show fineness versus per cent mercury.

River (Knight and McTaggart, 1986) and in the Wheaton Creek area is distinguished from the above by containing up to about 25 per cent copper and, in some specimens, showing regular two-phase patterns that resemble exsolution textures.

Only a few copper-gold lode deposits have been described. The Fifteen Mile Creek lode of the Coquihalla area (Cairnes, 1930) is the only British Columbia example known to the authors. Oen and Kieft (1974) describe copper-gold associated nickel and chromium minerals from the Beni Bousera ultramafite of northern Morocco. Platinum-palladium-copper-gold alloys and other platinum group minerals occur in dunite in the Shetland ophiolite complex (Prichard and Tarkian, 1988). Copper-gold occurs in a hortonolite-dunite pipe in the Bushveld Complex (Ramdohr, 1969). Several lode occurrences are known from the Urals and the best known of these is the Zolotaya Gora deposit in rodingite in ultramafic rocks (Murzin *et al.*, 1987) of which some details are given below.

Raicevic and Cabri (1976) describe placer copper-gold and platinum from the Tulameen river downstream from the Tulameen ultramafic complex. Stumpfl and Clark (1966) found placer copper-gold associated with platinum in the Riam Kanan river in Borneo that has its source within a peridotite terrain.

It appears that most copper-gold has been found in ultramafic rocks or associated rocks such as rodingites.

VARIATION OF GOLD COMPOSITION WITHIN MINES OR MINING CAMPS

Lode gold occurrences in the Coquihalla area and at the Blackdome mine (Knight and McTaggart, 1989) exhibit little variation in gold composition within veins or from vein to vein. However, data from the Bralorne mine, and particularly from the Erickson mine, show considerable variation.

If gold compositions were known for the various veins of a mine, it seems probable that the data could be used to identify new veins or of faulted segments of veins.

OBSERVATIONS ON PLACER AND LODE GOLD SAMPLES

COQUIHALLA GOLD BELT

LODE GOLD

Gold samples (Table B-5-1) in five out of six lode deposits in the Coquihalla gold belt (Figure B-5-1) northeast of Hope, B.C., (Cairnes, 1924, 1930; Ray, 1982, 1983, 1984) are very similar. Fineness ranges from about 870 to 900, with a pronounced maximum near 870. This is a remarkably small variation over a distance of 6.5 kilometres. Mercury is present in all samples and ranges up to 0.3 per cent. Copper values range to a maximum of 0.04 per cent. A sample from the Aurum Mine appears typical of these lodes.

The sixth lode sample, panned from the dump and crusher floor at the Fifteen-mile Creek lode, is quite different. A polished section shows the gold to be a complex intergrowth of three copper-gold phases with the most abundant compositions having about 12 per cent or 23 per cent copper. The intergrowth resembles, in part, a complex exsolution product. It is noteworthy that the cupriferous gold has a fineness greater than 960. Gold of these compositions will be referred to as the *Fifteen Mile Creek lode type*.

PLACER GOLD

Gold of the *Aurum type* (about 870 fine) occurs in Ladner Creek, Coquihalla River and Siwash Creek but is relatively scarce in Sowaqua, Peers and Fifteen Mile creeks (Figure B-5-2). Gold of fineness less than 800 is present in all placer samples except that from Upper Ladner Creek.

Gold of the Fifteen Mile Creek lode type, with 12 or 23 per cent copper, is easily identified in the Fifteen Mile, Sowaqua and Peers creeks, and Coquihalla River placer samples, and is scarce but present in Ladner Creek.

Seven of the eight placer samples contain gold of high fineness with copper in the 1 to 10 per cent range. Such gold was not identified in any of the lode samples. Judged from other occurrences of copper-gold, this gold is probably derived from lodes in ultramafic rocks.

The Siwash Creek sample differs from the other placer samples in its wide variation in mercury values and absence of copper. This sample may be slightly contaminated with mercury.

The placer sample collected near the mouth of Peers Creek may be from reworked glacial material.

It is interesting to compare the shapes of copper-rich particles from the Fifteen Mile placer sample (514) with those from the Coquihalla River. In the first, nearly all of the copper-rich grains are thick rather than flattened, most are equant or slightly elongate, many show angular corners and all show a rough surface covered with small angular pits and protuberances. These features suggest that they have travelled only a short distance from their source, which for most of them is probably the Fifteen Mile Creek lode. In the Coquihalla placer sample most of the copper-rich grains are equant or slightly elongate but surfaces are relatively smooth rather than angularly pitted, and corners are round. Evidently shape has evolved from one site to the other, over a distance of about 6 kilometres

DISCUSSION

The Fifteen Mile Creek lode occurs within serpentine near the western side of the serpentine belt. Cairnes (1930, p. 166A) states that "the gold appears chiefly as thin, polished films on smooth, slickensided surfaces of

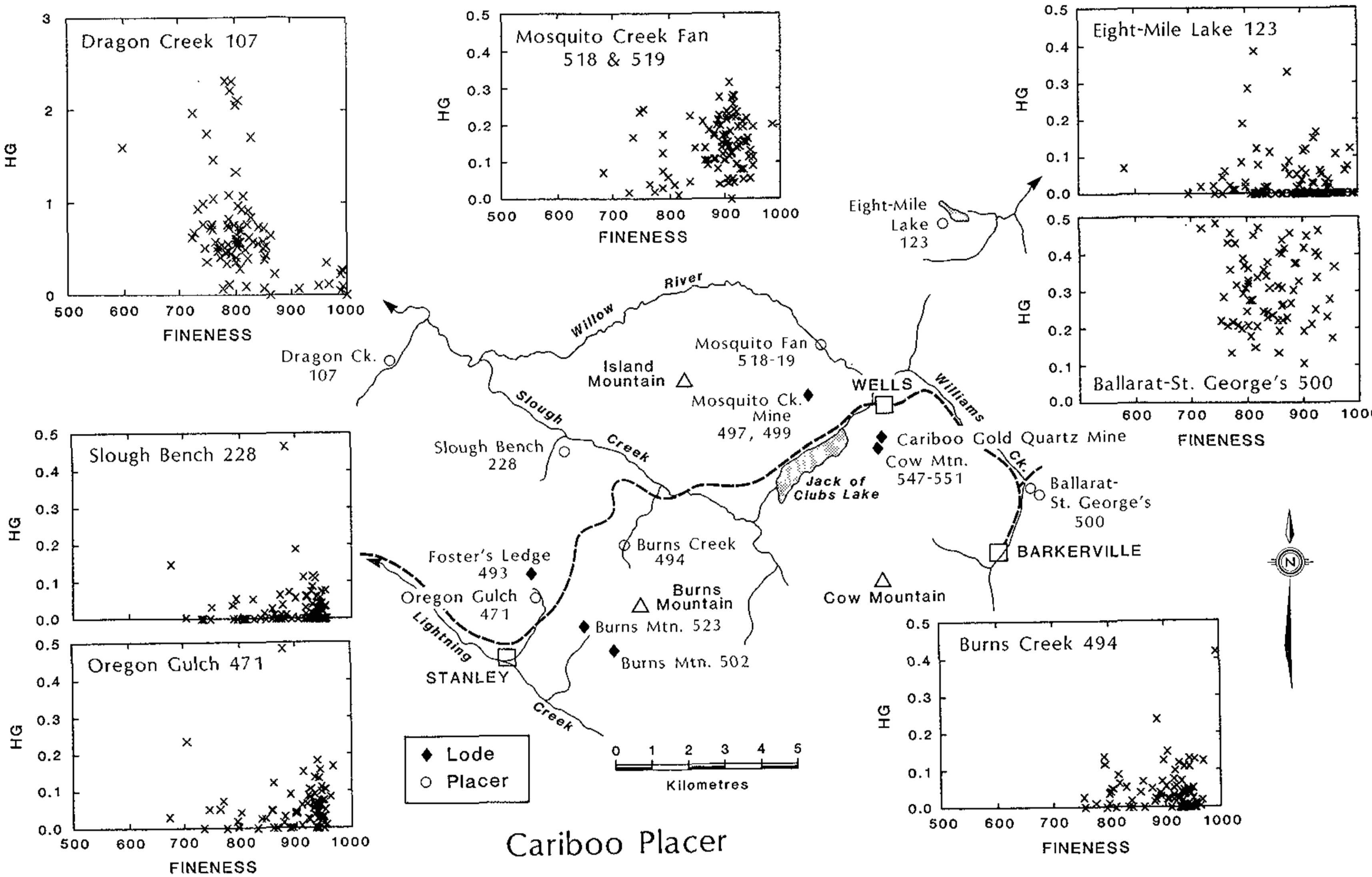


Figure B-5-4. Locations and analyses of placer gold samples from the Wells Area. Scatter plots show fineness versus per cent mercury. (Note: To reflect the higher amounts of Hg for Dragon Creek the Hg-scale is different than that for other samples.)

talc or talcose serpentine, but is also associated with chalcocite in stringers or small nodular masses of a 'white rock' ... " He discusses (p. 194A) the nature and origin of gold-bearing "white rock" (rodingite) noting that gold is more conspicuous in small rodingite stringers than in the larger masses. Cairnes notes that the gold is distinctly reddish and surmised, correctly, that its colour is due to the presence of copper.

Copper-rich gold is rarely reported in the British Columbia literature; however, the authors have identified it at Relay Creek, Bridge River, Fraser River and in Wheaton Creek.

The Coquihalla occurrence in rodingite at the Fifteen Mile Creek lode appears remarkably similar to a class of deposit exemplified by the Zolotaya Gora deposit in the southern Urals, USSR, described by Murzin *et al.* (1987). Mineralized zones occur in an ophiolite complex in which dunite, harzburgite and pyroxenites are strongly serpentinized, with zones of talcification and carbonatization. These widespread zones of listwanite which contain vein-like or irregular rodingites are associated with microgabbro. Vesuvianite, nephrite and chalcocite are common. Gold is found in rodingites and the diopside veins which intersect them. Gold, which shows a wide range of compositions, zoning and exsolution, has been reported on in detail by Pokrovskii *et al.*, (1979). Two distinctly different kinds of gold are described: 1) Copper-gold, with phases AuCu, $AuCu_3$, Au_2Cu_5, and $AuCu_{6\text{-}7}$ and solid solution with up to 10 per cent of copper, with some of these phases involved in exsolution patterns; 2) silver-gold solid solutions of various compositions with up to 12 per cent mercury. Copper-gold and silver-gold may occur in the same specimen. Murzin *et al.* (1987) believe that the gold was deposited near the end of the episode of rodingitization, from sulphur-poor fluids, at higher temperatures than those of listwanite formation. This appears to be a gold deposit of a type not generally recognized in North America.

Copper-rich placer gold has been described (Knight and McTaggart, 1986) from Relay Creek, north of Goldbridge. One might reasonably speculate that the source of this gold is in the ultramafic bodies of the Relay Creek area (Cairnes, 1943; Schiarizza *et al.*, 1989).

Copper-rich gold was identified in placer samples from Bridge River and at Lillooet. Although it is possible that this gold had its source near Relay Creek, some 80 kilometres to the northwest, it is perhaps more likely that it was derived from rodingites that are exposed along Bridge River and near Lillooet. Many ultramafites are exposed along the west branch of the Fraser River fault zone, for example just west and northwest of Lillooet (Wright *et al.*, 1982, Figure 1; Leaming, 1978)

The moderately copper-rich (1 to 10% copper) placer gold of the Coquihalla area is of a type not yet found in any of the lodes of the area but since it is found in Fifteen Mile and upper Ladner creeks its source is probably nearby.

WELLS AREA, CARIBOO REGION

LODE GOLD

Six lode samples from Wells and vicinity (Table B-5-1) were analyzed (Figure B-5-3). Copper is insignificant in these samples.

Gold from Cariboo Gold Quartz mine (402 to 404 and 17) was concentrated from four gold-quartz specimens collected from unknown locations within the mine. The specimens were unoxidized, fineness averages about 945 and mercury is below the detection limit

The Cow Mountain lode sample (547 to 551) was collected from surface, almost above the Cariboo Gold Quartz stopes. Coarser gold shows a slight but consistant difference in fineness from that of the smaller particles of gold. The average fineness of this sample is 937 and the mode is close to 945.

Two samples of pyritic ore from the Mosquito Creek mine, one (497) from the Jukes adit and one (499) from the 2184 stope on the second level, contain blebs and films of gold between and within pyrite crystals. The first has a fineness of 850 and the second, 869. Mercury is below the detection limit. The gold is similar in composition to that of the Midas showing at Yanks Peak (Knight and McTaggart, 1989).

Five particles of gold were extracted from a large dump at at the Foster's Ledge workings. Most of the gold resembles that from the Cariboo Gold Quartz mine, but one grain appears similar to that from the Mosquito Creek mine.

A sample from Burns Mountain (502), which was taken from exploration trenches and was slightly contaminated with mercury during recovery and polishing, yielded compositions resembling those of gold from Cariboo Gold Quartz mine and Mosquito Creek mine. It includes grains of fineness about 900 such as are found in the Cow Mountain lodes.

A single, relatively large grain from a lode on the western part of Burns Mountain (523) has a fineness of 790 and thus is quite different from the lode gold described above.

- It was found useful to distinguish four compositional types among the lodes of the Wells district:
- The Cariboo Gold Quartz type (fineness about 950, Hg less than detection limit.
- The Cow Mountain type (fineness 900 to 960, strong concentration at fineness 950, Hg up to 0.25%).
- The Mosquito Creek Mine type (fineness 850 to 870, Hg less than detection limit).

These three types may be considered together as typifying the main vein systems near Wells and together constitute the *Wells type* (fineness 850 to 950, Hg less than 0.25%).

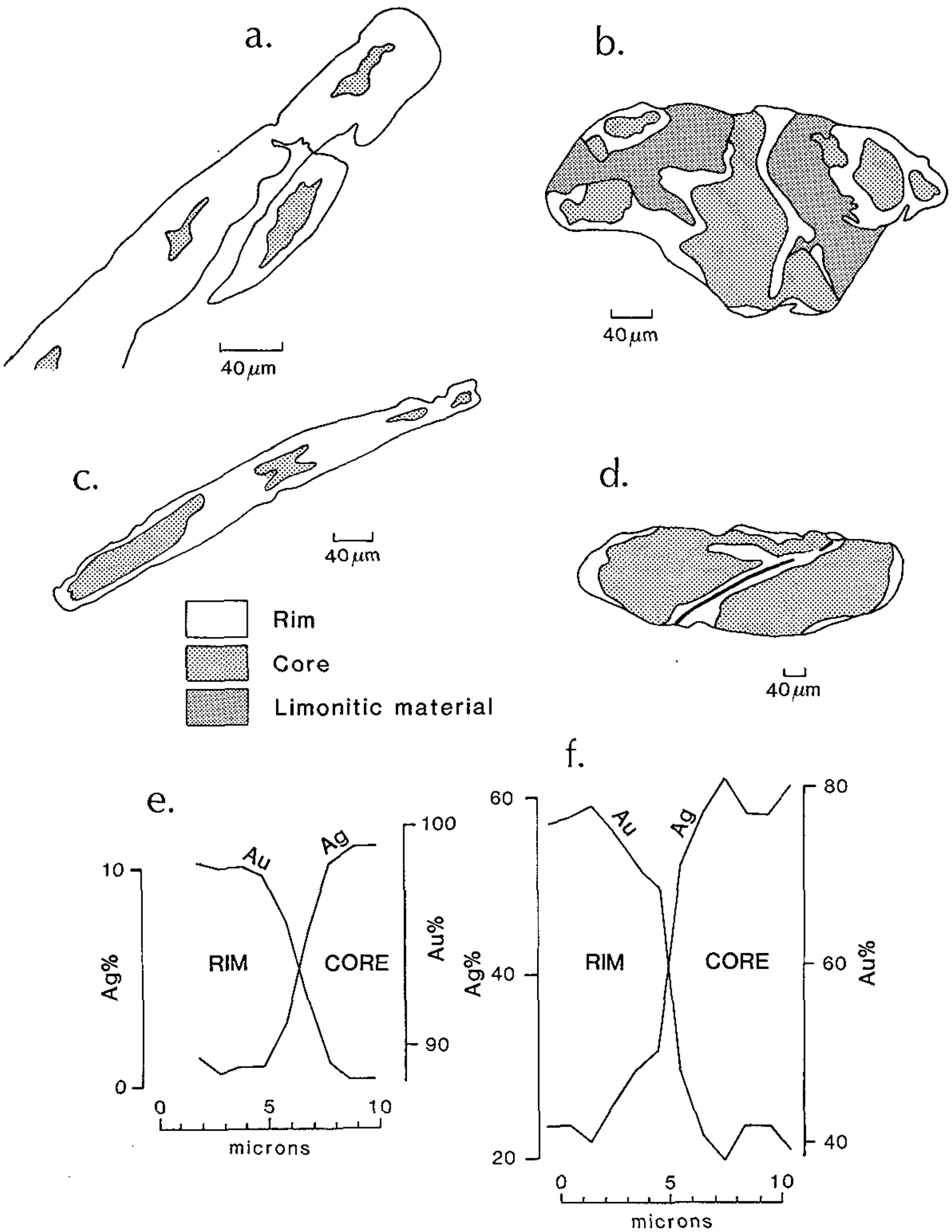


Figure B-5-5. (a) Rimmed grain from Fraser River near Lillooet. Four cores of composition 852±5 fine. Rim is 988 fine; (b) Rimmed grain from Cottonwood area. Five cores, all of composition 880±0 1 fine. Rim composition is 998 fine; (c) Rimmed grain from Quesnel River. Three cores of composition 794±1 fine. Rim is 963 fine; (d) Grain from Jerry Creek, northwest of Wells. Developing cores on either side of a fracture. Cores 792± 0.5 fine, rim is 995 fine; (e) Microprobe traverse across a core-rim boundary on a placer grain from Burns Creek, near Wells; (f) Microprobe traverse across an artificial core-rim boundary. Rim made by removal of silver from gold wire (40% gold - 60% silver) by nitric acid.

PLACER GOLD

About 80 per cent of the gold from the Mosquito Creek Fan sample (Figure B-5-4), which is slightly contaminated by mercury, is of the Wells type, with fineness between 850 and 950 and mercury content less than 0.25 per cent. This is not surprising because the placer is at most 4 kilometres from the Cariboo Gold Quartz and the Mosquito Creek mines. Most of the rest of the sample (17%) is of lower fineness, with a concentration around 800 fine.

The Eight-mile sample shows a wide dispersion. Slightly more than 50 per cent of the grains are of the Wells type and of these, most are of the Cariboo Gold Quartz compositional type. The remainder, with a strong concentration at about 815 fine, do not resemble any lode so far identified.

The Ballarat - St. George's sample is heavily contaminated with mercury from early placer operations. Individual grains are silvery in colour and strongly stained and corroded. Since this sample location is just 2 kilometres downstream from Barkerville and no alternative samples were available, 81 of the least contaminated grains were analyzed. Minimum mercury content is 0.1 per cent and is probably due to general contamination. It is considered unlikely that the finenesss values, determined in the middle of the grains, were much affected by contamination. Ignoring the mercury values (up to 0.9%), 50 per cent of the particles have a fineness in the Wells type range. The balance of the sample consists of grains ranging from 750 to 850 fine, averaging about 800, and not assignable to any known lode type.

The Burns Creek sample consists largely (68%) of the Wells type, with a strong concentration of Cow Mountain type and of the compositions found in Burns Mountain (502) lode which is less than 4 kilometres to the south. Much of the remainder centres around 800 fine.

In the Oregon Gulch sample, 75 per cent of the gold is of the Wells type, within which a strong concentration of the Cariboo Gold Quartz type is identified. The remaining analyses are scattered, centred mainly on 800 fine with low mercury. Gold from nearby Foster's Ledge and Burns Mountain (502) could be easily accommmodated in this array of analyses.

The Slough Bench sample contains 75 per cent of gold of the Wells type and includes a strong concentration of the Cariboo Gold Quartz type. The remaining 25 per cent is broadly dispersed around 800 fine.

The Dragon Creek sample differs markedly from the previously described placer samples. This sample of 89 particles contains only four of the Wells type. The mean fineness of the whole sample is 817 and it shows a strong concentration centred on 800 fine. The Dragon Creek sample shows a maximum of 2.5 per cent mercury, much higher than any other of these Wells area samples. These high values are not due to contamination as the rims are mercury-free.

A preliminary study of the shapes of placer gold particles from the Wells Area yields information about the origin of gold with fineness of about 800. In the Mosquito Creek, Eight-mile, Burns Creek, Oregon Gulch and Slough placer samples, most thick chunky gold particles are of the Wells type. Conversely, most of the particles in the 800 fine range are relatively flat and thin. This contrast may indicate that Wells type gold has travelled a shorter distance than the gold whose composition lies around 800 fine. The Ballarat - St. George's sample, however, shows a reversal of the above generalization in that there are more flattened grains in the Wells type range.

The gold particles of the Dragon Creek sample are conspicuously thicker, more ragged and less flat than those just described. Most of the relatively few flat particles in the sample have a fineness greater than 850.

DISCUSSION

- Gold identified as Wells type is prominent in all of the placer samples evaluated, except for the Dragon Creek sample.

- A second type of gold, of fineness ranging around 800 and with mercury less than 0.3 per cent, is conspicious in all placer samples except the Dragon Creek sample. The source of this type of gold is unknown. It may be from the known lodes as the authors have only a few samples from them for comparison. That gold of this composition is found with Wells type gold in many places, for example in the Burns Creek placer, may indicate that the sources are not far from lodes of the Wells type. The Burns Mountain (523) lode is possibly this type and may be one of the sources of 800 fine gold. Preliminary study of the shapes of gold particles suggests, however, that in general the 800 fine gold has travelled farther than the Wells type gold and some of its sources may be some distance from the Wells Area.

- The Dragon Creek sample consists almost entirely of gold of fineness near 800 with mercury ranging up to 2.5 per cent. Gold of this type is different from that of the lodes tested so far and its source is unknown. This gold is relatively angular and appears to be little travelled. Similar placer gold is found to the north and west (*e.g.* Toop and Frye Creek placers, Knight and McTaggart, 1989) and it appears that an irregular northeasterly-trending line, passing between Dragon Creek and Slough bench, separates areas of mercury-rich gold to the northwest from mercury-poor placer gold to the southeast.

THE SOLUTION AND REDEPOSITION HYPOTHESIS

Johnson and Uglow (1926), whose memoir on the Barkerville area was written while lode mining there was in its infancy, were struck by the scarcity of free gold in unweathered vein material. For this and other reasons, they concluded that "deep decomposition of the veins permitted oxidation of the sulphides and removal of the soluble constituents. Part of the free gold thus set free from the sulphides formed enrichments in the oxidized parts of the quartz veins. Gold enrichment also took place by a process of alternate solution and deposition of the free gold in the form of crystals, crystal groups, plates or veinlets, and irregular masses, in cracks and cavities in the veins and adjacent country rock near the base of the zone of oxidation. The crystal groups, plates, and irregular masses thus formed, and subsequently modified by the action of the streams, are the main source of the nuggets in the gravels".

New data, partly collected by the authors, do not support the conclusion that the lode gold has been dissolved and reprecipitated to form nuggets.

1) Plates and crystals of free gold, up to several millimetres across, have been found in the Cariboo Gold Quartz mine well below the zone of oxidation.
2) In other parts of the world where recrystallization has taken place under surface conditions, the resulting new gold almost invariably has a fineness close to 1000. This is in agreement with the composition of rims on placer gold from this area which is considered by the authors to, a) have formed subaerially by the removal of silver and, b) to be the stable composition in the surficial environment. Very few particles or crystals of this purity have been found in the present study except for a few in the Eight Mile Creek and Dragon Creek placers (Figure B-5-4).
3) This research demonstrates that gold samples from underground and surface workings are similar, (compare underground samples from Cariboo Gold Quartz mine with surface samples from lodes on Cow Mountain) and furthermore, similar gold is found in nearby placers. These observations cast serious doubt on Johnson and Uglow's hypothesis.

It should be pointed out that the authors have made no compositional studies of nuggets. The composition of a Cariboo nugget, about 820 fine (Uglow and Johnson, 1923) suggests that it is not 'new' gold. Indeed, if, as the authors believe, small particles are not 'new' gold, it is unlikely that nuggests are.

CONCLUSIONS

(1) The "rodingite type" of gold deposit, of which there is one in the Coquihalla Area, characterized by the presence of copper-rich (>10%) gold is of significant economic interest. It is suggested that other deposits of this type are to be found in the Coquihalla and in the Relay Creek areas, and possibly along Bridge and Fraser rivers.
(2) Much placer gold in the Coquihalla area is similar in composition to that of the lode gold of the area and has probably been derived from these lodes or from similar ones.
(3) Placer gold of high fineness and containing between 1 and 10 per cent copper is abundant in nearly all of the Coquihalla placers. Gold of this composition has not been identified in any of the lode samples and its sources are unknown although they probably lie in the ultramafic rocks.
(4) Wells type gold is abundant in most of the placers near Wells.
(5) The source of the abundant placer gold in the Wells area that has a fineness of about 800 and low mercury is unknown. Particles of this gold appear, in general, to have travelled farther than the associated Wells type gold.
(6) Placer gold with fineness about 800 containing abundant primary mercury, found in the Dragon Creek placer and in placers to the north and west of the Wells area, is derived from lodes yet to be identified.
(7) New information on the composition of lode and placer gold compositions throws doubt on the widely-held hypothesis that lode gold in the Cariboo recrystallized in the weathering zone before being incorporated into the Cariboo placers.
(8) 'New' gold has not been identified in placer samples from the Coquihalla or Cariboo areas.
(9) The collection, and analysis by microprobe, of gold samples from the Coquihalla and Wells areas would probably identify the sources of placer gold discussed in conclusions 1, 3, 5 and 6.

ACKNOWLEDGMENTS

This work has been supported by grants from the British Columbia Ministry of Energy, Mines and Petroleum Resources and from Westmin Resources Ltd. Gold samples have been provided by Ms. Anita Brock, Messrs. Hans Smit, Richard Hall, Andy Laird, Mike Poshnor, Guy Carter, Bert Ball, Max Lysakowski, Dave Caulfield, Drs. G.E. Ray, Paul Richardson and George Poling, Total Energold Corporation and Mosquito Creek Gold Mining Company Limited. We are happy to acknowledge the assistance of Ms. Yvonne Douma in solving the problem of mercury contamination during polishing. We would like also to thank Mr. Ed Montgomery for using his skills in making a photographic record of placer gold and in the study of multiphase gold-copper alloys. Mr. Jack McIntosh kindly translated several papers and abstracts from Russian.

We are particularly grateful to Ms. Kathy Wilkie and Ms. Margaret McTaggart for their assistance in collecting many of the gold samples described in this report.

REFERENCES

Boyle, R.W. (1979): The Geochemistry of Gold and its Deposits; Geological Survey of Canada, Bulletin 280, 584 pages.

Cairnes, C.E. (1924): Coquihalla Area, British Columbia; *Geological Survey of Canada*, Memoir 139, 172 pages.

_______ (1930): The Serpentine Belt of Coquihalla Region, Yale District, British Columbia; *Geological Survey of Canada*, Summary Report, 1929 Part A, pages 144A-197A.

_______ (1943): Geology and Mineral Deposits of Tyaughton Lake Area; *Geological Survey of Canada*, Paper 43-15, 39 pages.

Clague, J.J. (1987): Quaternary History and Stratigraphy, Williams Lake, British Columbia; *Canadian Journal of Earth Sciences*, Volume 24, pages 147-158.

Colin, F., LeComte, P. and Boulange, B. (1989): Dissolution Features of Gold Particles in a Lateritic Profile at Dondo Mobi, Gabon; Geoderma, Volume 45, pages 241-250.

Desborough, G.A. (1970): Silver Depletion Indicated by Microprobe Analysis of Gold from Placer Occurrences, Western United States; *Economic Geology*, Volume 65, pages 304-311.

Eyles, N and Kocsis, S.P. (1989): Sedimentological Controls on Gold Distribution in Pleistocene Placer Deposits of the Cariboo Mining District, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 377-385.

Giusti, L. (1983): The Distribution, Grades and Mineralogical Composition of Gold-bearing Placers in Alberta; unpublished M.Sc. thesis, University of Alberta, Edmonton, 396 pages.

Holland, S.S. (1950): Placer Gold Production of British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 28, 121 pages.

Johnson, W.A. and Uglow, W.L. (1926): Placer and Vein Gold Deposits of Barkerville, Cariboo District, British Columbia; *Geological Survey of Canada*, Memoir 149, 246 pages.

Knight, J.B. (1985): A Microprobe Study of Placer Gold and its Origin in the Lower Fraser River Drainage Basin; Unpublished Master's thesis; *The University of British Columbia*, 197 pages.

Knight, J.B. and McTaggart, K.C. (1986): The Composition of Placer and Lode Gold from the Fraser River Drainage Area, Southwestern British Columbia; *Geological Journal of the Canadian Institute of Mining and Metallurgy*, Volume 1, No. 1, pages 21-30.

_______ (1989): Composition of Gold from Southwestern British Columbia: a Progress Report; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1.

Leaming, S.F. (1978): Jade in Canada; *Geological Survey of Canada*, Paper 78-19, 8 pages.

Levson, V.M., Giles, T.R., Bobrowsky, P.T., and Matysek, P.F. (1990): Geology of Placer Deposits in the Cariboo Mining District, British Columbia; Implications for Exploration; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1.

Mann, A.W. (1984): Mobility of Gold and Silver in Lateritic Weathering Profiles: Some Observations from Western Australia; *Economic Geology*, Volume 70, pages 38-49.

Murzin, V.V., Kudryavtsev, V.I., Berzon, R.O. and Sustavov, S.G. (1987): Cupriferous Gold in Zones of Rodingitization; *Geology of Ore Deposits*, No. 5, pages 1-7. Language: Russian. Translated by J. McIntosh.

Nesterenko, G.V., Kuznetsova, A.I., Lavrent'ev, Yu. G. and Pospelova, L.N. (1982): Variations in Macrocomposition - Important Typomorphic Features of Native Gold. *Geologiya i Geofizika*, Volume 23, No. 3, pages 57-65. Language: Russian. Translated by J. McIntosh.

Oen, I.S., and Kieft, C. (1974): Nickeline with Pyrrhotite and Cubanite Exsolutions, Ni-Co Rich Lollingite and an Au-Cu alloy in Cr-Ni ores from Beni-Bousera, Morocco; *Neues Jahrbuch fur Mineralogie*, Monatshefte, pages 1-8.

Pokrovskii, P.V., Murzin, V.V., Berzon, R.O., and Yunikova, B.A. (1979): Mineralogy of Native Gold from the Zolotaya Gora Deposit; *Zapiski Vsesoyuznogo Mineralogicheskogo Obshchestva*, Volume 108, No. 3, pages 317-326. Language: Russian. (translated in: Soviet Geology and Geophysics, Volume 23, No. 3, pages 50-56).

Prichard, H.M. and Tarkian, M. (1988): Platinum and Palladiaum Minerals from Two PGE-rich Localities in the Shetland Ophiolite Complex; *Canadian Mineralogist*, Volume 26, pages 979-990.

Raicevic, D. and Cabri, L.J. (1976): Mineralogy and Concentration of Au and Pt-bearing Placers from the Tulameen River Area in British Columbia; *Canadian Institute of Mining and Metallurgy*, Bulletin, Volume 69, No. 770, pages 111-119.

Ray, G.E. (1982): Carolin Mine - Coquihalla Gold Belt; *B.C. Ministry of Energy, Mines and Petroleum*

Resources, Geological Fieldwork 1981, Paper 1982-1, pages 87-101.

______ (1983): Coquihalla Gold Belt Project (92H/6, 11); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1982, Paper 1983-1, pages 62-84.

______ (1984): Coquihalla Gold Belt Project; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1983, Paper 1984-1, pages 54-66.

Ramdohr, P. (1969): The Ore Minerals and Their Intergrowths; *Pergamon Press*, pages 321-336.

Rouse, G.L., Lesack, K.A., Hughes, B.L. (1990): Palynological Dating of Sediments Associated with Placer Gold Deposits in the Barkerville-Quesnel-Prince George Region, South-Central British Columbia (93G); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, page 531.

Schiarizza, P., Gaba, R.G., Glover, J.K., and Garver, J.I. (1989): Geology and Mineral Occurrences of the Tyaughton Creek Area; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1.

Stumpfl, H. and Clark, A. (1966): Electron-probe Microanalysis of Gold Platinoid Concentrates from Southeast Borneo; *Institution of Mining and Metallurgy Transactions*, Section B, Volume 74, pages 933 to 946.

Uglow, W.L. and Johnson, W.A. (1923): Origin of the Placer Gold of the Barkerville Area, Cariboo District, British Columbia, Canada; *Economic Geology*, Volume 18, pages 541-561.

Vasconcelos, P, and Kyle, R.J. (1989): Supergene Geochemistry and Crystal Morphology of Gold in a Semi Arid Weathering Environment, Application to Gold Prospecting; 13th International Geochemical Exploration Symposium, Rio de Janeiro 1989, *Association of Exploration Geochemists*, pages 22-24.

Warren, H.V. and Thompson, R.M. (1944): Minor Elements in Gold; *Econommic Geology*, Volume 39, pages 457-471.

Wright, R.L., Nagel, J. and McTaggart, K.C. (1982): Alpine Ultramafic Rocks of Southwestern British Columbia; *Canadian Journal of Earth Sciences*, Volume 19, pages 1156-1173.

METALLOGENIC STUDIES IN SOUTH-CENTRAL BRITISH COLUMBIA: MINERAL OCCURRENCES IN THE NICOLA LAKE REGION (92I/SE)

(Fig. B1, No. 6)

By R.E. Meyers, J.M. Moore, T.B. Hubner and A.R. Pettipas

INTRODUCTION

The Nicola Lake region has a long and varied history of mineral resource exploitation. The area is dominated by the Nicola volcano-sedimentary belt which, throughout its length in the Intermontane Belt of British Columbia, is known for its relationship to several major porphyry copper-gold and copper-molybdenum producers. However, despite the base metal mining history in adjacent regions, the prime exploration focus in the Nicola Lake area has been on precious metals targets. The known mineral occurrences vary from quartz and quartz-carbonate veins to base metal bearing and, to a lesser extent, precious metal bearing skarns; porphyry mineralization, so important elsewhere in the region, is generally under-represented.

This report consolidates data collected and compiled on the mineral occurrences in the Nicola Lake area in 1988 and 1989 during limited mapping programs (Moore, 1989) associated with the LITHOPROBE transect and subsequently to compile the geology of the 92I/SE map sheet (Moore and Pettipas, 1990). The regional geology, as described here, is modified from Moore *et al.* (1990).

HISTORY

In the 1890s prospectors working around Mineral Hill, near Stump Lake, discovered gold-silver-bearing quartz veins, which would later become the Joshua, Tubal Cain, Enterprise and King William properties. During early development of the prospects the area was described as "...a new and enormously rich mining district...", having geology "...similar to that of the richest mining districts in Mexico..." (Dodd, 1887, p. 274). Encouraging statements such as this attracted numerous prospectors and geologists to the region and eventually mining companies were formed to develop the newly discovered mineral deposits.

During this period, and well into the 1920s, promising-looking discoveries were made at Iron Mountain, near Merritt, Nicola Lake and Swakum Mountain. Most were gold-silver-bearing quartz veins, containing variable amounts of lead, zinc and copper; at some localities barite, tungsten and molybdenum were also found.

Stump Lake saw the first significant mine and mill development on the Enterprise and King William veins. This mine produced some 70 000 tonnes of gold-silver-lead-zinc-copper ore during intermittent operating periods between 1916 and 1942.

At Swakum Mountain the first discovery was the Lucky Mike copper-gold skarn in 1916, followed by the Old Alameda in 1920 and the Thelma/Bernice in 1927. The latter were polymetallic mesothermal to epithermal veins, from which only minor production came, amounting to about 80 tonnes of lead-zinc-silver-gold ore. In 1943, the Strategic Minerals Committee evaluated the Lucky Mike deposit for its tungsten potential, estimating a grade of 0.312 per cent WO_3.

By 1929, the Leadville/Comstock shaft was developed on Iron Mountain, with minor barite-rich lead-zinc-silver production. Small exploration shafts had already been sunk on the Charmer prospects, but without much success.

North of Nicola Lake, the Turlight (Copperado) copper-gold deposit was discovered and developed during 1928-29. Following several periods of exploration and construction, the property produced about 227 tonnes of 5 per cent copper ore by 1960.

During the 1950s, stimulated by activities and discoveries in the Highland Valley to the northwest, the Promontory Hills area, on the southern edge of the Guichon Creek batholith, became the focus of exploration. The initial approach was to follow-up magnetic lows (using a Highland Valley model); this strategy later changed when magnetite-copper skarn mineralization was recognized. Craigmont was discovered in 1957, and until 1982, a total of 29 325 342 tonnes were mined, averaging 1.37 per cent copper, 0.37 per cent iron, 0.0023 gram per tonnne gold and 0.0071 gram per tonne silver.

Despite a long and intermittently aggressive history of exploration, only the Craigmont deposit became a major producing mine. However, more than 200 known mineral occurrences have been discovered in this relatively small region, only a portion of which are shown on Figure B-6-2, 3 and the prospects for new discoveries continue to be high.

GEOLOGICAL SETTING

The geology of the Nicola Lake region (Figure B-6-1) was first mapped at 1:253 440-scale by Cockfield (1948), who summarized earlier studies and reported in detail on many small mines and mineral occurrences. More

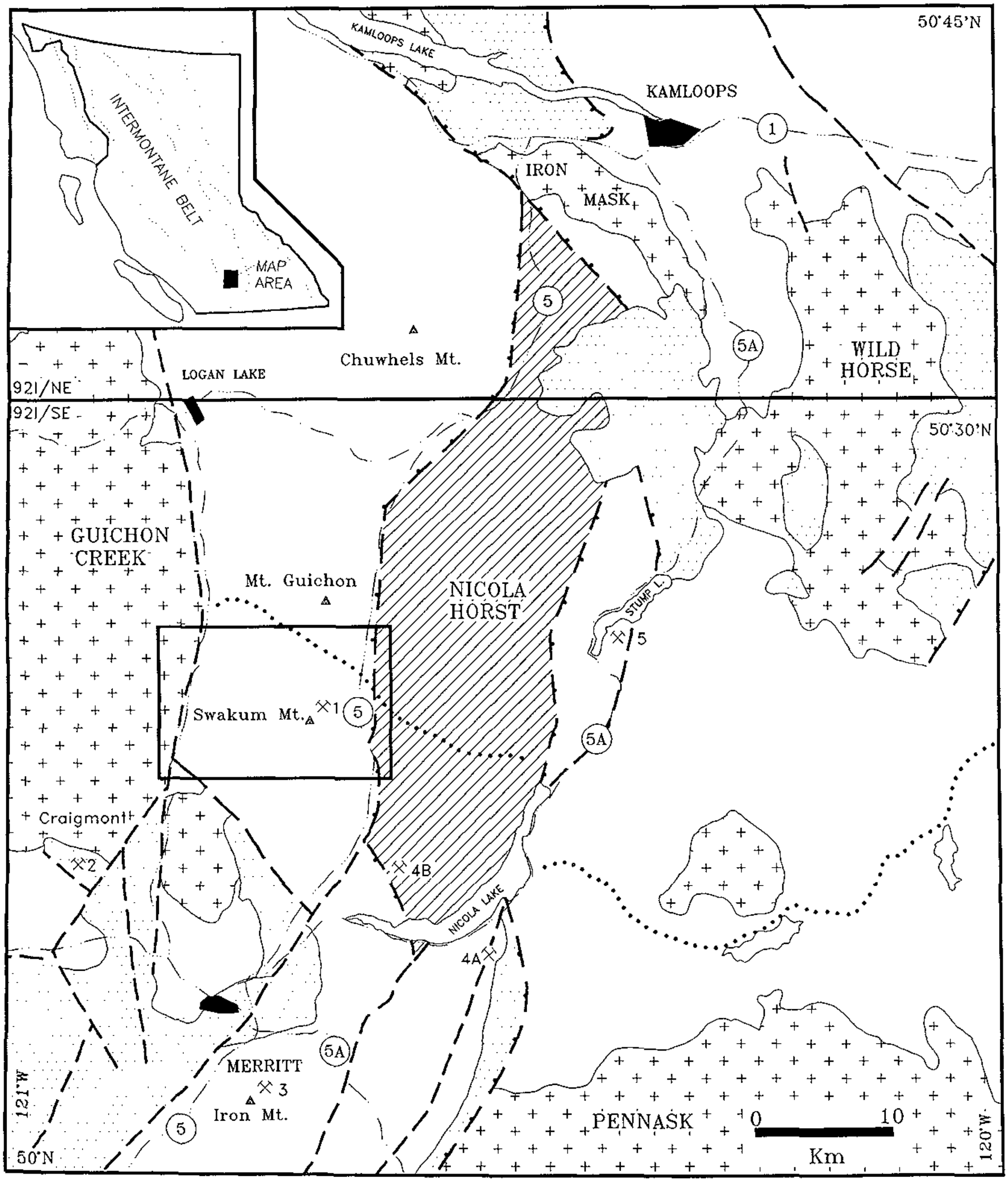


Figure B-6-1. Locality map of the Nicola Lake region. Nicola Group rocks (and minor pre-Nicola rocks in the NE) unpatterned; crosses: Triassic-Jurassic plutons; dots: post-Nicola stratified rocks. Swakum Mt. map area (Figure B-6-3) is outlined. Cross-hammer symbols denote concentrations of mineral occurrences as described in text: (1) Swakum Mt., (2) Craigmont, (3) Iron Mt., (4A) Quilchena, (4B) south Nicola Lake area, (5) Stump Lake.(From Moore *et al.*, 1990).

detailed mapping of the Nicola Group was subsequently carried out by Schau (1968), Preto (1979) and McMillan (1981). Ewing (1980, 1981) studied the Eocene volcanic rocks of the region a published an important synthesis of the early Tertiary tectonics. Monger and McMillan (1984, 1989) produced a new regional map of the Ashcroft sheet (92I), that includes the area; Moore (1989) and Moore and Pettipas (1990) have published short accounts of studies along the LITHOPROBE transect and in the Nicola horst.

The Nicola Lake area (Figure B-6-2) lies in the Intermontane Belt and is part of the Quesnel Terrane. It is underlain primarily by Late Triassic arc volcanic rocks and volcanogenic sedimentary facies of the Nicola Group. In the southernmost part of the map area and to the south, toward Princeton, the Nicola rocks have been divided into three "belts" by Preto (1979) that contain distinct facies and assemblages. The western belt is an easterly facing succession of calcalkaline, mainly plagioclase-phyric andesitic flows and breccias, with lenticular interlayers of limestone and bedded volcaniclastic rocks. Although flows are more abundant, relative to clastic facies, in the western part of the belt, the sequence reported by Preto (1979) in the southern part of the Nicola area is not evident on Swakum Mountain (Figures B-6-2, 3), where sedimentary facies can be found throughout its entire width. The alternation of thick successions of massive uniform green flows and unsorted breccias with bioclastic limestones, volcanic conglomerate and local subaerial volcanic facies such as maroon scoriaceous breccias is evidence of deposition near a rapidly changing shoreline. The central belt, as represented in the south-central part of the map area and probably in the extreme northwest, comprises mainly augite and plagioclase-phyric basaltic flows and associated breccias. These were considered by Preto (1979, pages 27-29) to be largely submarine and of alkalic composition; probable correlatives near Logan Lake are among the very few occurrences of pillow lava in the Nicola Group. Subvolcanic intrusions of diorite and gabbro are abundant in the central belt. The eastern facies consists almost entirely of mafic augite-phyric volcaniclastic rocks, ranging from coarse, probably laharic, breccias to fine wacke and siltstone; coarse facies predominate. In the fault blocks between the Nicola horst and Stump Lake there are thick successions of turbidite wacke. Fine-grained sedimentary facies of the Nicola Group, underlying the Meander Hills and the Douglas Lake area, are medium to thin-bedded wacke, siltstone and mudstone. An assemblage of red-brown, plagioclase-phyric subaerial andesitic flows and volcaniclastic rocks (TJV) that lies at the south edge of the map area, in the vicinity of Mount Nicola, contrasts with the surrounding Nicola Group facies, from which it is separated by faults and Ashcroft sedimentary rocks. This assemblage was originally assigned to the Kingsvale (now Spences Bridge) Group by Preto (1979), but has since been placed in the Nicola Group (central belt) by Monger and McMillan (1989). Although these rocks have yielded one questionable Jurassic fossil collection, they remain of uncertain age. The similarity of the succession to a few of the Nicola units on Iron Mountain and the presence of one copper prospect (62; all numbers denoting mineral occurrences refer to Figures B-6-2 & 3) suggest that it may be an emergent part of the Nicola western belt.

The Nicola Group rocks have been intruded by Triassic and Jurassic plutons (Figure B-6-1), of which the Guichon Creek batholith (McMillan, 1976, 1978) is the largest and most important from the metallogenic standpoint. The stratified rocks are complexly faulted and regionally metamorphosed, typically to low greenschist facies.

The Nicola Group is overlain unconformably by clastic sedimentary and volcanic rocks ranging in age from Jurassic to Tertiary, that are less altered but rotated to steep attitudes on mainly extensional faults. Clastic rocks correlated with the Early and Middle Jurassic Ashcroft Formation are mostly unlayered, poorly sorted coarse conglomerate, with discontinuous interbeds of pyritic, rusty weathering sandstone and siltstone. On Swakum Mountain and at Sophia Lake there is a grey, commonly fetid bioclastic limestone, up to 200 metres thick, near the base of the formation. Clasts in the conglomerate consist primarily of volcanic rocks resembling the Nicola Group; granitic and dioritic boulders are also present. On the south flank of Swakum Mountain, limy siltstone contains mid(?)-Jurassic ammonites (H.W. Tipper, personal communication, 1990). At several localities a chert-pebble conglomerate, containing distinctive green clasts, overlies the polymictic conglomerate and may be of Cretaceous age, as suggested by Monger and McMillan (1989). Andesitic volcanic rocks of the Cretaceous Spences Bridge Group occupy the southwest corner of the area. Eocene clastic sediments ("Coldwater beds"), that include coal at Merritt and Quilchena, and volcanic rocks (Kamloops and Princeton groups) occupy fault-bounded depressions; the Kamloops Group also underlies the highlands bounding the area on the northeast. The volcanic rocks are predominantly basalts and andesites, but rhyolitic centres occur north of Stump Lake and east of Guichon Creek.

The Nicola horst (Figure B-6-1; "Central Nicola horst" of Moore, 1989) is a major structure bounded by Tertiary faults. It contains both Nicola strata (comparable to central and eastern belt facies) and quartzite (metachert?) metaconglomerate and black schist of unknown age, that are penetratively deformed and metamorphosed to amphibolite facies. These are cut by a variety of plutonic rocks ranging from metagabbro and tonalite to granite. The youngest, and the only body that has escaped penetrative deformation and recrystalliza-

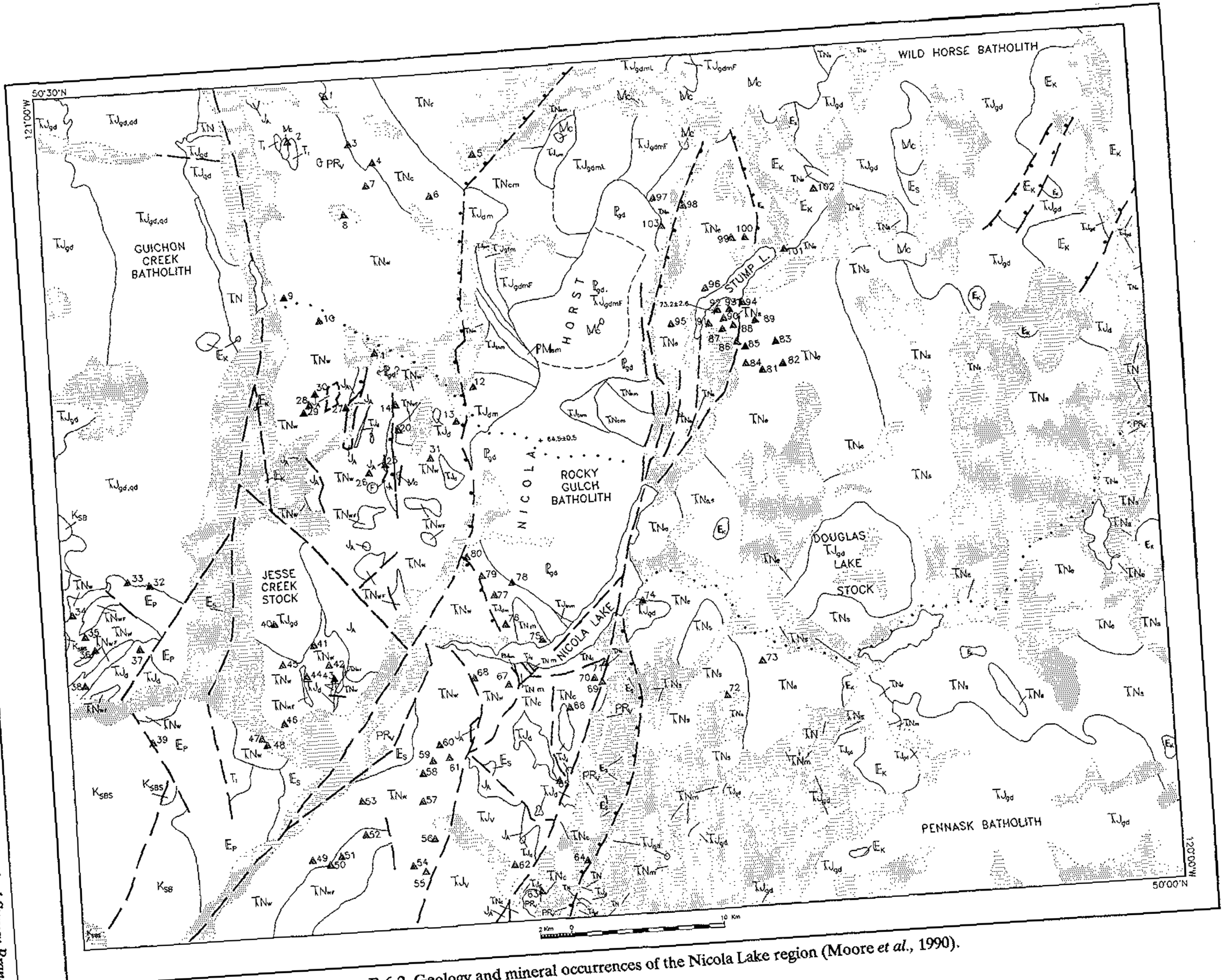


Figure B-6-2. Geology and mineral occurrences of the Nicola Lake region (Moore *et al.*, 1990).

LEGEND

LITHOLOGIC UNITS

QUATERNARY

- [pattern] Glacial, fluvioglacial, fluvial and lacustrine deposits; colluvium, landslide deposits
- PR_v Olivine basalt, typically vesicular ("Valley basalt")

TERTIARY

- T_i Small intrusions of mainly intermediate composition

MIOCENE

- Mc Olivine basalt ("Chilcotin basalts")

EOCENE
KAMLOOPS GROUP

- E_K Mainly basalt and andesite; local rhyolite, breccia, tuff and sandstone

PRINCETON GROUP

- E_P Intermediate, locally mafic or felsic flows, characterized by acicular hornblende phenocrysts
- E_S Sandstone, conglomerate, argillite, coal ("Coldwater beds")

PALEOCENE

- P_{gd} Granodiorite, tonalite and granite with K-feldspar megacrysts, of ROCKY GULCH batholith and possibly REY LAKE pluton

MID AND LATE CRETACEOUS

SPENCES BRIDGE GROUP

- K_{SB} Intermediate, locally felsic and mafic flows and pyroclastic rocks; sandstone, shale, conglomerate

SPIUS CREEK FORMATION (SPENCES BRIDGE GROUP)

- K_{SBS} Mafic volcanic rocks

EARLY AND MIDDLE JURASSIC

ASHCROFT FORMATION

- J_A Polymictic conglomerate, pyritic sandstone and siltstone, mudstone, bioclastic calcarenite

LATE TRIASSIC and/or OLDER

- TJ_{qd} Hornblende-biotite and biotite granodiorite and quartz diorite (qd) of GUICHON CREEK, WILD HORSE and PENNASK batholiths, JESSE CREEK and DOUGLAS LAKE stocks and unnamed bodies
- TJ_{gdm} Metamorphosed hornblende-biotite and biotite quartz diorite, granodiorite and granite (gt) of Nicola horst; F: Frogmoore variety; L: Le Jeune variety
- TJ_{tam} Metamorphosed, highly strained biotite leucotonalite and tonalite porphyry of Nicola horst
- TJ_d Augite, hornblende diorite, quartz diorite; includes subvolcanic intrusions into NICOLA GROUP. m:biotite-hornblende metadiorite of Nicola horst
- TJ_{um} Metaperidotite (Nicola horst)
- TJ_v Intermediate and mafic, maroon plagioclase- and augite-plagioclase-phyric sills and/or flows and volcaniclastic rocks; red volcanic conglomerate, sandstone, mudstone

LATE TRIASSIC

NICOLA GROUP

- TN Mafic and intermediate volcanic and volcaniclastic rocks, *undivided; m:upper greenschist-low amphibolite facies meta-*volcanic rocks, mainly in Nicola horst: hornblende and biotite-hornblende schist, amphibolite
- TN_w Western volcanic facies: mafic to felsic, plagioclase-phyric flows, pyroclastic and epiclastic breccias, tuff, wacke, minor limestone and limestone conglomerate
  f: predominantly felsic flows, tuff, welded tuff
- TN_c Central volcanic facies: mafic and intermediate plagioclase-augite-phyric flows, locally pillowed, and breccia; subordinate tuff, limestone, wacke and siltstone
- TN_e Eastern volcanic facies: mafic hornblende- and augite-phyric, predominantly epiclastic breccia, turbidite wacke, local siltstone
- TN_s Sedimentary facies: volcanic sandstone, siltstone, argillite, tuff; local polymict conglomerate

PALEOZOIC(?) or MESOZOIC

- PM_{sm} Quartzite metaconglomerate, black staurolite-andalusite-mica schist

SYMBOLS

- Lithologic contact (broken where speculative)
- Boundary of unconsolidated deposits
- Fault; solid circles on downthrown side
- Base and/or precious metal occurrence (Table 1)
- LITHOPROBE transect route
- \+ Uranium-lead zircon date locality *
- ✳ Potassium-argon sericite schist date locality *
- (F) Fossil locality *

* Supplementary to Monger and McMillan (1984)

SOURCES OF DATA

Monger, J.W.H. and McMillan, W.J., 1984: Bedrock geology of Ashcroft map area (92I), scale 1:125,000. Geological Survey of Canada, Open File 980.
Monger, J.W.H. and McMillan, W.J., 1989: Geology, Ashcroft, British Columbia. Geological Survey of Canada, Map 42-1989, sheet 1, scale 1:250,000.
Geological mapping by J.M. Moore (1988) and J.M. Moore and A.R. Pettipas (1989)

Base map: Merritt, B.C., Map 92I/SE, scale 1:100,000. Ministry of Environment, *British Columbia, 1980*

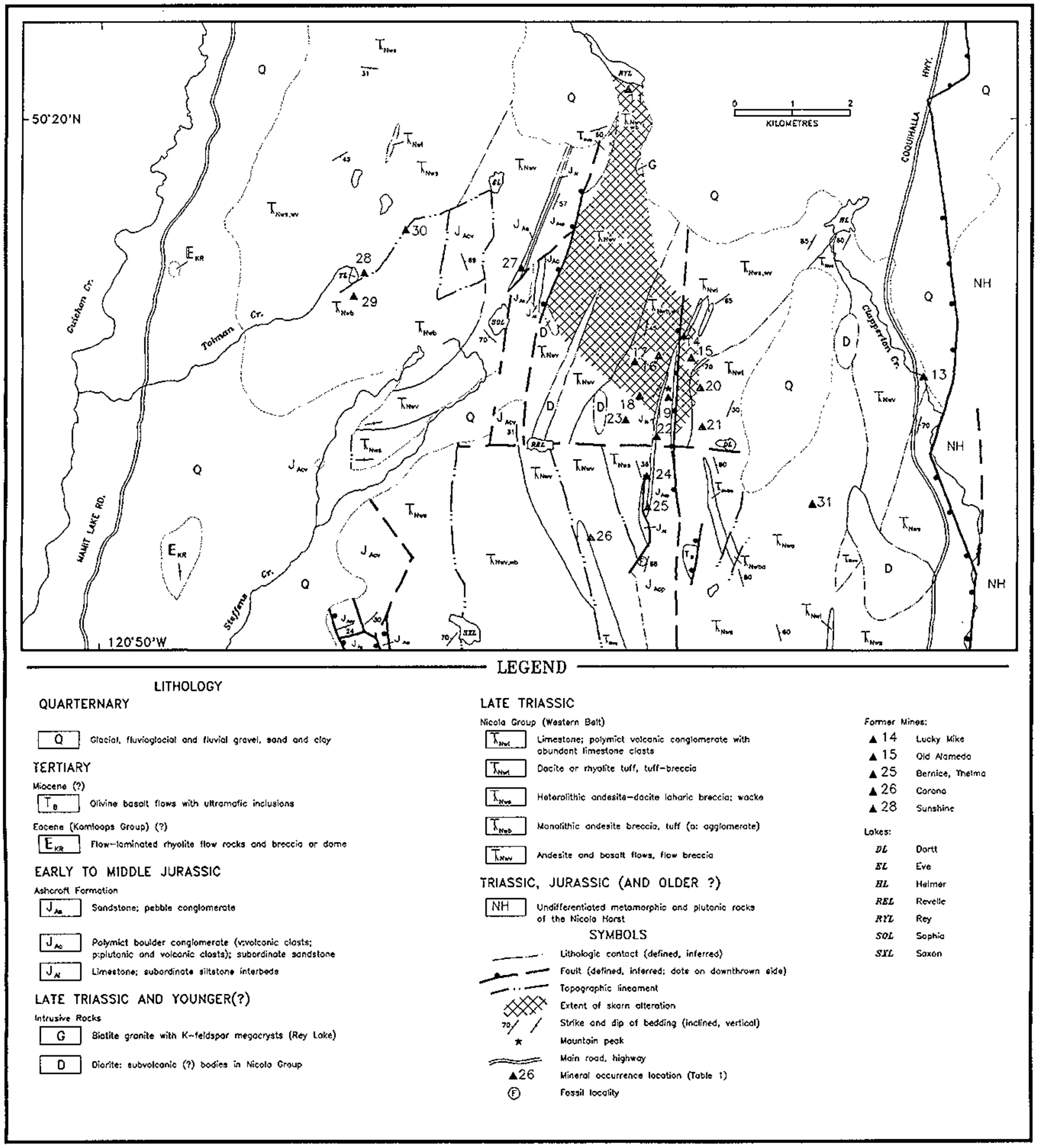


Figure B-6-3. Geology and mineral occurrences of Swakum Mt. (Moore *et al.*, 1990).

tion, is the Paleocene (64.5±0.5 Ma) Rocky Gulch granodiorite.

The oldest strata that are consistently flat-lying are Miocene Chilcotin basalts (Mathews, 1989) that occur northeast of Lac Le Jeune and probably in smaller outliers elsewhere. These flows are difficult to distinguish from the Pleistocene and Recent "Valley basalts" that once filled the major drainage channels of the area, but now occur as remnants in the Nicola and Quilchena valleys.

The tectonic history of the area is characterized by brittle deformation. Only in the Nicola horst are penetratively deformed rocks encountered; they exhibit westerly plunging stretching features that are probably related to accretion of the Nicola arc in Mesozoic time. Most of the Nicola rocks are steeply tilted, but not penetratively strained, except near small shear zones. Although a few mesoscopic folds were seen, the observed top-criteria indicate that the strata face east, implying that blocks have been rotated on listric faults. In the Swakum Mountain area (Figure B-6-2), discontinuities along strike of the Nicola rocks imply an easterly-striking fault, but in general the breaks must be oriented in a northerly direction. The Ashcroft strata occupy northwest to north-striking slices, bounded on their easterly sides by faults presumed to be normal. Major northwest-trending lineaments are also seen within the Nicola rocks (*e.g.* Rey Creek valley). These structures are transected by northerly striking Tertiary fault systems in the Nicola River, Guichon, Clapperton and Quilchena Creek valleys; along these faults Eocene sedimentary and volcanic strata have been rotated to dips approaching the vertical, and the Nicola horst elevated with respect to its surroundings. The faults are part of regional system of Eocene extensional features proposed by Ewing (1980) and elaborated by Monger and McMillan (1989). Where exposed, as in road cuts along the Coquihalla Highway and Nicola Lake, the fault zones exhibit intense shattering, veining and local alteration.

MINERAL OCCURRENCES

SWAKUM MOUNTAIN

Since discovery of the Lucky Mike deposit in 1918, the Swakum Mountain area has been recognized as a mining camp, and it has yielded small but significant quantities of base and precious metals (Cockfield, 1948). Although none of the early discoveries remains in production, there are many mineral occurrences that have not been thoroughly evaluated and exploration is active to the present day. There are two principal deposit types; both are polymetallic: (1) copper-bearing skarns within the alteration zone shown on Figure B-6-3, and (2) lead-zinc-copper-silver-gold-quartz stockwork veins associated with iron-rich carbonate alteration zones, that occur within and outside the skarn zone. The former type is exemplified by the Lucky Mike deposit (14), where copper is accompanied by subordinate tungsten, silver, gold, lead and zinc. Old Alameda (20), Thelma and Bernice (25) are representative of the latter type (only the main Swakum occurrences are shown in Figure B-6-2; all the known prospects are plotted on Figure B-6-3).

The Lucky Mike deposit occurs in a zone of coarse magnetite-pyroxene-calcite-epidote-garnet skarn localized on a footwall contact between andesite breccia and massive and brecciated limestone (Plate B-6-1) of the Nicola Group. The zone, which was drilled in 1943 (Cockfield, 1948), 1964 and again in 1988 (Wells, 1989), strikes about 020° and dips steeply toward the east; it is at least 100 metres long and 5 to 25 metres thick. The main metallic minerals are magnetite, hematite, scheelite, pyrrhotite, pyrite and chalcopyrite; chalcopyrite forms patches up to about 4 centimetres across in the skarn. Tungsten content was estimated *circa* 1943 at 0.15 per cent WO_3. The zone varies from some 25 metres wide at surface to 1 or 2 metres at 50 metres below surface (Wells, 1989).

Skarn alteration irregularly penetrates the volcanic rocks, where epitote and magnetite, with lesser pyroxene and garnet, are the main alteration minerals (Plate B-6-2). Pyrite is locally prominent and has apparently formed at the expense of magnetite. It is typically associated with iron-rich carbonate alteration and may postdate skarn formation (*see* below). The extent of the alteration zone, determined mainly by the anomalous presence of magnetite in the normally nonmagnetitic intermediate to mafic flows and breccias, has been approximately outlined on Figure B-6-3. The indicated area of 8.5 square kilometres is a minimum because exposure is poor; the zone is truncated against Ashcroft conglomerate by a normal fault to the west.

There are several prospected occurrences of chalcopyrite, with pyrite and magnetite, within the zone (17, 18). These are associated with prominent epidote alteration of volcanic rocks in the absence of limestone; scheelite is also reported at (17). At Rey Lake (11), chalcopyrite and molybdenite occur in porphyry-style veins, breccias and disseminations, but with spatially associated skarn-alteration zones (McMillan, 1974). The only intrusive rocks mapped in the area are quartz-feldspar-phyric granite and quartz monzonite. These rocks appear unaltered and thus postdate the skarn alteration; the granitic rocks, which yielded a K-Ar biotite date of 67.2±2.5 Ma (McMillan, 1974), bear a close resemblance to the Paleocene Rocky Gulch granite of the Nicola horst. Ashcroft sedimentary rocks on Swakum Mountain and northeast of Sophia Lake, tentatively dated at Early to Mid-Jurassic (Moore *et al.*, 1990), outcrop within tens of metres of altered Nicola rocks, but are unaffected by the skarn alteration. Given the association

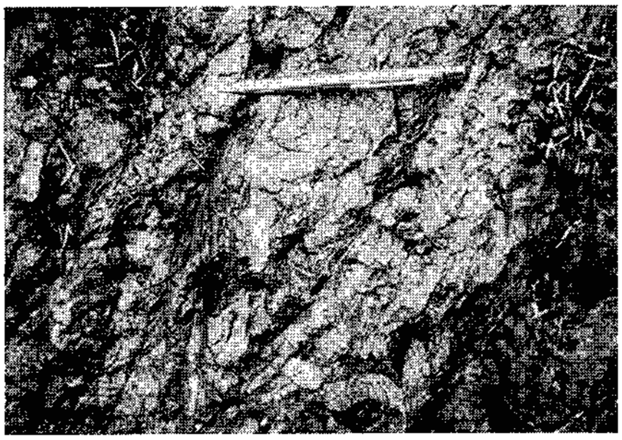


Plate B-6-1. Limestone breccia in altered Nicola volcaniclastic rocks, about 20 metres east of the main skarn zone of the Lucky Mike prospect (14).

Plate B-6-2. Incipient skarn development (dark areas) in Nicola volcaniclastic rocks, within the skarn alteration zone on Swakum Mountain southwest of Lucky Mike prospect (14).

Plate B-6-3. Quartz-carbonate flooding in rebrecciated vein mineralization at the Sunshine mine (28).

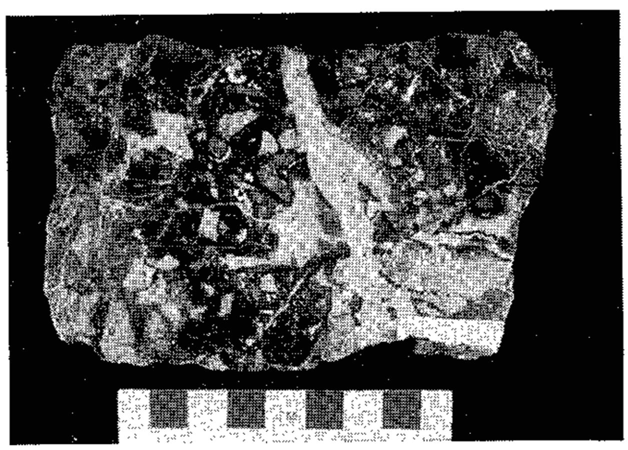


Plate B-6-4. Strongly hematite-altered vein breccia cut by later stage vein mineralization, hosted in Nicola volcaniclastic rocks; Sunshine mine (28).

of alteration with subvolcanic diorite/gabbro elsewhere in the Nicola Group, it is probable that the Swakum Mountain skarn zone is related to a Late Triassic mafic pluton that is not exposed.

The majority of prospects on Swakum Mountain are associated with rusty weathering iron carbonate alteration zones. They typically contain disseminated pyrite in quartz-calcite stockwork vein systems exhibiting prominent brecciation and open drusy cavities. The main ore minerals are galena and sphalerite, with subordinate pyrite, chalcopyrite, tetrahedrite and gold. Silver values are associated with galena. At the Sunshine deposit (28-30), mineralization is associated with multiple stages of quartz-carbonate vein brecciation (Plates B-6-3, 4, 5). The Sunshine and Corona (26) deposits are hosted by andesite flows and breccia and the Old Alameda (20) by felsic (dacite?) breccia, all of the Nicola Group. The Thelma and Bernice deposits (25) lie on the unconformity (?) between Nicola andesite breccia and conglomerate and overlying limestone of the Ashcroft formation. Although the veins are concentrated in the Ashcroft limestone, the alteration, which appears to be related to a northerly striking fault, affects both units. The Old Evelyn deposit (24) is in the same limestone. The base of the Ashcroft succession is also mineralized on Swakum Mountain and north of Sophia Lake, where it comprises intercalated limestone and sedimentary breccia with cherty clasts (19) or pyritic sandstone and mudstone (16, 27). At several localities, earlier reports identified the host to these deposits as Nicola volcanic rocks, but although these rocks occur nearby, the only workings observed are in Ashcroft strata. Accordingly, the carbonate alteration and stockwork mineralization at Thelma and Bernice are not part of a zonal sequence with the skarn mineralization at the Lucky Mike, but instead appear to be structurally controlled and result from a distinctly later event. They exhibit structural relationships both to northerly striking faults and to the probable unconformity at the base of the Ashcroft Formation. At some occurrences (*e.g.* 19, 25), carbonate-altered quartz-feldspar porphyry dikes cut the mineralized hostrocks .

The carbonate alteration and associated mineralization are younger than the Ashcroft limestone at the Thelma and Bernice properties and also north of Swakum peak, where limestone is mineralized and, together with Nicola rocks and post-Ashcroft porphyry, it is silicified and altered to iron carbonate. Age-dating of the sedimentary rocks is required to place an upper limit on the age of this mineralizing event, but it is clearly younger than, and distinct from the skarn formation.

PROMONTORY HILLS - CRAIGMONT AREA

Prior to discovery of the Craigmont copper-iron deposit (32), exploration activity in the area was sporadic and is not well recorded. The earliest work likely took place several kilometres to the north, in the Guichon Creek batholith, leading to the discovery and development of the Aberdeen mine (not shown) during the period from 1907 to 1926.

The Nicola Group volcano-sedimentary sequence in the central part of Promontory Hills comprises reddish volcaniclastic rocks of airfall origin, augite and plagioclase-porphyritic andesitic lavas interlayered with volcanic-derived laminated, waterlain epiclastic sediments and coarse breccias (McMillan, 1977). The central section is folded into a broad northeast-trending anticline, flanked to the north by quartzofeldspathic flows, tuffs and breccias with volcanic-derived quartz-feldspar-rich wackes, sandstones, tuffs and argillites. Farther to the northeast limestone, limy grits, breccias and argillites occur within the succession. South of the anticline, reefoid limestone is interlayered with spherulitic andesitic flows and epiclastic volcanic-derived sediments. Closer to the Craigmont area, andesitic flows and breccias of the Spences Bridge Group unconformably overlie Nicola rocks. The Nicola rocks are intruded by the Late Triassic to Early Jurassic Guichon Creek batholith, the Coyle stock, which is probably a Late Triassic subvolcanic intrusion (McMillan, 1977), and by quartz feldspar porphyry and dioritic dikes which may be related to Spences Bridge Group volcanic rocks.

Skarn alteration in the Craigmont area occurs within the limestone and limy clastic sedimentary rock sequence that hosts the Craigmont orebody. The sequence is folded into a tight subvertical antiform (Bristow, 1968); it is bounded on the west and south by steeply dipping faults and on the east by diorite and granodiorite of the Guichon Creek batholith. The alteration is zoned and has developed progressively approaching the mine area and batholith. In the upper part of the section, limestone is converted to marble and clastic rocks are hornfelsed and weakly epidotized. Deeper in the section, near the orebodies and contact of the intrusion, massive actinolite skarn is the dominent rock type and garnet skarn with minor diopside, is developed locally. Bristow (1968) described the skarn assemblage as magnetite, hematite, actinolite, epidote, garnet, pyrite and diopside. Magnetite and hematite accounted for about 25 per cent of the orebody and chalcopyrite is the main economic mineral, occurring with minor bornite. Native copper and chalcocite are present as supergene minerals near the paleosurface and to depths of 300 metres in limonitic fault zones. The mine produced 29.3 million tonnes averaging 1.37 per cent copper, 0.37 per cent iron, 0.0023 gram per tonne gold and 0.0071 gram per tonne silver (calculated from data in MINFILE). Reserves were exhausted in 1982, but the recovery of magnetite from stockpiles continued through 1989.

Several other copper-iron prospects have been explored in the area of the Craigmont pit. On the Marb

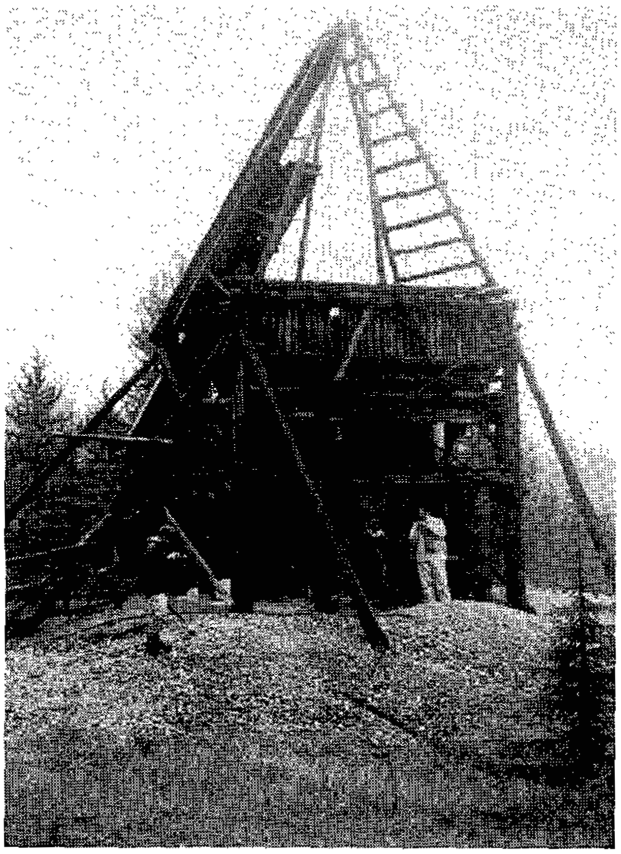


Plate B-6-5. Comstock-Leadville headframe, Iron Mountain.

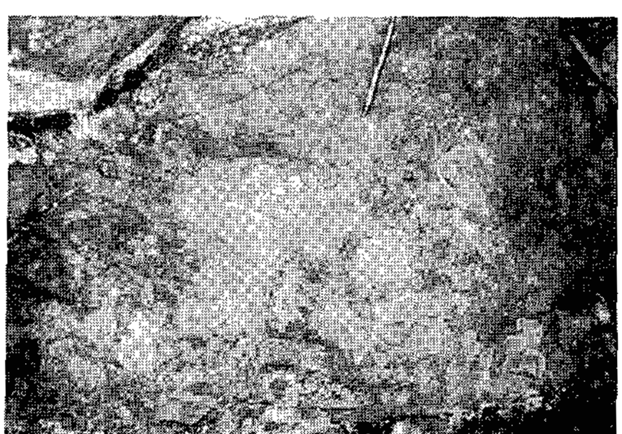


Plate B-6-6. Stockwork specularite veining with minor chalcopyrite in silicified Nicola andesitic volcanic breccia and tuff; Charmer prospect (50), Iron Mountain.

Plate B-6-7. Hematite-quartz-chalcopyrite veins in Nicola lapilli tuff; Charmer prospect (50), Iron Mountain.

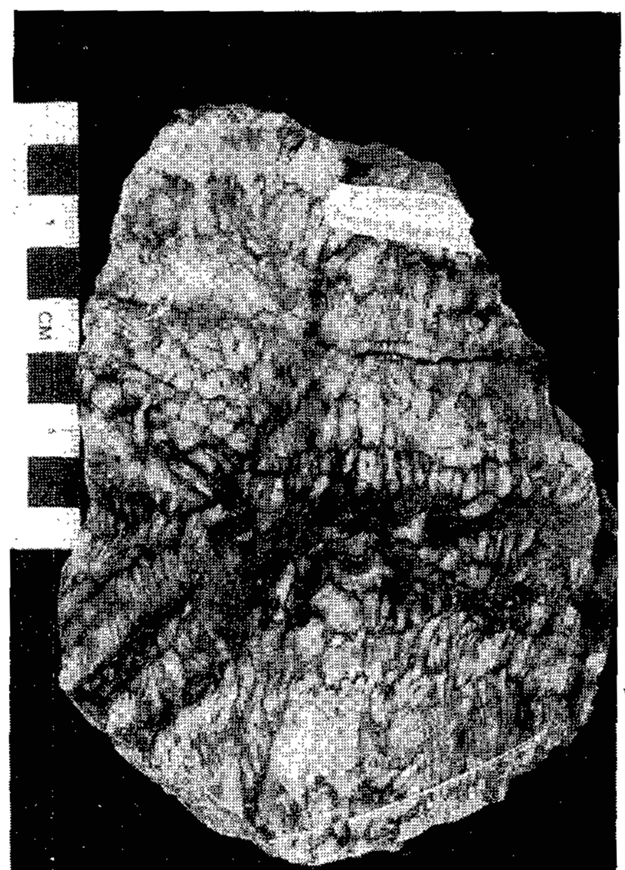


Plate B-6-8. Bladed and banded barite, with minor galena-sphalerite mineralization; Comstock-Leadville mine (51), Iron Mountain.

claims (34, Key Group) chalcopyrite, magnetite, pyrite and pyrrhotite occur as stringers and disseminations in chloritic shears cutting biotite hornfels in Nicola volcanic rocks (Bristow, 1988). A shallow exploration shaft was sunk on the Eric showing pre-1935 (Phoenix Group, not shown), 1600 metres east of the open pit, in epidote-altered biotite hornfels. Chalcopyrite, specular hematite, magnetite and malachite occur in skarns within sandstones and greywackes intruded by dioritic and granitic dikes (Bristow, 1985).

IRON MOUNTAIN

Iron Mountain is underlain by Nicola western belt volcanic and volcano-sedimentary rocks (Preto, 1969; McMillan, 1981). Two prospects have received most of the extensive exploration activity, which dates back to the 1890s (McKechnie, 1961). The Charmer/Judy (50) was staked in 1896 and the Comstock/Leadville (51) was discovered in 1927. Both properties received limited early underground development; a small tonnage of lead-zinc-silver-barite ore was mined at the Comstock (Plate B-6-5), but otherwise no significant production has come from either of the two prospects. However, the association of barite with base and precious metals in a potential volcanogenic massive sulphide environment has continued to attract explorationists to the present day.

The Nicola volcano-sedimentary succession, which is well exposed on Iron Mountain, was mapped in detail by McMillan (1981). Amygdaloidal andesitic flows, flow breccia and rhyolite to dacite flows and breccias are interlayered with submarine lapilli ash flow tuffs, mixed volcanic breccias, volcanic-derived siltstone and sandstone and impure limestone and limy breccias. Lithologic and stratigraphic interpretations have led to the suggestion that one or more volcanic centres occur within the sequence (McMillan, 1978). The rocks have been locally folded and crosscut by northwest-trending normal faults.

Three small exploration shafts were sunk on the Charmer property; at the No. 2 shaft, stockworks of quartz veins, quartz-specularite-chalcopyrite veins and quartz-poor veins of hematite±chalcopyrite (Plate B-6-6) cut intensely oxidized and silicified andesitic breccia and lapilli tuff (Plate B-6-7). Massive, banded and bladed quartz occurs in veins up to about 10 centimetres wide. Near the shaft the veining forms a grid-like pattern, with only remnants of recognizable wallrock.

Mineralization at the Comstock deposit contrasts distinctly with that at the Charmer prospects. Massive galena, sphalerite and minor tetrahedrite(?) occur in a "barite-flooded" or replacement stockwork-like matrix (Plate B-6-8). The hostrocks are reddish green potassium-feldspar bearing, moderately welded lapilli-ash rhyolite tuffs. McMillan (1978) interpreted two forms of Pb-Zn-Ag-Ba mineralization as: (1) banded and/or bedded veins and (2) rotated blocks of impure barite with sphalerite, galena and tetrahedrite in a sedimentary mélange.

At another small showing on the north flank of Iron Mountain (not shown on Figure B-6-2), a copper-bearing vein 1 metre wide (155/83W) cuts augite-hornblende-plagioclase-phyric flow-top breccia and tuff. The vein displays a crude zoning; the core contains breccia blocks of quartz-sericite-altered volcanic rock up to 20 centimetres across. On either side is a chalcopyrite-rich zone with azurite and malachite, 20 centimetres wide, bordered by about 5 centimetres of sericitic alteration; the wallrocks are altered with ankerite, malachite and azurite extending up to 2 metres from the vein margins.

NICOLA LAKE AREA

This area includes prospects north and south of the western end of Nicola Lake. The two main areas described are at Quilchena and in portions of the area between Nicola Lake and Pleasant Valley.

QUILCHENA

South of Quilchena, several copper-gold-silver prospects have been explored since the 1890s, following the discovery of the Guichon mine (71). No appreciable production has been reported, although significant exploration efforts have focused on several prospects. The area is underlain by purplish red and green amygdaloidal augite-porphyritic flows and flow breccia, interlayered with tuff, limestone and limy volcanogenic sediments (White, 1949; Preto, 1967; McMillan, 1981). The sequence is part of the central belt of the Nicola Group (Preto, 1969), near its boundary with the western belt.

The stratified rocks are intruded by small stocks and dikes of diorite, porphyritic and brecciated microdiorite and by later dikes of feldspar porphyry (White, 1949; McMillan, 1981). At some localities the microdiorite is cut by closely spaced northwest-striking joints that impart a sheeted appearance to the intrusive. Widespread epidote alteration characterizes the volcanic sequence in the area. Epidote fills amygdules and fractures and occurs as irregular wallrock alteration zones of a metre or more in width. Several major north-trending faults that branch from the main Quilchena fault transect the area. A number of the vein prospects occur along, or adjacent to these structures, or are associated with splays and tension fractures.

The precious and base metal bearing quartz veins at the Guichon mine occur immediately west of a major north-trending fault. They fill narrow shears and fractures and form irregular lenses and stringers that pinch and swell along the host structure. Calcite and pink potassium-feldspar are commonly associated with metallic minerals, which include chalcopyrite, bornite, malachite and minor tetrahedrite. Narrow hematite-rich veinlets

Plate B-6-9. Weakly bladed, gold-bearing quartz±carbonate vein, with diorite wallrock fragments; Sunnyboy (70) prospect, south of Quilchena.

Plate B-6-10. Deformed quartz veins in foliated metadiorite; Copperado/Turlight mine (77).

Plate B-6-11. Molybdenite-bearing quartz vein in a ductile shear in foliated metadiorite; TM prospect (78).

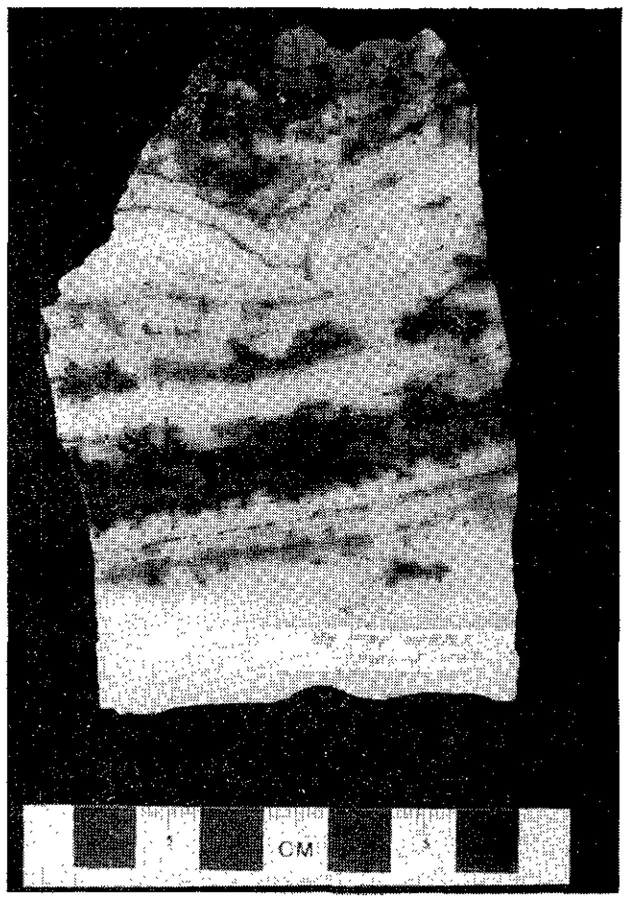


Plate B-6-12. Banded quartz-pyrite-galena-sphalerite-chalcopyrite veins from dump at the Joshua shaft (93), Stump Lake.

crosscut the veins and their wallrocks. McKechnie (1962) suggested that the veins may be coeval with the feldspar porphyry dikes that intrude the succession because some mineralized quartz veins were observed to cut the dike rocks and some dikes follow the same vein-bearing structures.

On the Sunnyboy (Iota; 70) claims, a northwest-trending (320/73 NE) milky white quartz vein 10 to 30 centimetres wide (referred to by current owners as the "Master Vein", Plate B-6-9) contains bladed salmon-coloured calcite, chalcopyrite with minor pyrite and accessory galena, bornite and native gold. The vein cuts Nicola augite-phyric andesitic breccias and a feldspar-porphyritic microdiorite dike, the south end of which terminates in a partially quartz-flooded breccia zone. Scattered blebs of chalcopyrite occur in the quartz and portions of the dioritic wallrock are intensely epidotized. A secondary set of quartz veins 1 centimetre wide (290/80N) cuts the diorite and the augite porphyry.

South of this area, several small copper-bearing veins occur in altered augite porphyry and diorite. Small malachite-stained veinlets and stringers of bornite, chalcopyrite and pyrite are associated with minor epidote, quartz and carbonate. Two kilometres to the southwest, on the G&G1 claims (66), quartz-carbonate veins occur in a north-trending, steeply east-dipping shear zone that is exposed in trenches over approximately 80 metres. These veins contain chalcopyrite, malachite and geochemically anomalous gold. The prospect occurs in reddish and grey-green Nicola volcanic rocks and porphyritic microdiorite. Trench rock chip samples returned gold values ranging from 26 to 14 040 ppb, however, the highest gold value returned from drill core intersections on the zone is 260 ppb over 3 metres (Miller, 1987). This style of disseminated and stringer copper mineralization with weak but anomalous gold values, may be part of a weakly developed, diorite-associated copper-gold porphyry system.

South Nicola Lake - Pleasant Valley

This area lies at the southern boundary of the Nicola horst, where coarsely foliated biotite hornblende metadiorite/gabbro of the horst, containing a large mass of schistose metavolcanic rocks, is faulted against western belt Nicola volcaniclastic rocks. Most of the prospects in this area are copper occurrences hosted by the metadiorite; the main properties are the Copperado (Turlight) mine (77) and a prospect (TM; 78) to the east, at the contact with the Paleocene Rocky Gulch batholith.

At Copperado, white quartz veins, dipping about 65 east, are mineralized with bornite and chalcopyrite. The veins cut the west-dipping mylonitic foliation of the metadiorite but are also folded and partly mylonitized (Plate B-6-10). The hostrock contains a downdip stretching lineation and kinematic indicators suggest that the penetrative deformation is associated with contractional faulting. The foliation shows ductile deformation at vein margins. Near the mine workings the foliated metadiorite is cut by an undeformed, unmineralized quartz feldspar porphyry that may be related to the younger granite. At the eastern prospect, relationships are similar, except that molybdenite is prominent in addition to bornite and chalcopyrite. These veins appear less deformed, but occur in small ductile shears that crosscut the main foliation (Plate B-6-11). The foliated metadiorite host is cut by coarse undeformed dikes of Rocky Gulch granite. Two grab samples showed amonalous copper and gold values (220 ppb Au, 6.0% Cu from the mine dump; 72 ppb Au, 0.65% Cu from the eastern prospect).

The metadiorite/gabbro is of unknown age. Its texture indicates that, before deformation and recrystallization under amphibolite facies conditions, it was a coarse plutonic rock, thus dissimilar to the fine to medium-grained subvolcanic diorites in the Nicola rocks to the south. It does, however, resemble facies of the Guichon Creek batholith, to which it may be related. The associated vein mineralization is, to some extent, porphyry in style and may have been generated, or remobilized, during metamorphism and deformation.

The metavolcanic rocks south of Copperado are strongly foliated, fine-grained epidote-amphibole schists that locally contain shear zones with sericitic and/or iron carbonate alteration. They host syntectonic carbonate-quartz veins, some of which contain disseminated chalcopyrite. One of the two samples assayed returned an anomalous 56 ppb gold. The hostrocks appear to extend to the south shore of Nicola Lake, where they are tentatively correlated with the central facies of the Nicola Group.

There are numerous trenches in epidote-altered, augite and plagioclase-bearing Nicola volcanic sandstones near their faulted contact with the metadiorite. The trenches expose quartz and calcite veins with weak copper mineralization as malachite and minor sulphides. The rocks have locally developed cleavage, but metamorphism is low greenschist facies. Adjacent metadiorite is brecciated and also mineralized locally as described above. The boundary fault between the metadiorite and Nicola rocks is interpreted as an early contractional feature that was reactivated, probably in Tertiary time, as a normal fault.

Stump Lake

Mineral exploitation at Stump Lake took place primarily between 1916 and 1944 (Cockfield, 1948). Although development work was started on several veins believed to hold promising potential, the bulk of ore produced was mined from the Enterprise vein (92). Total production is placed at 70 395 tonnes averaging 3.74 grams per tonne gold, 111.75 grams per tonne silver, 0.03

per cent copper, 1.42 per cent lead and 0.24 per cent zinc (calculated from production figures; Cockfield, 1948).

Most of the major veins in the camp are northerly trending, steeply east-dipping and less than a metre in average thickness, although vein widths of 2 or 3 metres have been reported (Dodd, 1887; Thompson, 1918). The veins are enclosed in west-dipping volcaniclastic rocks and volcanogenic and epiclastic sedimentary rocks, containing abundant augite porphyry clasts. They have been followed along strike for up to 500 metres and down dip for 300 metres. The hostrock sequence was originally interpreted by Cockfield (1948) and others to range from volcanic flows to dioritic intrusions (Dodd, 1887), but has recently been reinterpreted by Moore (1989). The wallrocks and veins are transected in places by hornblende-porphyritic dikes of intermediate to mafic composition (Hedley, 1936, pages D14-D23). Brittle faulting has broken the succession into a number of rotated blocks. Movement on the faults is variable; historical descriptions of underground workings indicate that most vein off-sets were rarely more than a few metres.

The veins at Stump Lake consist of polymetallic quartz-sulphide and quartz-carbonate-sulphide assemblages that are mesothermal to epithermal in character. The most abundant metallic minerals are pyrite, chalcopyrite, galena, sphalerite and tetrahedrite, with small amounts of bornite, scheelite, arsenopyrite, pyrrhotite and native gold. Quartz is massive to weakly banded, milky white with metallic minerals distributed in partings and in crudely developed, sulphide-rich bands or layers oriented parallel to vein walls.

Alteration adjacent to most veins is typically a carbonate-pyrite±mica assemblage. Near the Enterprise adit sericite, dated at 73.2±2.5 Ma by potassium argon methods (this study), and weak chlorite alteration display good penetrative foliation, apparently associated with localized shears, since this fabric is not widespread in the area. Veins exposed near the Joshua shaft (93, Plate B-6-12) strike north-northeast and dip about 50° to the east. Alteration is Fe-carbonate with abundant green mica. At some localities multiple veins 5 to 10 centimetres wide are oriented parallel to prominent north and north-northeast-trending fractures and joints. Similarly oriented veins with associated iron-carbonate and green mica alteration occur near the Planet (91) workings.

Early in the development of the camp the Enterprise, No Surrender (90) and King William (87) veins were recognized as probably being on the same northerly-trending structure (Cockfield, 1948). As suggested by Moore (1989), the orientation of these and other veins in the camp is subparallel, or conjugate to prominent fractures and faults, such as the early Tertiary Quilchena fault, which suggests that they formed during, or soon after, regional brittle faulting in an extensional tectonic environment.

DISCUSSION OF METALLOGENY

It is evident from the distribution of mineral occurrences (Figure B-6-2) that certain map units and localities in the project area have a much higher incidence of deposits than others. Almost all prospects are in the western and central belts of the Nicola Group; the eastern belt, except for the Stump Lake area, contains notably fewer deposits and the fine-grained sedimentary facies is almost devoid of occurrences. Similarly, the Nicola horst and all post-Nicola volcanic and sedimentary units in the area are low in known mineral potential.

Mineral occurrences in the Nicola Lake area may by tentatively classed into five main groups:

1. Skarn-hosted copper-iron deposits, with or without gold, at or near contacts of Late Triassic or Jurassic intrusions, in the intrusive body or the wallrocks. Craigmont and probably the early Swakum Mountain occurrences are of this type. Craigmont is associated with the Guichon Creek batholith; the supposed source of metals on Swakum Mountain is not exposed.
2. Porphyry-style copper-gold and copper-molybdenum deposits, associated with Triassic-Jurassic and younger plutons. This class is important because all the major Highland Valley and Iron Mask deposits are of this type. The south Nicola Lake and Quilchena occurrences lie in or near small, probably subvolcanic bodies of diorite/gabbro intrusive into the Nicola Group. The mineralization in the metadiorite and adjacent metavolcanics of the south Nicola area has experienced at least part of the metamorphism and deformation that affect rocks of the horst and may have been remobilized during these events. At Rey Lake (11) copper-molybdenum mineralization occurs within and adjacent to a Late Cretaceous - Early Tertiary granitic intrusion; mineralization and intrusive rocks are generally undeformed.
3. Lead-zinc-barite deposits, possibly volcanogenic in origin, within Nicola Group felsic volcanic and volcaniclastic rocks. These are uncommon but at least one occurrence on Iron Mountain (51) is of this type. The scarcity of this type of deposit in the region may relate to the shallow-marine or subaerial environment of much of the volcanic activity.
4. Precious metal-bearing quartz veins. This category consists of two subclasses:

(a) Quartz lode deposits in low-grade metavolcaniclastic rocks that lack associated igneous intrusive bodies, exemplified by some veins in the Stump Lake camp. Sericitic alteration zones bordering the veins are schistose, indicating that syntectonic metamorphism may have generated the mineralizing fluids. Although it is possible that this event was of Mesozoic age (related to accretion of the Nicola island arc?), it could alternatively be related to Late Cretaceous to Eocene extensional faulting.

(b) Epithermal gold-silver-bearing quartz veins and alteration zones associated with Late Cretaceous to Tertiary extensional faults. Examples of these are documented east of the project area, in the Tertiary volcanic rocks near Okanagan Lake (*e.g.* Brett deposit: Meyers, 1988). There are, however, potential analogues in the project area: pyritic sericite-carbonate alteration zones in the Nicola Group (13) associated with the Clapperton fault system, bordering the west side of the Nicola horst, exhibit gold anomalies. North of Stump Lake, chalcedony veins (100) cut Tertiary conglomerate containing clasts of silicified wood; similar veins to the west (99), carrying fluorite, have also been prospected for gold.

5. Stockwork quartz-carbonate veins, with open cavities, hosting polymetallic gold-silver-copper-lead-zinc mineralization. This is the predominant type on Swakum Mountain, where it is associated with prominent carbonate alteration zones and structures which crosscut and postdate Early to mid-Jurassic Ashcroft sediments, but also occurs in Nicola rocks. Deposits of this type are also common in the Merritt - Iron Mountain area. The energy source for fluid generation and circulation is not clear in this case. It could relate to arc accretion, Cretaceous regional heating accompanying Spences Bridge volcanism, or to Late Cretaceous to Eocene extensional tectonics.

ACKNOWLEDGMENTS

This report has benefited from a critical review by Bill McMillan. Potassium-argon dating was done by J. Harakal and D. Runkle at the University of British Columbia. We also acknowledge hospitality extended to J.M. Moore and A.R. Pettipas by the Guichon Ranch staff during the field mapping program.

REFERENCES

Bristow, J.F. (1968): The Geology of Craigmont Mines; *Canadian Institute of Mining and Metallurgy*, Annual Meeting, April 24, 1968, Vancouver, B.C.

______ (1985): Diamond Drilling Report on the Phoenix Claim Group; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 14102.

______ (1988): A Geological, Geophysical, Diamond Drilling Report on the Key Group of Mineral Claims; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 17677.

Cockfield, W.E. (1948): Geology and Mineral Deposits of Nicola Map Area, British Columbia; *Geological Survey of Canada*, Memoir 249.

Dodd, W. (1887): The Stump Lake Mines; *B.C. Minister of Mines*, Annual Report 1887, pages 274-275.

Ewing, T.E. (1980): Paleogene Tectonic Evolution of the Pacific Northwest; *Journal of Geology*, Volume 88, pages 619-638.

______ (1981): Petrology and Geochemistry of the Kamloops Group Volcanics; *Canadian Journal of Earth Sciences*, Volume 18, pages 1478-1491.

Hedley, M.S. (1936): Stump Lake Area; *B.C. Minister of Mines*, Annual Report 1936, pages D14-D23.

McKechnie, N.D. (1961): Copperado; *B.C. Minister of Mines and Petroleum Resources*, Annual Report 1961, pages 45-46.

______ (1962): Quilchena; *B.C. Minister of Mines and Petroleum Resources*, Annual Report 1962, pages 56-59.

McMillan, W.J. (1974): Stratigraphic Section from the Jurassic Ashcroft Formation and Triassic Nicola Group Contiguous to the Guichon Creek Batholith; *B.C. Ministry of Mines and Petroleum Resources*, Geological Fieldwork 1974.

______ (1976): Geology and Genesis of the Highland Valley Deposits and the Guichon Batholith, in Porphyry Deposits of the Canadian Cordillera, A. Sutherland Brown, Editor; *Canadian Institute of Mining and Mettalurgy*, Special Volume 15, pages 85-104.

______ (1977): Nicola Project, Promontory Hills; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geologic Fieldwork 1977.

______ (1978): Geology of the Guichon Creek Batholith and Highland Valley Porphyry District; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Preliminary Map 30.

______ (1981): Nicola Project - Merritt Area; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Preliminary Map 47 (North and South Sheets).

Mathews, W.H. (1989): Neogene Chilcotin Basalts in South-central B.C.; Geology Ages and Geomporhic History, *Canadian Journal of Earth Sciences*, Volume 26, No. 5, pages 969-982.

Miller, D.C. (1987): Diamond Drilling Report, G&G 1 Claim; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 15852.

Meyers, R.E. (1988): Brett Property, Vernon Mining Division; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1987, pages B7-B15.

Monger, J.W.H. and McMillan, W.J. (1984): Bedrock Geology of Ashcroft (92I) Map-area; *Geological Survey of Canada*, Open File 980.

______ (1989): Geology, Ashcroft, British Columbia; *Geological Survey of Canada*, Map 42-1989, Sheet 1, Scale 1:125,000.

Moore, J.M. (1989): Geology along the LITHOPROBE Transect between the Guichon Creek Batholith and Okanagan Lake, B.C.; *Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 93-98.

Moore, J.M. and Pettipas, A.R. (1990): Geology of the Swakum Mountain Area, Southern Intermontane Belt; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 73-78.

Moore, J.M., Pettipas, A.R., Meyers, R.E. and Hubner, T.B., (1990): Geology and Mineral Occurrences of the Nicola Lake Region (92I/SE); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1990-27.

Preto, V.A. (1967): Quilchena, Ensign, Ingersoll, etc.; *British Columbia Minister of Mines and Petroleum Resources*, Annual Report 1967, pages 169-171.

______ (1979): Geology of the Nicola Group between Merritt and Princeton; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 69.

Schau, M.P. (1968): Geology of the Upper Triassic Nicola Group in South-central British Columbia; unpublished Ph.D. thesis, *The University of British Columbia*.

Thomson, W.R. (1917): Donohoe Mines; *B.C. Minister of Mines*, Annual Report 1918, pages 228-230.

Wells, R.C. (1989): Diamond Drilling Report on the Petrie Property; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 18583.

White, W.H. (1949): Nicola; *B.C. Minister of Mines*, Annual Report 1949, pages 115-124.

COSMOPOLITAN (92JNE147)

By B.N. Church

(Fig. B1, No. 7)

LOCATION:	Lat. 50°47'42" Long. 122°47' (92J/15W) LILLOOET MINING DIVISION. The property is approximately 1.5 kilometres north of the town of Bralorne and 0.5 kilometre west of Mead Lake.
CLAIMS:	COSMOPOLITAN (Lot 584), NOELTON FR. (Lot 5456), and STAR FR. (Lot 5924) plus 18 additional reverted Crown grant claims and claim fractions.
ACCESS:	The property is connected directly to Bralorne by a dirt road following the power line on the northeast side of town.
OWNER\OPERATOR:	Levon Resources Ltd., Coral Energy Corp. Ltd. and Love Oil Ltd.
OPERATOR:	Levon Resources Ltd.
COMMODITY:	Gold.

GEOLOGY OF THE COSMOPOLITAN GOLD PROPERTY

INTRODUCTION

The Cosmopolitan property (MINFILE No. 092JNE 147), also known as the Love Oil or Taylor claim group at Bralorne, includes some of the oldest mineral prospects in the area. Current exploration is focused mainly on the southern part of the property (Figures B-7-1 and B-7-2).

The prospect and surrounding area were mapped and sampled in detail by the author and his field crew in 1987 and 1988. The present report is the result of this work and subsequent supporting research including new geochemical data and radiometric age determinations plus discussions with the operators (mainly James Miller Tait of Levon Resources Ltd.) regarding recent developments.

EXPLORATION AND DEVELOPMENT HISTORY

The Cosmopolitan claim, which adjoins the King workings of the Bralorne mine, was located by F.O. Richardson in 1897. According to McCann (1922, page 83), early work consisted of a shaft, several trenches and a short tunnel on a southeasterly striking quartz vein near the northwest boundary of the claim. The vein was reported to be steeply dipping, 0.7 metre wide at the shaft and was traced on strike for about 75 metres.

An assay of the vein yielded 26 grams per tonne gold. A second adit, about 30 metres long, was driven easterly to intercept a northerly trending mineralized shear zone near the southwest boundary of the claim.

Other old workings on the property, reported by Cairnes (1937, page 130), include a shaft on a quartz vein close to the southwest corner of the Noelton claim, and two short adits, about 30 metres apart, on the Star No.1 fraction.

By 1934 extensive underground development was in progress at the Bralorne mine. A crosscut was extended northerly from the King shaft on the No.8 level to explore quartz veins under the Cosmopolitan claim. Similar work was later completed on the No. 12 level.

The most recent activity began in 1987 with the discovery of a well-mineralized quartz vein near the old Taylor cabin in the western extremity of the Cosmopolitan claim. The discovery was tested by diamond drilling, followed by a broadly based exploration program which included more than 50 trenches and underground development. By October 1988 a crosscut tunnel 93 metres long had been driven to a point of approximately 25 metres below the discovery to prove vein continuity. Future plans by the operator include restoration of the 8th level workings to facilitate resampling and geological mapping.

GEOLOGICAL SETTING

The property is located on a smooth glaciated surface between 1300 and 1375 metres elevation, bounded on the east by the relatively steep slopes of Mount Fergusson and on the west by the deeply incised post glacial Hurley River valley. Owing to the extensive glacial drift and till on the property, natural rock outcrops are scarce - these are marked with a cross on Figure B-7-1.

Much of the property lies between northerly trending splays of the Cadwallader and Fergusson fault systems (Figure B-7-1). Subsidiary fractures appear to form boundaries between many of the major lithological units and these may have served as distributary channels for mineralizing solutions.

The bedded rocks on the property comprise the Bridge River metamorphic complex, of which the Fergusson chert (Unit 1) is the principal rock type, and the Cadwallader Group consisting of three units; the Noel (Unit 2), Pioneer (Unit 3), and Hurley (Unit 4) formations (Figure B-7-1).

The Fergusson chert is exposed near the northwestern and the southern boundaries of the claim group. The rock is medium to dark grey and commonly

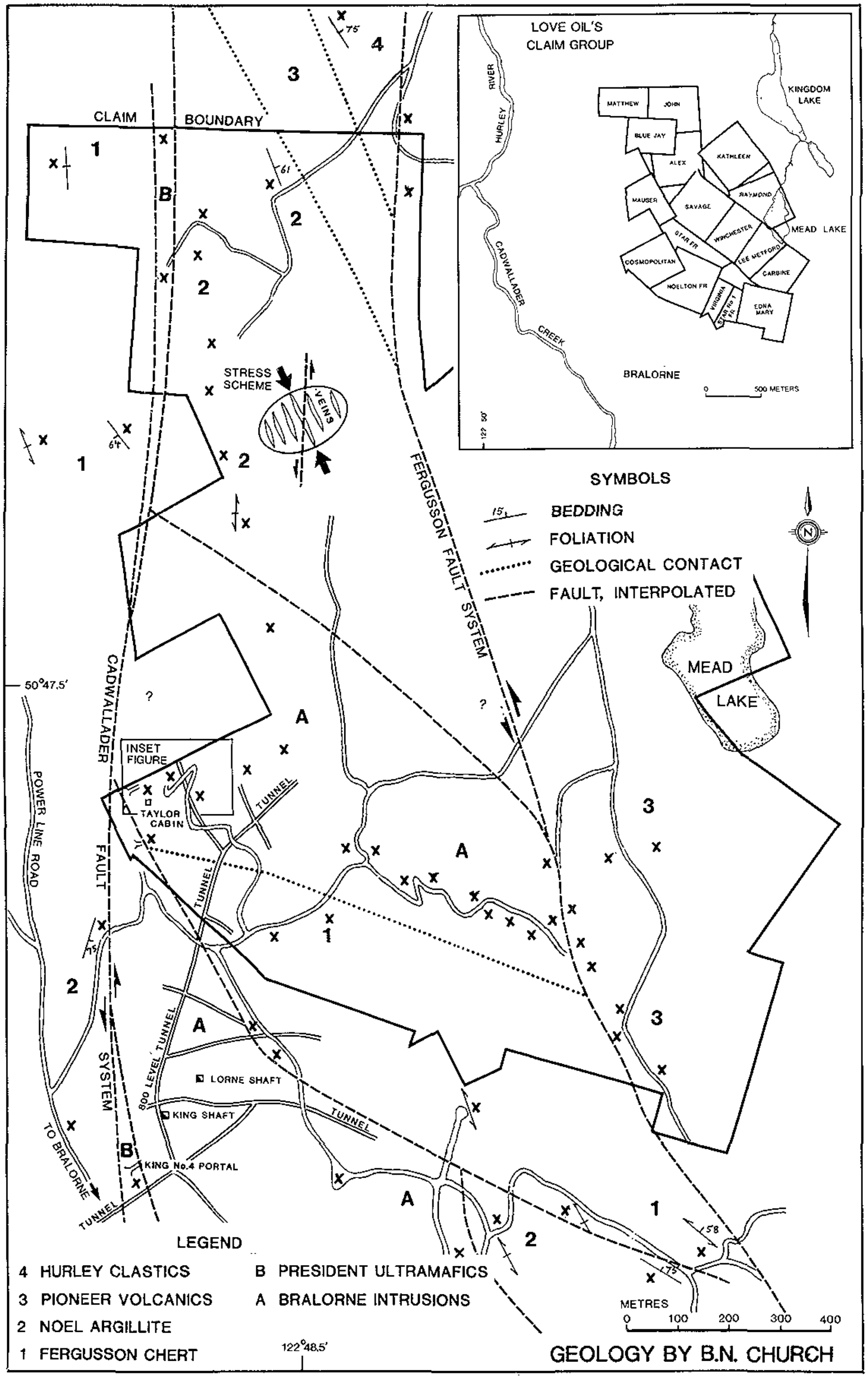


Figure B-7-1. Geology of the Cosmopolitan property, Bralorne area.

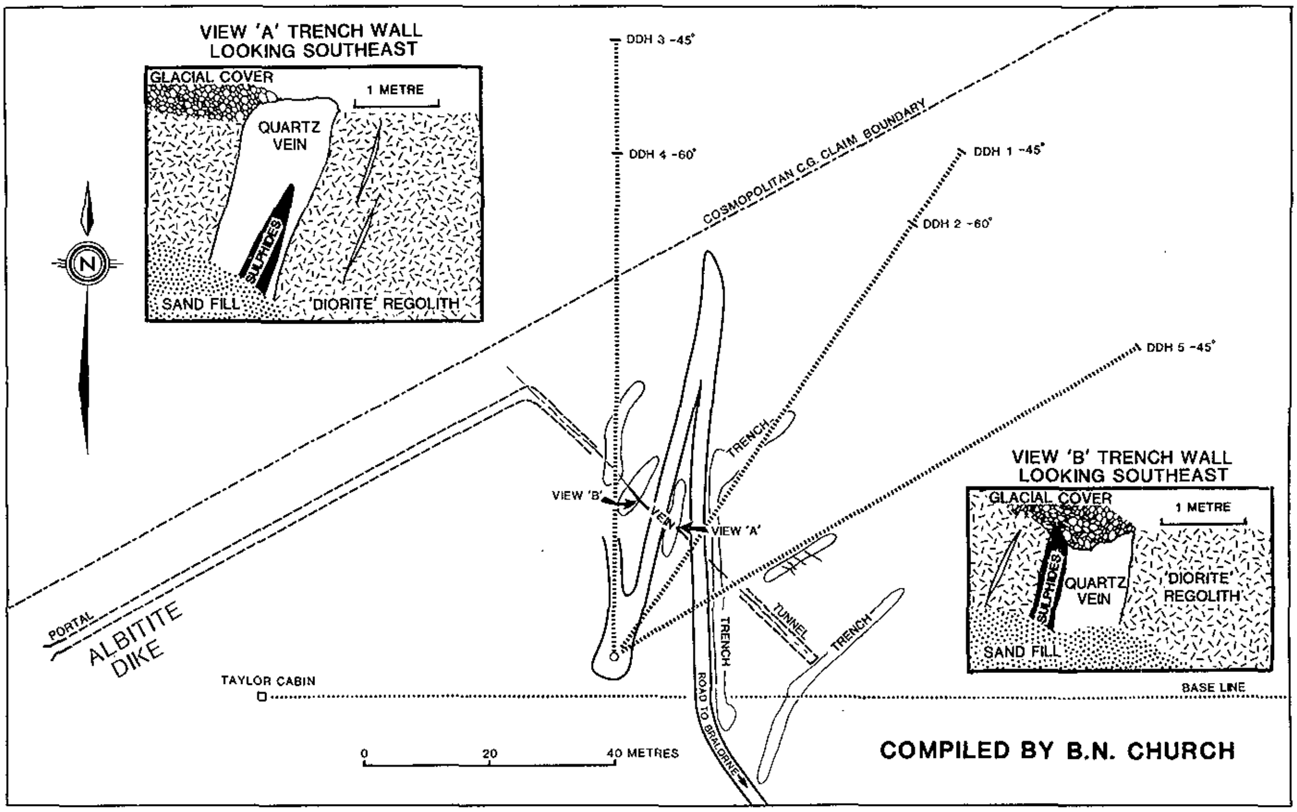


Figure B-7-2. Detailed geology and plans of the Love Oil tunnel and new workings on the Cosmopolitan claim (*see* inset on Figure B-7-1 for location).

ribbon banded. The bands are separated by seams of white mica, chlorite and, less commonly, some graphite. Folds are locally well developed but without consistent trend or pattern. Brecciated chert is also common and appears to be the result of widespread cataclasis - a major episode of dynamic metamorphism of Late Paleozoic - Early Mesozoic age.

The Noel Formation is exposed in the north-central part of the property and beyond the southwest and southeast boundaries. These sedimentary rocks are characteristically fossil-poor, thinly bedded, dark grey siltstones and argillites. Sheared phases of the Noel formation are not readily distinguished from the dark schistose Fergusson rocks, although the latter are typically associated with chert.

The Pioneer Formation is found mainly on the east side of the property. It consists of amygdaloidal basaltic lava, volcanic breccia and massive greenstone showing little evidence of primary structures. Well-preserved aquagene breccia, exposed in road cuts south of Mead Lake, appears to be a facies of basaltic pillow lava - a more common manifestation of the formation in the region. In thin section these rocks are seen to consist of a mixture of amphibole, sodic feldspar, chlorite, magnetite and varying amounts of epidote and calcite.

The Hurley Formation is exposed on the crest of a low ridge immediately north of the property boundary. This is a polymictic conglomerate containing a variety of porphyritic and fine-grained clasts of mainly volcanic derivation. Similar rocks found elsewhere in the region have been assigned an upper Triassic age based on fossil evidence (Church and Pettipas, 1989).

The Bralorne intrusions (Permian age - Armstrong unpublished and Leitch, 1989) consist of a relatively large gabbroic body in the Bralorne and Pioneer mine workings and a smaller related body on the Cosmopolitan claim group. The western extremity of the main intrusion, exposed just beyond the south boundary, is a grey rock characterized by numerous crisscrossing light colored veinlets. In thin section the rock is mostly medium grained and contains abundant chloritized amphibole with pyroxene relicts and altered feldspar accompanied by accessory calcite and epidote. The smaller intrusion is chemically similar to the Bralorne gabbroic phases found elsewhere in the area (Table B-7-1). The primary amphibole and plagioclase are extensively altered to chlorite, clay, and sericite. The rock is distinguished from the main intrusion by the presence of accessory quartz and pyrite.

The President intrusions comprise discontinuous elongate bodies of serpentinized dunite, peridotite and pyroxenite emplaced along a splay of the Cadwallader fault system near the west boundary of the property. Throughout the region these rocks are commonly associated with pre-Middle Cretaceous fault zones.

The youngest intrusive rocks in the area consist of a variety of Upper Cretaceous - Lower Tertiary albitite, feldspar porphyry, and lamprophyric dikes. These locally cut across the vein system and can be used for dating mineralizing episodes.

MINERALIZATION

The Bralorne intrusions are a common hostrock for the veins of the area, possibly because of this brittle, fissure-sustaining character and their location on a major intermittantly reactivated fault zone. The extent of the productive vein system is approximately 4 kilometres on strike between the Bralorne and Pioneer mines; the depth of mine workings at Bralorne is about 1.8 kilometres. The veins average about 1 metre wide and form an en echelon pattern throughout the mine workings. They are characteristically mesothermal consisting of banded milky quartz with minor amounts of carbonate, pyrite, arsenopyrite, free gold and less commonly pyrrhotite, sphalerite and a variety of grey sulphides. The average grade of the mined ore at Bralorne and Pioneer was 18 grams per tonne.

On the Cosmopolitan property the principal exploration target is a detached segment of the main Bralorne intrusion. This detached part is characterized by numerous veins and veinlets and the development of a locally thick rusty regolith. The regolith appears to be the result of oxidation of disseminated pyrite resulting in acid leaching that converts silicate minerals to a variety of oxides and clays.

The 'discovery vein', located about 70 metres northeast of the Taylor cabin, was exposed by trenching in the oxidized regolith below a cover of glacial gravel and till (Figure B-7-2). The vein varies from 90 to 110 centimetres wide and dips 60° to 70° northeast - it consists of locally banded white quartz with a few discontinous screens of wallrock and some pyrite-arsenopyrite pods. The vein is accompanied by quartz veinlets in the wallrocks. Contact alteration consists of clay minerals and carbonates. An assay across a 10 centimetre wide sulphide lens within the vein gives 332.9 grams per tonne gold, 69 grams per tonne silver, 55 ppm copper, 0.75 per cent lead, 0.45 per cent zinc, 2.40 per cent arsenic, and 0.11 per cent antimony. This suggests a predominance of arsenopyrite and only a minor amount of other sulphides such as chalcopyrite, galena and sphalerite.

TABLE B-7-1
ANALYSES OF BRALORNE GABBRO

Oxides recast to 100%	1	2
SiO_2	52.08	50.82
TiO_2	0.40	0.19
Al_2O_3	13.48	12.37
Fe_2O_3	1.80	1.68
FeO	7.68	3.78
MnO	0.17	0.13
MgO	10.91	10.10
CaO	10.94	20.20
Na_2O	2.27	0.07
K_2O	0.27	0.02
	100.00	100.00
Oxides as determined		
H_2O	2.53	2.83
CO_2		0.90
P_2O_5	0.04	-
S	0.03	0.03
Molecular Norm		
Qz	4.0	3.7
Ar	1.6	0.1
Ab	22.3	0.7
An	25.8	33.7
Wo	11.3	27.0
En	30.0	28.1
Fe	-	4.6
Il	0.6	0.3
Mt	3.3	1.8
He	3.1	-
	100.00	100.00

Key to analyses:

1. Lab No. 38663 - altered gabbro from Love Oil tunnel, Cosmopolitan claim.
2. Lab No. 35401 - gabbro from Wayside mine area.

Cairnes (1937, page 131) confirms the presence of two separated Bralorne intrusive bodies and continuation of the veins on the 800 (8th) level - part of the old Bralorne mine that is presently inaccessable: "More recent work on this group has been from the No. 8 adit level of the King mine. The main crosscut on this level has been extended northerly beyond Bralorne property into the Cosmopolitan claim of the Taylor (Bridge River) property, reaching the boundary about midway of the quartz diorite stock mentioned above. The crosscut continues in this for 140 metres and, 140 metres [450 feet] further, reaches the more northerly quartz diorite stock and continues in this to the face. In the interval between the two stocks several vein-bearing shears were intersected and four of them have been driven on for distances varying

Plate B-7-1. The Love Oil new cross-cut adit (August, 1989), Cosmopolitan C.G. claim (*see* Figure B-7-2).

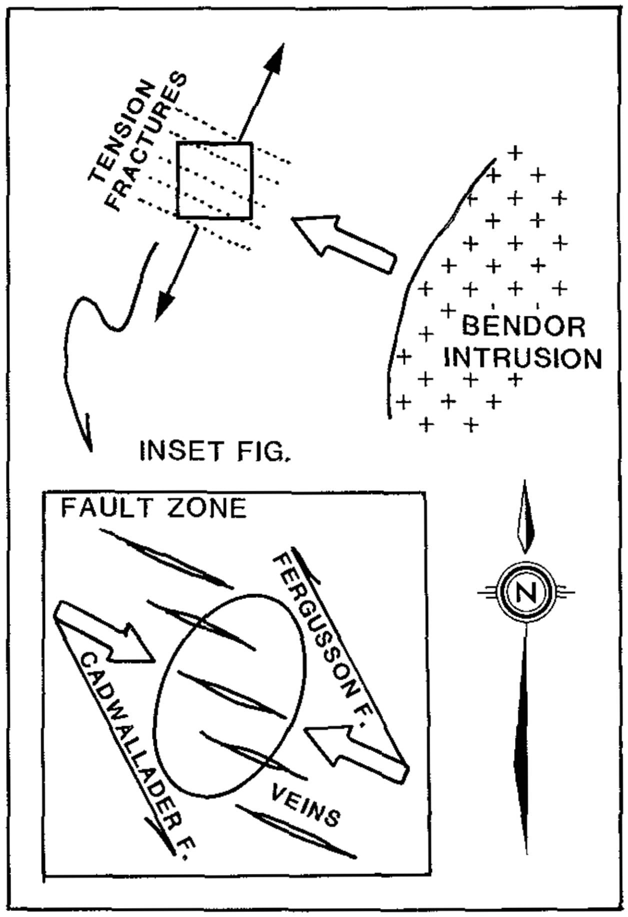


Figure B-7-3. Vein development lateral to the Bendor intrusions, Bralorne area.

from 30 to 245 metres [100 to 800 feet]. The rocks in this section are mainly Fergusson sediments, but include, towards the south, a narrow body of altered, dioritic rock that may be a faulted segment from the more northerly stock. Between this segment and the more southerly stock is a width of 15 to 30 metres [50 to 100 feet] of altered rocks of doubtful identity, but probably tuffs or tuffaceous sediments of the Hurley formation. All of the rocks in this section are fractured and sheared and at intervals there are strong shears up to 4.7 metres [15 or more feet] wide that are followed by the vein deposits. The shears strike northwesterly and dip northeast. Much of the movement along them is believed to be post-mineral and has resulted in fracturing the quartz deposits and interrupting their continuity. The vein deposits vary up to 1.8 metres [6 feet] wide, but are mostly much narrower and are discontinuous. In the main northwest drift, 245 metres [800 feet] long, the vein quartz is partly ribboned and sparcely mineralized and is reported to have provided some encouraging assay returns in gold, though average values are low." This vein described by Cairnes in the northwest drift is almost directly below, and appears to be a continuation of the 'discovery vein' exposed on surface (*see* Figure B-7-2).

The new tunnel on the Cosmopolitan claim (Plate B-7-1 - August 1988) was collared in an albitite dike and advanced northeasterly along the claim boundary, for 93 metres, passing through the Bralorne intrusion, intersecting the discovery vein at a point about 250 metres above the same or a similar vein on the 800 level. Here the tunnel turns southeast and follows the discovery vein 65 metres to the face of the drift. The vein strikes 135°, dips steeply and has a variable width that averages about 1 metre. It consists mostly of unbanded milky quartz with local concentrations of pyrite, arsenopyrite and sphalerite. According to company officials, the average gold grade of the vein ranges from 13 to 21 grams per tonne - the highest values were obtained between the face and midway along the drift (Figure B-7-2).

DISCUSSION AND CONCLUSIONS

Control of mineralization in the area is related to gash fractures and left-lateral movement on shears (Gaba and Church, 1989; Church, 1990). On the Cosmopolitan property a left-lateral shear couple developed between

TABLEB B-7-2
NEW RADIOMETRIC K-Ar DATES FROM THE BRALORNE AREA

Description	Location Easting	Northing	K Wt.%	Ar^{40} $x10^{-6}cc/g$	Ar^{40} %	Age Ma
1. Altered Bralorne gabbro (whole rock)	513600	5626300	0.198	0.671	61.9	85.1±3.0
2. Gwyneth Lake granite (biotite)	509800	5625700	6.34	21.67	90.9	85.9±3.0

(Samples collected by the author and analyzed by J. Harakal at U.B.C.)

the Fergusson and Cadwallader fault systems may be responsible for south and southeasterly trending vein-forming tension fractures in the Bralorne intrusion.

The age of mineralization is constrained by dikes dated 43.7 Ma (K-Ar on biotite) and 91.4 Ma (U-Pb on zircon) that bracket vein emplacement (Leitch, 1989). The exact timing of this event may be close to the age of the Gwyneth Lake satellitic stock dated 85.9 Ma (this study, Table B-7-2, sample No. 2) located just west of Bralorne. This also fits zircon dating giving an age range for the nearby Bendor pluton of 69.5 to 98.4 Ma (Church, 1989) and alteration of the Bralorne intrusion that hosts the gold quartz veins on the Cosmopolitan claim dated 85.1 Ma (Table B-7-2, No. 1).

It is concluded that the stresses caused by the intrusion of the Bendor pluton resulted in left-lateral shearing and the development of vein fissures in the area west and northwest of the pluton - space was required and the country rocks were simply shoved aside (Figure B-7-3). It is believed that much of this movement was a reactivation of the Cadwallader fault zone - a pre-existing major break. The evidence indicates that Bendor plutonism provided the necessary structural setting and was the principal thermal engine driving the mineralizing solutions.

ACKNOWLEDGMENTS

Assistance provided by prospectors and mining exploration companies in the Bralorne and Gold Bridge area is gratefully acknowledged. Special appreciation is owing James Miller Tait of Levon Resources Ltd. for detailed information on the Love Oil property, including the results of underground development and drilling. Field assistance was provided by Robert Gaba, Aaron Pettipas and Kim Safton.

REFERENCES

Annual Report to the Minister of Mines; *B.C. Dept. of Mines* 1932, pages A221; 1933, pages A265-A266; 1934, pages F29-F30.

Cairnes, C.E. (1937): Geology and Mineral Deposits of the Bridge River Mining Camp, British Columbia; *Geological Survey of Canada*, Memoir 213, 140 pages.

Church, B.N. (1990): The Control and Timing of Gold-quartz Veins in the Bralorne-Pioneer Area, Bridge River Mining Camp, B.C.; *Geological Association of Canada/Mineralogical Association of Canada*, Joint Annual Meeting "Vancouver '90", Abstracts.

Church, B.N. and Pettipas, A.R. (1989): Research and Exploration in the Bridge River Mining Camp (92J15/16); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 105-114.

Gaba, R.G. and Church, B.N. (1988): Exploration in Vicinity of the Wayside Mine, Bridge River Mining Camp; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1987, pages B.35-B44.

Leitch, C.H.B. (1989): Geology, Wallrock Alteration and Characteristics of the Ore Fluid at the Bralorne Mesothermal Gold Vein Deposit, Southwest British Columbia, Department of Geological Sciences; unpublished Ph.D. thesis, *The University of British Columbia*, 483 pages.

McCann, W.S. (1922): Geology and Mineral Deposits of the Bridge River Map Area, British Columbia; *Geological Survey of Canada*, Memoir 130, 115 pages.

MERRY WIDOW (092L 043, 051, 091, 115)

By H. Paul Wilton

(Fig. B1, No. 8)

LOCATION:	Lat. 50°21′ Long. 127°14.5′	(92L/6E, W)
	NANAIMO MINING DIVISION. At confluence of Merry Widow Creek and Benson River, 28 kilometres south-southwest of Port McNeill, Vancouver Island.	
CLAIMS:	L1524CG, L1530 - 1545CGs, L1548 - 1551CGs, L1553 - 1559CGs, L1562CG, L1625 - 1631CGs, L1634CG, L1635CG, L1638 - 1643CGs.	
ACCESS:	35 kilometres south from Port McNeill on Benson Main gravel road, then west approximately 5 kilometres on logging road M1000 and approximately 5 kilometres on logging road M1080 (four-wheel-drive advised) to the Merry Widow pit at an elevation of 700 metres above sea level.	
OWNER:	Taywin Resources Limited.	
OPERATOR:	TAYWIN RESOURCES LIMITED.	
COMMODITIES:	Gold, copper, cobalt, silver.	

EXPLORATION AND GEOLOGY OF THE MERRY WIDOW PROPERTY

INTRODUCTION

The Merry Widow property is a skarn-related gold-copper prospect located in the Benson Lake camp of northern Vancouver Island. Approximately 3.4 million tonnes of magnetite iron ore were mined between 1957 and 1967 from the Merry Widow and nearby Raven and Kingfisher open pits. From 1962 to 1973, the Cominco Ltd. subsidiary, Coast Copper Company Limited, mined 2.6 million tonnes of copper-gold-silver ore from the Old Sport (Benson Lake) mine located about 3 kilometres north of the Merry Widow pit (Ettlinger and Ray, 1989).

During the operating life of the Merry Widow iron mine, gold-bearing copper sulphides were known to occur in discrete zones within the magnetite orebodies. However, the operator, Empire Development Company Limited, regarded the sulphides as a contaminant to the iron ore and did not recover any of the copper, gold or related metals in its concentrating plant. In fact, the Raven pit was back-filled with "waste" containing a large component of copper-gold sulphide mineralization. With the current renewed interest in gold-bearing sulphide skarns in British Columbia, Taywin Resources Limited has acquired mineral title to all of the Crown grants and claims covering the former iron-producing property with the intention of evaluating the gold-silver-copper potential of the remaining sulphide mineralization. Taywin's holdings do not include the adjoining Old Sport property formerly operated by Cominco. The 1989 exploration program represents the first phase of Taywin's evaluation of the property.

EXPLORATION HISTORY

Magnetite mineralization was first discovered in the Benson Lake area in 1897. Extensive claim holdings covering all of the eventual producing mines and other deposits were held for many years by Quatsino Copper Gold Mines Limited. The property has a long history of exploration, first for copper and later for magnetite. The northern half of the property was sold to Coast Copper Company Limited and was eventually mined for skarn-hosted copper-gold-silver mineralization. Empire Development Company Limited, an affiliate of Quatsino Copper Gold, was formed in 1956 to exploit the magnetite reserves of the remainder of the property.

Since the cessation of iron mining in 1967 and of copper mining in 1973, the Benson Lake camp had received only cursory investigation prior to 1988 when Taywin Resources hired prospector Jim Laird to evaluate the extent and grade of copper-gold sulphide mineralization on the property. Laird mapped and sampled the sulphide zones exposed within the Merry Widow pit, the Kingfisher underground workings and at several surface showings (Marten, Bluebird, Snowline) south of the pit. The results of the 1988 prospecting indicated that the sulphide mineralization was widespread and locally contained very impressive gold values. Taywin proceeded to acquire title to all of the property previously leased by Empire Development, with a 12.5 per cent net profit interest retained by the vendor.

CURRENT ACTIVITY

Taywin spent approximately $450 000 in 1989 to explore the property. Work done included diamond drilling totalling 2769 metres in 42 holes, trenching, mapping and sampling of various surface showings north and south of the Merry Widow pit, limited magnetometer surveys and rehabilitation of the Kingfisher underground workings.

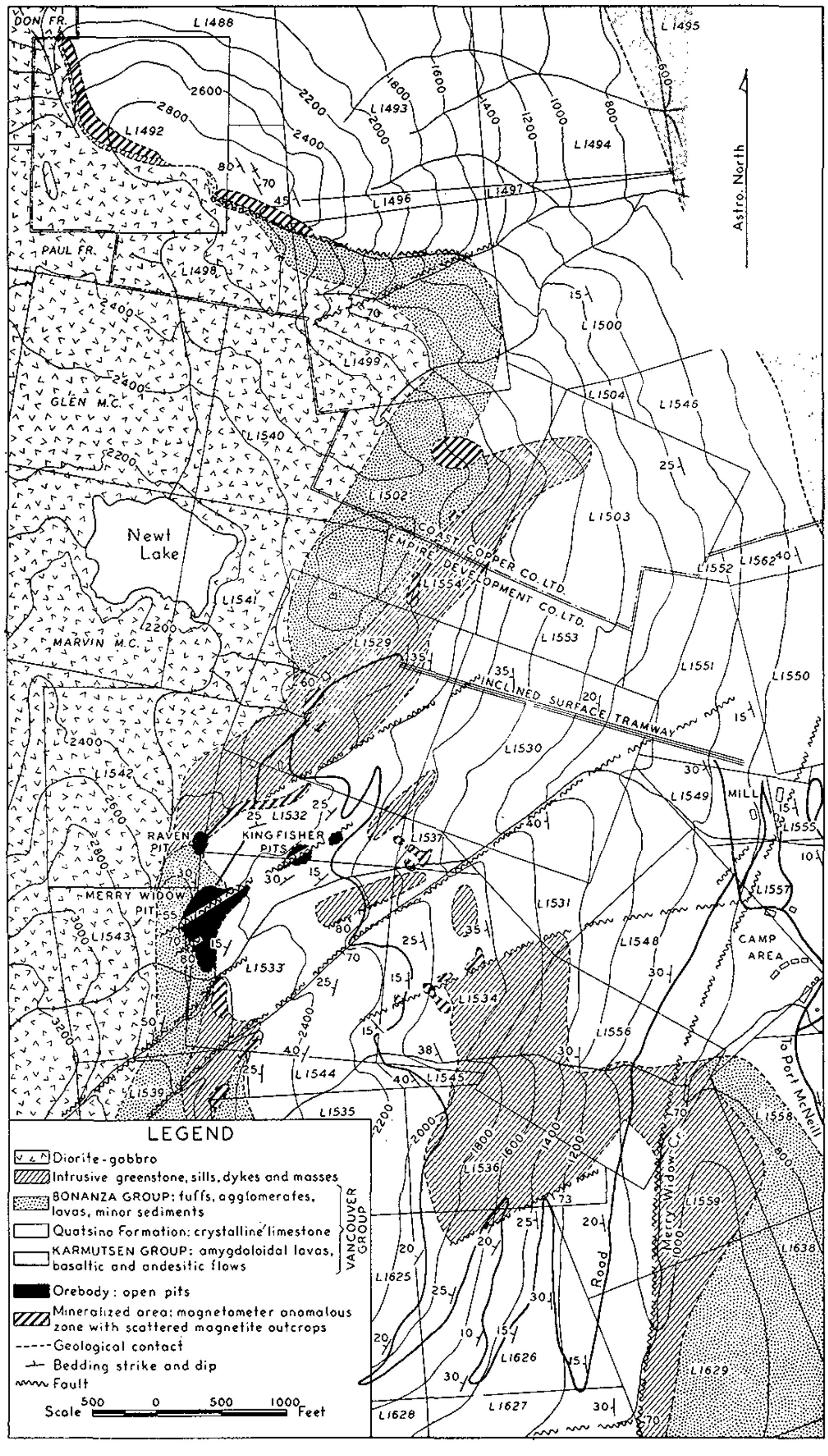


Figure B-8-1. Regional geology of the Merry Widow property (from Jeffery, 1960).

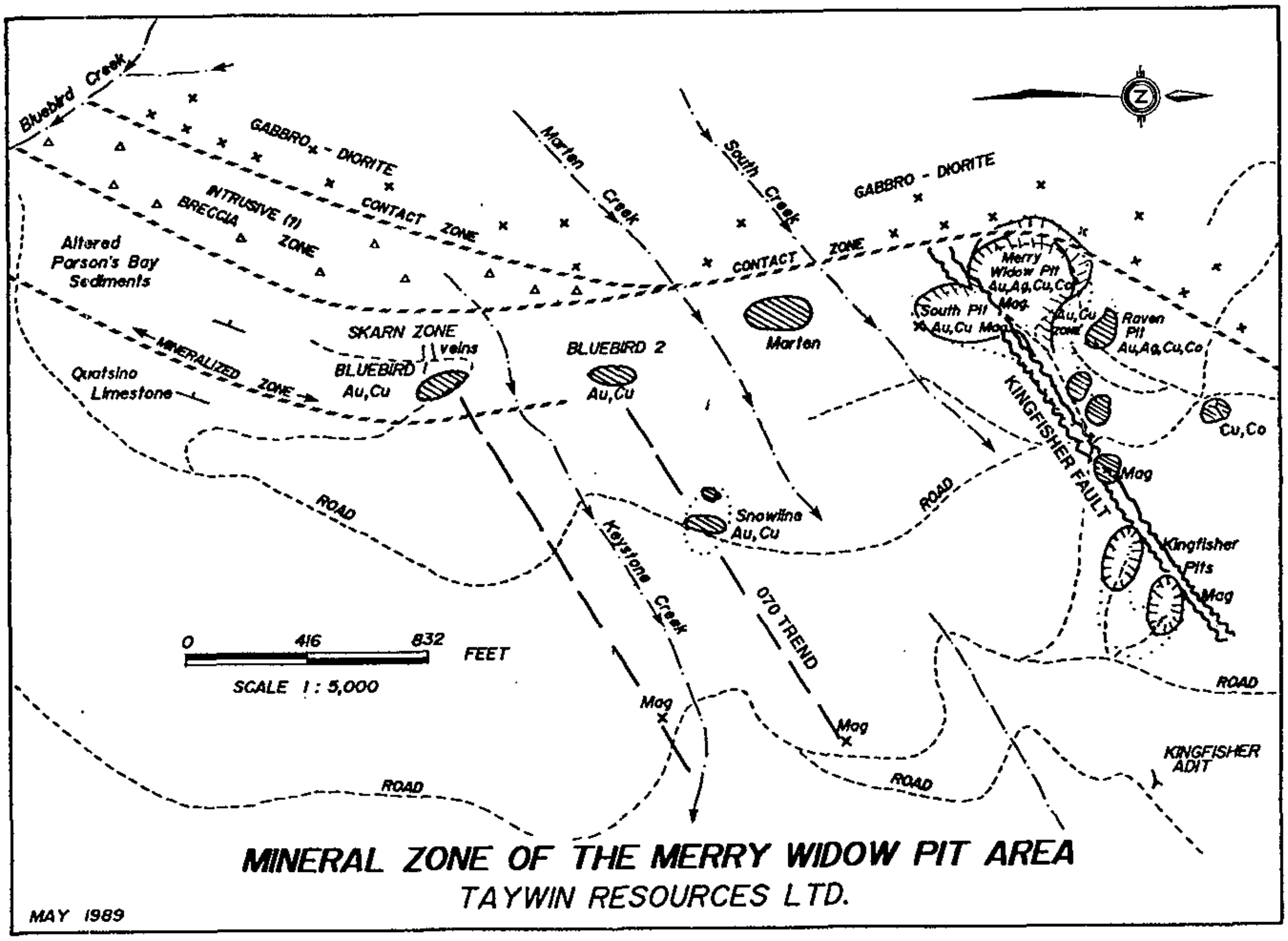


Figure B-8-2. Major lithological and structural trends on the Merry Widow property with distribution of orebodies and showings (courtesy Taywin Resources Limited, 1989).

GEOLOGY

REGIONAL SETTING

There are several published reports describing the regional setting and local geology of the Merry Widow property including Jeffery (1960), Eastwood and Merrett (1961), Sangster (1969) and more recently Ettlinger and Ray (1989).

The magnetite orebodies and associated copper-gold sulphide mineralization occur along a north-trending contact between the Jurassic Coast Copper stock and Late Triassic to Early Jurassic rocks of the Vancouver and Bonanza groups (Figure B-8-1). The layered rocks form a gently west-dipping, homoclinal package ranging from the upper part of the Karmutsen Formation in the valley of Benson River upward through the overlying Quatsino and Parson Bay formations into the lower Bonanza Formation in the vicinity of the Merry Widow pit. The Parson Bay Formation is discontinuous and appears to be absent between the Bluebird and Raven zones. The stratigraphic package is truncated by the eastern contact of the Coast Copper stock which ranges in composition from diorite-gabbro at the contact to monzonite in the interior. Carson (1973) has reported a K-Ar date of 181±8 Ma for phlogopite associated with skarn alteration inferring a Middle Jurassic age for the Coast Copper stock.

PROPERTY GEOLOGY

The oldest layered rocks exposed on the property are massive and pillowed basalt flows and breccias with interbeds of limestone and calcareous tuff. They outcrop at lower elevations on the eastern flank of Merry Widow Mountain. The Karmutsen basalts are overlain successively by massive limestone of the Quatsino Formation, calcareous and carbonaceous argillites and siltstones of the Parson Bay Formation, and andesitic to dacitic flows, tuffs, and volcanic breccias of the Bonanza Formation. Abundant andesitic dikes and sills intrude all of the layered rocks and probably represent feeders to the Bonanza volcanics. The layered rocks are intruded by massive, coarse-grained gabbro, a marginal phase of the Coast Copper stock, which is exposed on the high western headwall of the Merry Widow pit. It has been found in the underground workings and previous drilling that the gabbro contact has a moderate easterly dip.

Figure B-8-2 is a map showing the distribution of the various orebodies and showings on the property, as well as the major lithological contacts. The distribution of the mineralized zones is clearly controlled by two structural trends. One is the trace of the gabbro contact which roughly coincides with the local strike of the layered rocks and along which the Merry Widow and Raven pits and the Bluebird and Marten showings occur. The contact changes direction abruptly at the Merry Widow from an approximately northerly trend south of the pit to 040° north of the pit. The second structural trend is approximately 070° as shown in Figure B-8-2. It is manifest by the Kingfisher fault which cuts the Merry Widow and Kingfisher magnetite zones (*see* also Figure B-8-1). An andesite dike cuts the Snowline showing and has the same 070° trend. These are probably deep seated fracture zones which have controlled the distribution of dike emplacement, alteration and mineralization at various times.

ALTERATION AND MINERALIZATION

Skarn alteration in the Merry Widow pit has mainly affected the Bonanza volcaniclastic rocks. It consists of irregularly distributed zones of garnet, clinopyroxene, actinolite and epidote in various combinations. Recent mapping and core logging suggest that an overall zoning exists with predominantly garnet skarn close to the intrusive contact, grading outward through actinolite to predominantly epidote (Reynolds and Vulimiri, 1989). Within the pit, the finer grained volcanic tuffs have been recrystallized to clinopyroxene hornfels overprinted by zoned veins of garnet+calcite±pyroxene (Ettlinger and Ray, 1989).

Magnetite occurs as tabular bodies and lenses lying subparallel to the easterly dipping gabbro contact and along the northeasterly trending Kingfisher fault (Reynolds and Vulimiri, 1989). The sulphide zones, on the other hand, are mainly associated with tabular, steep-dipping fractures along which the primary garnet-pyroxene-epidote skarn has been retrograded to actinolite skarn. They are clearly superimposed as a later fracture-controlled mineralizing event cross-cutting the primary skarn alteration and magnetite zones. In the vicinity of the Merry Widow and Raven pits, Taywin's drilling and surface mapping have demonstrated that the sulphides occur in several discontinuous and locally interconnected actinolite zones oriented roughly parallel to, but steeper than the intrusive contact. The Bluebird, Snowline, and Marten showings were examined in detail by the author. They are clearly manto-type replacement zones produced by mineralizing fluids which have migrated upwards along one or both of the fracture trends referred to above and then moved outwards along the

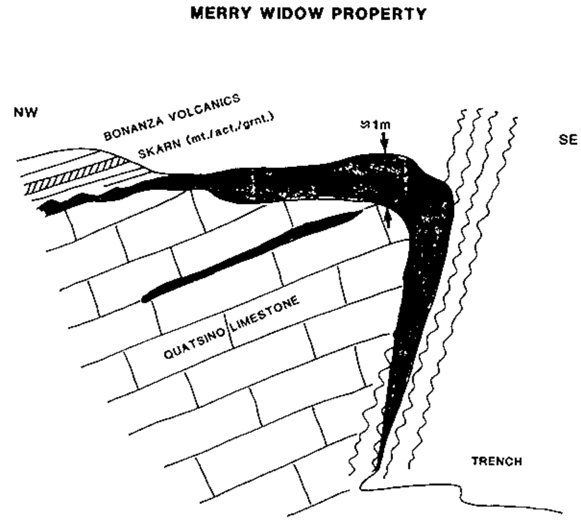


Figure B-8-3. Schematic crosssection of the Bluebird II showing.

limestone (Quatsino) - volcanic (Bonanza) disconformity and to a lesser extent along bedding planes in the limestone (Figure B-8-3).

The sulphide minerals are disseminated through a gangue of fine-grained actinolite and calcite and locally are concentrated into nearly massive sulphides. The manto deposits in the showings south of the Merry Widow pit are essentially massive sulphides with almost no skarn minerals present and with sharp contacts against limestone or andesite. Chlorite is sometimes present as an additional minor gangue mineral in some more massive zones. Pyrrhotite is the dominant sulphide mineral, comprising up to 80 per cent of some of the more massive intervals. Other sulphides include chalcopyrite, pyrite, arsenopyrite and cobaltite. Gold is associated mainly with concentrations of arsenopyrite and cobaltite. One particularly high-grade zone observed on the southeast wall of the Merry Widow pit contains visible native gold adhering to euhedral crystals of cobaltite.

ECONOMIC POTENTIAL

More detailed work remains to be done before any estimates of potential copper-gold sulphide reserves can be made. The drilling by Taywin in 1989 has shown, however, that the sulphide mineralization extends continuously over a distance of at least 400 metres through the Merry Widow and Raven pit areas with a trend parallel to the gabbro and andesite-limestone contacts. Most of the drill holes intersected three to four separate sulphide intervals each of which appears quite discontinuous from hole to hole. Total sulphide intersections averaged between 5 and 9 grams per tonne gold and up to 1 per cent copper over total widths of 15 to 30 metres.

The replacement deposits seen at the Bluebird and Marten showings are more irregular in shape and distribution. The largest concentrations of massive sulphide are tabular or lenticular concentrations at the Quatsino-Bonanza disconformity, so far seen as individually no more than a metre thick. Potential ore zones of this style will be more difficult to locate and evaluate although much of the trend remains to be investigated.

ACKNOWLEDGMENTS

The gracious hospitality and assistance on the property by Taywin Resources staff and consultants including Don Graham, Jim Laird and Paul Reynolds is appreciated. Brief but enlightening field discussions with Mohan Vulimiri contributed substantially as well. Thanks also to Shielagh Pfuetzenreuter for assistance in the field and with the preparation of this report.

REFERENCES

Carson, D.J.T. (1973): The Plutonic Rocks of Vancouver Island, British Columbia; *Geological Survey of Canada*, Paper 72-44, 70 pages.

Eastwood, G.E.P. and Merrett, J.E. (1961): Benson River; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Annual Report 1961, pages 95-97.

Ettlinger, A.D. and Ray, G.E. (1989): Precious Metal Enriched Skarns in British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1989-3, pages 56-58.

Jeffery, W.G. (1960): Empire Development Company Limited; *British Columbia Department of Mines and Petroleum Resources*, Annual Report 1960, pages 90-100.

Reynolds, P. and Vulimiri, M.R. (1989): Diamond Drilling Report with Geological Interpretation and Recommendations; *Taywin Resources Limited*, Private Report, 13 pages.

Sangster, D.F. (1969): The Contact Metasomatic Magnetite Deposits of Southwestern British Columbia; *Geological Survey of Canada*, Bulletin 172, pages 63-67.

NOTES

POST-DEPOSITIONAL NUGGET ACCRETION IN CENOZOIC PLACER GOLD DEPOSITS, CARIBOO MINING DISTRICT, BRITISH COLUMBIA (93A, B, G, H)

By N. Eyles
Dept. of Geology, University of Toronto

(Fig. B1, No. 9)

INTRODUCTION

The origin of nugget gold found in Cenozoic placer deposits is of fundamental economic and geologic significance. This paper presents size, morphological and geochemical data regarding the origin of nugget gold in glacial and nonglacial Quaternary sediments of central British Columbia. The study is based on 1636 gold grains collected from 22 locations across the Cariboo mining district, 450 kilometres north of Vancouver. Gold grains, ranging in diameter from 0.25 to 17 millimetres occur within lucrative pay zones contained in relatively recent (< 125 Ka) Quaternary glacial and nonglacial sediments. About 100 000 kilograms of placer gold has been mined in the area since 1858.

Previous work on the origin of the nugget gold in Quaternary Cariboo sediments argues that gold is released by the weathering of lode deposits and is concentrated in the surficial sedimentary environment as detrital particles (Bowman, 1888). Later work identified major discrepancies between the size, internal structure and fineness of placer and lode gold (Uglow and Johnson, 1923; Johnson and Uglow, 1926). A 'supergene' model developed by these workers envisages secondary mobilization of gold during the deep weathering of sulphide-bearing bedrock and the growth of coarse nuggets above the water table; evidence for secondary gold mobilization under a range of climatic conditions was discussed but considered unlikely.

Data from the Cariboo mining district indicate that supergene leaching of gold dispersed within massive sulphides by Tertiary deep weathering followed by Cenozoic erosion is the most likely explanation for the occurrence of coarse gold nuggets in Quaternary sediments. Because of repeated reworking, Cariboo placer gold is dominated by polycyclic grains; no systematic differences in grain size or shape can be distinguished for placers in various sedimentary facies. There is, however, clear evidence of the post-depositional accretion of large 'composite' nuggets under cool temperate conditions. Composite nuggets form about 10 per cent of the total nuggets studied to date and are aggregates of smaller grains welded together by high-grade (Ag = <2%) 'sponge-like' filament gold.

PHYSICAL SETTING AND BEDROCK GEOLOGY OF THE CARIBOO MINING DISTRICT

The Cariboo mining district extends across a dissected plateau on the east margins of the Interior Plateau of Central British Columbia (Figure B-9-1). Heavily forested cool temperate valleys rise to alpine tundra with small glaciers at about 2000 metres above sea level on the flanks of the Cariboo Mountains. The area experiences a high orographic precipitation (100 cm) and periodically formed one of several outflow centres for successive Cordilleran ice sheets that covered Western Canada during the Quaternary (Fulton, 1984). Placer gold was discovered in 1858 and just under 1 million kilograms has been recovered to date from glacial outwash gravels, lodgement tills deposited below the latest Cordilleran ice sheet and postglacial fluvial gravels. Lode gold has been of secondary importance. The mining district lies on the western margin of the Omineca Crystalline Belt, one of the five major tectono-stratigraphic divisions of the Canadian Cordillera. The bedrock geology of the region consists of northwest-trending terranes, each many kilometres wide, bounded by thrust faults and accreted to the western margin of North America during the Mesozoic (Struik, 1988). The so-called Cariboo gold belt, a zone of lode gold occurrences, straddles four terranes: Cariboo, Barkerville, Slide Mountain and Quesnel, each separated by steeply dipping thrusts (Struik, 1986; Figure B-9-2). Placer mining is centred on the communities of Wells and Barkerville and is largely restricted to the Barkerville Terrane (Eyles and Kocsis, 1988a, b, 1989) though several mines are located outside this belt on Quesnel strata (*see* below). Barkerville strata include volcanic tuffs, quartzites, conglomerates and limestones of Proterozoic and Paleozoic age that can be correlated with Kootenay Terrane strata in southeastern British Columbia.

LODE & PLACER GOLD DEPOSITS OF THE CARIBOO MINING DISTRICT

The most productive lode gold occurrences within the Barkerville Terrane occur near the communities of

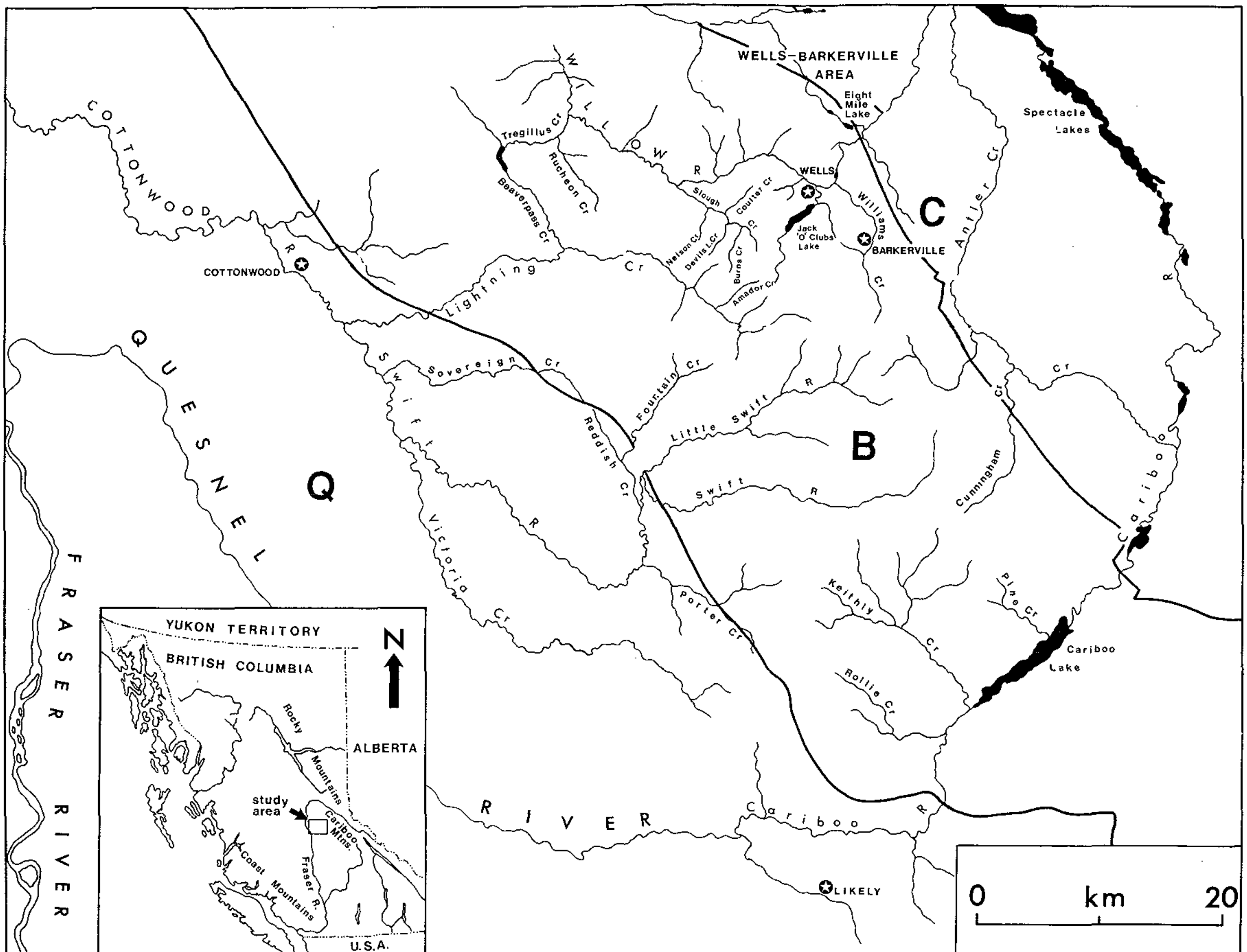


Figure B-9-1. Location of the Cariboo mining district showing Cariboo (B) terranes (*see* Figure 2) and (C) Barkerville .

Wells and Barkerville (Island Mountain, Cariboo Gold Quartz, and Mosquito Creek) at the head of Snowshoe Creek (Midas-Snowshoe vein system) and at Cunningham Creek (Cariboo Hudson), but smaller occurrences are widespread. There is a fairly close geographic association between lode and placer mines. The most productive lodes, centred on Wells and Barkerville, are restricted to the upper part of the Snowshoe Group just below the Permian sugar limestone. These strata comprise variably metamorphosed limestones, tuffs and basalts of the Downey Creek succession; the sedimentology is not well constrained but intercalations of limestone and volcanogenic units suggest a volcanic arc setting with carbonates in shallower water environments on the margins of unstable volcanic cones (Struik, 1988). An Ordovician to Silurian age is suggested for these strata. Placer mines associated with this succession form a northwest-trending belt about 10 kilometres wide centred on Wells and Barkerville (Figure B-9-2).

A stratigraphically-lower unit (Harveys Ridge succession) of Late Cambrian to mid-Ordovician age contains gold-bearing quartz veins and is associated with lode gold mining at the head of Snowshoe Creek (Figure B-9-2). This succession gives rise to another broad belt of placer operations to the west of that identified above, centred along Lightning Creek and along the contact of the Eureka thrust which defines the east margin of the Quesnel Terrane (Figure B-9-2).

Placer gold is also found in economic concentrations within sediments overlying black phyllites of the Quesnel Terrane and the westernmost part of the Barkerville Terrane at Alice Creek, Mary Creek, Lightning Creek and Fontaine Creek (Figure B-9-2). Although the precise relationship between the Triassic black phyllites and placer gold has not been established, lode gold has been identified in pyritic sections of the black phyllite near the confluence of Mary and Norton creeks (T. Toop, personal communication, 1989) and near Alice Creek (R. Schmidt, personal communication, 1989).

The origin of lode gold is better constrained for those occurrences in the principal mining belt at Wells (Sutherland Brown, 1957; Alldrick, 1982; Andrew *et al.*, 1983). Gold occurs principally as a fine coating on replacement sulphides within limestones along northwest-trending hinge zones of regional folds and in northeast-trending, crosscutting quartz veins. The former are thought to have been deposited coevally with low-grade chlorite metamorphism of Downey Creek rocks involving hydrothermal groundwaters and structural traps along fold axes; a Cretaceous age is suggested by Andrew *et al.* (1983). Downey Creek strata showing higher grades of metamorphism are not auriferous. Subsequent fracturing in response to regional stress fields, provided the structural control for crosscutting northeast-trending gold-bearing quartz veins. These veins, consisting of quartz-siderite-ankerite fillings, contain galena, arsenopyrite, pyrite and scheelite; Uglow (1922) and Johnson and Uglow (1926) in the first detailed study of these veins, reported gold values of over 4700 grams per tonne of pure arsenopyrite. Free gold was identified in near-surface parts of the oxidized vein systems but not in unoxidized veins below.

Placer gold in the Cariboo is distinguished by its coarse, nuggety character with nuggets up to 1 kilogram and fineness values between 775 and 950. "Rimmed" grains showing bright gold extremities and delicate crystalline gold forms such as dodecahedrons are common. Knight and McTaggart (1986) showed that Cariboo gold contains low values of natural mercury (below microprobe detection limits) and on this basis can be distinguished from placer gold of the Bridge River, Yalakom and Bralorne placer districts along the Fraser River to the south.

The first exhaustive study of the relationship between vein systems and placer operations in the Cariboo mining district was that of Bowman (1888). The first part of his report described lode gold operations but the second part, consisting of detailed descriptions of the placer operations was unfortunately never published. Bowman argued that Cariboo placer gold was entirely detrital in origin having been released into the surficial sedimentary environment largely as is, by the mechanical weathering of lode gold contained in vein systems. Uglow (1922) and Johnson and Uglow (1926) showed that the size, quantity and fineness of placer gold was incompatible with this simple model and instead argued for deep Tertiary weathering of disseminated sulphides and supergene enrichment close to the watertable at the base of the oxidized zone. They pointed out the presence of delicate gold forms such as dodecahedrons, octahedrons and cubes, together with arborescent and filament forms, which they argued were the result of secondary reprecipitation of gold. They argued that nuggets were composed of crystalline gold and had formed by gradual accretion, owing their irregular outline to the shape of the cavities in which they had accumulated (Johnson and Uglow, 1926, page 224). Gold was subsequently released by erosion into the sedimentary environment as a result of Cenozoic uplift and dissection of the deeply weathered plateau. These workers argued that modern accretion processes and secondary gold mobility in Quaternary sediments had been of little importance in generating nugget gold. A similar 'supergene' model was invoked by Lay (1941) for the small, locally-developed placers along the Fraser River some 80 kilometres west of the Cariboo mining district. Johnson and Uglow (1926) identified rims of bright gold, depleted in silver, on the margins of nuggets which they interpreted as evidence of leaching of silver during surficial transport; a model widely employed to explain the enhanced fineness in placer gold compared

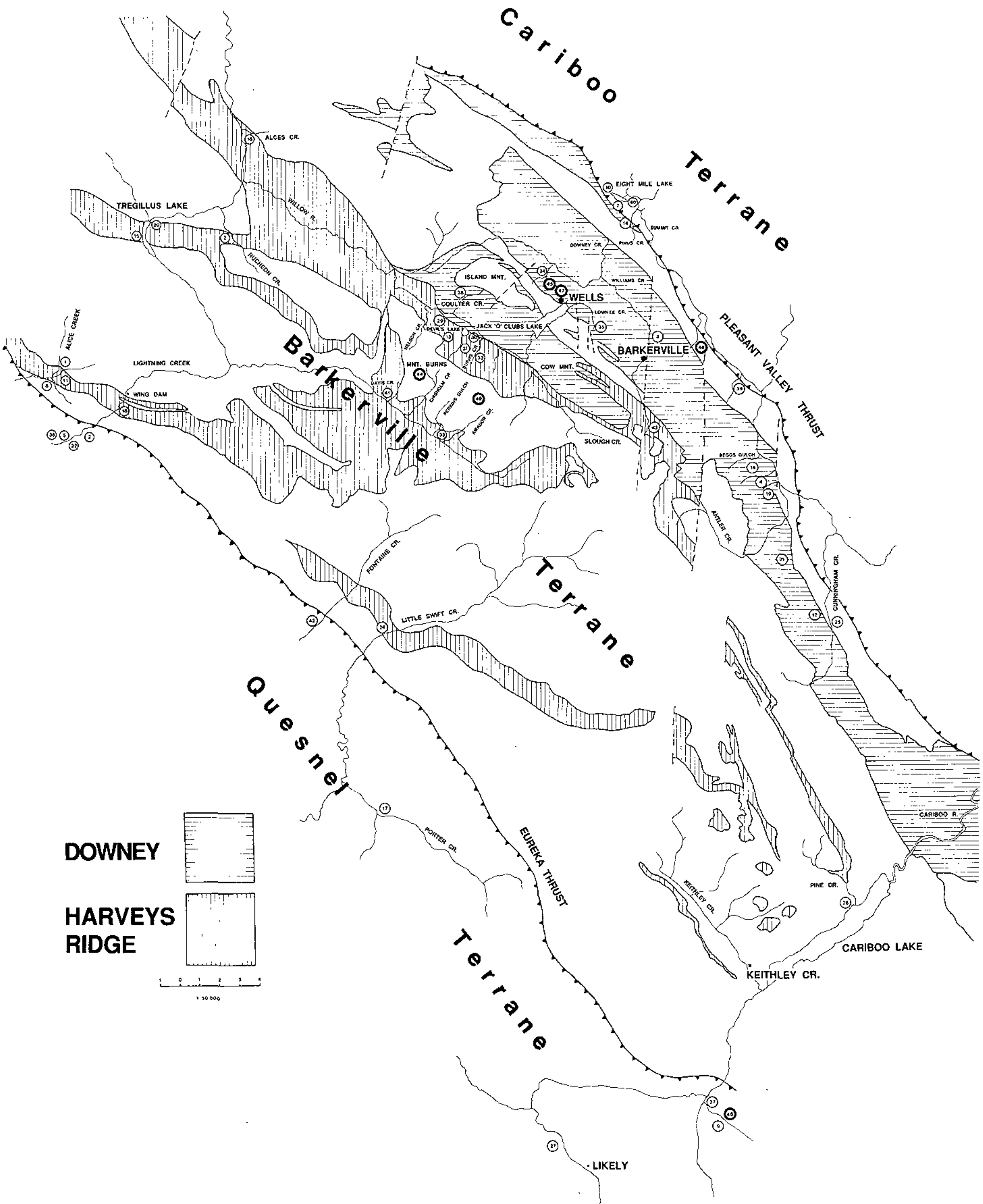


Figure B-9-2. Cariboo mining district showing location of 43 placer mines studied to date (*see* Eyles and Kocsis, 1989; Table B-9-1) and principal lode gold bearing strata of the Downey and Harveys Ridge successions. *See* Table B-9-2 for placer gold sample localities. Sites 44 to 9 inclusive are lode gold sample sites (Table B-9-2). Bedrock map after Struik (1988).

with lode gold (*e.g.* McConnell, 1905; Fisher, 1945; Knight and McTaggart, 1986).

The results of the work outlined in this report agree substantially with the model for placer gold developed by Johnson and Uglow whereby crystalline nugget gold is concentrated into surficial sediments as a result of the Cenozoic erosion of deeply weathered, supergene-enriched bedrock in which gold nuggets had formed by accretion. The present study differs from earlier work in being able to clearly demonstrate that coarse, nuggety gold has also been generated by the welding together of smaller crystals or grains by high-grade filamentous spongy gold. Gold is mobile under the present day cool-temperate climate of the Cariboo and morphological and geochemical evidence identifies the postdepositional accretion of coarse nuggets in the Quaternary sediments of the area.

AGE AND STRATIGRAPHY OF CARIBOO PLACER DEPOSITS

The detailed sedimentology of gold pay zones contained in Late Pleistocene sediments has been described by Eyles and Kocsis (1989) and this work is briefly reviewed here as a basis for geochemical work. Three principal pay zones characterize the Cariboo placer deposits and form a stratigraphic 'sandwich' characterized by: (a) lower fluvial gravels, (b) a middle till unit recording maximum regional extent of the Cordilleran ice sheet between 30 000 and 10 000 B.P. (Fraser glaciation) and (c) uppermost postglacial fluvial gravels and alluvial fan deposits. **Older gravels** attain considerable thicknesses along valley floors and record cool to glacial climatic conditions from at least 50 000 B.P. to the onset of the Late Wisconsin Fraser glaciation; they may have begun to accumulate much earlier, perhaps as early as 125 000 B.P.. Older stratigraphic units have not been found and it is apparent that pre-exisiting Pleistocene sediments have been eroded and reworked; the richest pay zones therefore occur toward the base of the older fluvial sequence on the bedrock surface. Older gravels comprise massive, poorly stratified and coarse-grained deposits of braided rivers and show gold grades up to 8.18 grams per cubic metre. Overlying glacial pay zones are contained within 'Fraser' **lodgement tills** which are grey coloured, heavily overconsolidated diamict units deposited by the progressive 'smearing' of englacial debris at the base of the ice sheet against a rough substrate. The tills are up to 20 metres thick and commonly contain intraformational gravel bodies, elongated in the direction of ice flow, deposited by subglacial meltstreams; these are particularly lucrative gold targets. Other subglacially formed placers also record the natural sluicing action of high-pressure meltwaters under the ice sheet. These comprise meltwater-cut notches on bedrock ('gutters') and 'tails' of coarse-grained bouldery talus deposited in waterlogged subglacial cavities down-ice of bedrock highs.

Finally, **postglacial** rivers, repeatedly migrating across the valley floors have reworked large volumes of pre-existing sediments and form local economic deposits.

SAMPLE SITES

Complete suits of gold grains, recovered by commercial wash plants, were examined from 22 placer mines (Table B-9-2). These operations are located on bedrock strata belonging to the Downey succession and Harveys Ridge succession of the Barkerville Terrane and as-

TABLE B-9-1

PLACER MINES STUDIED TO DATE AS PART OF ONGOING SEDIMENTOLOGICAL AND STRATIGRAPHIC STUDY. FOR LOCATION *SEE* FIGURE B-9-2.

Alice Creek	1
Larsens Gulch: Rucheon Creek	2
Williams Creek Ballarat	3
California Gulch	4
Lightning Creek (Lookout Point)	5
Grouse Creek (Heron Channel)	6
Eight Mile Lake (lake bottom)	7
Mary Creek (Troop 'A')	8
Spanish Mountain	9
Eight Mile Lake (west side of lake)	10
Mary Creek (Troope 'B')	11
Cunningham Creek (McPherson)	12
Mount Nelson (Werner)	13
Pinus Creek (Hatton)	14
Tregillus Lake (Quesnel Ready-mix)	15
Alces Creek	16
Porter Creek	17
Lightning Creek (Romano)	18
Wolfe Creek	19
Tregillus Lake (northeast corner)	20
Nugget Gulch hydraulic pit	21
Lightning Creek (west of Mousitique Creek)	22
Soverign Creek (Allen)	23
Little Swift River	24
Cunningham Creek (Van Halderen)	25
Pine Creek	26
Bullion Pit	27
Coulter Creek	28
Point Bench	29
Ketch Bench along Slough Creek	30
Devils Lake Creek (Mount Burns)	31
Burns Creek (Bjornson)	32
Fosters Ledge (Mount Burns)	33
Mosquito Creek (Drinkwater)	34
Lowhee Creek	35
Coldspring House	36
Spanish Creek	37
Antler Creek	38
Maude Creek	39
Summit Creek; Nestle mine	40
Davis Creek	41
Fontaine Creek	42
Williams Creek, Richfield	43

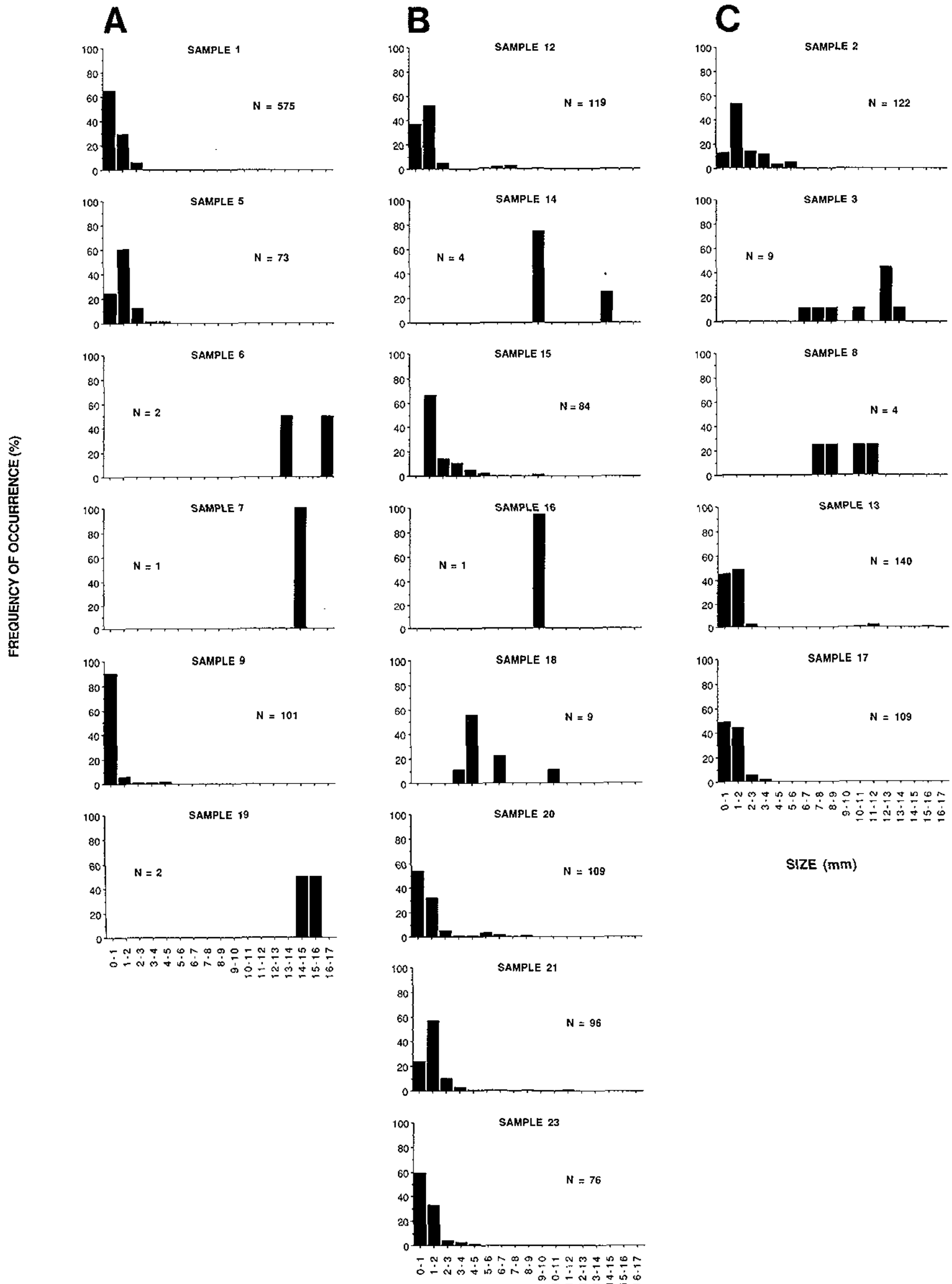


Figure B-9-3. Placer gold grain-size. Size frequency histograms for 1636 gold grains recovered from older gravels (a) lodgement tills (b) and postglacial gravels (c) see text for details.

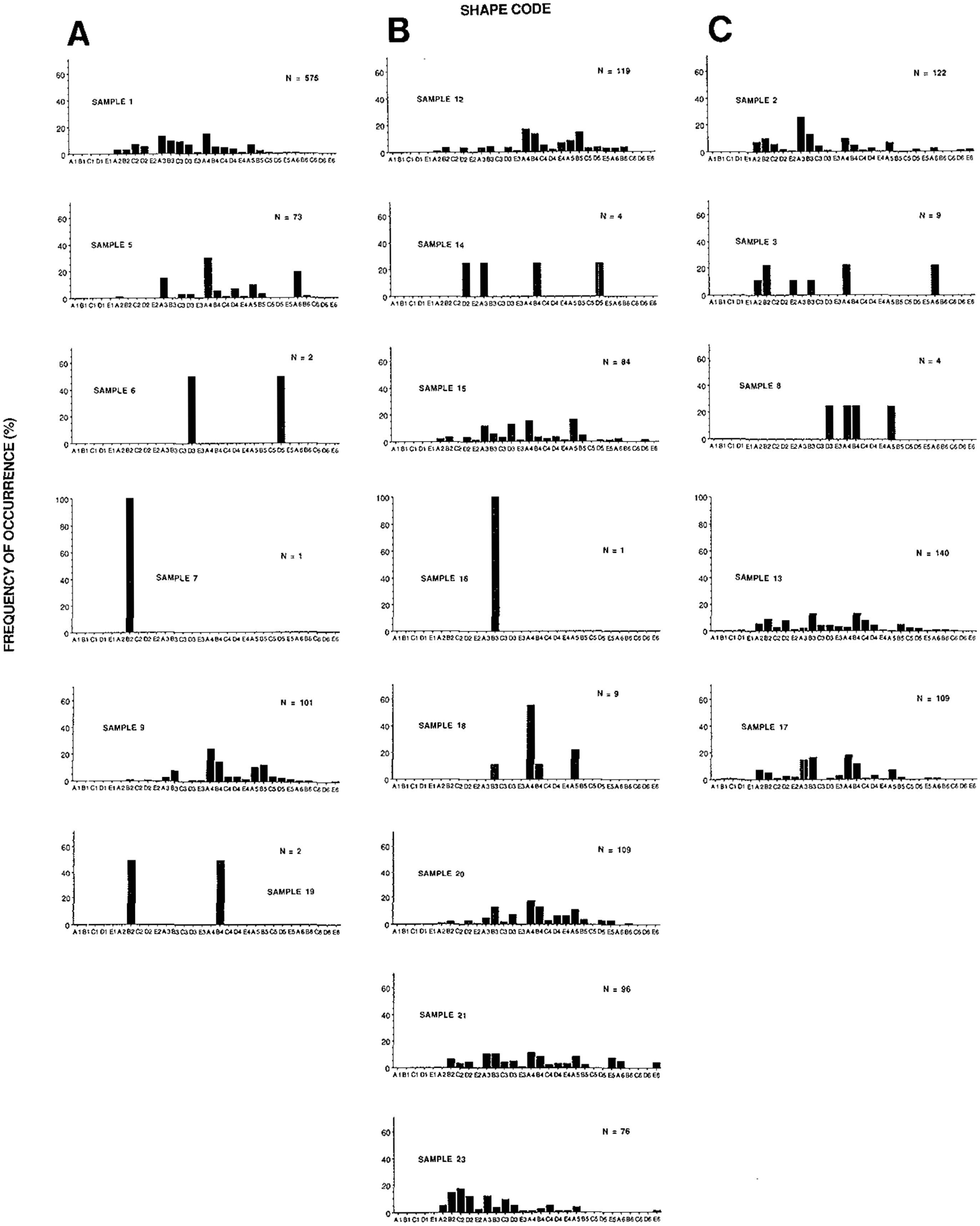


Figure B-9-4. Placer gold shape. Roundness and sphericity classes for 1636 gold grains recovered from older gravels (a) lodgement tills (b) and postglacial gravels (c) *see* Figure B-9-5.

sociated strata of the adjacent Eureka Terrane (Figure B-9-2). The sites include seven new placer sites (36-43; Table B-9-1, 2; Figure B-9-2) not documented by Eyles and Kocsis (1989) in their sedimentological study of Cariboo placers (Sites 1-35; Table B-9-1, Figure B-9-2). In addition six samples (44-49 inclusive) were collected from vein and lode gold localities on Barkerville and Eureka strata (Table B-9-3; Figure B-9-2). Table B-9-2 identifies the nature of the pay zone, whether older fluvial gravels (a) lodgement till (b) or postglacial gravels (c) for the 22 placer mines sampled. Considerable care was taken at each site to ensure that mercury released from previous recovery operations was not present (*see* below).

TABLE B-9-2

SAMPLE LOCATIONS FOR PLACER GOLD GRAINS
[Recovery methods: (1) conventional sluice, (2) trommel, (3) jig or shaker table]

A	**OLDER GRAVELS**	
(2)	Larsens Gulch; Rucheon Creek	1
(1)	Alice Creek	1, 2, 3
(3)	Williams Creek; Ballarat mine	1, 2
(4)	California Gulch	1, 3
(9)	Beach Point mine; Spanish Mountain	1, 2, 3
(11)	Mary Creek, Troop 'B' Mine	1, 2
(27)	Bullion mine	1, 2, 3
B	**TILL**	
(12)	Cunningham Creek;	
(13)	Devils Lake Creek; Streicek mine	1, 2
(14)	Pinus Creek	1
(38)	Antler Creek; Beggs Gulch	1, 2
(39)	Maude Creek	1, 2
(29)	Nelson Creek; Point Bench mine	1
(41)	Davis Creek	1
(43)	Williams Creek, Richfield	1
(3)	Williams Creek, Ballarat mine	1, 2
C	**POSTGLACIAL FAN & FLUVIAL GRAVELS**	
(16)	Alces Creek	1
(18)	Wingdam; Lightning Creek	
(36)	Coldspring House; Lightning Creek	1, 3
(37)	Spanish Creek	1, 2, 3
(40)	Summit Creek; Nestle mine	1, 2
(42)	Fontaine Creek	1, 2

Placer Gold Recovery and Grain-Size Distributions

Gold grains used in this study were collected using three main methods: two being conventional sluice systems which recover coarse gold and trommels which recover fine gold. Most operations employ a combination of a sluice box and a trommel. A sluice system consists of a sluice box with interior riffles combined with expanded metal mesh overlying a nylon carpet. This system is efficient at trapping relatively coarse gold (0.25 millimetre) and is normally combined with a 'grizzly' screen at the hopper which removes outsize boulders and larger nuggets. This system is most often used in combination with a trommel which consists of a drum with interior baffles, rotating at high speed (600 rpm). The trommel is commonly set up at the end of a sluice system in order to recover fine gold contained in the sand-size fraction. The third technique, a jig or shaker table, is also efficient at recovering fine gold. The jig consists of a steel sluice that is moved up and down by a cam. The feed enters the head of the sluice box and moves as a traction carpet over packed, steel ball bearings. Fine gold works its way down through the bearings, through a fine-mesh screen and is collected by a drain-hole at the base of the jig. Table B-9-2 lists the recovery method used at each sample site.

TABLE B-9-3
SAMPLE SITES FOR LODE GOLD

(48) Spanish Mountain; quartz-gold vein in black Triassic phyllites of Quesnel Terrane
(49) Burns Mountain; vein gold in Eaglesnest succession of Snowshoe Group
(44) Mount Nelson, Oregon Gulch. Quartz and base metal vein assemblages in Eaglesnest succession of Snowshoe Group
(45) Island Mountain; massive pyrite from Aurum limestone of Downey Creek Succession from Jukes adit (4000' level) in Island Mountain mine (Barkerville Terrane)
(46) Mount Conklin, French Creek; massive pyrite in phyllites of Hardscrabble Mountain succession
(47) Mosquito Creek; quartz and base metal vein assemblages of Downey Creek succession in Mosquito Creek mine (3-220 stope)

The total population (N) of gold grains used in this paper is 1636 with a maximum nugget size of 17 millimetres and a minimum grain size of 0.25 millimetre. The number of grains recovered at each placer operation (n) varies considerably as a function of the number of grains in the sediment and the efficiency of the commercial sluicing operation. Many samples consist of a few coarse nuggets, others show much fine gold less than 0.25 millimetre in size. The grain-size distribution was estimated for each sample by use of a low-powered binocular microscope and gridded paper. These data are plotted as size-frequency histograms on Figure B-9-3. Because of the severe limitations on the quality of the data they are interpreted in a qualitative sense only. The data serve as a general guide to the relative proportions of coarse and fine gold recovered at each site. No clear relationship between grain size frequency and parent sediment can be identified.

Analysis of Grain Shape

Grains were examined under a low-power stereo microscope and the overall shape of each gold particle was described by assigning grains to one of 24 categories of roundness and sphericity based on the published chart

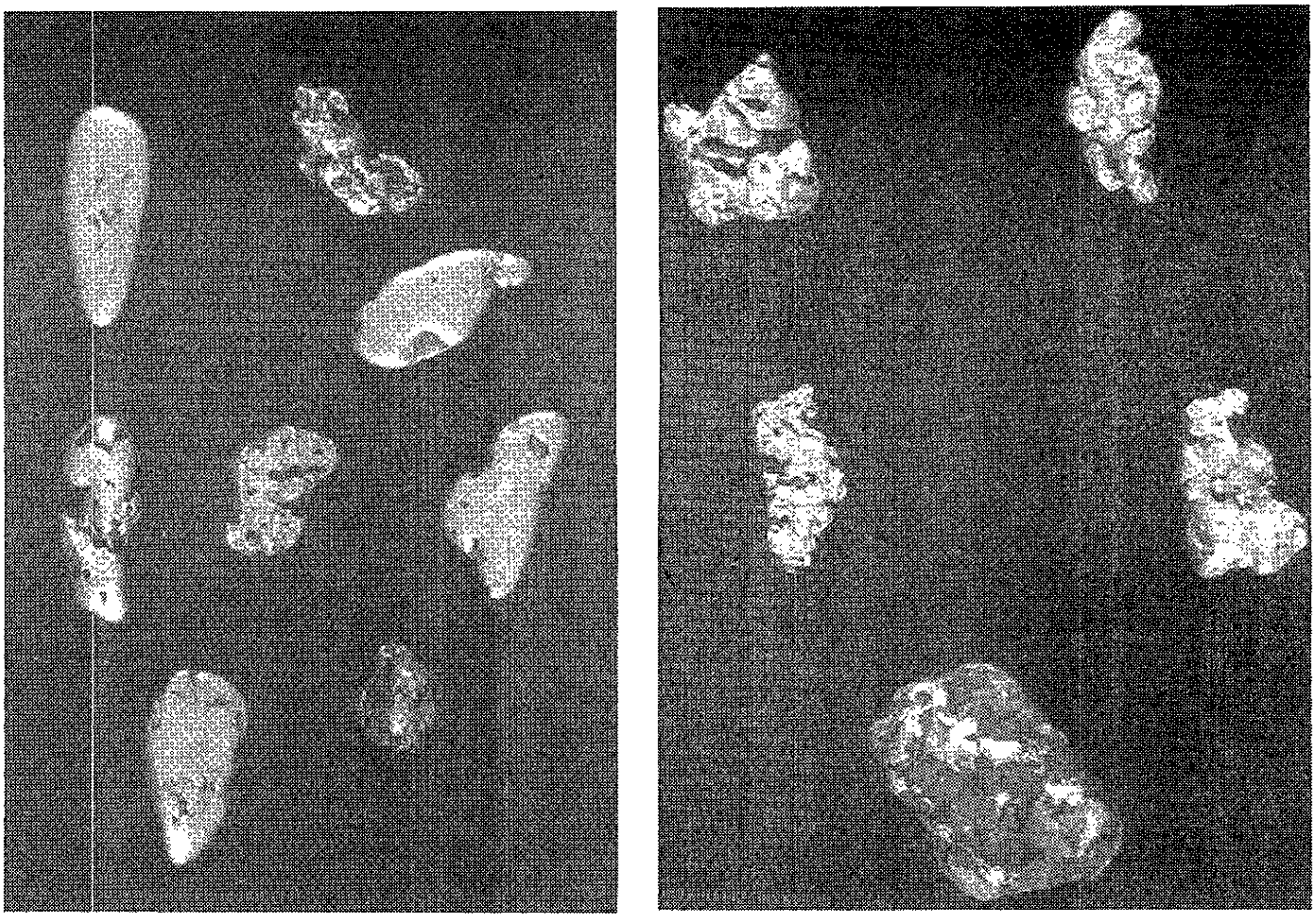


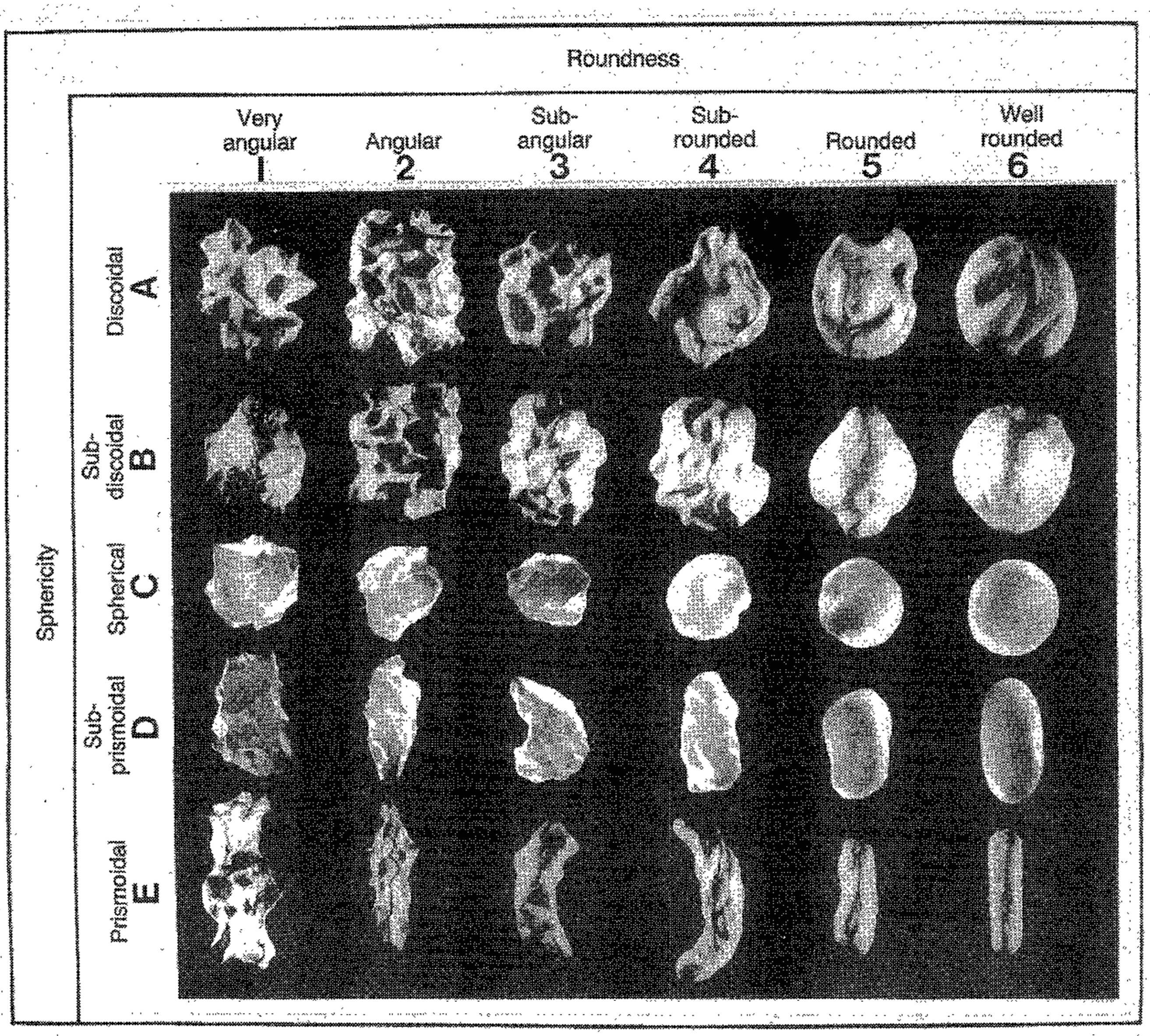
Plate B-9-1. Typical nuggets from (a) older gravels (Site 3) and (b) lodgement till. Note presence of Stage V 'melon-seed' nuggets in (a) and composite angular Stage I grains in (b). Scale in centimetres. Gold occurs with quartz in the lowermost nugget in b.

of Powers (1982) (Figures B-9-4, 5). Values of sphericity were assigned a letter code (A-E) and roundness categories were represented by numbers (1-6) such that the shape of any one grain is given by a simple code, *e.g.* A3 or B1 *etc*. The frequency of these shape classes within samples is depicted in Figure B-9-4 and discussed below.

Because of the long history of reworking of auriferous Quaternary sediments during repeated glaciation and interglacial environments Cariboo placer gold is dominated by polycyclic grains. Discrimination between gold grains present within the different pay zones is not possible though there are important exceptions. Systematic differences in grain shape cannot be clearly distinguished between grains from postglacial gravels, lodgement till and older fluvial gravels (Figure B-9-4). With regard to the entire gold-grain population, discoidal and subdiscoidal grains predominate (sphericity classes, A, B respectively; Figure B-9-4) with angular subangular and subrounded roundness classes being most common (roundness classes 2, 3, 4 respectively; Figure B-9-4). Very angular grains (Class 1) are not present but well-rounded shapes (Class 6) are represented by 'pumpkin-seed' grains (Plate B-9-1a, b) that are only rarely present in younger pay zones. Discoidal and subdiscoidal gold grains having subangular to rounded forms (*e.g.* classes A3, B3, A4, B4, A5, B5) are most common in lodgement tills probably in response to grain flattening as a result of high shear stresses during subglacial transport and deposition. Postglacial and older fluvial gravels show a wide variation in grain type with a tendency for angular (roundness class 2) grains to be better represented in alluvial fan gravels.

SCANNING ELECTRON MICROSCOPY

More detailed resolution of grain shape and origin is possible using a scanning electron microscope. Grains were placed on standard mounting stubs using a silver cement and examined under a Hitachi S-530 SEM unit at magnifications up to 400x. This work shows that many angular grains (roundness class 2; Figure B-9-4) are composite and result from the aggregation of smaller gold particles and crystals. A distinct evolution of grain shapes is apparent irregardless of parent pay zone, from angular, high-sphericity aggregates consisting of small grains partially welded together at grain boundaries (Stage I; Figure B-9-5) through subangular fused aggregates where grains are almost completely welded together (Stage II; Figure B-9-5) through smoothed lower sphericity grains, where



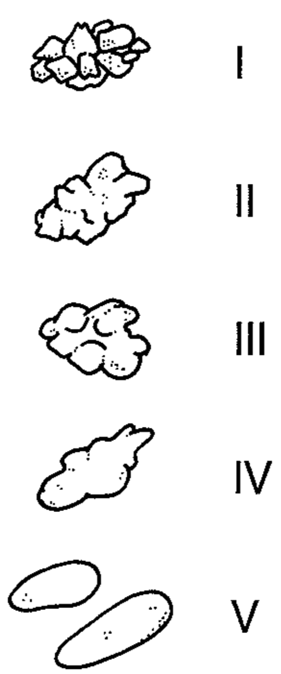


Figure B-9-5. (a) Roundness and sphericity classes used in this study, from Powers (1982). (b) Simple model for grain shape evolution from composite grains.

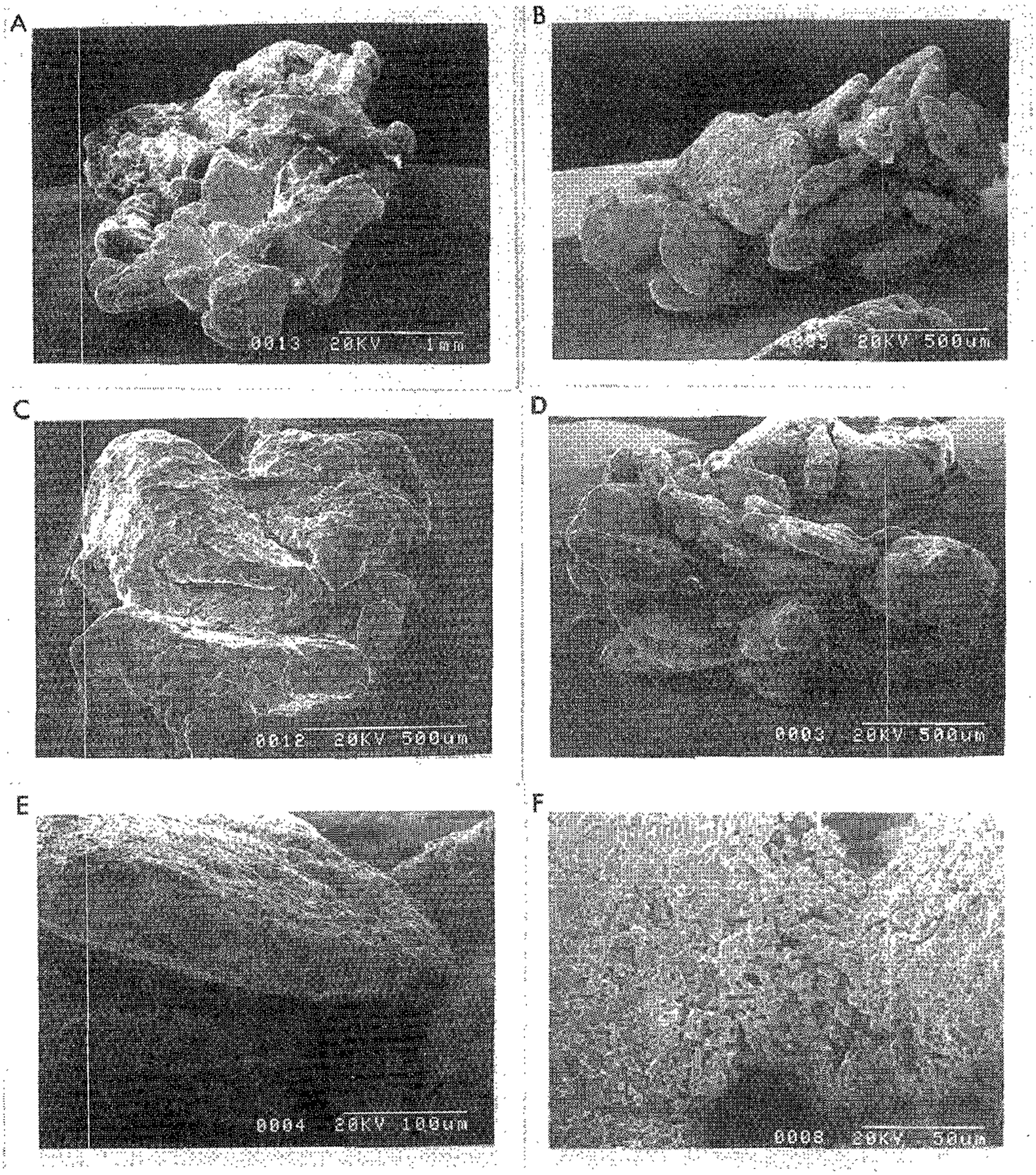


Plate B-9-2. SEM microphotographs of composite, Stage I gold grains. (A) Aggregate of small grains showing flat, weathered crystal faces. Site 20. (B, C, D) Aggregates of discoidal particles, Site 17. (E, F) Pure gold 'welds' joining gold particles identified in (C) above.

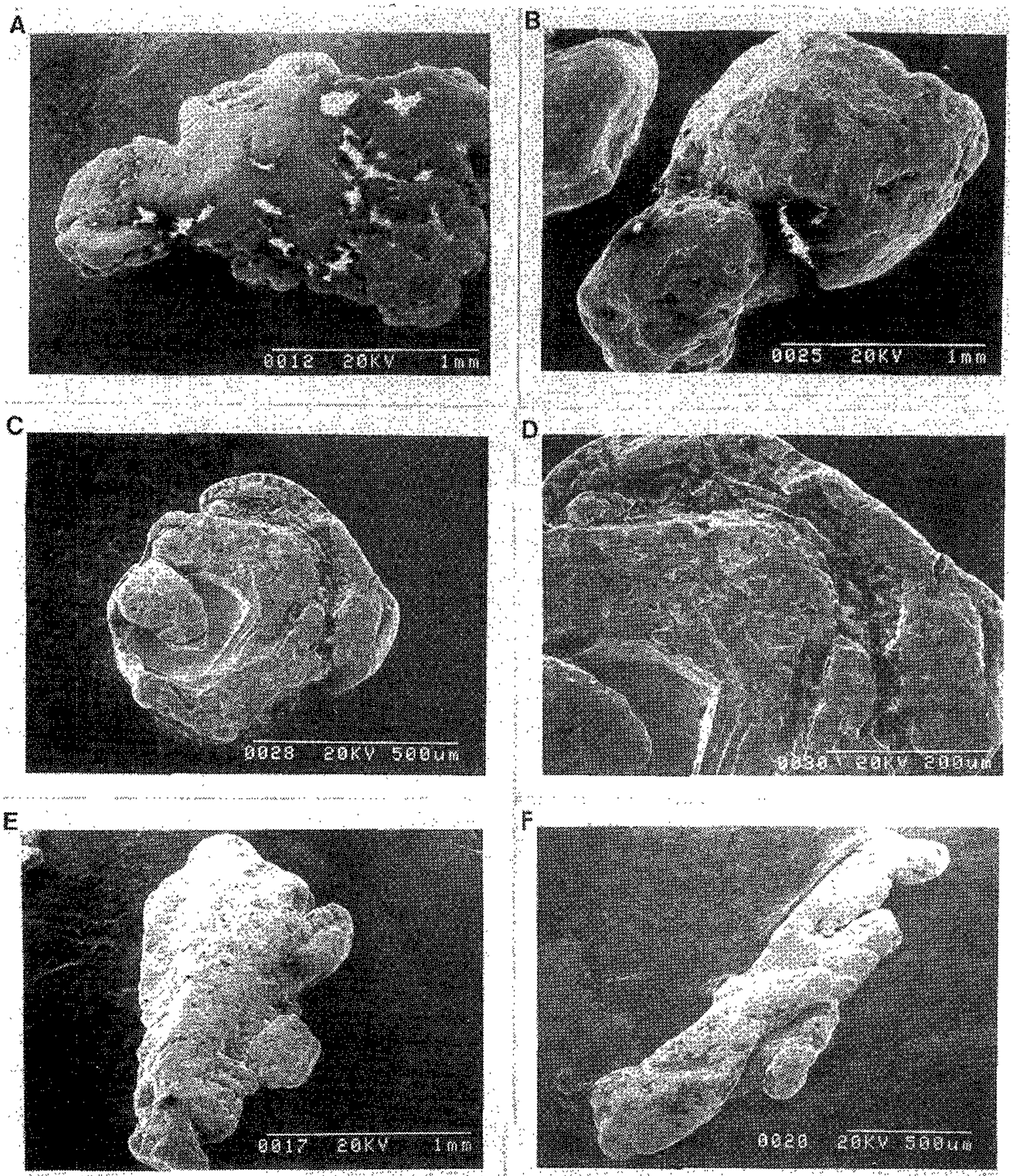


Plate B-9-3. (A, B) Composite Stage II grains where surface wear has partially obliterated evidence for aggregation; a B Site 13, 9 respectively. (C) Small particle adhering to left-central margin of grain with larger particle attached at top right; magnified in (D), Site 9. (E, F) Composite grains, Stage III showing enhanced surface roundness (Site 17). Note in (F) lower half of grain folded over onto upper part of grain.

grain rounding and abrasion has occurred and where evidence for a composite origin is obscured, through increasingly rounded and flattened grains (Stage III; Figure B-9-5) to well-rounded, elongated disc-shaped 'melon-seed' grains (Stage IV; Figure B-9-5).

As identified by binocular microscopy and visual classification of grain shape there is an overall tendency for greater numbers of angular, composite nuggets (Stage I; Figures B-9-5 and Plate B-9-2) to occur in postglacial gravels. Eyles and Kocsis (1989) briefly noted the presence of large numbers of highly angular grains in recent valleyside fan deposits from Spanish Creek. These distinctive grains occur rarely in lodgement tills and in older gravel deposits. The latter instead contain a higher frequency of smoothed 'melon-seed' nuggets consistent with a long and complex history of fluvial transport. Experimental laboratory studies of gold grain evolution during river transport, together with field observations, have shown that gold particles commonly evolve into smoothed flakes that can be more easily transported compared with rounded particles of the same weight (Yeend, 1975; Kolesov, 1975; Hallbauer and Utter, 1977). 'Melon-seed' grains found within the older gravel placer deposits are identified as a mature morphological grain with the composite, aggregate grains representing a youthful stage (Plate B-9-1a, b). High sphericity, well-rounded grains result from repeated rolling (Tishenko, 1981) and again, may represent 'mature' forms.

Primary, angular grains made up of grain aggregates show meniscus-like cements of lace-like gold along grain-to-grain contacts (Plate B-9-2). This 'new gold' records the welding together by secondary gold solutions of concentrates of gold crystals and irregular gold particles (*see* below). This is important evidence for the formation of coarse nuggets by the sintering of smaller gold particles within Quaternary sediments.

INTERNAL STRUCTURE AND GEOCHEMISTRY OF GOLD GRAINS

Polished sections through composite gold nuggets show that the meniscus-like welds between individual grains shown in Plate B-9-2 are sponge-like, honeycombed gold (Plates B-9-6, 7). Honeycomb gold is particularly evident on polished grains etched in a solution of 3 per cent ammonium persulphate and 3 per cent potassium cyanide in water, neutralized by ferrous sulphate. This very distinctive gold type occurs at grain boundaries within nuggets (Plate B-9-7) and is present as a distinct 'invasive' form within internal pore spaces (Plate B-9-6). This gold has a filamentous structure often with a consistent preferred orientation to the filaments.

Detailed microprobe investigations using E.T.E.C. energy dispersive, and CAMEBAX SX-50 energy and wave-dispersive microprobes show honeycomb gold, present as surface 'welds' between gold grains, as having a silver content of less than 2 per cent and in many cases pure gold. Plate B-9-7 is a backscattered scanning electron and microphotographs of the same polished and carbon-coated gold grain as in Plate B-9-6. Plate B-9-7 shows the changing content of gold and silver across this zone ranging from gold with silver contents of around 15 per cent to less than 2 per cent within the zones of filamentous gold. This pattern is repeated on other grains and demonstrates that the 'welds' between gold particles in angular composite grains are composed of secondary high-grade gold different from the adjacent gold particles. Many gold grains show internal pore spaces completely or partially filled with high-grade honeycomb gold; these are interpreted as the remnants of voids produced as 'abutment cavities' between original grains (Plate B-9-7).

Sections through Stage II and all other remaining types of grains, with their evidence of extended abrasion, show either a well-developed coarse crystalline structure (Plate B-9-10) or an irregular structure composed of juxtaposed gold grains where crystal facies can be less well identified and where there is considerable internal pore space (Plates B-9-5, 6, 7, 8, 9). A coarse-crystalline texture is best developed in grains of high roundness values (Stages III, IV; Plates B-9-4, 10) that have undergone considerable modification by abrasion and impact during transport. This texture is identified as a 'metamorphic' structure produced by the repeated hammering of gold during transport at low temperatures (Giusti, 1986). This texture progressively evolves during transport in the surficial environment and may replace any original primary texture. Fractures along grain boundaries can be identified in many grains. This can lead to the breakup of large grains with the production of loose gold 'crystals' (*see* below).

Most grains show partial or complete patinas of pure gold up to 0.5 millimetre thick (Plates B-9-6, 8, 9, 10). Rimmed grains are widely reported from Cenozoic placers and result from progressive leaching of silver from grain surfaces and the development of a chemically resistant, protective gold rim of high fineness. Rims are absent from projecting areas subject to repeated abrasion; gold is remobilized and reprecipitated in more sheltered areas of the grain surface. *In situ* leaching of silver is a widely invoked mechanism used to explain, the progressive development of high fineness placer gold from lower fineness lode gold (Fisher, 1945). The repeated bending of rimmed gold particles results in incorporation of rim gold into the nugget (*see* Giusti, 1986 and Figures).

ORIGIN OF GOLD IN CENOZOIC PLACER DEPOSITS

The evidence presented above demonstrates that coarse nugget gold found in Cariboo placers has

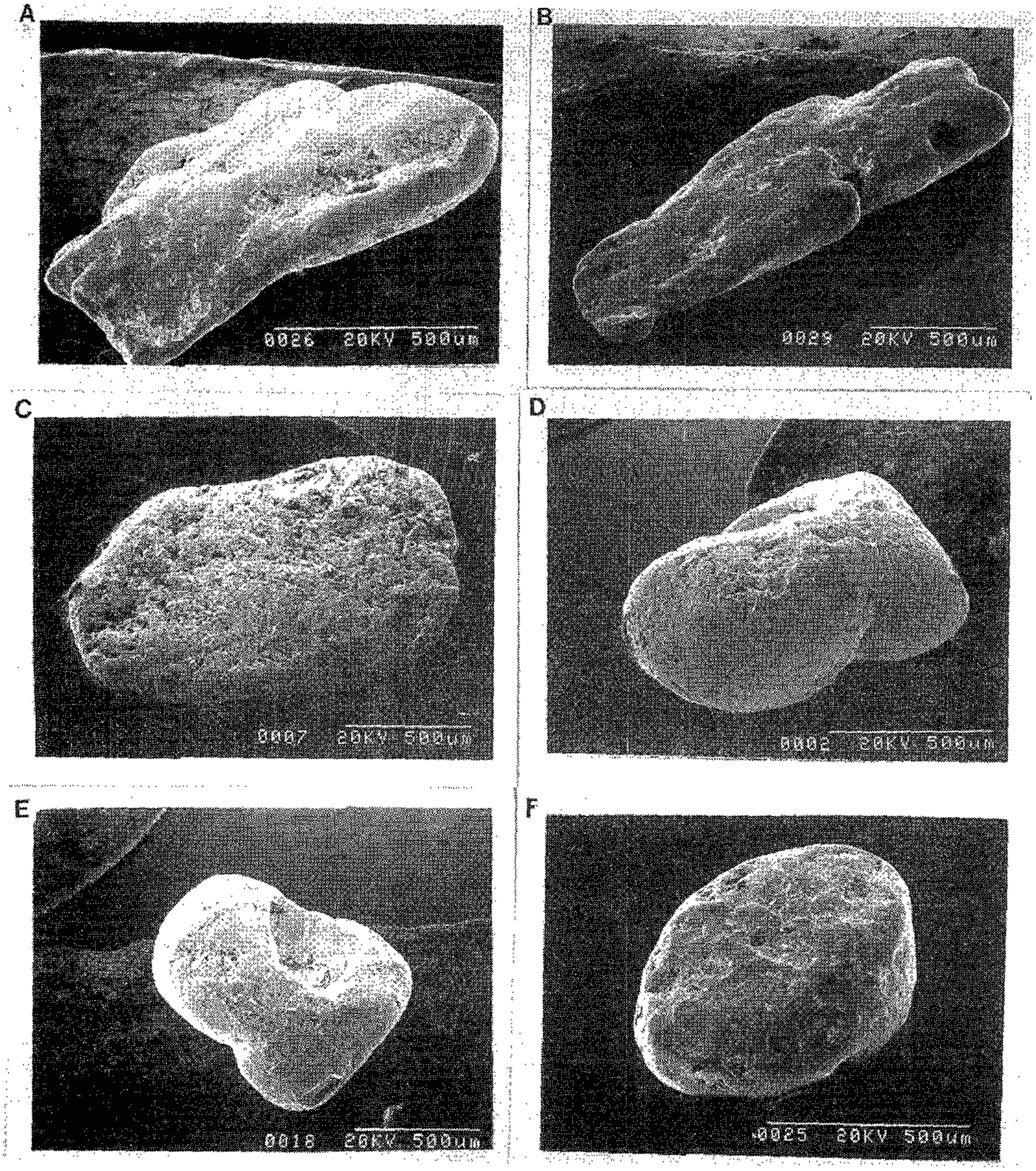


Plate B-9-4. (A, B) Stage IV grains; Site 12. (C, D, E, F) Rounded Stage V grains.

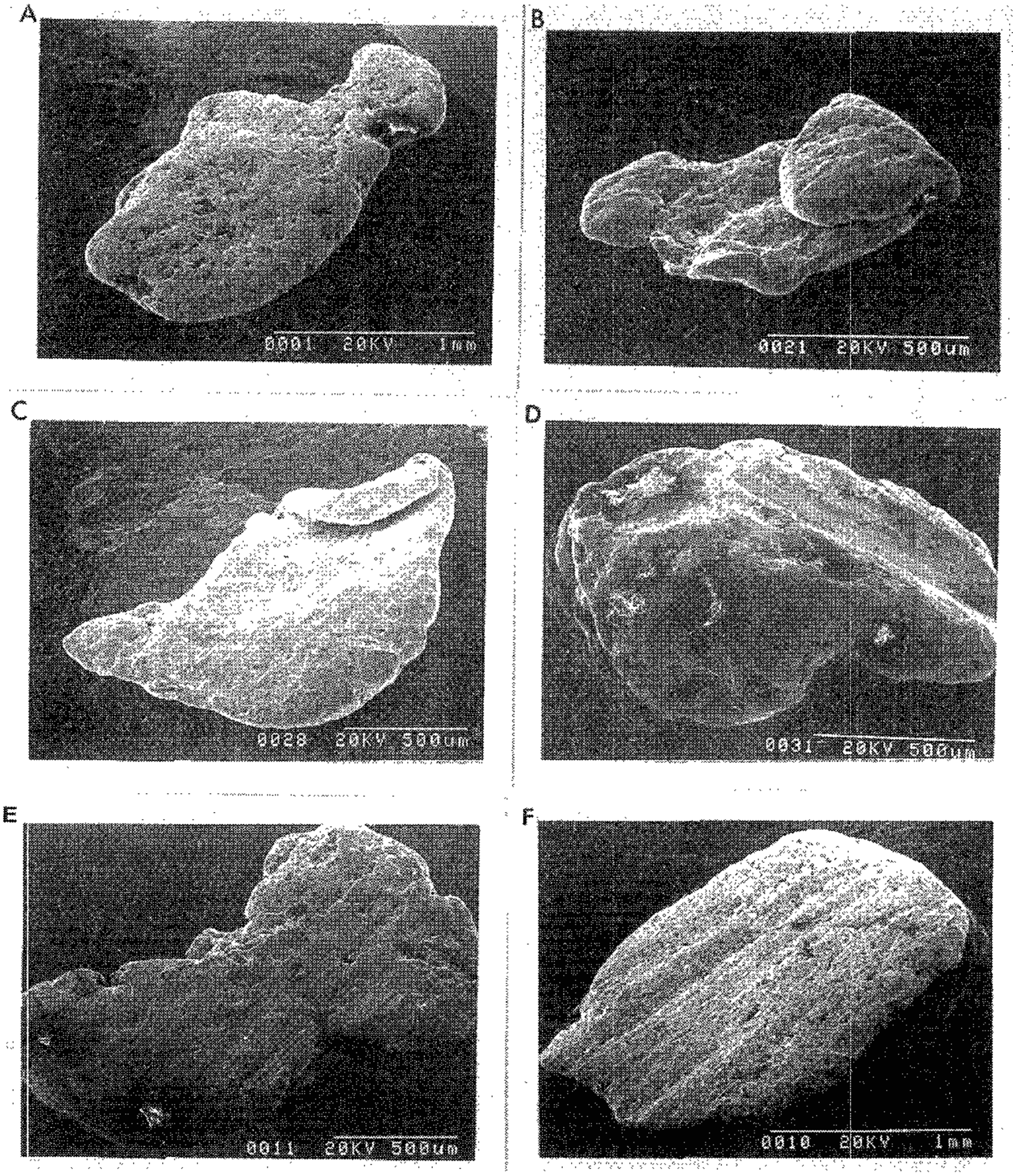


Plate B-9-5. Surface-wear patterns on gold grains. (A, B, C) 'Necking' and folding (Sites 13, 9, 12 respectively). (D) Gouging (Site 9). (E, F) Striations (Sites 17, 20 respectively).

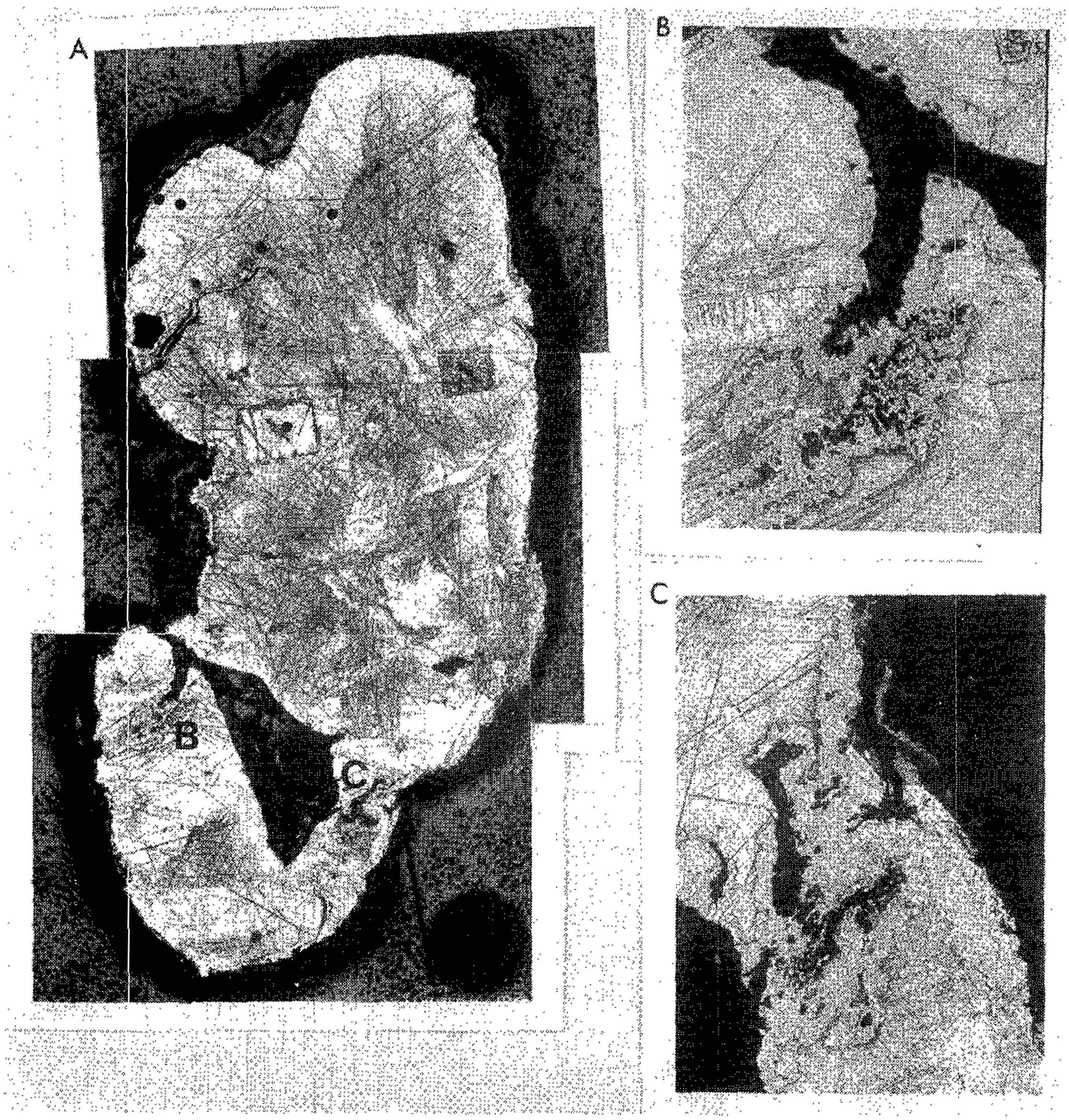


Plate B-9-6. (A) Mosaic of etched section of composite Stage II grain (A, Figure 7) at 5x magnification. Microprobe sample sites shown by black circles (*see* Figure B-9-1). Site 20. Rim is of pure gold, internal gold has 14 per cent silver. (B, C) Close ups (x20) of sites marked (B), (C) on a above showing filamentous high-grade gold weld. (C) Demarcates interior pore space shown on Figure B-9-12.

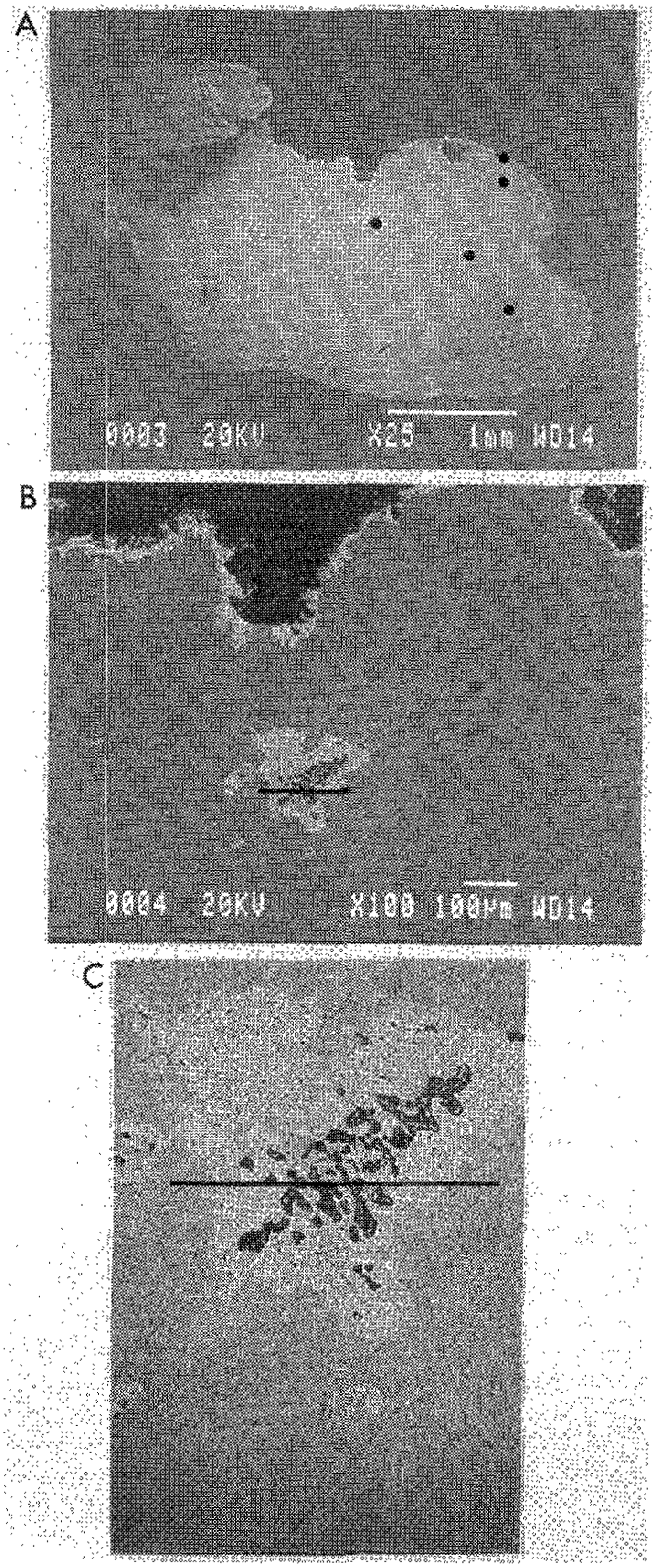


Plate B-9-7. (A, B) Backscattered electron microphotograph of same grain as in Plate B-9-6(A) showing microprobe points. Internal sites show silver contents up to 15 per cent. Rim and filamentous gold in pore space are pure gold. (C) Close-up of pore space and filamentous gold. Line shows path of probe analyses.

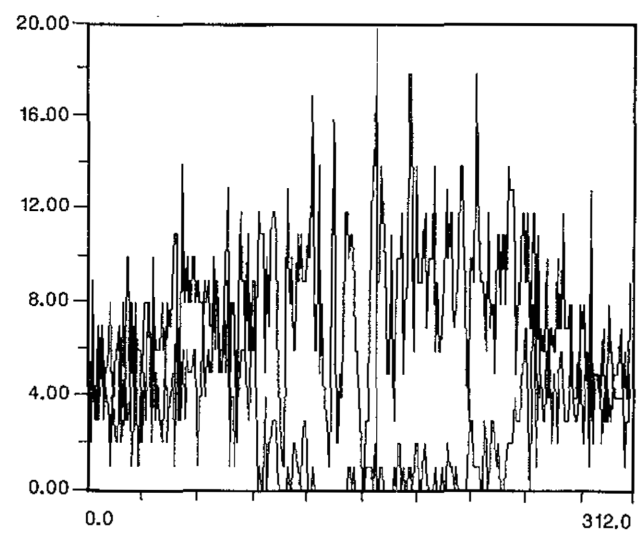
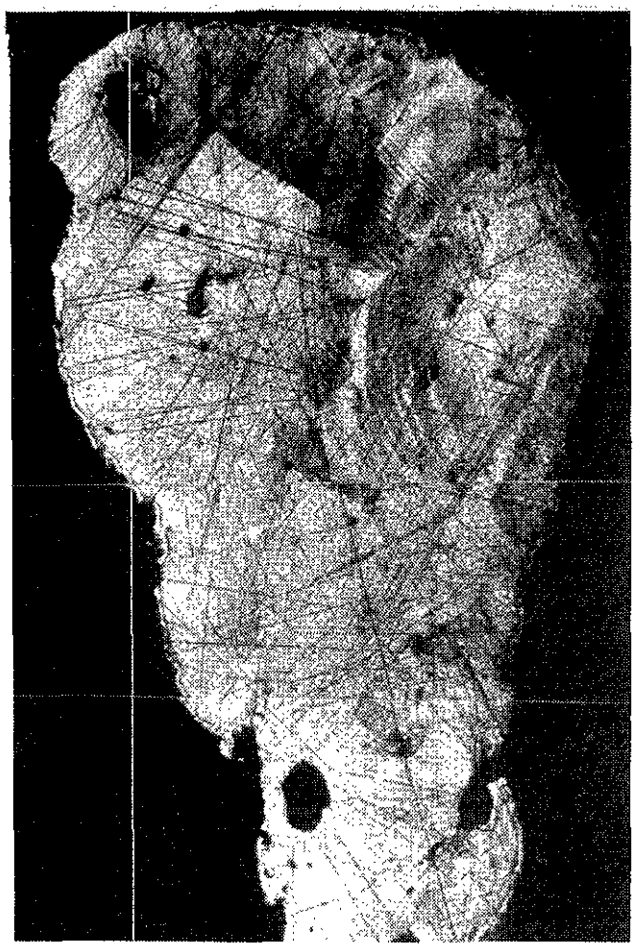


Figure B-9-6. Spectral diagram showing variation in gold and silver content across pore space (C) on Plate B-9-7. Lower line in central portion is silver, upper is gold. Note decrease in silver content (up to 2%) across filamentous gold filling pore space. Gold outside pore space contains 15 per cent silver.

A



B

Plate B-9-8. (A) Mosaic of etched section of stage III grain (Site 18) showing microprobe sample points (circles). Magnification x5. (B) Close-up (x20) of upper-left margin of grain showing rim of pure gold. Interior probe points have silver contents up to 15 per cent.

originated in part by *in situ* accretion processes within relatively young Pleistocene sediments. This is of very considerable significance for the interpretation of coarse gold in other Cenozoic placers in areas of high latitude (*see* below) but it is unlikely that this has been the principal means of generating nugget gold. The most significant process has undoubtedly been supergene weathering of massive sulphides under Tertiary warm climates and the growth of coarse crystalline gold at or close to the watertable (Johnson and Uglow, 1926).

The Cariboo mining district experienced tropical and subtropical weathering conditions during most of the Tertiary, allowing for substantial supergene weathering followed by alternating cool-temperate and glacial climates for the last several million years. Substantial thicknesses of Tertiary sediments have been preserved along the down-faulted Fraser River valley to the west. These appear typical of Tertiary strata found throughout the Cordillera from Idaho to the Yukon and comprise fluvial, lacustrine and volcanic lithologies (Rouse and Mathews, 1988). Included spore and pollen assemblages provide an important proxy climate record for northern and central British Columbia. The oldest sediments for which climate data can be generated are Eocene in age (circa 50 Ma) and record a diverse subtropical flora with a mean annual temperature of over 20°C (Rouse and Mathews, 1979) with paratropical rainforest extending in North America as far north as 60° to 65° (Wolfe, 1985). Late Eocene cooling gave way to temperatures between 12° and 16°C in central British Columbia, perhaps typical of present day conditions in the mid-Mississippi valley with a mixed broad-leaved deciduous and coniferous forest cover. Mixed coniferous forests as young as 5 Ma (Late Miocene) are reported from 65° north by Hopkins *et al.* (1971) British Columbia. A rapid climatic deterioration to cool temperate conditions is recorded by Late Miocene locustrine sediments from the Fraser Valley (Rouse and Mathews, 1979). Through the Tertiary, cooler and wetter conditions probably obtained in the Cariboo Mountains compared to lowland locations.

Supergene Weathering Processes

The earliest work on supergene weathering of sulphides identified the importance of gold transport as a stable chloride complex $AuCl_4$ (Krauskopf, 1951) but subsequent work showed that the necessary conditions, involving highly acidic and saline groundwaters (pH <5.5, Eh >0.9V $aCl^- > 10^{-3.2}$) are rarely developed (Mann, 1984; Webster and Mann, 1984). These conditions obtained in Western Australia where acid, saline groundwaters occur in iron-rich lateritic weathering profiles on gneissic and ultramafic rocks in areas of arid climate (annual rainfall cm) with little vegetation cover (Wilson, 1984). Finely disseminated primary gold is produced from quartz reefs and the secondary, remobil-

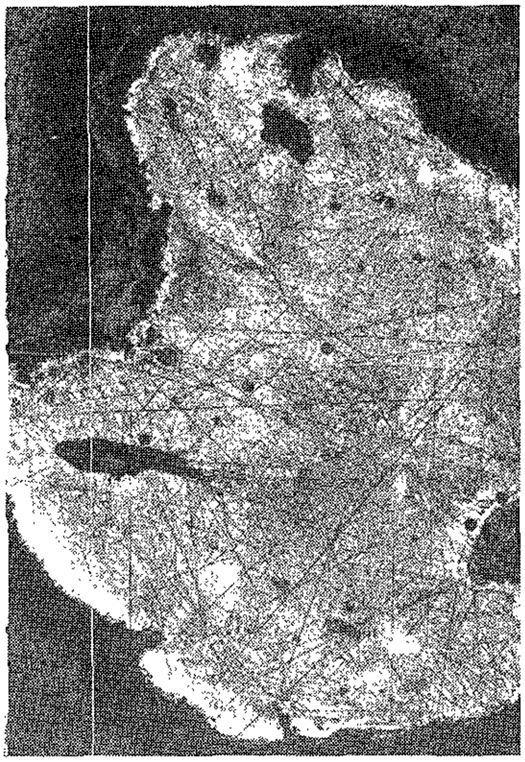


Plate B-9-9. Mosaic gold grain (x5) showing microprobe sample sites (circles). Internal points have silver contents up to 14 per cent, with pure gold rims clearly evident.

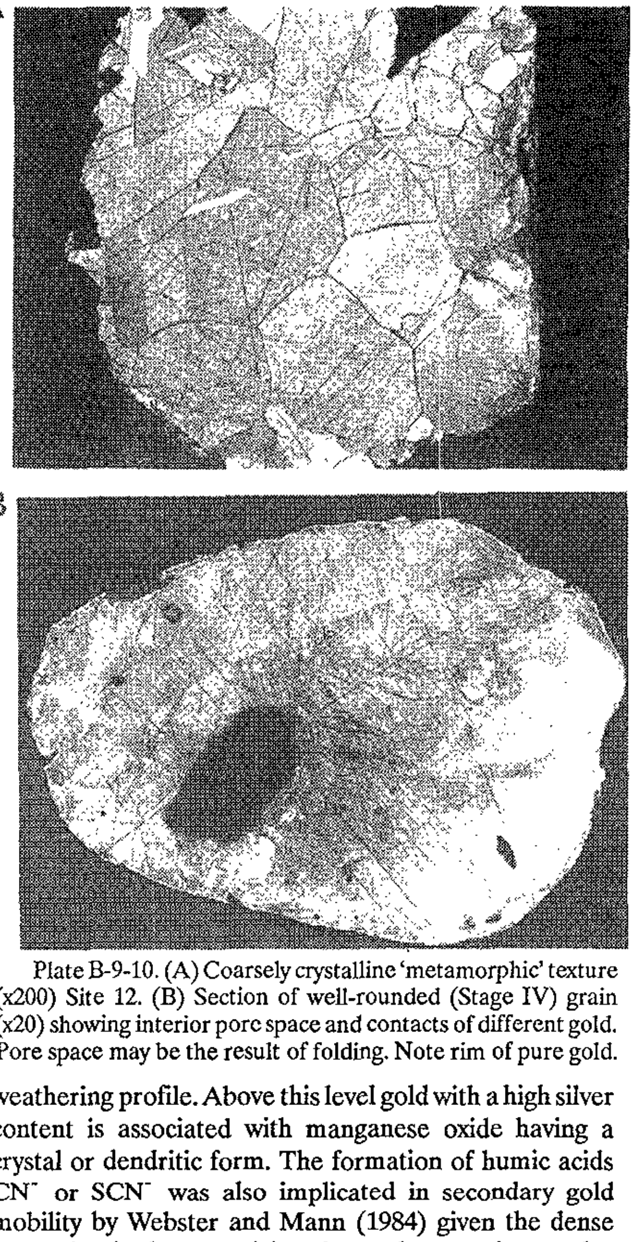


Plate B-9-10. (A) Coarsely crystalline 'metamorphic' texture (x200) Site 12. (B) Section of well-rounded (Stage IV) grain (x20) showing interior pore space and contacts of different gold. Pore space may be the result of folding. Note rim of pure gold.

ized gold occurs at various levels within laterites up to 40 metres thick. This model is of limited application to the Cariboo district where rock strata that might produced saline groundwaters are absent.

During the Tertiary, the Cariboo area supported a dense subtropical forest cover under conditions of high rainfall. Secondary, supergene gold mobility, under similar conditions of rugged relief and high rainfall occurs in the highlands of Papua New Guinea where primary gold occurs in pyrite-rich brecciated volcanic rocks, fractured by phreatomagmatic explosions. These strata are oxidized to depths of 25 metres in which secondary gold and silver is associated with manganese oxides. The high rainfall and rugged relief results in considerable lateral flow of groundwaters and the absence of any concentration of chloride. The principal gold complexing agent under these basic to neutral conditions is the thiosulphate ion produced during pyrite oxidation. This complex allows gold and silver mobilization as $Au(S_2O_3)^{3-}_2$ and $Ag(S_2O_3)^{3-}_2$. Gold of very low fineness (circa 900) is reprecipitated at or near the water table at the base of the weathering profile. Above this level gold with a high silver content is associated with manganese oxide having a crystal or dendritic form. The formation of humic acids CN^- or SCN^- was also implicated in secondary gold mobility by Webster and Mann (1984) given the dense vegetation in the area giving rise to the organic complex $Au(CN)^{-2}$ (*see* below).

Thiosulphate ions and humic acids have been identified as possible complexing agents in the formation of secondary nugget gold in Cenozoic placer deposits of Waimumu, Southland, New Zealand by Clough and Craw (1989). This work is of particular significance to the present study because climate history and topography of the area are similar to that of the Cariboo district. The Waimumu area is underlain by Tertiary lignites and fluvial quartz gravels. Uplift and glaciation has resulted in reworking of the gravels into Quaternary deposits up to 20 metres thick, covered by a thick (metre) peat soil. In Otago and Westland, almost all the currently active and recently active placer mines are in glacial or glacially-derived sediments similar to those of the Cariboo area;

the most lucrative deposits typically occur in gutters cut on bedrock (D. Craw, personal communication, 1989). Placer gravels contain authenigenic marcasite and irregularly shaped gold nuggets up to 6 millimetres in diameter. Nuggets of this size do not occur in underlying Tertiary lithologies which contain only small detrital gold flakes. Coarse gold forms, often craggy in surface texture, have a silver content of between 4 and 6 per cent but, in section, show diffuse margins with finer grained gold distributed throughout either a sediment matrix or a kaolinite-silica-marcasite cement ('mustard gold'; Wilson, 1984). Overgrowth rims of gold and very fine grained octahedral gold crystals are also common. Mustard gold, overgrowth rims and crystals have silver contents below microprobe detection limits. Rims of fine gold on gold grains are commonly explained by reference to silver depletion during detrital transport (*see* above) but the delicate structure of the pure gold found on grain surfaces in the Waimumu area indicates instead *in situ* accretionary origin within the fluvial gravels. The peat soil on the surface of the gravels is acidic and groundwaters are enriched in sulphur derived from pyrite oxidation in underlying lignites. Gold complexing by $S_2O_3^{-2}$ is possible but does not result in any significant partitioning between silver and gold. Clough and Craw (1989) concluded that HS^- or humic acid complexes are the most likely complexing agents responsible for the pure gold overgrowths. In contrast, the similarity in silver content between the detrital gold flakes in Tertiary gravels and the nugget gold in the Cenozoic gravels suggests an earlier phase of thiosulphate complexing was responsible for the initial formation of the coarse gold grains prior to the growth of pure gold rims.

A Model for Cariboo Placer Gold

Based on the above review, a two-stage origin for Cariboo placer gold is proposed. The first and longest stage saw deep Tertiary weathering of massive sulphides, the release of gold present as films on arsenopyrite and the growth of coarse crystalline gold at the base of the weathering profile. Late Cenozoic uplift of the plateau after about 6 Ma, dissection by streams and glaciers resulted in the erosion of the gold-bearing supergene-enriched saprolite and the creation of coarse gold placers of generally low fineness. The consistent silver values of 14-15 per cent identified in grain interiors may be representative of such supergene gold (*see* above). As suggested by the New Zealand Cenozoic placers located in an area of similar geological history, thiosulphate complexing as a result of pyrite oxidation may have been the principal agent allowing secondary gold mobility in weathered bedrock horizons under conditions of elevated Tertiary temperatures. Once released into the surficial environment and trapped within sediments, local groundwater conditions and hydromorphic movement of gold is indicated by the creation of composite nuggets by the welding of smaller grains (Plates B-9-2, 3). This requires a high concentration of grains which is consistent with the lucrative 'runs' or 'streaks' for which the Cariboo is well known. Also well known in the area are the anecdotes among miners relating the recovery of artifacts that have been plated with pure gold indicating continuing gold mobility (S. Kocsis, personal communication, 1989). Local hydrogeological conditions within the Cenozoic sediments, in the presence of an extensive forest cover, may have been important influences on the postdepositional history of the placer gold. Low-temperature hydromorphic dispersion of gold in the presence of organic complexing agents is widely reported (Julien, 1879; Boyle, 1979; MacEachern and Shea, 1985; Mossman and Dexter-Dyer, 1985). Gold is moved as a colloid, and to a lesser extent as gold cyanide and thiocyanate ions; cyanides are produced in organic peaty soils by the hydrolysis of cyanogenic glycosides producing the stable gold cyanide ion $Au(CN)^-_2$ (Baker, 1976). Furthermore, Watterson (1985) has drawn attention to the electrochemical dispersion of gold in sediments subject to deep freezing as a result of metal-chelating organics exuded into liquid soil phases.

This process is of particular application to the cold-climate conditions under which most of the Cariboo placers were deposited. Support for the above model can be found in the literature. 'Composite' fine gold grains formed by the sintering of small gold particles are common in glacially-influenced fluvial placers of the North Saskatchewan River in Alberta. Polished sections published by Giusti (1986) show composite grains made up of particles attached by high-grade 'spongy' gold similar to that identified in the present study. Giusti attributed this to circulating groundwaters and noted the similarity of composite grains to masses of gold that are amalgamated by mercury; a common recovery method used until recently to recover fine gold. The action of anthropogenic mercury in creating composite grains can be ruled out for the Cariboo gold samples studied in the course of this work. Most importantly, honeycomb 'weld' gold is observed inside grain interiors. In addition, composite grains are recovered not only from gravels but impermeable lodgement tills where the possiblity of infiltration of mercury from past mining activity is remote. Furthermore, the surface wear seen on many composite grains is not consistent with a modern origin. However, the action of naturally occurring mercury, released by the same Tertiary supergene weathering processes as released gold, cannot be dismissed. It is noted, however, that Cariboo gold is distinguished from gold in other Fraser River placers (*e.g.* Bridge River, Watson Bar Creek, Yalakom Creek) by natural mercury contents that are below microprobe detection limits (0.05 per cent; Knight and McTaggart, 1986). Natural mercury contents elsewhere along the Fraser River fall in the range 0.1 to 6.38 per cent. Composite gold nuggets have also been identified in glacial fluvial sediments of the Gulf of Alaska continental margin (Eyles, 1990). It may be that the process of welding smaller gold particles may be more widespread than considered hitherto.

Once formed, composite grains are subject to wear during transport and morphological evidence for a composite origin is progressively obliterated (Plates B-9-2, 3). 'Metamorphic' recrystallization, surface abrasion and repeated bending, further destroy any original internal structure. Plate B-9-2 depicts weathered crystals within composite gold grains. These crystals are likely to have been released by the fracturing of cold-hammered gold; incipient fractures can be seen on photomicrographs of grains showing this metamorphic texture (Plate B-9-9). In this context it is interesting to note that Warren (1979) reported large numbers of loose gold crystals along Stirrup Creek about 200 kilometers south of the present study area. These were interpreted as the product of supergene weathering and reprecipitation from solution but are now regarded as the product of the fragmention of metamorphic-textured grain (M.W. Milner, personal communication, 1990).

Clearly, the formation of high-grade gold rims on grain surfaces and the growth of 'honeycomb' gold between particles is coeval. It is interesting to speculate whether the two are simply different facies recording leaching of silver from grain surfaces and the reprecipitation of high grade gold either as a thin patina on exposed grain extremities or as filamentous masses in protected cavities and voids. The secondary mobility of gold under low temperatures clearly has been instrumental in post-depositional accretion of composite nuggets in the Cariboo area and future work should more closely examine the relationship between 'rim' and void filling filamentous gold types.

ACKNOWLEDGMENTS

I thank the many Cariboo miners who donated material for this study and allowed unhindered access to their properties. Marg Rutka and Claudio Cermignani provided expert technical assistance in the laboratory at Toronto and together with Mike Milner are thanked for very useful comments and discussions. This work was funded in part by the British Columbia Geoscience Research Grant Program and by the Natural Sciences and Engineering Research Council of Canada. I thank Brian Grant of the British Columbia Ministry of Energy, Mines and Petroleum Resources for encouragement, John Newell for editorial assistance and Steven P. Kocsis for his excellent assistance and stimulating discussions of Cariboo placers.

REFERENCES

Alldrick, D.J. (1982): The Mosquito Creek Mine, Cariboo Gold Belt. *in* ; *B.C. Ministry of Mines and Petroleum Resources*, Geological Fieldwork 1982, Paper 1983-1, pages 99-112.

Andrew, A., Godwin, C.I. and Sinclair, A.J. (1983): Age and Genesis of Cariboo Gold Mineralization Determined by Isotope Methods; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1983, Paper 1983-1, pages 305-313.

Baker, W.E. (1976): The Role of Humic Acid in the Transport of Gold; *Geochem*, Cosmochimoca. Acta Volume 42, pages 645-649.

Boyle, R. (1979): Geochemistry of Gold and its Deposits; *Geological Survey of Canada*, Bulletin 280, 584 pages.

Bowman, I. (1888): Report on the Geology of the Mining District of Cariboo, British Columbia; *Geological Survey of Canada*, Report III, New Series issue C, 1-49.

Clough, D.M. and Craw D. (1989): Authigenic Gold-marcasite Association: Evidence for Nugget Growth by Chemical Accretion in Fluvial Gravels, Southland, New Zealand; *Economic Geology*, Volume 84, pages 953-958.

Eyles, N. and Kocsis, S.P. (1988a): Placer Gold Mining in Pleistocene Glacial Sediments of the Cariboo District, British Columbia, Canada 1858-1988; *Geoscience Canada*, 15, pages 291-299.

______ (1988b): Gold Placers in Pleistocene Glacial Deposits; Barkerville, British Columbia, Canada; *The Canadian Mining and Metallurgical Bulletin*, Volume 81: pages 71-79.

______ (1989): Sedimentological Controls on Gold in a Late Pleistocene Glacial Placer Deposit, Cariboo Mining District, British Columbia, Canada; *Sedimentary Geology*, Volume 65: 45-68.

Eyles, N. (1990): Glacially-Derived, Shallow-Marine Gold Placers of the Cape Yakataga District, Gulf of Alaska; *Sedimentary Geology*, *in press*.

Fisher, N.H. (1945): The Fineness of Alluvial Gold with Special Reference to the Morobe Gold Field, New Guinea; *Economic Geology*, Volume 40 (7, 8), pages 449-495, 537-563.

Fulton, R.J. (1984): Quaternary Glaciation, Canadian Cordilleran, in Quaternary Stratigraphy of Canada, R.J. Fulton (Editor); *Geological Survey of Canada*, Paper 84-10, pages 39-48.

Giusti, L. (1986): The Morphology, Minerology, and Behavior of "Fine-grained" Gold from Placer Deposits of Alberta: Sampling and Implications for

Mineral Exploration, *Canadian Journal of Earth Sciences*, Volume 23, pages 1662-1672.

Hallbauer, D.K. and Utter, T. (1977): Geochemical and Morphological Characteristics of Gold Particles from Recent River Deposits and the Fossil Placers of the Witwatersrand; *Mineralum Deposita* (Berl), Volume 12, 293-306.

Hopkins, D.M., Mathews, J.V., Wolfe, J.A. and Silberman, M.L. (1971): A Pliocene Flora and Insect Fauna from the Bering Strait Region, *Palaeogeography, Palaeoclimatology and Palaeoecology*, Volume 9, pages 211-231.

Johnson, W.A. and Uglow, W.L. (1926): Placer and Vein Gold Deposits at Barkerville, Cariboo District, British Columbia; *Geological Survey of Canada*, Memoir 149.

Julien, A.A. (1879): On the Geological Action of Humus Acids; *Proceedings of American Association for the Advancement of Science*, Volume 28, pages 311-340.

Knight, J. and McTaggart, K.C. (1986): The Composition of Placer and Lode Gold from the Fraser River Drainage Area, Southwestern British Columbia; *Canadian Institute of Mining and Metallurgy*, Volume 1, pages 21-30.

Kolesov, S.V. (1975): Flattening and Hydrodynamic Sorting of Placer Gold, *International Geological Review*, Volume 17 (8), pages 940-944.

Krauskopf, K.B. (1951): The Solubility of Gold; *Economic Geology*, 46, pages 858-870.

Lay, D. (1941): Fraser River Tertiary Drainage History in Relation to Placer-gold Deposits (Part 2); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 11: 75 pages.

MacEachern, I.J. and Shea, R.R. (1985): The Dispersal of Gold and Related Elements in Till and Soil, at the Forest Hills Gold District, Guysborough County, Nova Scotia; *Geological Survey of Canada*, Paper 85-18, 31 pages.

Mann, A.W. (1984): Mobility of Gold and Silver in Lateritic Weathering Profiles: Some Observations from Western Australia; *Economic Geology*, Volume 79, pages 38-49.

McConnell, R.G. (1905): Report on the Klondike Gold Fields; *Geological Survey of Canada*, Memoir 284, pages 64-113.

______ R.G. (1905): Report on the Gold Values in the Klondike High Level Gravels; *Geological Survey of Canada*, Memoir 284, pages 217-238.

Mossman, D.J. and Dexter-Dyer, B. (1985): The Geochemistry of Witwatersrand-type Gold Deposits and the Possible Influence of Ancient Prokaryotic Communities on Gold Dissolution and Precipitation; *Precambrian Research*, Volume 30, 303-319.

Powers, M.C. (1982): Comparison Chart for Estimating Roundness and Sphericity; *American Geological Institute*, Data sheet 18.

Rouse, G.E. and Mathews, W.H. (1979): Tertiary Geology and Palynology of the Quesnel Area, British Columbia; *Bulletin of Canadian Petroleum Geology*, Volume 27: 418-445.

______ (1988): Paleontology and Geochronology of Eocene Beds from Cheslatta Falls and Nazko Area, Central British Columbia; *Canadian Journal of Earth Sciences*, Volume 25, pages 1268-1276.

Struik, L.C. (1986): Imbricated Terranes of the Cariboo Gold Belt with Correlations and Implications for Tectonics in Southeastern British Columbia; *Canadian Journal of Earth Sciences*, Volume 23, pages 1047-1061.

______ (1988): Structural Geology of the Cariboo Gold Mining district, East-central British Columbia; *Geological Survey of Canada*, Memoir 421, 100 pages.

Sutherland Brown, A. (1957): Geology of the Antler Creek Area, Cariboo District, British Columbia; *Ministry of Energy, Mines and Petroleum Resources*, Bulletin 38.

Tishenko, E.I. (1981): The Problems of the Evolution of Gold Flattening in Alluvial Placers; *Geologiya i Geofizika*, Volume 22, pages 34-40.

Uglow, W.L. (1922): Quartz Veins of Barkerville Area, Cariboo District, British Columbia ; *Canadian Institute of Mining and Metallurgy*, Bulletin, November, pages 1165-1175.

Uglow, W.L. and Johnson, W.A. (1923): Origin of Placer Gold of the Barkerville Area, Cariboo District of British Columbia; *Economic Geology*, Volume 18 (6), 541-561.

Warren, H.V. (1979): Supergene Gold Crystals at Stirrup Lake, British Columbia; *Western Miner*, Volume 52 (6), pages 4-14.

Watterson, J.R. (1985): Crystalline Gold in Soil and the Problem of Supergene Nugget Formation: Freezing and Exclusion as Genetic Mechanisms; *Precambrian Research*, Volume 30, pages 321-335.

Webster, J.G. and Mann, A.W. (1984): The Influence of Climate, Geomorphology and Primary Geology on the Supergene Migration of Gold and Silver: *Journal of Geochemal Exploration*, Volume 22, pages 21-42.

Wilson, A.F. (1984): Origin of Quartz-free Nuggets and Supergene Gold Found in Laterites and Soils - A Review of Some New Observations; *Australian Journal of Earth Sciences*, Volume 31, pages 303-316.

Wolfe, J.A. (1985): Distribution of Major Vegetation Types during the Tertiary; The Carbon Cycle and Atmospheric CO_2: Natural Variations Archean to Present; E.T. Sunquist and W.S. Broecker (Editors), (Geophysical Monograph 32), *American Geophysical Union*, pages 357-375.

Yeend, W.E. (1975): Experimental Abrasion of Detrital Gold; *U.S. Geological Survey*, Journal of Research, Volume 3(2), pages 203-212.

NOTES

SNOWBIRD (93K 36)

By E.L. Faulkner and B.E. Madu

(Fig. B1, No. 10)

LOCATION:	Lat. 54° 27'55"	Long. 124° 31' 25"	(93K/7E, 8W)
	OMINECA MINING DIVISION. The property is located on the south shore of Stuart Lake, 15 kilometres west of Fort St. James.		
CLAIMS:	SNOWBIRD, SNOWBIRD 1-7, SOWCHEA 1-5, CAMPSITE, BOARCHEA AND ONE FRACTIONAL CLAIM (100 UNITS).		
ACCESS:	From Fort St. James to the Sowchea Bay Provincial Park, then 7 kilometres west on a dirt access road.		
OWNER:	Pipawa Explorations Ltd.		
OPERATOR:	X-Cal Resources Ltd.		
COMMODITIES:	Gold.		

INTRODUCTION

This report is an update of a previous report by Faulkner (1987). Extensive drilling and trenching since that date have established that mineralization occurs in an extensive northwest-trending alteration zone more than 2 kilometres long and up to 90 metres wide, and in some northeast-trending cross-faults and zones of altered country rock. A mineral inventory of 225 000 tonnes grading 6 grams per tonne or more gold has been established and additional claims staked. Quartz fluid inclusion and stable isotope studies show a typical mesothermal "Mother Lode" type gold-quartz vein pattern.

HISTORY

The property has a lengthy history of exploration, underground development and some small-scale mining of hand-picked stibnite, dating from 1920. This history has been ably summarized by Dunn (1986).

WORK DONE

Since 1987 more than 6650 metres of diamond drilling in 45 holes, extensive trenching together with soil geochemistry, induced polarization, Max-Min EM, VLF and magnetometer surveys, have been completed. A program of 100 percussion-drill holes averaging 25 metres deep was carried out for basal till geochemical studies and bedrock characterization.

GEOLOGY

REGIONAL GEOLOGY SETTING

The property is located in an area underlain by chert, argillite, limestone and greenstone of the Cache Creek Group of Pennsylvanian to Permian age (Monger 1977). In the property area these rocks trend northwest and are sharply separated from the Quesnel trough to the northeast by the Pinchi fault system. The Cache Creek Group includes a number of alpine-type ultramafic bodies now largely altered to serpentinite, that are spatially related to the Pinchi fault system, and is intruded by granitic stocks, probably of Jurassic age.

PROPERTY GEOLOGY

Outcrop on the property is limited, and is largely confined to two northwest-trending ridges, and to areas that have been stripped or trenched. The geology of the property is shown on Figure B-10-1. The Cache Creek group is comprised largely of mixed argillites, cherts and greywackes with lesser amounts of limestone, andesitic flows and pillow lavas, diorite dikes, banded tuffs and coarse basaltic wacke. The local strike is approximately 140° and dips are steep, mostly to the southwest. Some of the units on the property may have been repeated by faulting or folding and the exact succession is not known.

Several small lens-like bodies of serpentinized harzburgite have been exposed by trenching. They appear to be fault-bounded and are generally less than 30 metres thick, with their long axes parallel to the local strike. A small elongate biotite granite pluton, possibly also fault bounded, occurs on the eastern side of the area of current exploration (the Granite zone, Figure B-10-1). It is similar to granite of Jurassic age that borders the claim group to the southwest.

STRUCTURE AND ALTERATION

The dominant structural trend on the property is related to the northwest-trending Pinchi fault system. A parallel shear zone, the Sowchea Bay shear zone, has been inferred by Armstrong (1949) on the basis of topographic lineaments to border this part of Stuart Lake, and it may pass through the northeast edge of the property. The strike of the rocks, the long axes of minor intrusions, the strike of the principal mineralized zone and many minor quartz veins, all parallel the Pinchi fault trend. The contact of the granite, mentioned above, that borders the property to the southwest is a prominent ridge, probably a fault scarp, also parallel to the Pinchi fault.

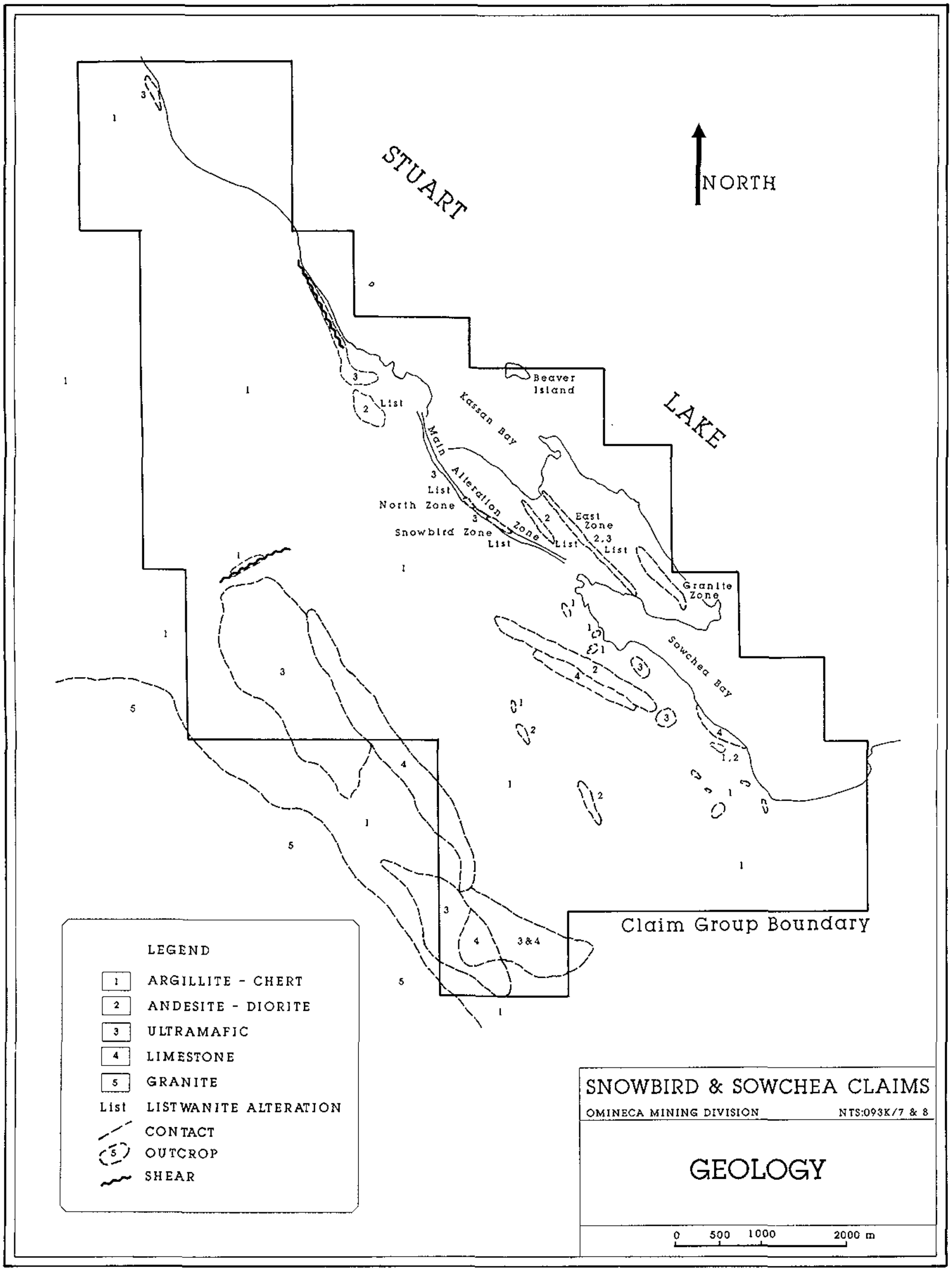


Figure B-10-1. Geology and claim locations for the Snowbird and Sowchea claims (NTS 093K/7 and 8).

A number of northeast-striking and steeply dipping cross-faults and shear zones offset intrusions, mineralized zones and hostrocks, generally with apparent displacements of a few metres to a few tens of metres.

Alteration is extensive on the property, particularly in the vicinity of mineralized zones and the northeast striking cross-faults. The ultramafic bodies are completely altered to serpentinite, with an overprint of talc-carbonate or listwanite alteration near shear zones. Clastic sedimentary rocks are in places silicified, and the volcanic rocks are weakly but pervasively silicified and carbonatized. The granite in the Granite zone is weakly sericitized.

MINERALIZATION

Most of the mineralization discovered to date occurs in the Main alteration zone, an extensive shear zone that contains discontinuous lenses of listwanite-altered serpentinite and sheared argillite. The zone strikes northwest and dips 40° to 50° northeast. It is up to 90 metres true width, and has been traced on strike for more than 2 kilometres.

Economic mineralization occurs in two parts of this zone, the North zone and Snowbird zone. Both zones are open at depth, and the North zone is open to the northwest. The Snowbird zone has been explored in more detail. The mineralization occurs in two quartz-stibnite veins, the Main and the Peg-leg, that occur at the hangingwall and footwall contacts respectively, of the Main alteration zone. The quartz is white to grey and massive. The stibnite is fine grained and massive, but locally occurs in coarsely radiating aggregates. Pyrite and arsenopyrite are present in small quantities. Gold occurs as fine free gold and in association with sulphides.

At the surface, the Main vein is 64 metres long, averages 0.9 metre wide and contains 4.45 grams per tonne gold. The Peg-leg vein is 66 metres long, averages 0.8 metre wide, and contains 13.03 grams per tonne gold (S. Kennedy, X-Cal Resources Ltd., personal communication). Narrow sinuous quartz veinlets with erratic gold values occur between the two veins, and anomalous to ore-grade assays have been obtained from the listwanitic zones.

The North zone consists of ribboned quartz-pyrite-arsenopyrite veins and veinlets with rare stibnite. Typical intersections grade 4 to 8 grams per tonne gold over a few metres, with gold in both quartz veins and host silicified argillite.

Gold also occurs in the northeast-striking cross-faults. In the East zone, a steeply dipping sheared contact between highly fractured and silicified argillite and listwanite-altered serpentinite has returned gold assays up to 7 grams per tonne over 1 metre widths. It is noticeable that where this shear zone enters the listwanite, it decreases in both width and gold content.

In the Granite zone, an area marked by high-contrast gold and arsenic soil geochemical anomalies, erratically distributed gold mineralization has been found in sheared argillite and greywacke and sericitized granite, with occasional assays in the low grams per tonne range.

A drill-indicated inventory of 225 000 tonnes grading 6 grams per tonne gold or more has been established for the Main zone and North zone. Both zones have potential for additional tonnage, and there is good potential for small additional tonnages from the East and other zones.

NATURE OF THE ORE-FORMING FLUIDS

The character of the veins on the Snowbird property is mesothermal. The origin of the ore-forming fluids in mesothermal vein systems has been extensively debated (for a summary *see* Bursnall *et al.*, 1989). Taylor (1979) has shown that quantifying the relative abundances of hydrogen and oxygen isotopes in these systems can give valuable insight into the source and history of the ore-forming fluids.

A fluid inclusion and stable isotope study of selected quartz vein specimens from the property has been described by Madu *et al.* (in press). Thermometric analyses of fluid inclusions in quartz show that the vein forming brines contain 90 mole per cent H_2O, 10 mole per cent CO_2 and minor CH_4. The minimum temperature of entrapment determined was 240±20°C, and the estimated pressure at the time of formation was more than 800 bars. Assuming a hydrostatic fluid regime, this corresponds to a depth of ore formation of more than 8 kilometres, with temperatures consistent with geothermal gradient calculations at that depth (Nesbitt and Muehlenbachs, 1989).

Stable isotope analyses of extracted inclusion fluids (Madu *et al.* - in press) gave an observed δD of - 139±2.5 per mil, which is characteristic of meteoric waters at the latitudes of the northern Cordillera. Calculated $\delta^{18}O$ values averaged +13±1.5 mil. This is 30 to 40 per mil higher than meteoric waters, and indicates that considerable isotopic exchange occurred between ^{18}O depleted meteoric waters and ^{18}O enriched rocks. The $\delta^{13}C$ average for CO_2 from the fluid inclusions was -9.8±1.1 per mil, a value consistent with a carbon source from reduced organic matter.

DISCUSSION

The results of the fluid inclusion and stable isotope study are typical of mesothermal "Mother Lode" type gold-quartz vein deposits of the Canadian Cordillera (Nesbitt *et al.*, 1986). They indicate that the Snowbird veins were formed from fluids with salinity less than sea water, moderate CO_2 content, extreme ^{18}O enrichment, δD values that indicate the involvement of meteoric water.

The local control of ore deposition is not clear however. Gold mineralization occurs with quartz and stibnite in the Main zone, with quartz, pyrite and arsenopyrite in the North zone, and in clearly later northeast-trending cross-faults with pyrite and arsenopyrite, as well as in significant amounts in a variety of altered igneous and sedimentary rocks including listwanite, diorite, granite and argillites and greywackes. The listwanite-gold association is poor, with gold contents typically being higher in immediately adjacent rocks than in the listwanite. It is curious that stibnite is present in quantity in the Main zone, rare in the North zone and at background levels elsewhere, possibly indicating that the introduction of antimony into the Main alteration zone was a separate and highly localized event.

ACKNOWLEDGMENTS

The cooperation of Shawn Kennedy of X-Cal Resources Ltd., and Brian Game, project geologist, and his field staff in providing information and access to company plans is greatly appreciated.

REFERENCES

Armstrong, J.E. (1949): Fort St. James Map Area, Cassiar and Coast District, British Columbia; *Geological Survey of Canada*, Memoir 252.

Bursnall, J.T., *et al.* (1989): Mineralization and Shear Zones; *Geological Association of Canada*, Short Course Notes, Volume 6.

Dunn, D. (1986): *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 15261.

Faulkner, E.L. (1987): Snowbird; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Exploration in B.C. 1987, pages B47-48.

Madu, B.E., Nesbitt, B.E., and Muehlenbachs, K.: A Mesothermal Gold-stibnite-quartz Vein Occurrence in the Canadian Cordillera; *Economic Geology* (in press).

Monger, J.W.H. (1977): Upper Paleozoic Rocks of the Western Canadian Cordillera and their Bearing on Cordilleran Evolution; *Canadian Journal of Earth Sciences*, Volume 14, page 1844.

Nesbitt, B.E. and Muehlenbachs, K. (1989): Origins and Movement of Fluids During Deformation and Metamorphism in the Canadian Cordillera; *Science*, Volume 245, pages 733-736.

Nesbitt, B.E., Murowchick, J.B., and Muehlenbachs, K. (1986): Dual Origins of Lode Gold Deposits in the Canadian Cordillera; *Geology*, Volume 14, pages 506-509.

Taylor, H.P., Jr. (1979): Oxygen and Hydrogen Isotope Studies of Hydrothermal Mineral Deposits; *in* Geochemistry of Hydrothermal Ore Deposits, H.L. Barnes, Editor, Second Edition, John Wylie & Sons, New York, pages 236-277.

TELKWA COAL NORTH (93L 152)

By M.L. Malott

(Fig. B1, No. 11)

LOCATION:	Lat. 54°40′ Long. 127°10′	(93L/11E)
	Omineca Mining Division, The Telkwa Coal North zone is 10 kilometres southwest of Smithers.	
CLAIMS:	NORTH ZONE, TELKWA COAL.	
ACCESS:	Tatlow and Chapman roads, off Highway 16, on the south side of Smithers.	
OWNER:	Shell Canada Limited.	
OPERATOR:	CROWS NEST RESOURCES LIMITED.	
COMMODITY:	High volatile-bituminous 'A' coal.	

TELKWA COAL, NORTH ZONE

INTRODUCTION

Exploration by Crows Nest Resources Limited, in the Telkwa area from 1979 to 1984, focused on the south side of the Telkwa River in the vicinity of Goathorn Creek (Figure B-11-1). Reserves totalling 21 760 000 tonnes were identified and the company's Stage II report was approved by the provincial government in November 1986. The company did not put the deposit into production citing poor market conditions.

Exploration since 1985 has concentrated on coal licences situated east of Pine Creek on the north side of the Telkwa River. Crows Nest Resources submitted a Stage II report for the North zone in March 1990.

HISTORY

The following is a brief outline of the history of Telkwa coal. For greater detail the reader is referred to an article by Schroeter, White and Koo (1986) for Telkwa South and the British Columbia Minister of Mines Annual Reports of 1921, 1923, 1940 and 1945 for Telkwa North.

Coal leases were first staked near Telkwa vicinity in 1901. From 1903 to 1910 several companies actively explored and drove adits on coal seams. Production first began in 1918 at a rate of 27 tonnes per day from a colliery on the east side of Mud (Tenas) Creek. On the north bank of the Telkwa River, the Aveling (Telkoal) mine (Betty seam) produced during 1921 and 1922 then again during World War II from 1940 to 1945. South of the Telkwa River, Telkwa colliery (McNeil mine) began producing in 1923. Between 1930 and 1943 Bulkley Valley Collieries Ltd. supplied coal from the No. 1 mine, then from the No. 2 mine until 1950 and from the No.3 mine during 1950-51. Markets at that time were for local domestic heating and during the war for a military installation near Prince Rupert. Between 1952 and 1983 a succession of owners and operators produced from two surface mines. Numerous exploration programs were carried out, from the 1940s through 1970s, on both the north and south sides of the Telkwa River. Unfortunately poor drilling techniques and structural complexities hampered many of the investigations.

In 1979 Crows Nest Resources began work on the Telkwa coal licences. Since that time it has conducted yearly exploration programs except during 1980 and 1987. In 1985 a Stage II document, in application for mine development on the coal measures to the south of the Telkwa River, was submitted to the provincial Mine Development Review Steering Committee. Further exploration programs focused on the North zone in 1985, 1986 and again in 1988 and 1989. A detailed listing of the exploration activity conducted by Crows Nest Resources since 1979, is presented by Ryan, McKinstry and Cameron (1986). Four NQ diamond-drill holes were completed in each of 1985 and 1986 on the Telkwa North zone. Exploration continued in 1988 with the drilling of 14 NQ diamond-drill holes and with a surface electrical resistivity survey (direct current profiling). In 1989 further DC profiling diamond drilling (13 holes) and rotary drilling (18 holes), were undertaken to determine the geology and ascertain reserves in potential pit areas of the Telkwa North zone. Four 6-inch cores were drilled to obtain bulk samples for coal quality testing. Localities were assessed for plant and waste-rock sites and piezometers were installed in order to better understand the hydrology of the zone.

During the summer of 1989, a nine-hole drilling program was conducted on the Telkwa Coal as part of a province-wide study of coal quality. The program was jointly funded by the British Columbia Ministry of Energy, Mines and Petroleum Resources and the Geological Survey of Canada (Matheson and Van Den Bussche 1990).

The stratigraphy, sedimentology and depositional environment of the Lower Skeena Group in the Telkwa Coalfield was studied during the summer of 1989 by Palsgrove and Bustin (1990) of the University of British Columbia.

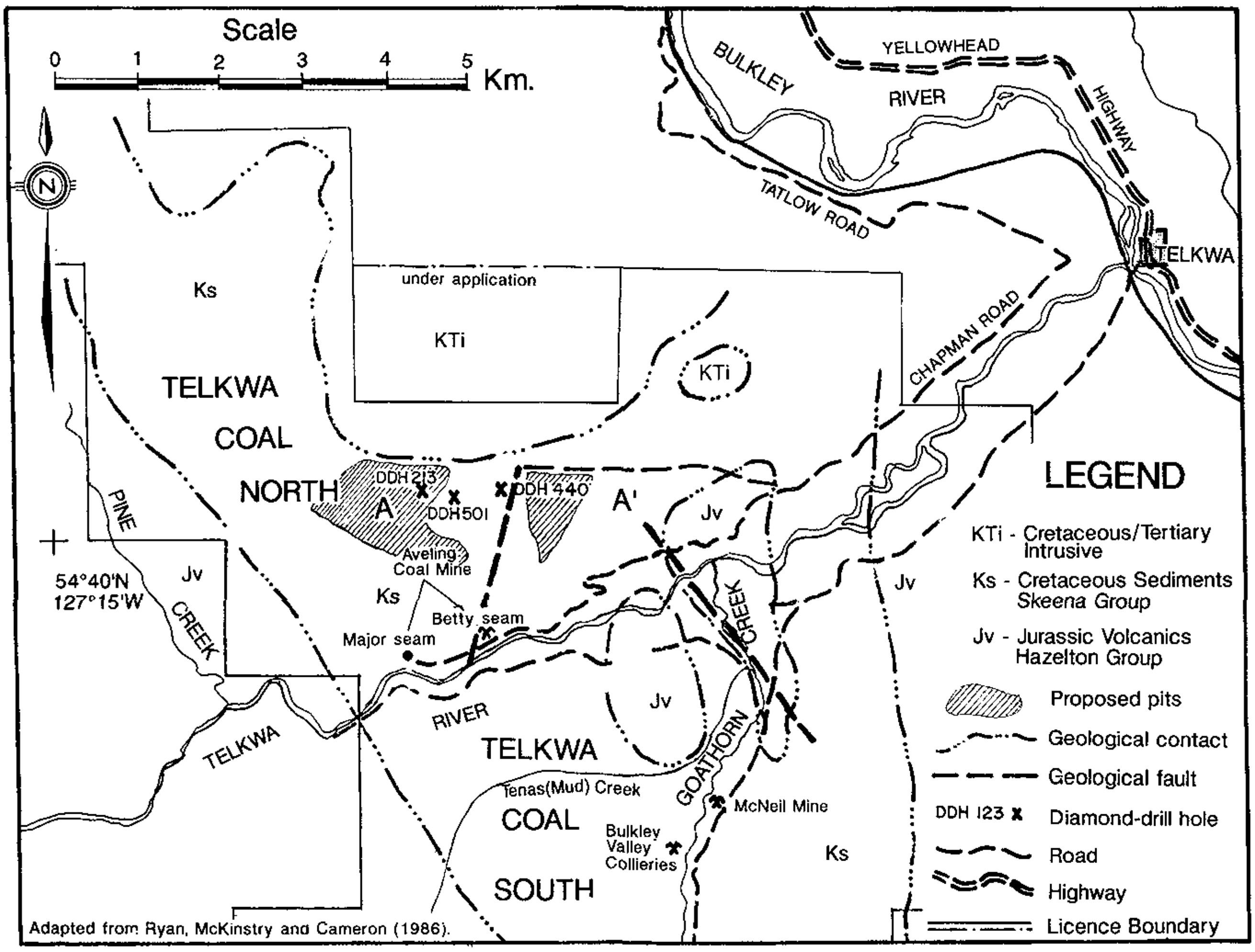


Figure B-11-1. Location and Geology of Telkwa Coal North.

REGIONAL SETTING

The Telkwa Coal project is located within the Stikine Terrane, a component of the Intermontaine Belt (Richards, 1988). This terrane evolved during a period of island arc volcanism in the late Paleozoic to Middle Jurassic. North and south of the Telkwa river the Lower Jurassic Telkwa Formation outcrops westward from the vicinity of Pine Creek as well as east of the confluence of Goathorn Creek and the Telkwa River.

As the arc volcanism waned in the late Middle Jurassic to middle Early Cretaceous the marine to nonmarine clastic units of the Skeena Group were deposited regionally. These clastics are the main rock unit found throughout the Telkwa coal property.

With the welding of Stikinia to the craton in the Early Cretaceous the regional Omineca uplift occurred to the east. The accretion of the Wrangel and Alexander terranes to the west occurred at about the same time and resulted in the emergence of the Coast crystalline complex. From the middle of the Cretaceous through to the Eocene, transtensional continental stresses influenced the Stikine Terrane. It was during this period that an intrusive plug was emplaced on the north of the Telkwa property.

Since the Paleocene, the area has been influenced by uplift. The basin-and-range morphology typical of the region developed during the Tertiary and was followed by extensive glaciation.

PROPERTY GEOLOGY

The Telkwa Coal North zone is comprised of interbedded marine and nonmarine sediments and minor volcanics of the Early Cretaceous Skeena Group. The coal measures have been placed either within an undifferentiated Early Cretaceous Skeena Group (Tipper and Richards, 1976) or the Red Rose Formation (MacIntyre *et al.*, 1989). They include siltstone, sandstone, coal and minor amounts of conglomerate which lie unconformably upon volcanics of the Jurassic Hazelton Group. At the contact the volcanics are characteristically weathered, to a deep purplish red (Ryan *et al.*, 1986). MacIntyre *et al.*,

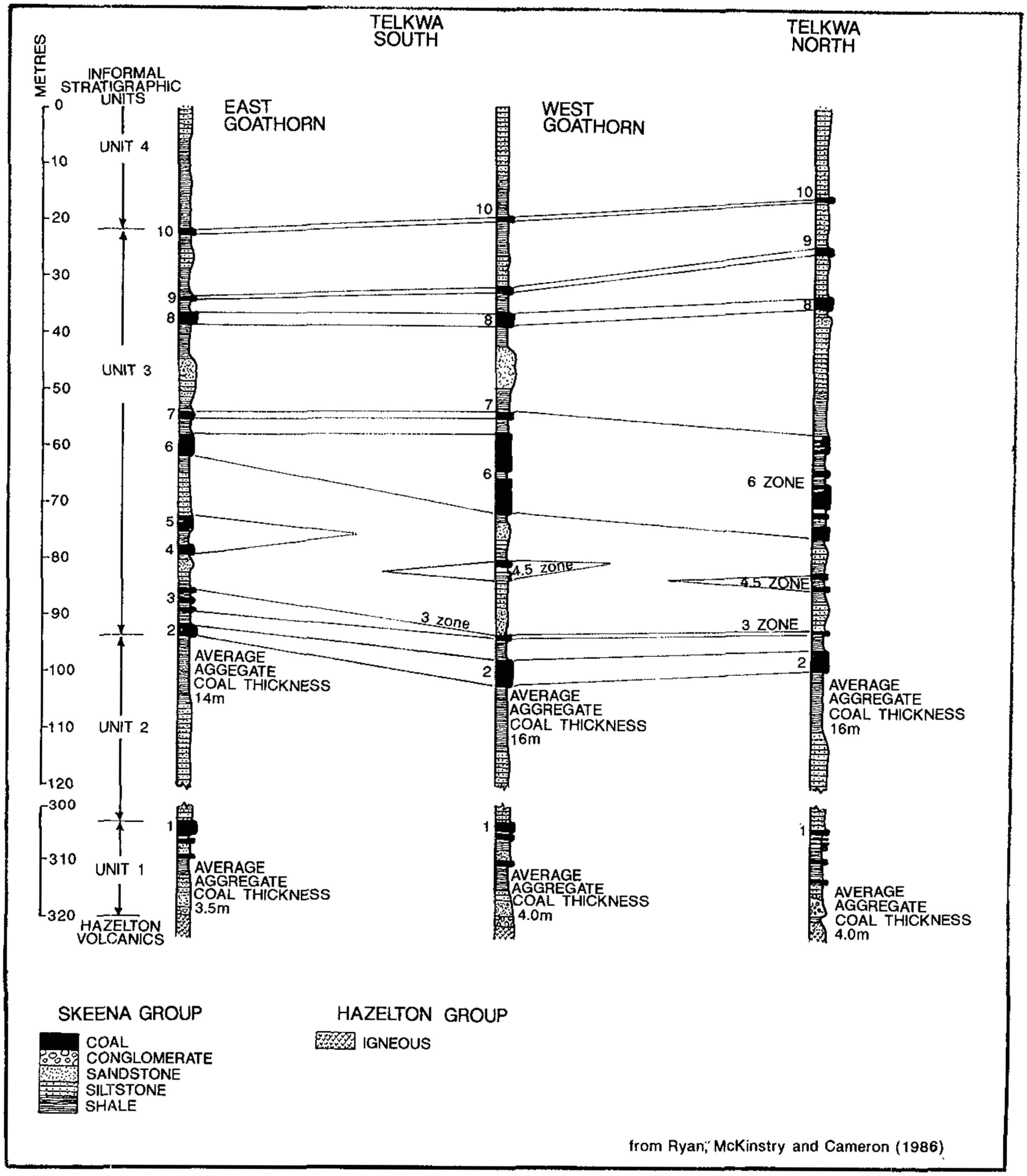


Figure B-11-2. Comparison of Stratigraphy, Between Telkwa Coal North and South Zones.

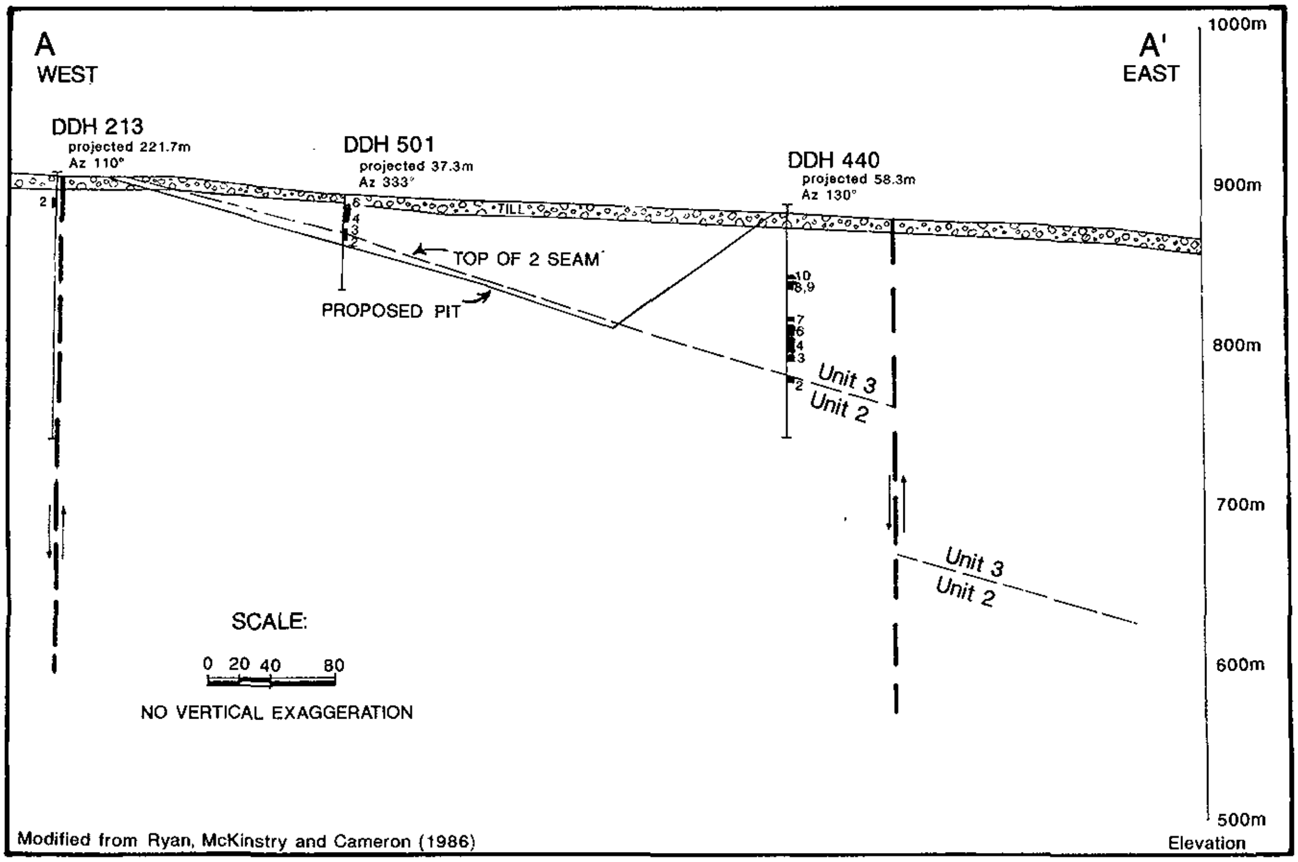


Figure B-11-3. Vertical Section Through Telkwa Coal North.

(1989) describe these volcanics as aphyric to augite-feldspar-phyric basaltic flows interbedded with maroon to red crystal and lapilli tuffs. Intruding the Jurassic and Cretaceous strata on the north is a quartz monzonite plug of Late Cretaceous or Eocene age. Extensive glacial drift covers much of the property with outcrop usually limited to stream valleys or the higher ridges.

In the Telkwa area, the Skeena Group section varies in thickness up to 500 metres. The units strike north-northwest and generally dip 5° to 25° to the northeast. It is not uncommon for individual beds to pinch out over short distances. Crows Nest Resources, through drilling and paleontological analysis has informally subdivided the Skeena Group section into four units (Figure B-11-2) (Ryan *et al.*, 1986) as do Palsgrove and Bustin (1990). From a study of the Telkwa Coal measures Koo (1983, 1984) divided the stratigraphy into three units, lower, middle and upper, roughly corresponding to the lower three of the four units recognized by Crows Nest Resources and, Palsgrove and Bustin.

For the purpose of this paper the stratigraphic division of four units is used. The conglomerate, sandstone, siltstone and mudstone of the lowermost (Unit 1), were deposited in a fluvial environment during the Neocomian. A marine regression then brought about fluvial flood plain conditions with coal seam No. 1 deposited near the top of the unit. In the Telkwa North area this seam is 2 to 5 metres thick. It is overlain by Unit 2 which is up to 150 metres thick and consists of siltstones, and mudstones deposited in a shallow, low-energy marine setting. Unit 3 is the predominant coal-bearing section with up to nine seams interbedded with sandstones, mudstones and siltstones. The coal seams vary in thickness between 1 and 5 metres. The lateral extent of the seams is also variable as they split and interfinger with the sediments. A near-shore or deltaic environment with marsh and swamp vegetation was the source of the coal. The average aggregate seam thickness in the Telkwa North zone is 16 metres. Near the top of the third unit there were several minor marine transgressions before a significant marine regression brought about the fluvial siltstone and sandstone sedimentation found in Unit 4.

A number of north to northwesterly trending faults disrupt the coal seams on the north side of the Telkwa River (Figure B-11-3). The majority are high-angle faults with the down thrown block on the west.

Coal Seams

Initial planning by Crows Nest Resources in 1986 proposed two open pits in the North zone, to mine coal seams 2 through 10 located within Unit 3 of the stratigraphic sequence. The outlines of the proposed pits are shown on Figure B-11-1.

SUMMARY

During 1988 and 1989 Crows Nest Resources Limited completed exploration drilling and geophysical programs on the Telkwa North zone. The company was able to further delineate both coal reserves and coal quality. The 1989 drilling established additional coal measures within one of the projected pits and added to the coal quality data for the upper seams.

The direct current profiling undertaken in 1988 and 1989 was found to be cost effective and useful in delineating both shallow coal zones and major structures, as well as guiding drill hole placement. Crows Nest Resources conducted studies for plant-site location and waste-rock disposal as well as piezometer installations to test the hydrology regime. This was work done for the Stage II report submitted March, 1990 as part of the mine development review process.

ACKNOWLEDGMENTS

Brian McKinstry and Steve Cameron of Crows Nest Resources Limited were very helpful in providing information as well as field tours. I am grateful to Dave Lefebure for constructive suggestions and critical review of earlier manuscript versions. Anne Havard kindly drafted and redrafted the figures and Sue Ciampichini patiently typed several revisions of the manuscript.

References

Koo, J. (1983): Telkwa Coalfield, West-central British Columbia (93L); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1982, Paper 1983-1, pages 113-121.

Koo, J. (1984): The Telkwa, Red Rose and Klappan Coal Measures in Northwestern British Columbia (93L, M; 104H); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1983, Paper 1984-1, pages 81-90.

MacIntyre, D.G., P. Desjardins and Tercier, P. (1989): Jurassic Stratigraphic Relationships in the Babine and Telkwa Ranges; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 195-208.

Matheson, A. and Van Den Bussche, B. (1990): Subsurface Coal Sampling Survey, Telkwa Area, Central British Columbia (93L/11); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 445-448.

Palsgrove, R.J. and Bustin, R.M. (1990): Stratigraphy and Sedimentology of the Lower Skeena Group, Telkwa Coalfield, Central British Columbia (93L/11); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 449-454.

Richards, T. (1988): Geologic Setting of the Stikine Terrane; *in* Abstracts of the Geology and Metallogeny of Northwestern British Columbia Workshop, Smithers, B.C., pages A75-A81.

Ryan, B., McKinstry, B. and Cameron, S. (1986): Telkwa Project; Assessment Report; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report (00725), 26 pages.

Schroeter, T.G., White, G.V. and Koo, J. (1986): Coal in Northwestern British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1986-5, 27 pages.

Tipper, H.W., Richards, T.A., (1976): Jurassic Stratigraphy and History of North-central British Columbia; *Geological Survey of Canada*, Bulletin 270, 73 pages.

NOTES

MOUNT MILLIGAN (93N 194)

(Fig. B1, No. 12)

By E.L. Faulkner, V.A. Preto, C.M. Rebagliati and T.G. Schroeter

LOCATION:	Lat. 55°08'00" Long. 124°04'00" (93N/1E) OMINECA MINING DIVISION. The property is located on the southeast flank of Mount Milligan, approximately 95 kilometres north of Fort St. James.
CLAIMS:	PHIL 1, 8-12, 21-26, 29 HEIDI 1-4 and one fractional claim (275 units).
ACCESS:	Approximately 145 kilometres northwest of Prince George via Highway 97, Windy, Philips Mainline and Rainbow Creek logging roads.
OWNER/OPERATOR:	Joint Venture between CONTINENTAL GOLD CORP. (69.8%) and BP RESOURCES CANADA LIMITED (30.2%). Continental Gold Corp. is the operator.
COMMODITIES:	Gold, copper.

INTRODUCTION

This report is an update of previous reports by Faulkner (1986, 1988). A major exploration program, with year-round drilling by as many as seven machines since late 1988, has outlined two large-tonnage low-grade open pittable gold-copper deposits, the Mount Milligan and Southern Star. The total mineral inventory currently exceeds 400 million tonnes, with grades ranging from 0.15 to 0.7 per cent copper and 0.17 to 2.75 grams per tonne gold.

A Prospectus has been filed with the British-Columbia Mine Development Review Committee, with a production decision expected late in 1990.

HISTORY

The earliest record of exploration activity in the area is by prospector George Snell, who found gold-bearing float on the western flank of Mount Milligan in 1937. In 1945 Mr. Snell returned to the area and staked 10 two-post claims west of Mitzi Lake. Five pyritic andesite float samples returned assays ranging from trace to 148.8 grams per tonne gold. The source of the float was not found and no other gold-bearing mineralization was found in place.

In 1972 Pechiney Development Ltd. staked 10 two-post claims on the western flank of Mount Milligan and the following year drilled five holes to test induced polarization and copper soil geochemical targets for porphyry copper mineralization. The claims were subsequently allowed to lapse.

In 1982 and 1983, Selco Inc. (now BP Resources Canada Inc.) staked the Phil claims, encompassing the former Pechiney claims, as an alkali-porphyry copper-gold prospect.

In April 1984, Richard Haslinger staked the Heidi claims, tying on to the eastern side of the Selco/BP claim block to cover a copper-gold prospect he had discovered in 1983. BP optioned the Heidi claims from Richard Haslinger in August 1984 and staked additional claims.

In 1984-85, BP undertook extensive geological, soil geochemical, magnetic and induced polarization surveys, identifying large, high-contrast coincident anomalies. A modest backhoe-trenching program identified two medium-grade auriferous, polymetallic, multiple vein systems and low-grade porphyry gold-copper mineralization.

In early 1986, the Mount Milligan property became inactive when BP discontinued exploration for bulk tonnage porphyry gold-copper deposits in British Columbia.

In April, 1986, Lincoln Resources Inc. entered into an exploration agreement with BP and work resumed on the property. On September 25, 1987, Lincoln Resources drilled discovery hole 87-12 into the Mount Milligan gold-copper deposit. Additional drilling, in early 1988, substantiated the discovery of a major porphyry gold-copper deposit. By early 1988 BP's interest had been diluted to 30.16 per cent but since late 1988 it has participated in funding on-going exploration to maintain its interest at this level.

In July, 1988, Lincoln Resources reorganized to become United Lincoln Resources Inc. and continued drilling to expand the deposit. In August 1988 Continental Gold Corp. acquired 64 per cent of the outstanding shares of United Lincoln Resources Inc., and the two companies subsequently merged.

Delineation drilling on the Mount Milligan deposit continued and on July 12, 1989, Hole 89-200 discovered the Southern Star deposit.

WORK DONE

To December 31, 1989, after coring 96 390 metres in 406 diamond-drill holes, drilling had delineated in excess of 400 million tonnes of gold-copper mineralization in the Mount Milligan and Southern Star deposits. Expenditures on the property to December 31, 1989 were approximately $11.35 million.

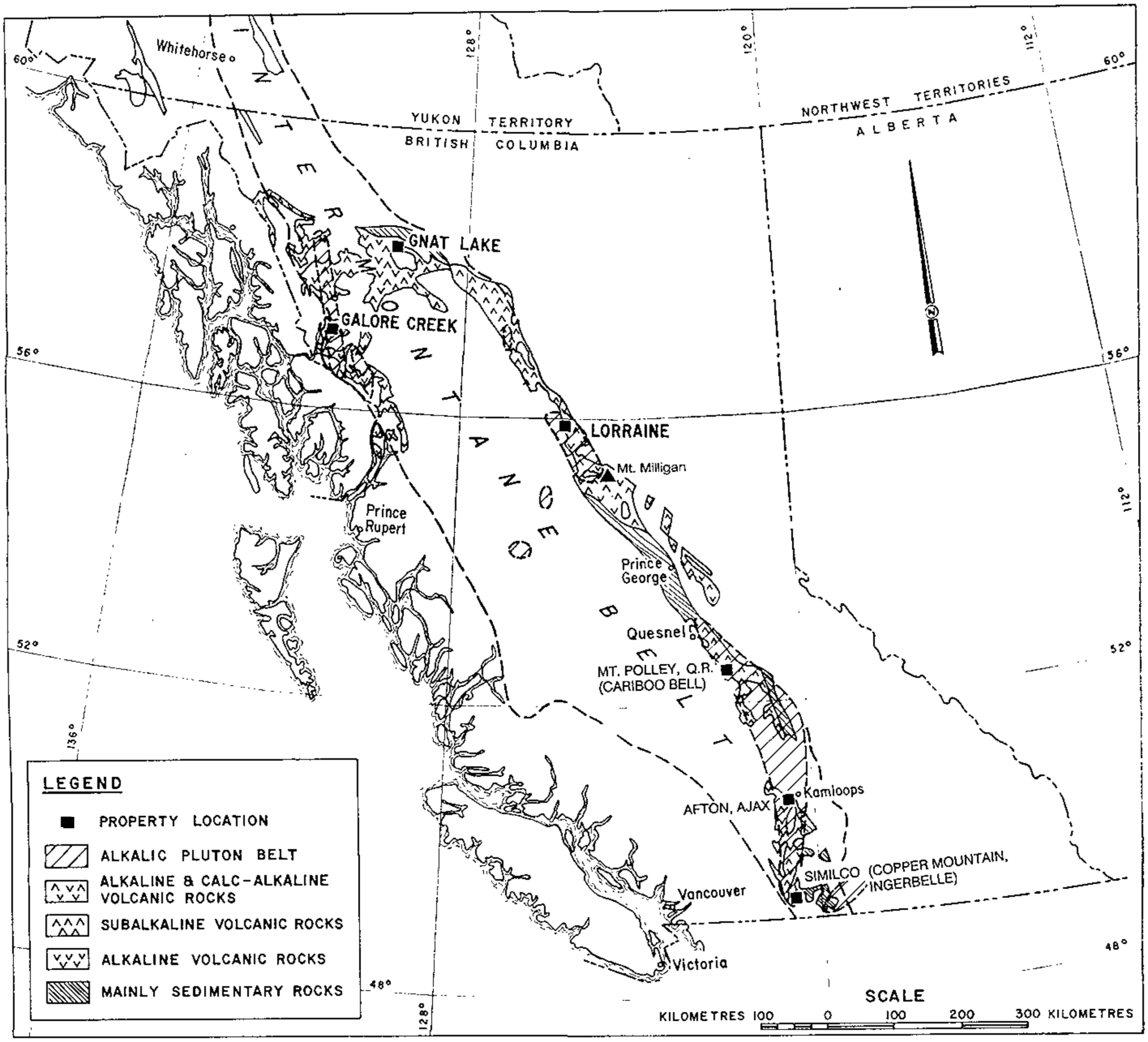


Figure B-12-1. Upper Triassic and Lower Jurassic volcanic rocks, significant copper deposits and associated alkalic plutons in the Canadian Cordillera.

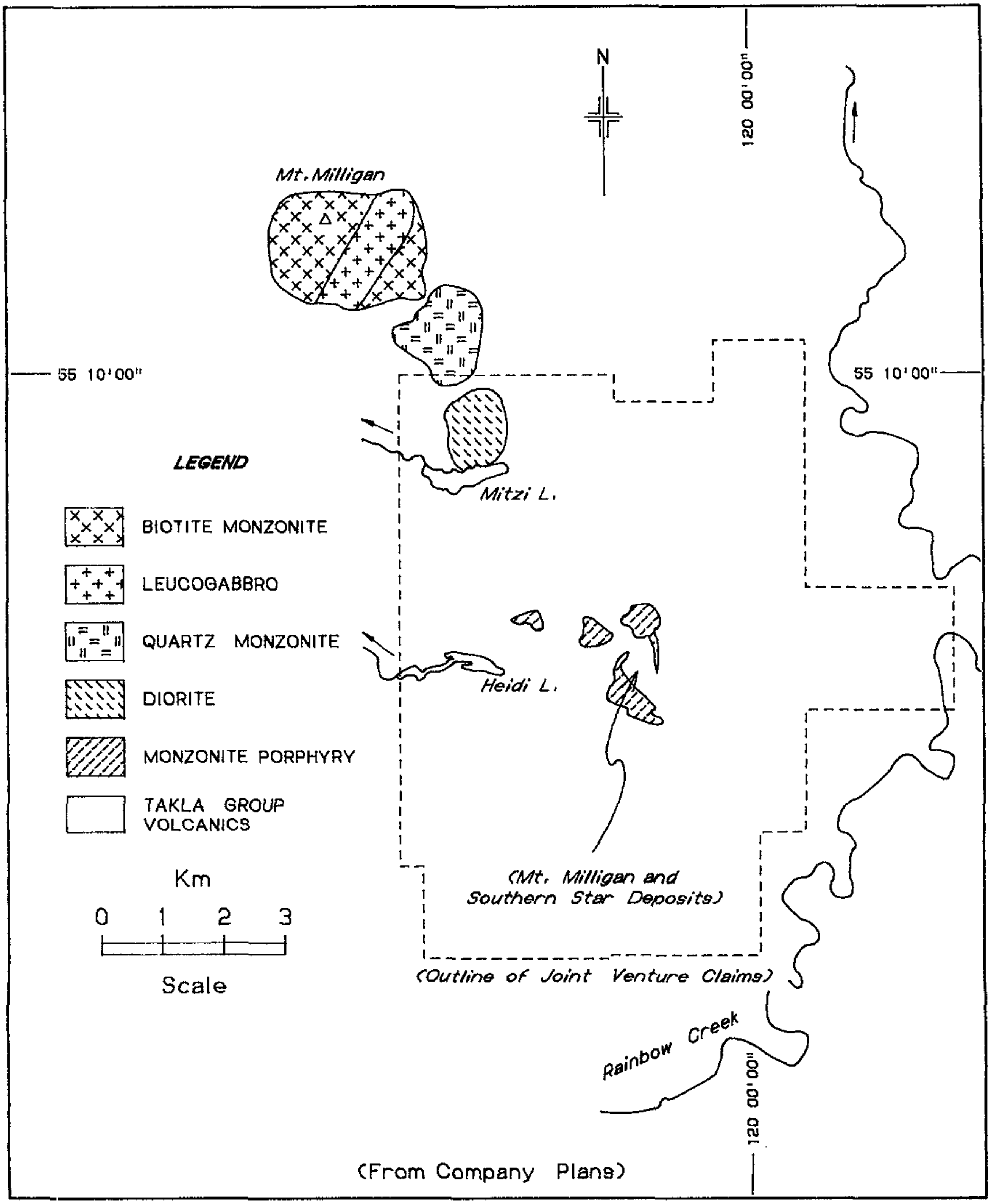


Figure B-12-2. Mount Milligan intrusive complex.

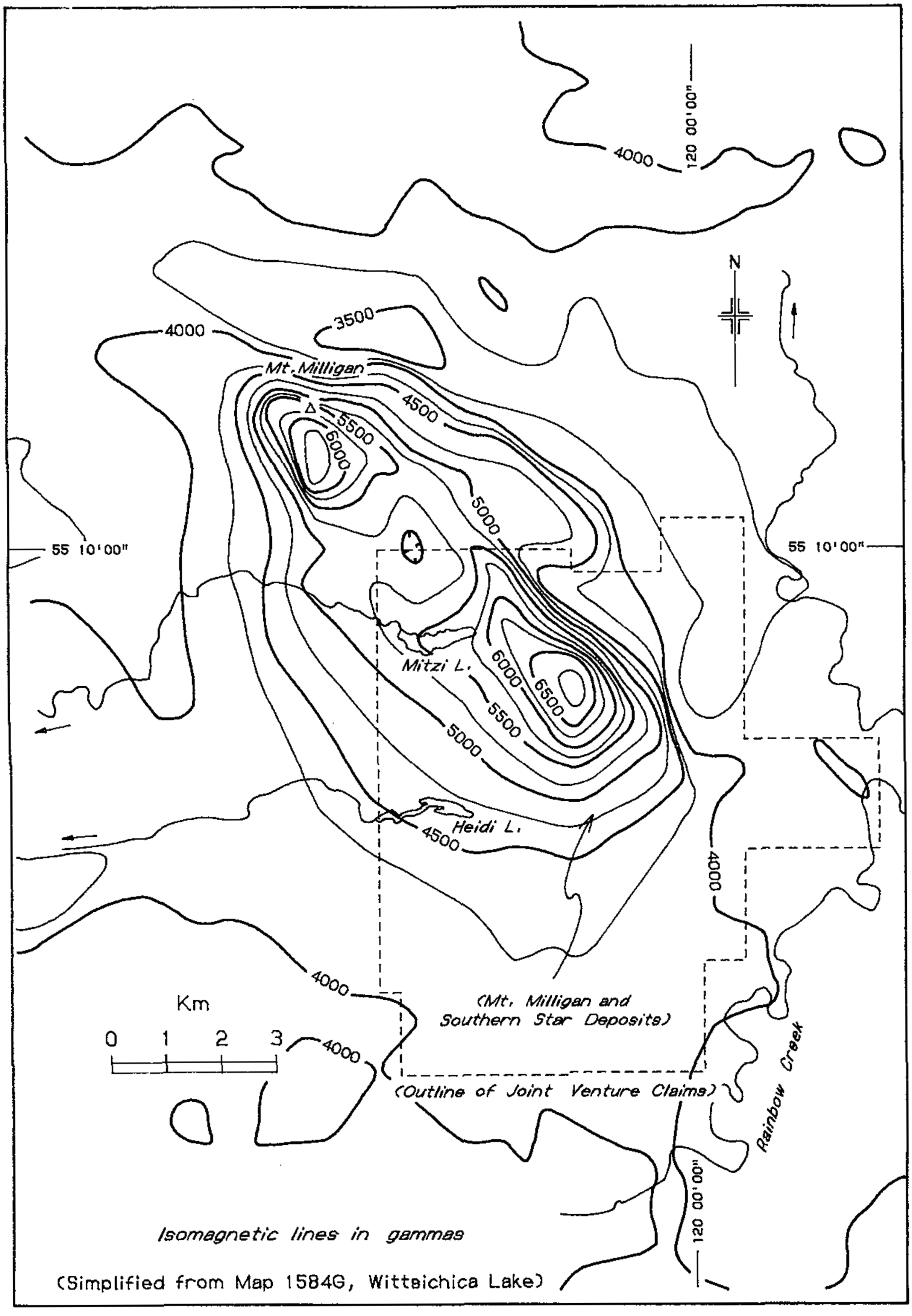


Figure B-12-3. Mount Milligan aeromagnetic map.

GEOLOGY

REGIONAL GEOLOGICAL SETTING

The Mount Milligan property lies within the regionally extensive early Mesozoic Quesnel belt. This belt extends northwesterly for 1200 kilometres and includes equivalent rocks of the Upper Triassic to Lower Jurassic, Takla, Nicola and Stuhini groups (Mortimer, 1986) (Figure B-12-1).

To the west, deformed uplifted Permian Cache Creek Group rocks are separated from the Quesnel belt by the Pinchi fault zone. To the east, the Manson fault zone separates this belt from the uplifted Proterozoic/early-Paleozoic Wolverine metamorphic complex and the Mississippian-Permian Slide Mountain Group (Garnett, 1978).

The volcanic centres are intruded by generally coeval alkaline stocks of monzonite, syenite and diorite. In the southern part of the Quesnel trough, many of these stocks have a northwest linear alignment, suggesting a strong fault control of intrusions and associated volcanic rocks. In the northern Quesnel trough however, the intrusions appear to be more scattered. Throughout the trough, several of these intrusions are the sites of significant alkali-porphyry copper-gold mineralization.

In the Mount Milligan area, the Takla Group is dominated by a thick sequence of subaqueous augite porphyry and hornblende porphyry flows and related pyroclastics of intermediate composition. These form a homoclinal succession which strikes northwest with steep to moderate easterly dips. Regional metamorphism is of greenschist grade, with some local skarn-like assemblages that are probably the result of hydrothermal alteration.

The Mount Milligan intrusions comprise biotite monzonite, quartz monzonite, monzonite porphyry, diorite and leucogabbro phases (Figure B-12-2) and have a pronounced magnetic signature (Figure B-12-3). Discrete magnetic highs reflect the composite nature of the intrusions. The contact of the leucrogabbro with the biotite monzonite (Figure B-12-2), where observed, is strongly sheeted. Other contacts have not been observed.

The quartz monzonite is medium to very coarsely porphyritic, fresh and unaltered, and appears to be of later, possibly Cretaceous age.

PROPERTY GEOLOGY

Figure B-12-4 shows the property geology. There is little outcrop in the area of current exploration, and none in the area of the Mount Milligan deposit. The geology has been inferred largely from drill-hole information, and the degree of geological detail therefore largely reflects the density of drilling. Consequently the Mount Milligan deposit is defined in some detail, the Southern Star deposit is less well defined, and other areas are poorly defined. Areas between drill targets are largely unexplored.

Figure B-12-5 shows the geology of the Mount Milligan deposit inferred at the 1050 metre elevation. Figures B-12-6, and B-12-7 are east-west cross-sections of this deposit.

The hostrocks are a thick east-dipping sequence of massive, pale to dark greenish-grey pyroxene porphyries of andesite and latite composition, with lesser heterolithic agglomerates, some discontinuous, pale, bedded tuffs and rare tuffaceous argillites. This sequence has been intruded by a number of small stocks and dikes of porphyritic monzonite and lesser syenite. Similar rocks have been intersected at depth in several drill holes, and it is probable that many of these plutons are continuous below the level of current drilling, rather than separate intrusions or discrete phases of a single intrusive event.

The porphyritic monzonite is typically fine to medium grained, and consists of approximately 20 per cent plagioclase laths in an aphanitic groundmass of potash feldspar, with minor mafic minerals. The MBX stock has a steep-sided funnel shape (Figure B-12-7). A prominent porphyritic dike, the Rainbow dike, 10 to 45 metres thick, trends south from the MBX stock and several smaller dikes have been intersected. Porphyritic monzonite with scattered volcanic fragments, fractured to brecciated monzonite and monzonite intrusion breccia occur around the margin of the MBX stock and throughout the Southern Star stock.

Some diorite and trachyte dikes are unaltered contain only traces of pyrite, and appear to be the youngest rocks in the area of exploration.

STRUCTURE

The Mount Milligan area is dominated by strong northwest and lesser northeast structural trends. The area of the Mount Milligan and Southern Star deposits appears to be a zone of extension characterized by northwest and northeast-striking fault and fracture systems.

The plutons of the Mount Milligan suite are aligned in a northwesterly direction (Figure B-12-2) as are the main body of the Southern Star stock, dike-like offshoots of the MBX stock, both orebodies, and a number of steeply dipping faults such as the Harris fault which separates the deposits (Figure B-12-4). A number of pre and post-mineral dikes also trend in a northwesterly direction. Two intersected low-angle faults, the east dipping Rainbow and west dipping Franzen faults, trend northerly to northwesterly and appear to have controlled the emplacement of dike-like offshoots of the MBX stock. Recent drilling east of this stock has indicated the presence of a north or northwesterly trending graben filled with younger sediments and basaltic flows.

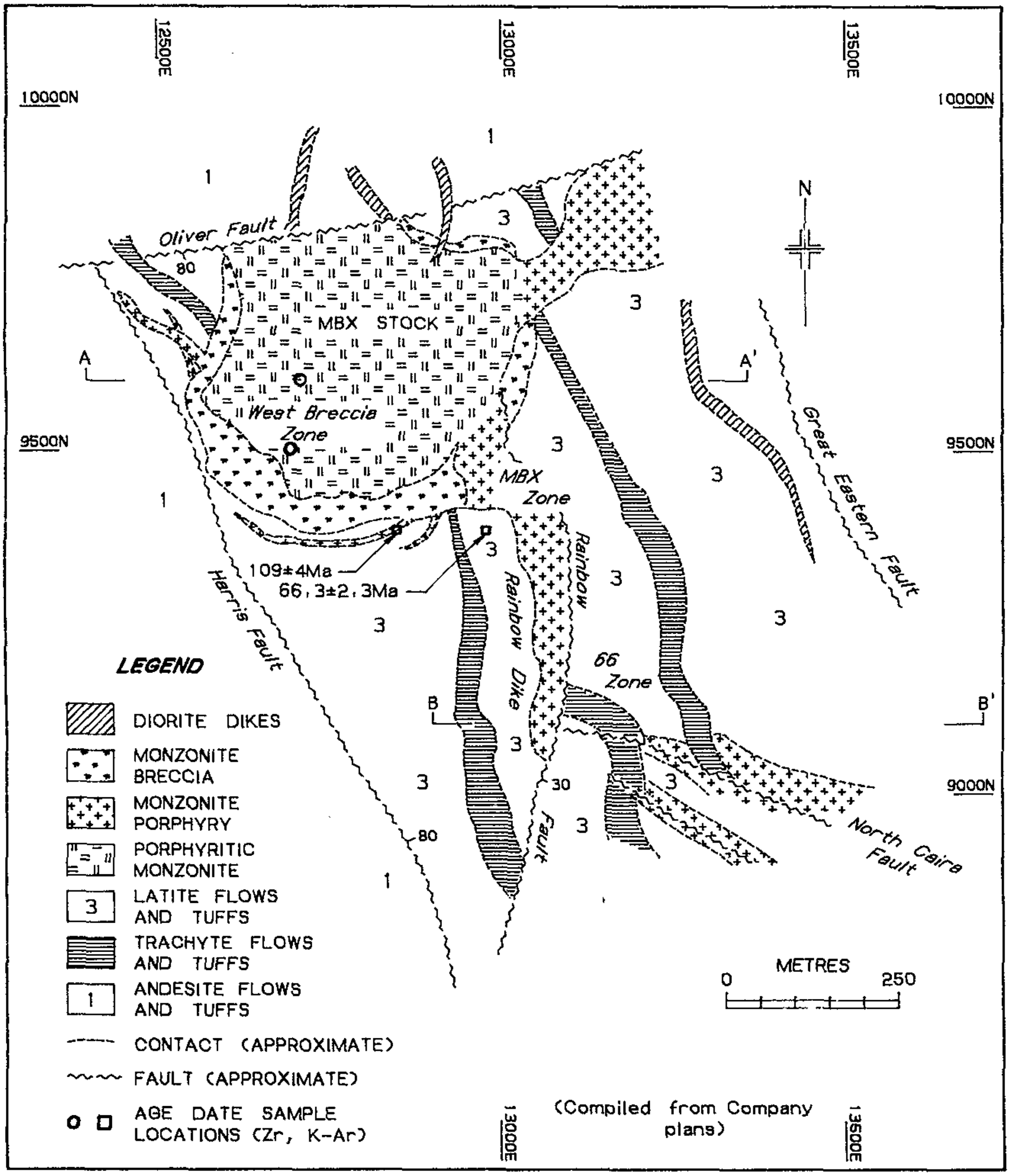


Figure B-12-5. Geology of Mount Miligan deposit inferred at 1050 m elevation.

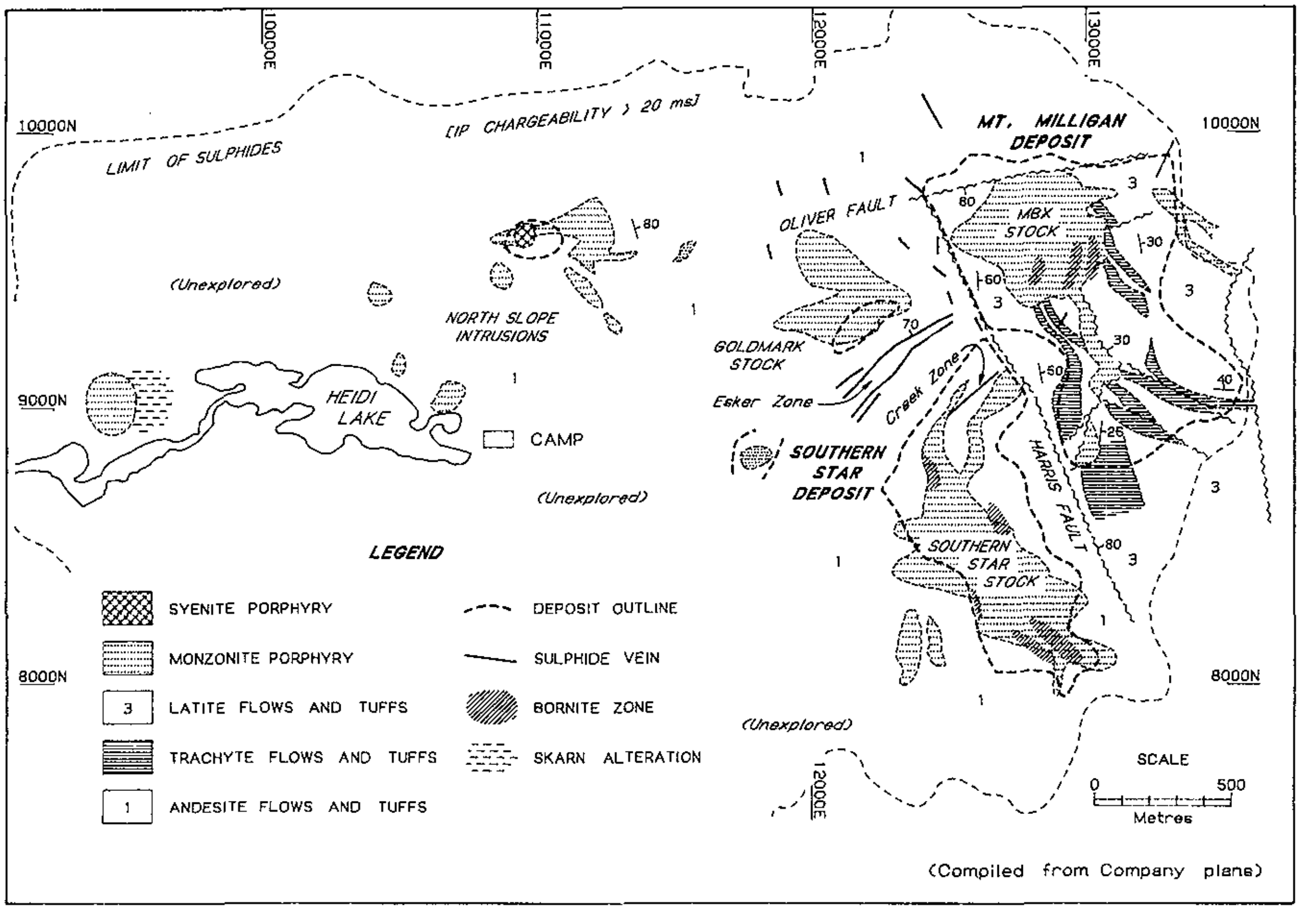


Figure B-12-4. Geology of Mount Milligan property.

The northeasterly trend is marked by dike-like offshoots of the Southern Star stock and by prominent polymetallic sulphide veins, the Esker and Creek zones north of this stock (Figure B-12-4). The northeast-trending Oliver fault truncates part of the MBX stock to the north and approximates the northern boundary of the Mount Milligan orebody.

ALTERATION

Alteration is widespread and generally pervasive, with subordinate fracture-control. Weak pervasive propylitic alteration characterized by epidote, pyrite and carbonates, extends outward from the MBX and Southern Star stocks up to 2500 metres. The propylitic alteration is overprinted by strong potassium silicate alteration localized around the periphery of the MBX stock, the Rainbow dike, and the Southern Star stock. In the volcanic rocks the potassic alteration assemblage comprises from 10 to 35 per cent early, fine-grained biotite and from 1 to 10 per cent (locally to 50 per cent) later, grey potassium feldspar. Pyroxene phenocrysts, where present, are replaced by actinolite and calcite. In the stocks, pink potassium feldspar is common, becoming pervasive in the marginal zones, and the mafic minerals are partially replaced by sericite. Clusters of radiating crystals of black tourmaline are found occasionally on fractures and some late magnetite-chalcopyrite veinlets are also present. Two zones of albite alteration also occur in the MBX and 66 zones. Gold values are low in the centres of these zones of albitization, with higher values in the outer parts.

MINERALIZATION

Economic mineralization occurs in both intrusive and volcanic rocks and is of two types - disseminated and vein. Widespread disseminated sulphide mineralization accompanied by lesser veinlet and fracture-filling mineralization occurs in two deposits - the Mount Milligan and Southern Star - and in a number of smaller zones. Disseminated grains and grain aggregates of pyrite and chalcopyrite are the most common form of sulphides. Pyrite and chalcopyrite veinlet and fracture-filling mineralization is less common but locally important, and sulphides associated with quartz veining are rare. Bornite is present in minor amounts, generally confined to a number of small zones within the disseminated mineralization; these zones contain little or no pyrite.

Native gold is associated with bornite, pyrite and chalcopyrite, typically as small particles up to 100 micrometres in diameter, located along sulphide grain boundaries and microfractures in pyrite. Some gold is also associated with magnetite (D. Harris, Geological Survey of Canada, personal communication). Silver is uniformly distributed throughout the mineralized zones in small amounts, typically of the order of 1.5 grams per tonne.

The Mount Milligan deposit consists of three gradational zones; the West Breccia zone (WBX), the Magnetite Breccia zone (MBX) and the 66 zone (*see* Figure B-12-5). Approximately 70 per cent of the ore is in volcanics and 30 per cent in porphyritic monzonite. The pyrite content increases from 1 to 2 per cent in the MBX zone to 5 to 10 per cent along the south and east margins of the deposit. The sulphides are irregularly zoned, with pyrite to chalcopyrite ratios varying from 1:1 north of the MBX zone, increasing to the west and south to 20:1. There is a relative enrichment of gold with increasing pyrite to chalcopyrite ratio. This enrichment reaches a maximum at the potassic alteration front, where the gold content locally approaches 2.75 grams per tonne. As a consequence of this irregular zoning, the 66 zone is gold-rich, and the WBX and northern part of the MBX zones are copper-rich. The northwestern corner of the deposit is cut by a gold-copper-bearing quartz vein stockwork.

The Mt. Milligan deposit is bounded on the north and west by the steeply dipping Oliver and Harris faults, and is cut by the pre and postmineralization Rainbow and Franzen faults. Two steep 115° striking faults termed the Caira faults appear to post date the gold mineralization in this area. Mineralization is open both to the east and southeast, below economic mining depths.

The Southern Star deposit is dominated by crackle stockwork and intrusion breccia yet is qualitatively similar to the Mount Milligan deposit, but to date grades appear to be lower. This may be because predominant volcanic hostrocks in the Southern Star deposit are andesites, compared to latites and trachytes in the Mount Milligan deposit which may be more favorable hosts. Approximately 70 per cent of the ore in the Southern Star deposit is in brecciated monzonite and only about 30 per cent in volcanic rocks.

Polymetallic sulphide vein mineralization occurs within the zone of propylitic alteration north and west of the two deposits, mostly within 500 metres of the main stocks (Figure B-12-4). At least seven zones have been identified that appear to radiate outward from the MBX stock. The best developed of these, the Creek and Esker zones, strike northeast and dip steeply northwest. Each of these zones consists of three to five subparallel veins of semimassive to massive pyrite and chalcopyrite 0.3 to 3.0 metres thick within a 60 to 90-metre zone width. Individual veins within a zone assay from 3 to 100 grams per tonne gold and 0.2 to 10 per cent copper and contain 1 to 3 per cent sphalerite and traces of arsenopyrite and galena. The hostrocks within and adjacent to these zones are propylitically altered and contain anomalous gold and silver concentrations.

ECONOMIC POTENTIAL

The total mineral inventory of the Mount Milligan and Southern Star deposits currently exceeds 400 million tonnes. Current preliminary calculations by Continental Gold Corp. indicate that 265.5 million tonnes of probable ore grading 0.19 per cent copper and 0.56 gram per tonne gold are contained in the Mount Milligan deposit, and 145.8 million tonnes of possible ore grading 0.23 per cent copper and 0.34 gram per tonne gold are contained in the Southern Star deposit. To date there has been insufficient exploration to develop mineable reserves in any of the vein zones.

Preliminary mine planning has been based on a milling rate of 50 000 tonnes per day, with production coming initially from a starter pit in the southern part of the MBX zone, where higher grade ore is available at a low stripping ratio. Stripping ratios are expected to be between 1.1:1 and 1.3:1 and recoveries, based on preliminary metallurgical testing, are approximately 80 per cent for gold and 88 per cent for copper.

SHOSHONITIC ASSOCIATION

Spence (1985) has discussed the chemical compositions of volcanic rocks from the Quesnel trough in some detail and has demonstrated the shoshonitic nature of the alkaline potassic suites of the trough. Whole rock analyses were made of 12 drill-core samples from the area of current exploration. Table B-12-1 gives details of the samples and the analytical results. Figure B-12-8 shows these results plotted on various oxide ratio diagrams, with the fields obtained by Spence for the majority of the samples in her study.

The samples chosen had low sulphide contents, but were all altered to some extent, as can be seen from the generally high losses on ignition. However, both intrusive and extrusive samples, with the exception of the postore dikes in some plots, generally fall within the shoshonite fields. Similarities include SiO_2 range of 49.7 to 56.8 per cent, high K_2O:Na_2O ratios (average = 1.94 per cent), low TiO_2 (average = 0.59 per cent) and high Al_2O_3 (average = 14.65 per cent). The most notable differences are that the samples are not as high in CaO and MgO as most of the samples reported by Spence, and the total iron relative to SiO_2 is lower. It is probable that during mineraliza-

TABLE B-12-1
WHOLE-ROCK ANALYSES - MT. MILLIGAN
(all analyses expressed as %)

FIELD NAME	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.	SUM
1) diorite porphyry	63.51	0.40	15.10	4.56	0.06	1.45	3.54	2.24	3.53	0.19	5.24	99.82
2) monzonite, MBX	48.62	0.60	12.42	8.20	0.11	9.09	7.27	2.71	3.86	0.42	6.09	99.39
3) latite lapilli tuff	50.62	0.90	12.48	9.88	0.12	7.61	6.49	3.36	3.26	0.30	4.19	99.21
4) andesite flow breccia	49.73	0.96	12.60	10.88	0.25	8.50	7.97	3.00	1.92	0.33	3.33	99.47
5) trachyte	50.65	0.64	15.75	6.45	0.15	1.64	5.16	2.15	8.96	0.56	7.00	99.11
6) monzonite	56.79	0.49	17.83	5.47	0.04	2.87	3.35	5.16	3.50	0.36	3.49	99.35
7) syenite orthoclase porphyry	55.34	0.41	19.09	4.59	0.05	1.69	2.03	1.66	10.02	0.22	4.72	99.82
8) diorite, MBX	60.30	0.46	15.27	4.99	0.13	1.93	4.05	1.64	3.94	0.22	6.95	99.88
9) trachyte dike	53.07	0.41	16.03	5.81	0.15	3.09	4.55	4.74	4.71	0.22	6.54	99.32
10) monzonite	50.98	0.77	16.66	9.46	0.18	4.37	5.27	3.25	4.61	0.44	3.22	99.21
11) andesite lapilli tuff	51.32	0.69	11.98	8.66	0.12	10.19	7.36	2.19	2.19	0.26	4.38	99.34
12) diorite porphyry dike	55.40	0.31	10.60	11.36	0.50	1.72	7.91	0.08	3.85	0.16	7.20	99.09

XRF Analyses by EMPR Laboratory

tion calcium was remobilized into the alteration zones and some of the iron formed sulphides.

DATING

Two samples were submitted to the University of British Columbia in early 1989 by two of the authors (C.M.R. and T.G.S.) for whole-rock K-Ar dating. One sample was from a dike of porphyritic monzonite intruding latitic pyroclastics and the other was from altered latitic pyroclastic rocks. Both were from drill core from two separate holes drilled along the southern contact of the MBX stock (Figure B-12-5). Results from these two samples were highly discordant and inconclusive with the altered latitic pyroclastic rock giving an Albian age of 109±4 Ma and the monzonite giving a Late Cretaceous to early Tertiary age of 66.3±2.3 Ma. As a result, two additional samples of monzonite from near the core of the MBX stock were collected and submitted to T. Krogh at the Royal Ontario Museum in Toronto for further dating, utilizing either zircons or titanium-bearing minerals. Results from these samples are not yet available.

DISCUSSION

The Mount Milligan property is clearly part of the alkaline-suite porphyry deposits which occur in the Intermontane Belt from the Stikine region to the International Boundary (Figure B-12-1) and are associated with the Upper Triassic to Lower Jurassic Nicola-Takla-Stuhini volcanic assemblages and comagmatic alkaline plutons. As such it displays many features common to other deposits of this type, but also some significant differences.

Alkaline-suite deposits are subvolcanic porphyry systems that are localized along fault, fracture or rift zones of regional extent and are invariably associated with small complex alkaline plutons that are coeval and comagmatic with the surrounding volcanic rocks (Barr *et al.*, 1976, page 359). The deposits are generally low-sulphur copper systems with abundant magnetite in which molybdenite is rare but gold and silver are usually present in sufficient quantities to constitute a significant credit. In some deposits, such as Q.R., gold is the only economically recoverable product.

Hydrothermal alteration in alkaline-suite deposits is dominated by extensive biotite, potassium feldspar and albite closer to the mineralizing stocks, with a broad fringe of propylitic alteration. Quartz veining is very rare or absent. Some deposits, such as Ingerbelle, exhibit considerable scapolite veining and occasional garnets indicating the tendency of these high-level systems to grade towards skarn assemblages. In some deposits, including Mount Milligan (Figure B-12-4), skarn alteration fringes the porphyry system. Massive to semimassive sulphide veins, usually containing some lead and zinc mineralization and radiating outward from the mineralizing stocks, are another common feature of alkaline-suite porphyry systems, as well as of calcalkaline porphyries.

The mineralizing porphyry stocks are generally of monzonite to diorite composition, with phases or offshoots grading to syenite. They are invariably related to larger, deeper seated diorite and gabbro intrusions in which the earlier or border phases may contain considerable amounts of hybridized country rock. Field, chemical, petrogenetic and structural relationships are such that productive alkaline-suite porphyry systems invariably appear to have been emplaced in active structural zones and to have evolved in an active structural regime progressing

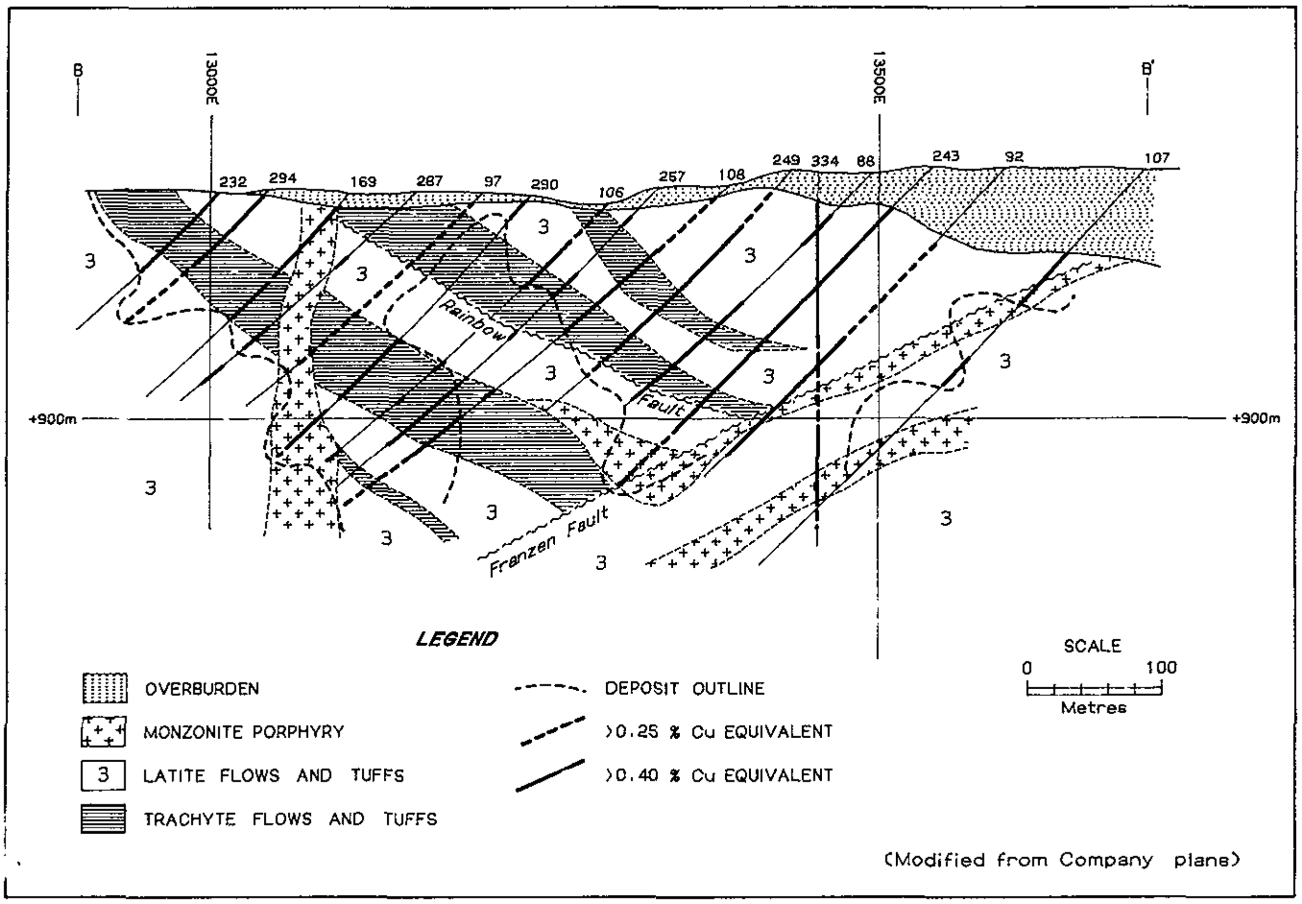


Figure B-12-6. Mount Milligan deposit cross section: 9100N.

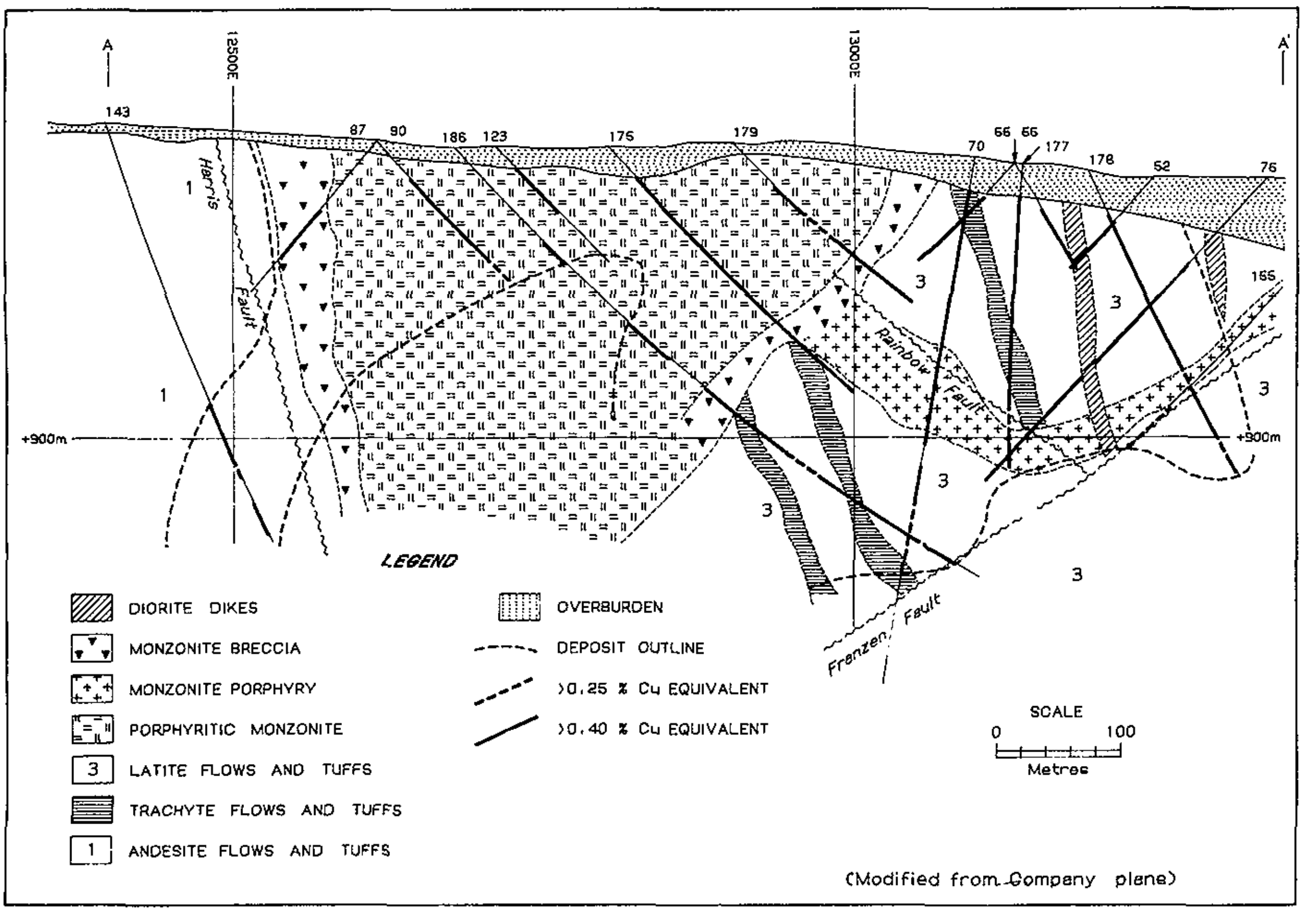
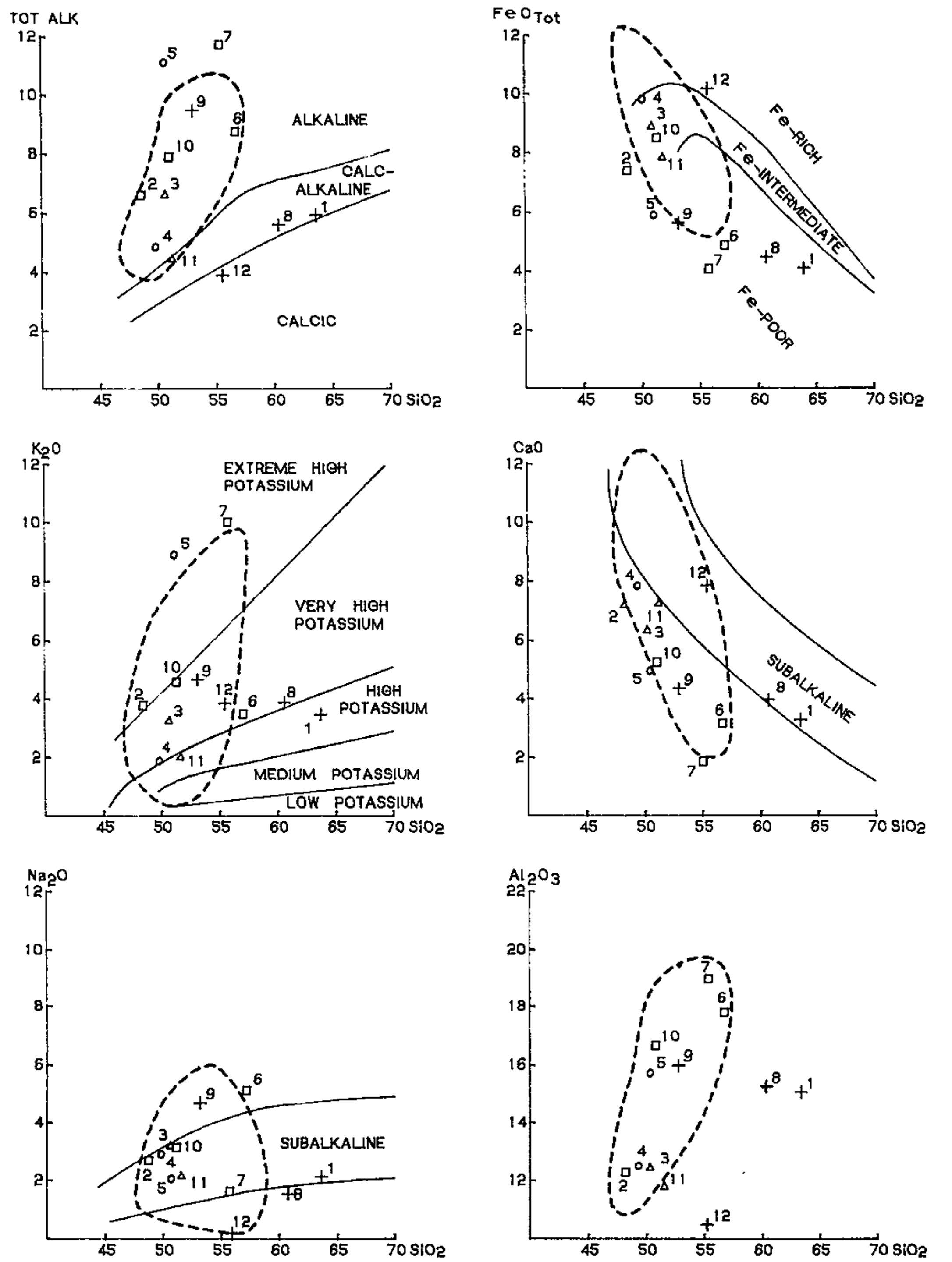


Figure B-12-7. Mount Milligan deposit cross section: 9600N.



Sample numbers are as in Table 1. Fields (solid lines) are those of Spence (1985). Fields (dashed lines) are for the majority of samples (9 of 10) of Upper Triassic shoshonites as determined by Spence (1985)

Symbols: □ = Intrusive rocks, O = Volcanic flows, Δ = Fragmentals, + = Post-ore dikes

Figure B-12-8. Chemical Plots: Mount Milligan samples.

from an earlier structural level of several kilometres depth to a subvolcanic level of only several hundred metres depth in the final stages. The porphyry stocks of alkaline-suite systems invariably contain bodies of explosion breccia which commonly exhibit evidence of multiple stages of brecciation and mineralization. Intrusive offshoots and fragments of the porphyry stocks are also commonly found in the volcanic rocks hosting or surrounding the porphyry deposits indicating that the intrusive system vented through and invaded its own earlier volcanic products during its evolution.

With some notable exceptions (Similco, Galore Creek), most alkaline-suite porphyry deposits are in the 25 to 35 million tonne class and have tenors that range from 0.3 to 1.1 per cent copper and 0.17 to 0.86 gram of gold per tonne (0.005 to 0.025 oz/t). Until Mount Milligan was discovered the largest known deposit of this type was Galore Creek with indicated and inferred reserves of 125 million tonnes grading 1.06 per cent copper, 0.445 gram per tonne gold and 8.57 grams per tonne silver (Barr *et al.*, 1976, page 363).

Although present knowledge of the Mount Milligan deposit is based almost entirely on examination of drill core and on geophysical data, the system appears to exhibit all of the fundamental characteristics of alkaline-suite porphyries. It is, however, significantly above average in its size and gold grade, while being well below average in copper grade. In short, Mount Milligan is a large, bulk-mineable gold deposit.

The deposit is also well above average in respect of the area affected by hydrothermal alteration and mineralization. Most porphyry systems of this type are confined to an area of less than 5 square kilometres (Barr *et al.*, 1976, page 365) whereas at Mount Milligan, porphyry stocks and anomalous sulphides are known to occur over an area well in excess of 10 square kilometres (Figure B-12-4) thus suggesting that the MBX and Southern Star stocks and the several small stocks found as far west as Heidi Lake are continuous below the level of current drilling.

ACKNOWLEDGMENTS

Material presented in this paper is the result of the work of one of the authors (C.M.R.) while providing geological consulting services to Continental Gold Corp., and of information gathered by the other authors in the course of several visits to the Mount Milligan property. The cooperation of Continental Gold Corp. management and staff in providing information and ready access to company plans and reports is greatly appreciated. In particular, thanks are given to the field staff for taking the time from their busy schedules to accommodate our visits.

REFERENCES

Barr, D.A., Fox, P.E., Northcote, K.E. and Preto, V.A. (1976): The Alkaline Suite Porphyry Deposits: A Summary; *in* Porphyry Deposits of the Canadian Cordillera; A. Sutherland Brown, Editor, *Canadian Institute of Mining and Metallurgy*, Special Volume 15, pages 359-367.

Faulkner, E.L. (1986): Phil, Heidi; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1985, pages 816-817.

______ (1988): Mount Milligan (Phil-Heidi); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1987, pages 133-135.

Garnett, J.A. (1978): Geology and Mineral Occurrences of the Southern Hogen Batholith; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 70.

Mortimer, N. (1986): Late Triassic, Arc-related, Potassic Igneous Rocks in the North American Cordillera; *Geology*, Volume 14, pages 1035-1078.

Map 15849 (1963) Wittsichica Creek, British Columbia; *Geological Survey of Canada*, Geophysics Paper 1594.

Spence, A. (1985): Shoshonites and Associated Rocks of Central British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1984, Paper 1985-1, pages 426-442.

CARBONATE-HOSTED LEAD-ZINC OCCURRENCES IN THE GERMANSEN LANDING AND END LAKE AREAS (94C/2, 93N/15)

(Fig. B1, No. 13)

By D. M. Melville

INTRODUCTION

Stratabound lead-zinc occurrences hosted by Devonian platformal carbonates occur in north-central British Columbia between Germansen Landing and the Osilinka River. These occurrences appear to be associated with a specific stratigraphic interval at the top of the carbonate sequence. Due to an increase in base metal prices, there has been a renewed interest in these long-known occurrences.

Access to the northern part of the area has greatly improved with the advancement of logging along the Osilinka River valley. Access from the south is limited to a road built for exploration purposes in the 1970s. It starts from the Omineca mining road 9 kilometres west of Germansen Landing and follows Nina Creek north for approximately 6 kilometres. From there it continues northward for approximately 10 kilometres.

HISTORY

Exploration for lead-zinc-silver deposits in the area between Germansen Landing and the Osilinka River began in the late 1920s (Lay, 1930). Subsequent exploration was sporadic until the early 1970s, when several major companies carried out geochemical programs, geological mapping, drilling, trenching and road construction (Leighton, 1988). Interest in the area fell off again until the recent rise in metal prices stimulated renewed interest in these deposits.

Companies now exploring this area include Noranda Exploration Company Limited (the NL claims) and a joint venture between Equinox Resources Ltd. and Darren Resources Ltd. (the Biddy and Vernon occurrences).

REGIONAL GEOLOGY

The Devonian stratigraphic interval hosting lead-zinc mineralization occurs near the boundary between para-autochthonous North American rocks and allochthonous rocks of the Intermontane Superterrane. This boundary roughly corresponds to the Omineca - Intermontane Belt boundary. In this area, the Intermontane Superterrane is represented by the Slide Mountain and Quesnel terranes. Together with the autochthonous North American stratigraphy, these rocks form part of a southwest-dipping homoclinal sequence. This homoclinal sequence has been cut by a series of normal faults which trend northwesterly in the northern portions of the map area, and in the south the trend is northeasterly (Figure B-13-1). With the exception of the eastern portion of the pericratonic strata, all other rocks have been weakly metamorphosed.

The pericratonic North American rocks are primarily carbonates and siliciclastics of miogeoclinal origin. They include the Proterozoic to Early Cambrian Ingenika Group, the Lower Cambrian Atan Group, the Cambrian to Ordovician Kechika Group, the Ordovician Road River Group, the Silurian to Lower Devonian Sandpile Group, the Middle Devonian McDame Group, and the Devono-Mississippian Earn Group (Ferri and Melville, 1990b). The eastern part of this sequence (mainly the Ingenika Group) is deformed and highly metamorphosed to sillimanite grade (Ferri and Melville, 1990a). These high-grade metamorphic rocks are included in the Wolverine complex.

Enigmatically overlying these pericratonic rocks are Pennsylvanian to Permian volcanic and sedimentary strata belonging to the Slide Mountain Group. This oceanic marginal-basin sequence is comprised of a lower argillite-dominated sedimentary package; a middle siliceous argillite, chert and gabbro division; and an upper pillowed to massive basalt, gabbro, argillite, chert, and ultramafite sequence (Ferri and Melville, 1989). The westernmost Slide Mountain strata are in fault contact (Manson fault zone) with rocks of the Quesnel Terrane.

Quesnel rocks in the area are predominantly represented by Upper Triassic to Lower Jurassic Takla Group volcanics and sediments (Monger, 1977). The Takla Group is comprised predominantly of pyroclastic and related epiclastic rocks with lesser massive flows (Ferri and Melville, 1989).

HOSTROCKS

The hostrocks for mineralization are primarily dolomites of the Middle Devonian McDame Group and the Silurian to Lower Devonian Sandpile Group. The McDame Group is capped by the Upper Devonian Earn Group and this sequence can be traced throughout most of the map area (Figure B-13-1). The following descriptions are summarized from Ferri and Melville (1990).

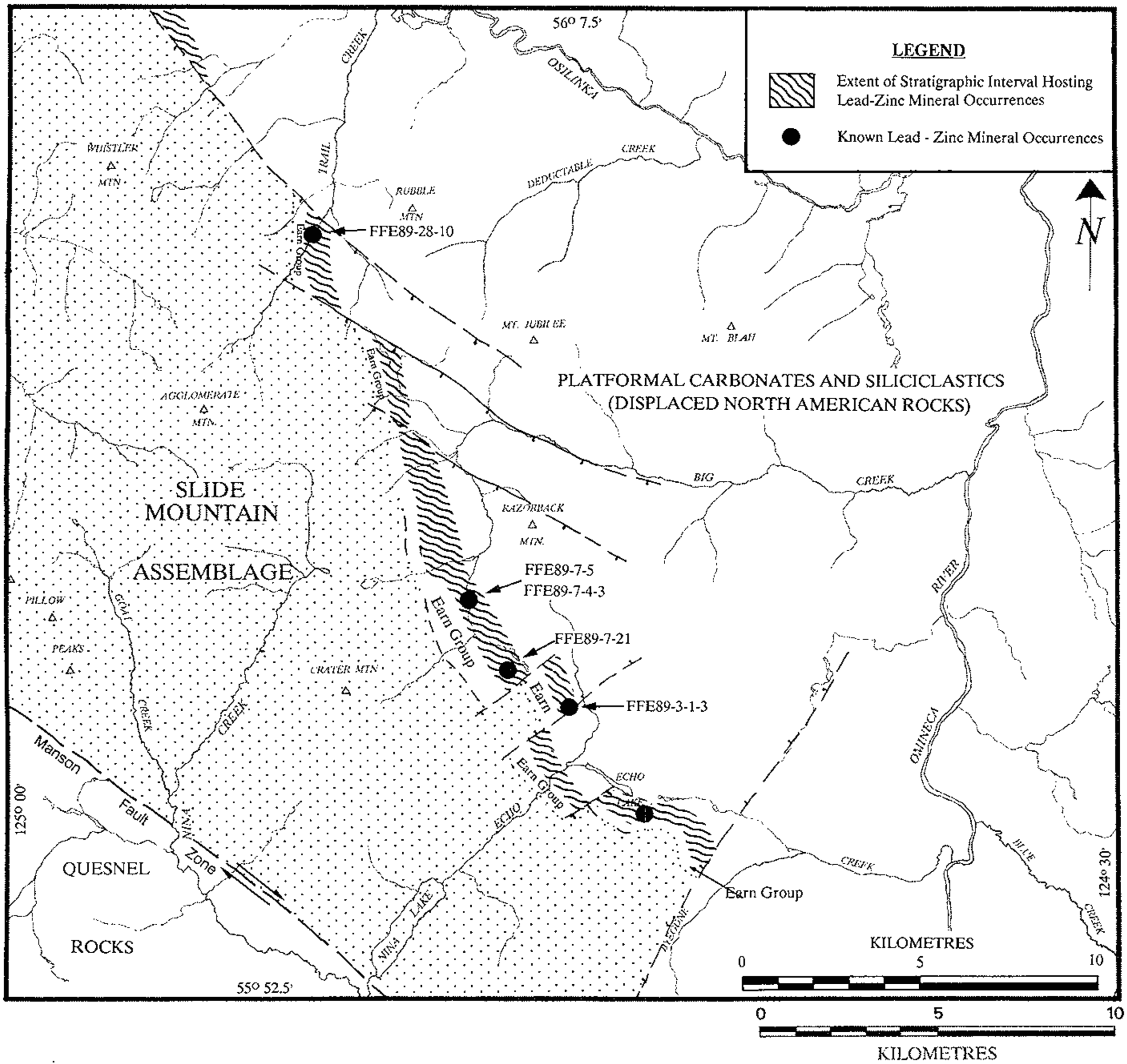


Figure B-13-1. Simplified geology (After Ferri and Melville, 1990) showing extent of the stratigraphic interval favorable for lead-zinc deposits.

The Sandpile Group is a thick succession of approximately 1000 metres of limestone, dolomite, sandy dolomite and minor quartzite. It is divided into two units with the lower unit consisting primarily of carbonate and the upper unit, sandy dolomites and quartzites.

The McDame Group is characterized by approximately 150 to 200 metres of grey to black limestones and dolomites. The limestones are typically thin to thick bedded, fetid and found lower in the sequence. The dolomites are finely crystalline, tan to grey in colour and are found near the top of the McDame Group.

The Earn Group, represented by blue-grey to dark grey shales, argillites and minor sandstones, caps this succession. This group is approximately 500 metres thick with extremely fissile shales at the base.

MINERAL OCCURRENCES

Stratabound sulphide mineralization is contained within a stratigraphic interval ranging from the McDame-Earn contact downwards to the uppermost sandy dolomites of the Sandpile Group. It consists of yellow to red-brown sphalerite, argentiferous galena, barite and minor pyrite. The sulphides occur as semimassive irregular shaped pods in solution breccias, as massive sulphides in localized shear zones, or as disseminated blebs in arenaceous dolomites. Germanium is commonly associated with the sphalerite.

The brecciated dolomites (collapse breccias) host semimassive sphalerite and galena together with megacrystic barite. Typical grades average 3 to 4 per cent sphalerite (Leighton, 1988) with variable galena (usually less than sphalerite). Grades can be as high as 14.7 per cent zinc, 0.67 per cent lead and 115 grams per tonne silver (Ferri and Melville, 1990). The sulphides also occur as clasts in a calcite-barite matrix; as matrix with carbonate clasts; or as a combination of both.

The tectonic breccias are similar to the dolomitic breccias in terms of variable galena, sphalerite, and barite mineralization. The sulphides occur either as semimassive irregular pods (Leighton, 1988) or as the matrix of fault breccia (Sonnendrucker, 1975).

Mineralization within the lower McDame and upper Sandpile Groups is generally restricted to disseminated sphalerite in arenaceous dolomites, fine-grained dolomites, and rarely, sandstones. The sphalerite occurs with minor amounts of pyrite and grades may reach up to 4 per cent zinc with less than 0.5 per cent lead and typically less than 6 grams per tonne silver (Sonnendrucker, 1975).

Germanium occurs as germanium-bearing sphalerite in the Biddy area and has been reported to be on average 0.05 per cent of the sphalerite mineralization (Leighton, 1988). Preliminary results presented in Table B-13-1 indicate that sphalerite averages 0.20 per cent germanium (using samples greater than 100 ppm germanium and assuming the metal content of sphalerite to be entirely zinc and germanium). This may also be expressed as ratios ranging from 669 to 345:1 zinc to germanium.

DISCUSSION

The dolomitic breccias commonly occur just below the McDame-Earn contact and no stratabound lead-zinc mineralization has been found above this level. This suggests that the Earn shales acted as an impermeable barrier to the movement of mineralizing fluids and the breccias were formed by the channeling of these fluids through the carbonate rocks resulting in the formation of solution-collapse breccias.

These deposits are similar to the Midway camp in the Cassiar area in that the mineralized zones occur in the same stratigraphic interval and are gently dipping. In the breccias, the sulphides occur as combinations of matrix and/or clast replacement, suggesting multi-phase fluid influx and deposition (Bradford, 1988).

However, in the Cassiar area, the larger deposits like Midway are mantos which exhibit a characteristically complex sulphide mineralization suite. In the Germansen Landing - End Lake area, a much simpler sulphide suite

TABLE B-13-1

GRAB SAMPLES COLLECTED FROM THE 1989 FIELD SEASON OF THE MANSON CREEK PROJECT

Sample No.	Property	MINFILE Number	Ag ppm	Pb[1] %	Zn[1] %	Ge* ppm	Zn:Ge
FFE89-3-1-3	Vernon	093N 076	84	5.20	8.70	130	669:1
FFE89-7-4-3	Biddy	093N 114	28	10ppm	4.11	120	345:1
FFE89-7-5	Biddy	093N 114	32	5.40	20ppm	<100ppm	—
FFE89-7-5D	Biddy	093N 114	32	5.50	16ppm	<100ppm	—
FFE89-7-21	Jemima	093N 010	115	0.67	14.7	220	668:1
FFE89-28-10	Whistler	094C 096	0.8	0.32	6.60	d	----

* - Samples run by the B.C. Geological Survey - Analytical Sciences Laboratory. Preliminary results using a semi-quantifying spectograph. Error±25%.

[1] - Unless otherwise indicated.

exists (primarily galena and sphalerite). This difference together with the strong bias towards the dolomitic units, indicates that these deposits are like Mississippi Valley-type lead-zinc deposits.

Current exploration has been limited largely to the north-central part of the 93N/15 map sheet and the north-west quadrant of the 94C/2 map sheet, primarily due to accessibility. Recent regional mapping by the British Columbia Geological Survey Branch has discovered a new lead-zinc showing in dolomites between these two explored areas. The regional extent of favorable hostrocks and the local crosscutting faults make this area highly prospective.

ACKNOWLEDGMENTS

The author would like to thank Filippo Ferri and Don MacIntyre for reviewing the manuscript and providing discussions, ideas and improvements on both the geology and mineralization.

I would also like to thank JoAnne Nelson for providing stimulating discussions about lead-zinc carbonate replacement deposits in the Cassiar area and their comparisons to the prospects in the Germansen Landing area.

REFERENCES

Bradford, J.A. (1988): Geology and Genesis of the Midway Silver-Lead-Zinc Deposit, North-Central British Columbia; unpublished M.Sc. thesis, *The University of British Columbia.*

Ferri, F. and Melville, D.M. (1989): Geology of the Germansen Landing Area, British Columbia (93N/10, 15); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 209-220.

______ (1990a): Geology between Nina Lake and Osilinka River, North-central British Columbia (93N/15, North Half and 94C/2, South Half); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 101-114.

______ (1990b): Geochemistry and Mineral Occurrences Between Nina Lake and Osilinka River, NTS 93N/15 (North Half) and 94C/2 (South Half); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1990-17, Sheet 2.

Lay, D. (1930): Report of Activities - Fort Graham Section; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Annual Report 1930, pages 152-153.

Leighton, D.G. (1988): Geological Report on the Nina Property, Germansen Landing, B.C.; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 16946.

Monger, J.W.H. (1977): The Triassic Takla Group in McConnell Creek Map Area, North-central British Columbia; *Geological Survey of Canada*, Paper 76-29, 45 pages.

Sonnendrucker, P.F., (1975): A Geological and Geochemical Report on the Sheila M.C. Group; Nine Miles North of Germansen Landing; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 5453.

ESKAY CREEK (104B 008)

(Fig. B1, No. 14)

By J.M. Britton, J.D. Blackwell[1] and T.G. Schroeter

LOCATION:	Lat. 56°38′ Long. 130°27′ (104B/9W) SKEENA MINING DIVISION. The property is located 84 kilometres north-northwest of Stewart and 4 kilometres east of Tom Mackay Lake on the Prout Plateau between the Unuk and Iskut rivers.
CLAIMS:	TOK 1-22, KAY 11-18.
ACCESS:	By fixed-wing aircraft to gravel strips at Bronson Creek or Johnny Mountain and thence by helicopter to the property, or by helicopter from bases at Bell-Irving River or Bob Quinn Lake on Highway 37.
OWNERS:	Stikine Resources Limited and Prime Resources Group Incorporated.
OPERATOR:	PRIME EXPLORATIONS LIMITED.
COMMODITIES:	Gold, silver, zinc, lead, copper, arsenic, antimony, mercury.

#21 ZONE DEPOSITS, ESKAY CREEK, NORTHWESTERN BRITISH COLUMBIA

SUMMARY

Exploration in northwestern British Columbia has received international attention as a result of the #21 zone gold, silver and base metal discoveries at Eskay Creek, 80 kilometres north of Stewart. Geological reserves total 5 023 000 tonnes grading 15.6 grams per tonne gold and 441 grams per tonne silver at a cut-off grade of 1.4 grams per tonne gold. Included in this is a high-grade core of 1 223 000 tonnes averaging 49.4 grams per tonne gold, 1392 grams per tonne silver, 5.5 per cent zinc and 2.2 per cent lead.

The discovery area lies within a well-known belt of base and precious metal showings that has been explored intermittently since the 1930s. These prospects are contained in felsic volcanic rocks near the top of the Lower to Middle Jurassic Hazelton Group. Hostrock stratigraphy is: a lower sequence of interbedded dacitic tuffs and wackes; a middle sequence of rhyolitic tuffs and breccias; and an upper sequence of andesitic pillow breccias and flows, intercalated with mudstones.

The recent discoveries result from drill-testing the subsurface extensions of an old prospect, the #21 open cut, a low-grade, base and precious-metal stockwork that occurs in the rhyolite sequence. Drilling has traced exceptionally high-grade gold and silver-bearing sulphide mineralization more than 1400 metres along strike and 250 metres down dip.

Two deposits, the 21A and 21B, have so far been delineated. Both comprise stratabound massive sulphide lenses within a tuffaceous mudstone unit at the rhyolite-andesite contact. Disseminated and stockwork mineralization is also present in immediately underlying rhyolite. The northern part of the 21B deposit has two massive sulphide lenses within interflow mudstones of the upper sequence. The deposits have distinctively different mineralogies. The 21A is rich in stibnite and realgar with only minor pyrite and base metal sulphides. The 21B lacks stibnite and realgar but contains abundant sphalerite, tetrahedrite, boulangerite, bournonite, galena and pyrite.

Current work includes definition drilling and development of the 21B deposit as well as outlining additional discoveries such as the 21C and Pumphouse zones.

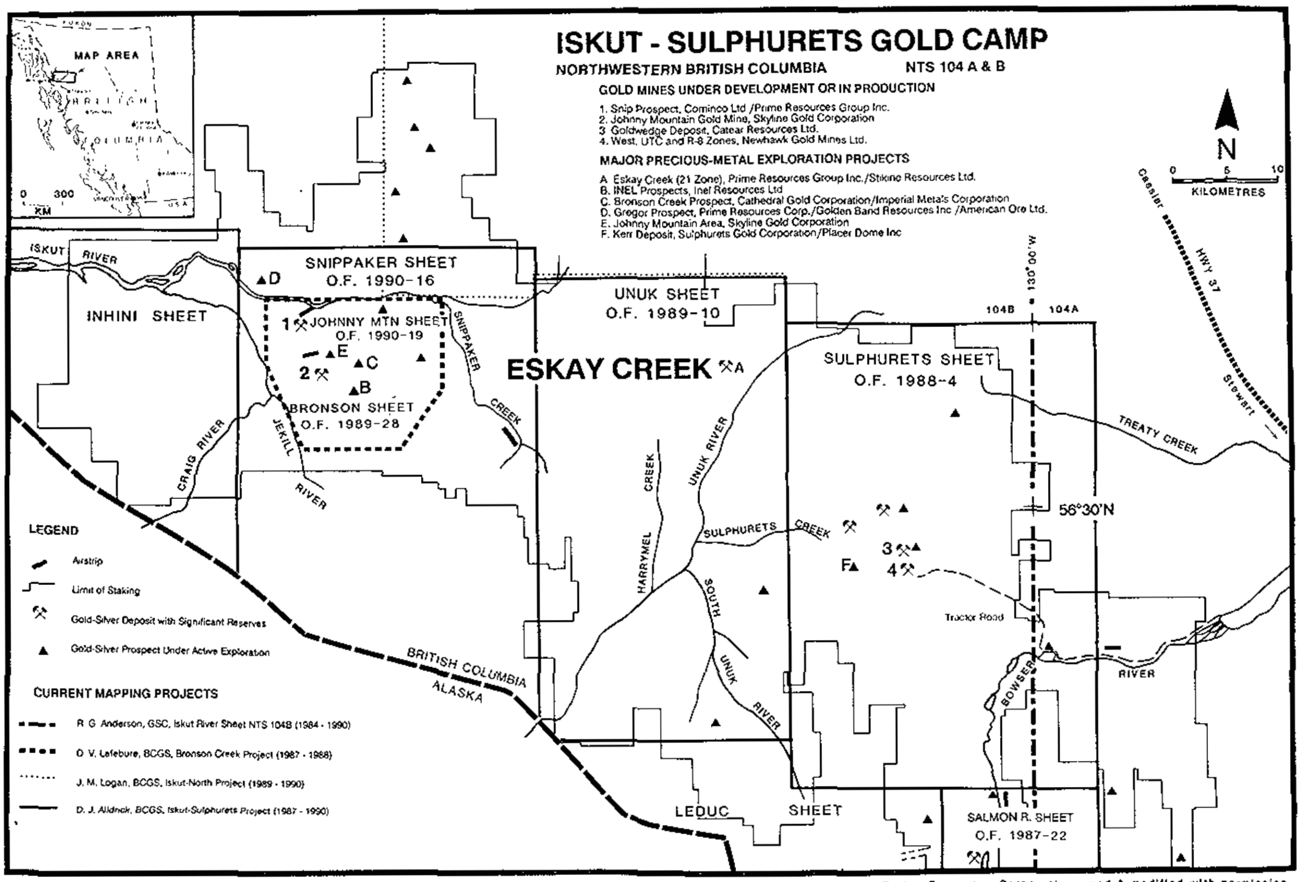
The Eskay Creek project is an exploration and development joint venture between Prime Resources Group Incorporated and Stikine Resources Limited, with Prime Explorations Limited as project operator.

INTRODUCTION

This report describes the geology and mineral deposits of Eskay Creek highlighting the exciting discoveries made since September, 1988. It is necessarily a snapshot since aggressive exploration continues to bring fresh facts to light.

It is also a collaborative paper with contributions as follows: regional and property geology (JMB) are based on reconnaissance mapping conducted in the Iskut-Sulphurets gold belt since 1987 and property visits in July and August, 1989. Property history, stratigraphy and mineralization (JDB) stem from an association with the project since December, 1988. Photography, deposit sampling and geology (TGS) come from a property visit in September, 1989.

1 Consulting geologist to Prime Explorations Limited.



Map courtesy of Teuton Resources Corporation, used & modified with permission.

Figure B-14-1. Eskay Creek and the Iskut-Sulphurets gold camp: precious metal deposits and current mapping projects.

Location and Access

The Eskay Creek property is located 84 kilometres north-northwest of Stewart and 4 kilometres east of Tom Mackay Lake, in the upper Unuk River valley (Figures B-14-1, 2). Present access is by helicopter but transportation infrastructure is good. Stewart has the nearest paved air strip. Gravel air strips at Bronson Creek and Johnny Mountain, 40 kilometres west, receive scheduled fixed-wing service from Smithers and Terrace, B.C. and Wrangell, Alaska, and can handle aircraft up to the freight capacity of a Hercules transport. Helicopter bases at Bell-Irving River crossing, 42 kilometres east, and Bob Quinn Lake, 34 kilometres northeast, provide links with Highway 37.

Tom Mackay Lake was used by the first prospecting parties for float-plane support. Now-overgrown tote roads from the lake and a 425-metre air strip on Coulter Creek were built by early prospectors.

The recently completed Iskut River road access study (Smith and Gerath, 1989) proposed routes that would pass within 20 kilometres of the property.

Physiography, Vegetation and Climate

The property is located on the Prout Plateau, a rolling subalpine upland on the eastern flank of the Boundary Ranges of the Coast Mountains. Plateau elevation averages about 1100 metres. The property straddles a northeast-trending ridge that is flanked by Argillite Creek to the west and Eskay Creek to the east. These and other locally named creeks (Mackay and Ketchum) descend as deeply incised tributaries to the Unuk River canyon (elevation 300 metres) 3 kilometres to the east.

Below treeline (1050 metres) vegetation is typical of coastal rain forest. Mature stands of sub-alpine conifers have a locally dense understorey of flowers, bushes and slide alder. Precipitation is heavy, more than 100 centimetres a year, much of it falling as snow from November to March.

Claims and Ownership

The TOK 1-22 and KAY 11-18 two-post claims cover the mineralized areas described in this report. Some surrounding mineral claims are being contested for irregularities in staking (The Northern Miner, February 12, 1990). The TOK and KAY blocks are jointly owned by Stikine Resources Limited and Prime Resources Group Incorporated (formerly Calpine Resources Incorporated). Prime Explorations Limited manage the exploration programs on these claims.

PROPERTY HISTORY

The Eskay Creek area has a long history of intermittent exploration since its discovery and first staking in 1932 by T.S. Mackay, A.H. Melville and W.A. Prout (*B.C. Minister of Mines*, 1932 *et seq.*; Panteleyev, 1983; Harris, 1985, 1987; Blackwell, 1989). Early prospectors were attracted by a line of gossanous bluffs that extends more than 7 kilometres beside Eskay and Coulter creeks. Most exploration has been aimed at delineating high-grade precious metal mineralization, especially silver. Base metal deposits have been secondary targets.

The early work of Premier Gold Mining Company Limited (1935-1938) identified more than 30 distinct mineralized zones in upper Coulter and Eskay creeks and established a numerical labelling scheme (*e.g.* #5, #13, #21, #22). Earliest exploration efforts focused on the southern part of this area, subsequently shifting to the north. In 1939 an 84-metre adit (the Mackay adit) was driven on the "North End workings" which lie 3 kilometres southwest of the #21 zone.

Since World War II the #5, #6 (Emma), #21, #22 and #28 zones have been the main exploration targets. The period 1946-1976 saw the extension of the Mackay adit to 110 metres, 180 metres of drifting and crosscuts on the Emma adit, several thousand metres of diamond drilling, plus sampling of numerous trenches, pits and open cuts by Canadian Exploration Limited, American Standard Mines Limited, Western Resources Limited, Canex Aerial Exploration Limited, Mount Washington Copper Company, Kalco Valley Mines Limited and Texasgulf Inc. (*B.C. Department of Mines and Petroleum Resources*, 1970-1973; *B.C. Ministry of Mines and Petroleum Resources*, 1975, 1976; Gasteiger and Peatfield, 1975; Schink and Peatfield, 1976).

Between options Stikine Silver Limited continued surface work. In 1971 it extracted a 1.5-tonne sample of high-grade ore that yielded 9.3 grams of gold, 7435 grams of silver, 29 kilograms of lead and 42.7 kilograms of zinc from trenches on the #22 zone. In 1979 May-Ralph Industries Limited mined these trenches to produce 8.75 tonnes of hand-cobbed ore yielding 1263 grams of gold, 25 490 grams of silver, 412 kilograms of lead and 1008 kilograms of zinc.

In the early 1980s Ryan Exploration Limited (a subsidiary of U.S. Borax) completed a geochemical survey followed by shallow diamond drilling near the Emma and Mackay adits (George, 1983a, b). In 1985 Kerrisdale Resources Limited drilled four holes near the #21 open cut to test the extent of mineralization beneath Premier's earlier trenches and drilling (Kuran, 1985). This drilling identified a new zone of spotty gold and silver values hosted in altered felsic volcanics. The best intersection was 5 metres of 1342 grams per tonne silver and 3.4 grams per tonne gold.

DISCOVERY AND CURRENT WORK

Calpine Resources Incorporated announced its discovery in November, 1988, during the initial ($300 000) phase of a $900 000 program to earn a 50 per cent interest in the TOK and KAY claims. It had optioned the property in May, 1988, commencing soil sampling and geological mapping in early August and a six-hole diamond drilling program in mid-September. Five holes were planned to test the #21 open cut and its possible extensions. Three holes (CA88-2, 4 and 5) encountered stockwork mineralization in rhyolite. Two 50-metre step-out holes (CA88-3 and 6) intersected a massive sulphide body, above target depths, at the contact between rhyolite and overlying andesite. These are considered the discovery holes, with hole CA88-6 cutting over 29 metres of stibnite and realgar-rich core grading 26 grams gold and 38 grams silver per tonne, including 16 metres of 46 grams gold and 68 grams silver (George Cross News Letter No. 213/1988). Follow-up drilling during November and December 1988 established the orientation and continuity of this blind discovery. Ten addditional holes (CA88-7 to 16) totalling 2 099 metres were completed.

In January 1989 the Joint Venture started a winter program of definition and step-out diamond drilling (Mallo, 1989b). A total of 13 368 metres in 54 holes (CA89-17 to 70) was completed by early May, 1989. The work outlined the 21A deposit, then called the South zone, and suggested the presence of more blind mineralization farther to the north. During this period a geophysical survey was flown over the Prout Plateau (Mallo, 1989a; Mallo and Dvorak, 1989).

Drilling resumed in June. On August 22 results from step-out drilling 1 kilometre north of CA88-6 were announced. Hole CA89-109 had intersected 61 metres that assayed 99 grams gold and 29 grams silver, including 19 metres of 266 grams gold and 46 grams silver per tonne (George Cross News Letter No. 161/1989). The news galvanized the Vancouver Stock Exchange, and new trading records were set. Speculative euphoria was such that just two weeks later hole CA89-126, which cut 43 metres of 18 grams gold and 378 grams silver per tonne was considered "low grade" and caused a dip in share prices (The Northern Miner, September 18, 1989).

By December, 1989, a total of 29 550 metres had been completed in 125 holes (CA89-71 to 205). This work identified the most important area of mineralization discovered so far, the 21B deposit (initially termed the Central and North zones) and further defined the 21A deposit. Other exploration work included establishing a survey grid over the entire property, geochemical and ground geophysical surveys, prospecting, geological mapping of selected areas and legal surveys of the TOK and KAY claims. Seven diamond-drill holes were completed on the #22 zone totalling 1321 metres. Initial environ-

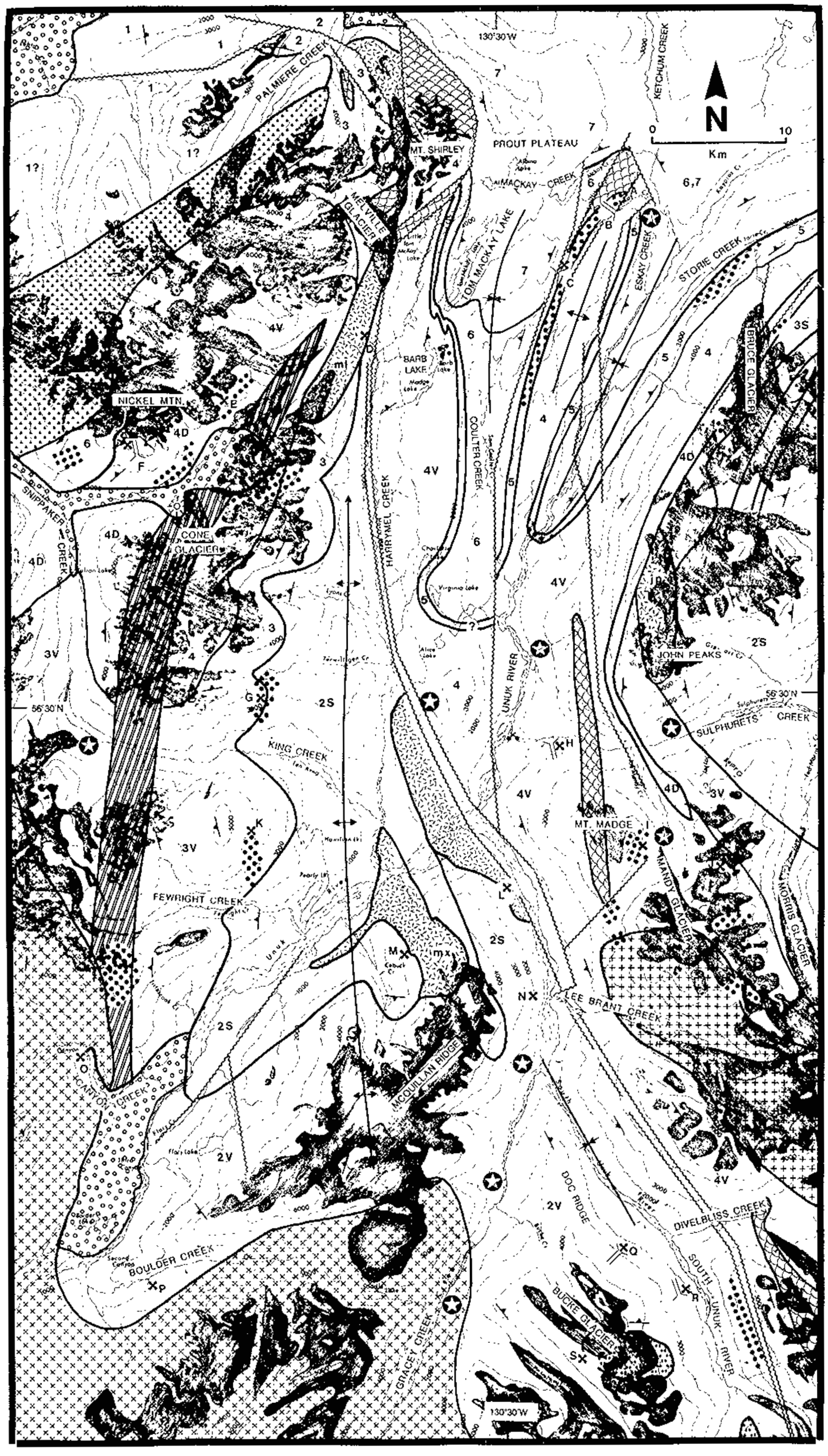


Figure B-14-2. Regional geology, Unuk map area.

LEGEND

INTRUSIVE ROCKS

Eocene
- King Creek dike swarm
- Coast plutonic complex
- Lee Brant stock

Jurassic
- Lehto batholith

M. Jurassic to U. Triassic
- Diorite and Gabbro:
  - Nickel Mountain (nm)
  - John Peaks (jp)
  - Melville (mv)
  - Max (mx)

U. Triassic
- Meta-quartz-diorite
  - Bucke Glacier stock

STRATIFIED ROCKS

Recent to Pleistocene
- Basalt flows and tephra

M. Jurassic
- 7 Bowser Lake Group: shale, conglomerate
- 6 Salmon River formation: turbidite, pillow lava
- 5 Mount Dilworth formation: felsic pyroclastics

L. Jurassic
- 4 (D, V, S) Betty Creek formation: epiclastic and pyroclastic rocks
- 3 (V, S) Unuk River formation: andesitic tuff, wacke, siltstone

U. Triassic
- 2 (V, S) Stuhini Group: basaltic tuff, wacke, limestone

D = Dacite
V = Andesitic volcanics (with <40% sediments)
S = Sediments (with <40% volcanics)

Permian and older
- 1 Stikine assemblage: phyllite, meta-volcanics, limestone

SYMBOLS

Compositional layering (bedding; foliation)

Contact

Anticline; syncline

Fault; lineament

Pillow lavas

Recent volcanic vent

Gossan

Adit

Stream sediment gold values >90th percentile

Mineral occurrence

Placer occurrence

MINERAL OCCURENCES

	NAME	COMMODITY
A	Eskay	Au,Ag,Pb,Zn,Cu,As,Sb,Hg
B	Emma	Au,Ag,Pb,Zn,Cu
C	Mackay	Au,Ag,Pb,Zn,Cu
D	Copper King	Cu,Fe
E	Colagh	Cu
F	E&L Nickel	Ni,Cu
G	Cole	Cu,Au,Ag
H	Cumberland/Daly	Au,Ag
I	Mt. Madge (C-10)	Au,Ag,Zn
J	Mt. Madge (GFJ)	Au,Ag,Cu,Zn
K	VV	Cu,Mo,Au,Ag
L	Chris & Anne	Cu,Fe
M	Max	Fe,Cu
N	Unuk Jumbo	Fe,Cu
O	Black Bear	Au,Pb,Zn
P	Boulder Creek	Pb,Zn,Au,Cu
Q	Doc	Au,Ag,Pb,Cu
R	Globe	Au,Ag,Pb,Cu
S	Alf	Au,Ag

TABLE B-14-1
PUBLISHED RESERVE ESTIMATES, ESKAY CREEK

COMBINED #21 ZONE DEPOSITS

	Geological Reserve Category	Tonnes[a]	Gold g/tonne	Silver g/tonne
1[b]	Cut-off grade = 1.4 grams per tonne gold			
21A & B DEPOSITS	Probable	3 343 000	19.2	521.1
	Possible	1 680 000	8.6	281.1
	TOTAL	5 023 000	15.6	440.8
2[c]	Cut-off grade = 1.7 grams per tonne gold equivalent			
SOUTH & NORTH AREAS	Indicated	4 157 890	17.8	453.6
	Inferred	3 033 990	16.7	357.9
	TOTAL	7 190 890	17.4	413.1

RESERVE ESTIMATES BY DEPOSIT AND GRADE

Deposit	Geological Reserve Category	Tonnes	Gold g/tonne	Silver g/tonne	Lead[d] %	Zinc[d] %
1[c]	Cut-off grade = 1.7 grams per tonne gold equivalent					
SOUTH AREA	Indicated	1 036 920	8.9	127.5		
	Inferred	434 610	7.7	117.6		
	SOUTH TOTAL	1 471 530	8.6	124.5		
NORTH AREA	Indicated	3 119 980	20.8	561.9		
	Inferred	2 599 380	18.2	388.1		
	NORTH TOTAL	5 719 360	19.6	487.5		
2[b]	Cut-off grade = 1.4 grams per tonne gold					
21A	Probable	1 058 000	8.2	96.0		
	Possible Geological	355 000	4.1	181.7		
	21A TOTAL	1 412 000	7.2	116.6		
21B	Probable	2 285 000	24.3	716.6		
	Possible	1 325 000	9.9	5.1		
	21B TOTAL	3 610 000	19.2	565.7		
3[b]	Cut-off grade = 3.4 grams per tonne gold					
21A	Probable	751 000	11.0	109.7		
	Possible	215 000	5.1	188.6		
	21A TOTAL	966 000	9.6	126.9		
21B	Probable	1 317 000	39.4	1422.9		
	Possible	593 000	17.8	562.3		
	21B TOTAL	1 910 000	33.6	1155.4		
4[b]	Cut-off grade = 8.6 grams per tonne gold					
21A	Probable	156 000	24.7	236.6		
	Possible	28 000	11.7	202.3		
	21A TOTAL	184 000	22.6	229.7		
21B	Probable	875 000	58.6	1604.6	2.2	5.4
	Possible	347 000	26.4	857.2	2.1	5.6
	21B TOTAL	1 223 000	49.4	1392.0	2.2	5.5

NOTES:

a) Tonnage and grade figures are converted from imperial measurements reported in George Cross News Letter No. 72/1990 and include drill-hole data to the end of December, 1989 (hole CA89-205). Conversion factors are: 1 troy ounce per short ton = 34.286 grams per tonne; 1 short ton = 0.90718 tonne; numbers are rounded off. Cut-off grades are stated on each table.

b) Calculated by Roscoe Postle Associates Incorporated on behalf of Calpine Resources Incorporated. Reserves are undiluted and uncut. The calculation uses 2 metres minimum thickness and a specific gravity of 2.76.

c) Calculated by Orcan Mineral Associates Limited on behalf of Stikine Resources Limited. The calculation includes all mineralization down to 0.050 ounce per ton (1.714 grams per tonne) gold equivalent over 3.0 metres of core length (80 ounces silver = 1 ounce gold). Reserves are undiluted. Gold assays greater than 20.0 ounces per ton (685.7 grams per tonne) were cut to that figure. The calculations use a minimum block thickness of 3.0 metres and a specific gravity of 2.8.

d) blank = not calculated.

mental and engineering studies commenced, including an assessment of possible surface routes to Highway 37.

Since early January, 1990, six diamond drills have been at work on the 21B deposit defining it on 25-metre centres and testing for extensions beyond the currently outlined reserve. To the end of March 44 970 metres have been drilled in 235 holes (CA90-206 to 440).

Ore reserve estimates have been calculated utilizing drill results to the end of December, 1989 (Table B-14-1). Advanced engineering studies have been started to evaluate deposit metallurgy, and underground exploration and mine planning requirements. This program is ongoing.

It is one of the ironies of exploration history that these deposits were not discovered years earlier. Orpiment and realgar rich-boulders were found in the most northerly of the trenches on the #21 open cut in the 1930s (G.A. Dirom Sr., personal communication, 1990). These returned high gold and silver assays, but were not followed up. Premier drilled beneath the southern trenches and intersected spotty, lower grade mineralization. The float boulder analyses were omitted from all but the earliest versions of assay plans and soon slipped into obscurity.

REGIONAL GEOLOGY

GEOLOGIC SETTING

The Eskay Creek deposits sit in the centre of the Iskut-Sulphurets gold camp (Figure B-14-1) which has been a focus of recent geological mapping by the B.C. Geological Survey Branch (Alldrick and Britton, 1988; Alldrick *et al.*, 1989, 1990a; Britton, 1988; Britton and Alldrick, 1988; Britton *et al.*, 1989, 1990) and the Geological Survey of Canada (Anderson, 1989; Anderson and Thorkelson, 1990; Read *et al.*, 1989). Earlier work by Grove (1969, 1971, 1986) incorporating the unpublished geological maps of Newmont Mines Limited (1959-1962) has also contributed to a modern understanding of the geology of the area.

The Unuk valley lies along the western margin of the Intermontane tectonic belt and, according to terrane concepts, is entirely within Stikinia (Wheeler *et al.*, 1988). Anderson (1989) has defined the regional stratigraphic framework of this part of Stikinia to consist of four tectonostratigraphic assemblages bounded by unconformities:

- Paleozoic Stikine assemblage.
- Triassic to Jurassic volcanic-plutonic arc complexes;
- Middle and Upper Jurassic Bowser overlap assemblage;
- Tertiary Coast plutonic complex;

Stratigraphic nomenclature in this part of the Intermontane Belt is in a state of flux. For this reason local formation names used in this report are informal. Resolution awaits advances in mapping. Terms shown in brackets refer to previously published maps and reports (Alldrick *et al.*, 1989; Britton *et al.*, 1989; Grove, 1986).

Stratigraphic reconstruction of the Unuk area has proved an intractable task due to a lack of good markers and way-up structures, particularly in volcanic successions, paucity of fossils and faults. A reasonably well-defined lithostratigraphic succession extends from Stewart through the Sulphurets area to the Unuk valley (Alldrick and Britton, 1988; Alldrick *et al.*, 1989; Anderson and Thorkelson, 1990). Correlation across the Unuk is complicated by north-striking faults that are part of a major structural break that extends from the South Unuk River along Harrymel Creek to Forrest Kerr and More creeks in the north (Alldrick *et al.*, 1989; Read *et al.*, 1989).

Sufficient fossil, radiometric and lithostratigraphic data exist to permit broad correlation with the main Mesozoic groups: Stuhini (Takla)[2], Hazelton and Bowser Lake. Correlation with formations, members or facies of these groups is more conjectural. Lithostratigraphic similarities alone are an uncertain basis for correlation.

STRATIGRAPHY

Bedrock in the Unuk map area consists of a thick (more than 5000 metres) succession of Upper Triassic to Middle Jurassic volcano-sedimentary arc-complex lithologies underlain by Permian and older arc and shelf sequences and overlain by Middle and Upper Jurassic marine-basin sediments (Figure B-14-2). Rocks have been folded, faulted and weakly metamorphosed, mainly during Cretaceous time. Dioritic to granitic rocks that crop out east and west of the Prout Plateau represent at least four intrusive episodes spanning Triassic to Tertiary time. Remnants of Pleistocene to Recent basaltic eruptions are preserved locally.

2 Prior to the early 1980s Takla was the usual name for Triassic strata (Grove, 1986). Since then the term Stuhini has become more common. The Stuhini Group was first defined by Kerr (1948); the Takla by Armstrong (1949). The groups comprise Upper Triassic strata that fringe the Bowser Basin. As terrane concepts emerged and became entrenched in the literature a new convention has developed. Stuhini is now the preferred term for Triassic strata west of the Cache Creek Terrane (*e.g.* in Stikinia); Takla for similar strata east of the Cache Creek Terrane (*e.g.* in Quesnellia). Otherwise there is little difference in lithology, chemistry, rock associations, and age between Stuhini and Takla groups.

PALEOZOIC

PERMIAN AND OLDER STIKINE ASSEMBLAGE

Stikine assemblage rocks crop out along the Iskut River (Read *et al.*, 1989), 15 kilometres northwest of Eskay Creek. They consist of phyllite, siliceous siltstone, ribbon chert, tuffaceous wacke and foliated plagioclase porphyry. Thick limestones, felsic tuffs and basaltic pillow lavas occur farther west (Anderson, 1989; Logan *et al.*, 1990a, b). The assemblage presumably forms the basement to Mesozoic strata in the Unuk area.

MESOZOIC

Mesozoic strata form an apparently conformable, but discontinuous succession spanning Carnian to Bathonian time. Five lithostratigraphic packages are recognized.

UPPER TRIASSIC STUHINI GROUP

The oldest rocks consist of immature clastic sediments with volcaniclastic interbeds. Pyroxene-phyric breccias form distinct markers east of Unuk valley between Bruce and Jack glaciers. Limestone lenses and beds, locally quite coarsely crystalline, crop out to the south and west along the South Unuk River and Harrymel Creek. The upper strata of this unit may be marked by a distinctive granite-cobble conglomerate exposed locally around John Peaks (Anderson and Thorkelson, 1990; Britton *et al.*, 1989). Rare occurrences of Carnian and Norian index fossils (Grove, 1986; Gunning, 1986) such as *Halobia*, found on McQuillan Ridge, and *Monotis*, found north of Bruce Glacier, and radiometric dating of intrusive rocks (Anderson and Bevier, 1990) establish a Late Triassic age. On the basis of age and lithology these rocks can be assigned to the Stuhini Group. The group includes parts of the Lower Volcanosedimentary and Andesite sequences of Alldrick *et al.* (1989). They appear to pass conformably upwards into Lower Jurassic Hazelton Group strata between Storie and Treaty creeks but elsewhere there is a marked unconformity (Anderson, 1989; Anderson and Thorkelson, 1990).

LOWER TO MIDDLE JURASSIC HAZELTON GROUP

Most of the upper Unuk valley is underlain by rocks of the Hazelton Group. Four lithostratigraphic sequences ("formations") have been distinguished (Alldrick *et al.*, 1989; Britton *et al.*, 1989).

Unuk River Formation (Andesite Sequence)

The lowest is a thick, monotonous sequence of fine-grained andesitic pyroclastics and flows with tuffaceous turbidite, wacke and conglomerate interbeds. Andesite tuffs are feldspar and hornblende phyric. There are few useful markers in this sequence. The uppermost strata, particularly around Brucejack Lake, are distinguished by the appearance of coarse potassium-feldspar phenocrysts in plagioclase-hornblende-phyric andesite ("Premier porphyry"). East of the Unuk River and north of John Peaks, sedimentary rocks increase in the section, probably representing the distal facies of an island arc.

Rocks of this formation have not yet been identified at Eskay Creek. Age of this formation is poorly constrained by fossils.

Betty Creek Formation (Pyroclastic-Epiclastic Sequence)

Overlying the Unuk River formation is a heterogeneous sequence of varicoloured andesitic to dacitic tuffs and flows, interbedded with volcanic-derived sedimentary rocks and columnar-jointed dacites. Epiclastic and volcaniclastic members are locally hematitic. Thin beds of fine-grained purple tuff that crop out in the headwaters of Eskay Creek (Whiting, 1946) are probably members of this formation (Figure B-14-4). There is evidence for both subaerial and submarine deposition: airfall pyroclastic textures on the one hand; marine fossils and pillow lavas on the other. In the Unuk area thick sequences of pillow lavas, mostly andesite to basaltic andesite, crop out near Divelbliss Creek, Mount Madge and Mount Shirley. Anderson and Thorkelson (1990) correlate some of these with the Bajocian Salmon River formation.

Early Jurassic, probably Sinemurian or Pliensbachian, fossils have been identified near the base of this formation near Atkins Glacier (T.P. Poulton, personal communication, 1988). Late Pliensbachian fossils have been found near its top, at Eskay Creek (Smith and Carter, 1990). Its upper age may be early Toarcian.

Mount Dilworth Formation (Felsic Volcanic Sequence)

The Betty Creek formation is overlain by a thin but widespread sequence of felsic pyroclastic rocks, including welded tuffs. Rocks are typically white weathering, or rusty where pyritiferous, waxy grey to white, dacitic ash and lapilli tuffs with centimetre-scale bedding. No radiometric dates have been obtained from this formation despite several attempts (Alldrick *et al.*, 1987a; Brown, 1987). On the basis of fossil evidence elsewhere (Alldrick, 1987; Brown, 1987) its age is Toarcian. The sequence represents the terminal stages of widespread volcanism in the Stewart complex. The unit is traceable from Kitsault to the Prout Plateau, where it is host to many base and precious metal showings (Figure B-14-4), but it has not been found west of the South Unuk - Harrymel fault (Hancock, 1990; MacLean, 1990).

Salmon River Formation (Siltstone Sequence)

The uppermost formation of the Hazelton Group is a thick sequence of mainly turbiditic siltstones and fine sandstones with rare conglomeratic, tuffaceous or volcanic interbeds.

Alldrick *et al.* (1989) did not separate the Salmon River formation and the overlying Bowser Lake Group because of their lithologic similarity. Contacts between Salmon River and Bowser Lake strata are locally conformable and even gradational (Anderson and Thorkelson, 1990). Strata are best distinguished by their fossil fauna.

The Salmon River formation (Toarcian to Bajocian) reflects the transition between the last vestiges of arc volcanism and the onset of entirely marine sedimentation represented by the Bathonian and younger Bowser Lake Group.

On the basis of fossil assemblages Anderson and Thorkelson (1990) divide the Salmon River formation into two unnamed members: a lower, Toarcian member and an upper, Bajocian member.

The **lower member of the Salmon River formation** is a coarse, pyritiferous, fossil-bearing, calcareous wacke, typically less than 2 metres thick. Although generally too thin to map it is richly fossiliferous. Overlap of belemnites and the pelecypod *Weyla* confines this member to the lower to middle Toarcian.

It is best exposed from Stewart north along the Bowser River. This unit has been identified in fault-bounded slices on the east and west sides of the Bruce Glacier but has not been recognized in the Unuk valley. Anderson and Thorkelson (1990) correlate it with folded and faulted siltstones near Storie Creek and a 1500-metre thick sequence of Toarcian basinal sediments located 40 kilometres north of Eskay Creek (Read *et al.*, 1989). It may also correlate with the richly mineralized "contact unit" of the Eskay Creek deposit (Figure B-14-4).

The **upper, Bajocian member of the Salmon River formation** is divided into three major facies: an eastern facies in the Stewart-Sulphurets area ("Troy Ridge"); a medial facies in the Unuk area ("Eskay Creek"); and a western, speculative facies in the Snippaker area.

The eastern (Troy Ridge) facies extends north from Stewart along the Bowser River into the Sulphurets area. It comprises "black, cherty, radiolarian-bearing shale and white-weathering, reworked felsic tuffs" (Anderson and Thorkelson, 1990). The striped appearance of these rocks has given rise to the name "pyjama beds" (Brown, 1987; Anderson and Thorkelson, 1990).

The Eskay Creek facies is stratigraphically equivalent to these pyjama beds. It consists of "limestone, limy or cherty siltstone and shale [that] interfinger with, and overlie thick pillow lava and pillow lava breccia" (Anderson and Thorkelson, 1990). Its age is middle Toarcian to Bajocian based on fossil data from Eskay Creek (Smith and Carter, 1990). On the basis of age and lithology Anderson and Thorkelson include pillow lava sequences that extend up to 65 kilometres north of Eskay Creek.

Thick pillow volcanic sequences form marker units up to 5 kilometres long east of the South Unuk River near Divelbliss Creek and from Mount Madge to John Peaks (Figure B-14-2; Grove, 1986; Alldrick *et al.*, 1989). Pillow lavas are also exposed at two stratigraphic levels on Mount Shirley (Read *et al.*, 1989; B.C. Geological Survey Branch unpublished data). These sequences are poorly constrained by fossils. Alldrick *et al.* (1989) assigned them to the Betty Creek formation on the basis of stratigraphic position and correlation with similar rocks in the Sulphurets area (Alldrick and Britton, 1988). Anderson and Thorkelson (1990) correlate them with the Eskay Creek facies on the basis of lithology.

MIDDLE TO UPPER JURASSIC BOWSER LAKE GROUP

Ashman Formation

Much of the northern Prout Plateau is underlain by sedimentary strata that can be assigned to the Bowser Lake Group on the basis of lithology and age. The rocks comprise thick sequences of thinly bedded siltstone, shale and sandstone with thin lenses and sheets of chert-pebble conglomerate that represent both shoreline and river-channel facies. The conglomerates permit correlation the Ashman Formation, the widespread basal unit of the Bowser Lake Group (Tipper and Richards, 1976). The provenance of the chert is generally considered to be the Cache Creek Group. The Bathonian ammonite *Inniskinites* occurs in shale overlying conglomerate, near the southern end of Tom Mackay Lake, indicating that Bowser Lake Group rocks extend this far southwest (Gunning, 1986; Smith and Carter, 1990).

PLEISTOCENE AND RECENT

Pleistocene and Recent basaltic flows and tephra are preserved west of the Harrymel-Unuk drainage and in the Iskut valley (Grove, 1986; Read *et al.*, 1989; Stasiuk and Russell, 1990). None have been reported on the Prout Plateau. They consist of coarsely porphyritic feldspar and olivine-bearing basalts. Most flows occupy valley bottoms and many display columnar jointing. Some are poorly preserved and may have erupted onto or under ice. Radiocarbon ages from sediments in the Iskut valley indicate eruption as recently as 2610±70 years B.P. (Read *et al.*, 1989).

INTRUSIVE ROCKS

Stratified rocks in the Unuk area have been intruded by a series of plutons, sills, dikes and dike swarms that range in age from Late Triassic to Oligocene (Alldrick *et al.*, 1989).

The oldest dated plutons are the McQuillan Ridge diorite and Bucke Glacier gneissic quartz diorite which yielded Late Triassic ages (Anderson and Bevier, 1990).

Jurassic stocks nearest the Eskay property are the Melville and John Peaks diorites. The large diorite stock mapped on the southern part of Mount Shirley (Grove, 1986; Read *et al.*, 1989) is a small dioritic sheet that appears to be conformable with the volcanic stratigraphy. It may represent a synvolcanic sill similar to the Barb

Lake intrusions, southwest of Tom Mackay Lake. These form a discontinuous line of fine to medium-grained hornblende diorite dikes, sills or plugs intruding mixed sedimentary and volcaniclastic rocks. They may be feeders to pillow lavas seen on Mount Shirley. Apart from these, intrusions are rare on the Prout Plateau.

Tertiary magmatism is mainly represented by Eocene granitic rocks of the Coast plutonic complex which crops out 30 kilometres southwest of Eskay Creek and also forms a large satellitic pluton (the Lee Brant stock) south of Mount Madge (Figure B-14-2). The Tertiary (Eocene) King Creek dike swarm which forms a north-trending belt west of Harrymel Creek may record the youngest major intrusive event in the map area. Rare lamprophyre dikes are products of Oligocene-Miocene ultrapotassic magmatism (Brown, 1987; Alldrick *et al.*, 1987a; Anderson and Bevier, 1990).

STRUCTURE

FOLDS

Regional folds are interpreted on the basis of lithologic correlation. The Mount Dilworth formation and overlying sediments form a tight anticine-syncline pair between Unuk River and Harrymel Creek (Figure B-14-2). Felsic strata form dip slopes on both sides of the Unuk valley. They also form a traceable unit extending along the east side of Coulter Creek from its confluence with the Unuk almost to Mackay Creek. Felsic tuffs that crop out near Little Tom Mackay Lake are interpreted to be the western limb of this regional fold but they have not been traced north beyond the base of Mount Shirley. The unit has not been traced around the nose of the anticline at Eskay Creek nor the keel of the synclines in Coulter and Unuk valleys.

FAULTS

Along the eastern slopes of the South Unuk River valley schistose rock fabrics define a northwest-trending, northeast-dipping belt of shearing and faulting. It is interpreted as a major northeast-side-down normal fault. This structure passes along strike into the subvertical Harrymel Creek fault which juxtaposes Triassic strata to the west against Jurassic rocks to the east (Alldrick *et al.*, 1989; Britton *et al.*, 1989). This fault extends, with offsets, into Forrest Kerr and More creeks where a subvertical, east-side-down normal fault has been mapped (Read *et al.*, 1989; Logan *et al.*, 1990a,b). It is a zone of recent faulting that may represent a long-lived crustal break.

Splays off the South Unuk - Harrymel fault strike northwards up the Unuk valley, Coulter Creek and across the Prout Plateau. The pattern visible in both air photos and synthetic aperture radar images (Webster and McMillan, 1990) is that of a festoon of arcuate splays or horsetails characteristic of strike-slip fault complexes. These splays are truncated by a younger east-west structure along the Iskut valley.

Strike-slip faulting may have modified regional folds. Volcanic rocks of Eskay Creek may be a "pop-up" or positive flower structure (Woodcock and Fischer, 1986) in a strike-slip complex. The siltstone sequence may be tectonically draped over more competent blocks of volcanic strata.

Low-angle reverse, thrust or décollement faults with small displacements are common in the Iskut-Sulphurets area (Britton and Alldrick, 1988; Britton *et al.*, 1989, 1990). They are not easily recognized unless there is duplication of a distinctive lithostratigraphic sequence. Repetition is commonly in the order of 10 to 100 metres of section. Regional-scale reverse faults may also be present (Alldrick and Britton, 1988; Britton and Alldrick, 1988).

The patterns of folds and faults suggest changes in the regional stress field through time. Folds and thrust faults may result from early east-west compression. Later strike-slip deformation could result from north-south compression. More work is required to resolve the structural geology of the Prout Plateau.

METAMORPHISM

Regional metamorphic grade is lower greenschist facies characterized by saussuritized plagioclase, chloritized mafic minerals and conversion of clay constituents to white mica. Rare, relict porphyroblasts of prehnite occur in mudstones at Eskay Creek. Within a kilometre of the Coast plutonic complex metamorphic grade rises to lower amphibolite facies. Narrow contact metamorphic aureoles occur near the margins of the larger plutons.

Based on resetting of K-Ar ages in the Stewart and Sulphurets areas regional metamorphism peaked in mid-Cretaceous time (Alldrick *et al.*, 1987a).

PROPERTY GEOLOGY

STRATIGRAPHY

Detailed descriptions of property geology stem from work by Premier Gold Mining Company (Whiting, 1946), Texasgulf Inc. (Donnelly, 1976; Peatfield, 1975, 1976; and summarized by Panteleyev, 1983) and Calpine Resources Incorporated (Blackwell *et al.*, 1989). They have concentrated on mineralized areas between the Mackay adit and the #21 zone (Figure B-14-3).

The TOK and KAY claims are underlain by a northwest-facing sequence of interbedded volcaniclastic rocks, flows and sediments. Strata strike north-northeasterly and dip moderately to the northwest. The presence of fossils, pillow lavas and hyaloclastites suggests that many of the rocks were deposited in a subaqueous environment. No lithogeochemistry has been

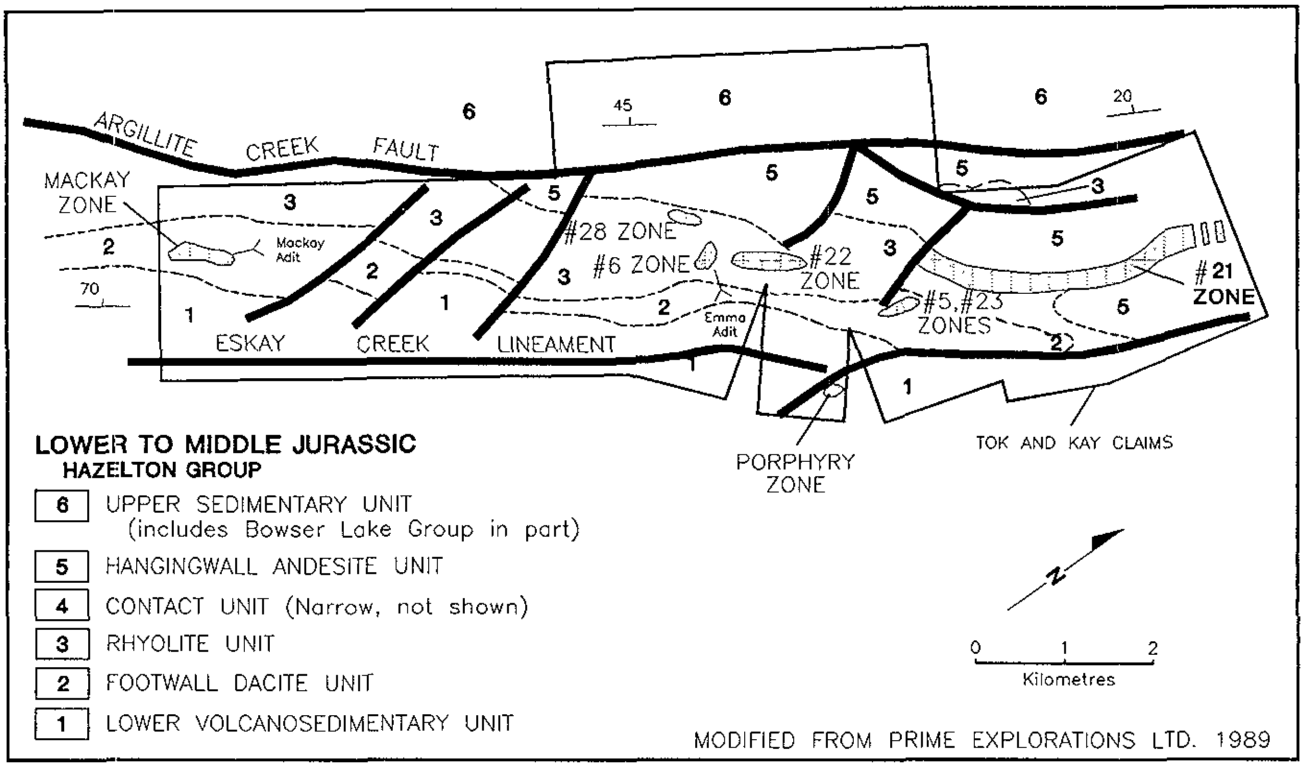


Figure B-14-3. Surface geology and mineral zones, Eskay Creek.

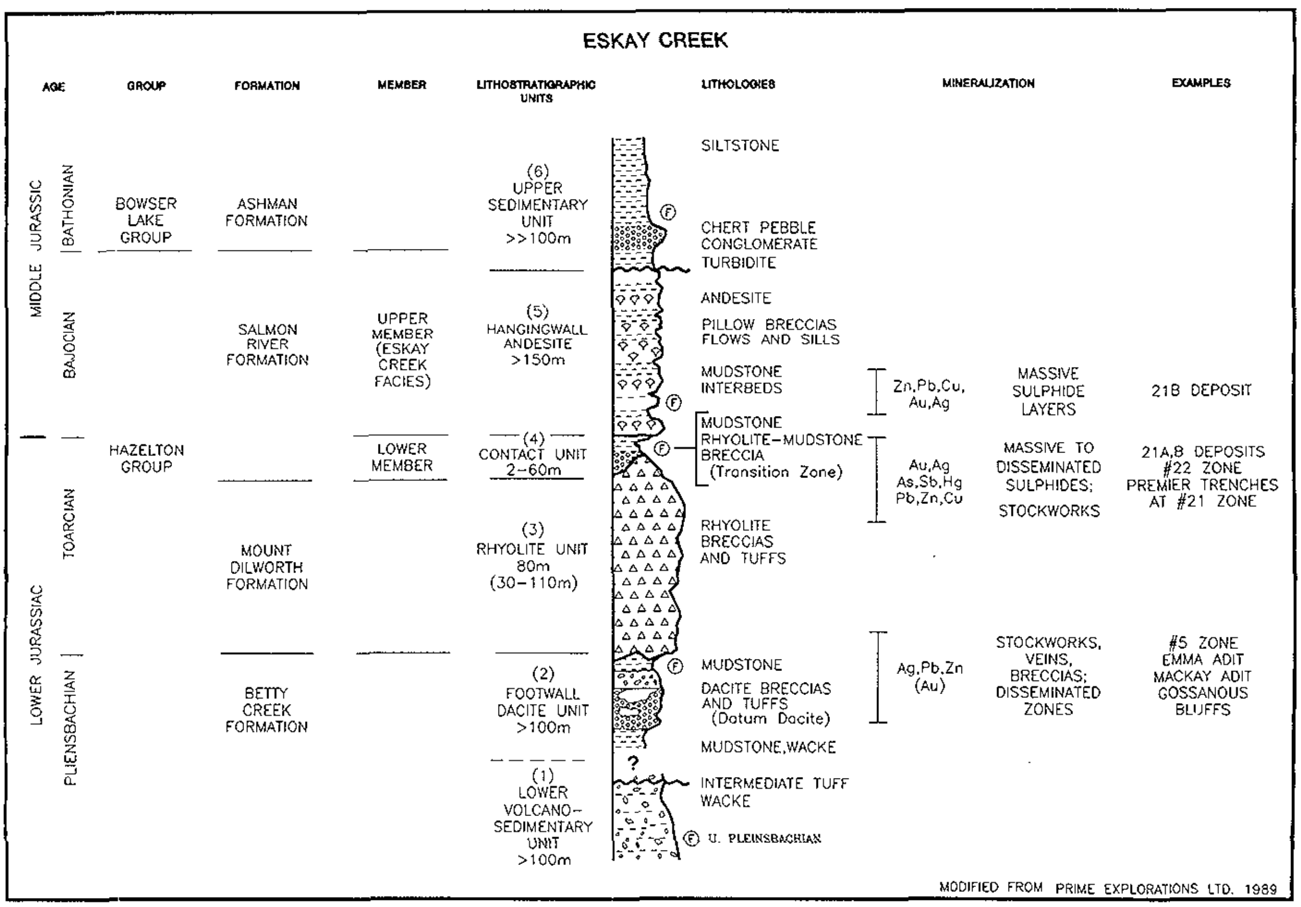


Figure B-14-4. Stratigraphy and mineralization, Eskay Creek.

completed on the volcanic rocks; classification is based on field identification alone.

Donnelly (1976) divided a 1100-metre thick section straddling Eskay Creek into four lithostratigraphic sequences, from oldest to youngest:

(1) an undivided unit, more than 500 metres thick, of volcanic fragmental rocks, the upper part of which consists of crystal tuff, lapilli tuff and agglomerate. The base is not seen;
(2) a sedimentary unit, 130 metres thick, of well-bedded, black argillite with some tuffaceous sandstone and pebble conglomerate interbeds. These contain the Lower Jurassic pelecypod *Weyla* and ammonite *Paltarpites*. Contained in the argillite is a 60-metre thick body of rhyolite;
(3) a felsic volcanic unit, approximately 400 metres thick, consisting of rhyolitic breccia, flows or domes. At its base are lithic tuffs and tuffaceous wacke;
(4) basaltic pillow lavas and pillow breccias with minor, thin mudstone units containing the Middle Jurassic ammonite *Stephanoceras*; the top is not seen.

Prime geologists have modified this sequence (Blackwell, 1990; Idziszek *et al.*, 1990a,b). Donnelly's felsic volcanic unit (3) is now subdivided into a lower dacite unit and an upper rhyolite unit. Between the rhyolite and overlying pillow lavas a contact unit is distinguished. This report adds an older volcano-sedimentary unit and a younger sedimentary unit (including strata of the Salmon River and Ashman formations) to the previously published stratigraphy of the #21 zone. The revised stratigraphic sequence at Eskay Creek (Figure B-14-4) is, from oldest to youngest:

(1) lower volcano-sedimentary unit: inferred basement to the footwall dacite unit including the oldest rocks on the property.
(2) footwall dacite unit: dacite lapilli, crystal and lithic tuffs interbedded with black mudstone and waterlain tuff (includes the "datum dacite" member);
(3) rhyolite unit: rhyolite breccia and tuff; minor mudstone;
(4) contact unit: basal rhyolite-mudstone breccia ("transition zone") grading upwards into carbonaceous mudstone;
(5) hangingwall andesite unit: pillowed andesite flows and breccias with thin carbonaceous mudstone interbeds;
(6) upper sedimentary unit: thin-bedded siltstone and fine sandstone with minor arenite-conglomerate beds.

Recent exploration success has been predicated on drilling through the contact unit (4). Most drill holes are collared in the hangingwall andesite (5) and stopped when they encounter recognizable members of the footwall dacite (2). Mapping has lagged far behind core logging so the surface extent of these units is not well known (Figure B-14-3).

LOWER VOLCANO-SEDIMENTARY UNIT

This is a sequence of unknown thickness that underlies the footwall dacite unit. Information comes mainly from surface exposures. Mixed andesitic to dacitic volcaniclastic rocks and immature fine to medium-grained sedimentary rocks underlie much of the area east and south of upper Eskay Creek. These rocks include parts of Donnelly's unit 2 which locally contains the Lower Jurassic pelecypod *Weyla*. They appear to be the oldest rocks on the claims.

The deepest holes bottomed in medium to coarse, medium green, feldspar-phyric, andesitic to dacitic lapilli tuff overlain by volcanic conglomerate with porphyritic felsic clasts. These are lithologically similar to some of the rocks that crop out east of Eskay Creek and may be tentatively correlated with this unit.

FOOTWALL DACITE UNIT

This unit comprises in excess of 100 metres of drab grey to white dacite tuff, tuffaceous wacke and mudstone. Dacitic volcanics are predominantly tuff and ash-flow tuff, with lesser volumes of lithic tuff and breccia. Clasts are angular and commonly strongly compressed. Fragmental rocks are locally heterolithic with clasts of dacite, porphyritic felsite and mudstone. Clasts are matrix supported. Volcanic members are extensively altered and commonly pyrite-bearing.

An important marker, the datum dacite member, comprises pink to green, fine-grained, feldspar phyric tuff and lapilli-breccia. It occurs near the top of the unit. Its most diagnostic feature is the presence of abundant quartz-filled vesicles up to 1 centimetre in diameter.

Intercalated epiclastic rocks comprise thick to thin-bedded, grey to black, tuffaceous wacke and mudstone. These are commonly pyritic. The presence of belemnite fossils is taken to indicate a subaqueous depositional environment for the entire unit. Its top exhibits considerable relief and may represent an unconformity.

RHYOLITE UNIT

This consists of grey to white aphyric breccia, tuff-breccia, lapilli tuff, tuff and subordinate massive rhyolite. Thin intercalations of mudstone and waterlain tuff occur locally and provide markers to correlate between closely spaced drill holes. Rhyolite fragments are massive to flow banded; matrix is tuffaceous. Perlitic and lithophysal textures are locally preserved but on the whole the unit is remarkably thick-bedded and monotonous. Within mineralized zones it is altered to an assemblage of quartz, muscovite and chlorite which obscures primary textures. The base of the unit is commonly massive, aphanitic and weakly brecciated. The top is fine grained and may be foliated. Thickness ranges from 30 to 110 metres, averaging 80 metres.

CONTACT UNIT

The contact unit consists of an areally restricted basal member of rhyolite-mudstone breccia (the "transition zone") that grades into a widespread upper member of carbonaceous mudstone. The entire contact unit ranges from less than 1 to more than 60 metres thick.

The basal member comprises angular to subrounded fragments of rhyolite, chert, mudstone and mineralized and altered fragments set in an argillaceous matrix. Clasts exhibit a wide range of sizes and are commonly matrix supported. Clasts appear to be derived from the subjacent rhyolite unit. The matrix consists of very fine grained chalcedonic quartz, muscovite, chlorite, pyrobitumen and graphite. It is variably mineralized.

The upper member is carbonaceous, pyritic and locally tuffaceous, laminated black mudstone. In thin section it is seen to contain numerous quartz eyes, highly altered tuff particles, rare calcareous clasts (limestone?) in a matrix of exceedingly fine grained quartz, possibly primary chert. An opaque hydrocarbon residue, possibly pyrobitumen, is ubiquitous. Near sulphide lenses rocks are strongly altered to chlorite, muscovite and calcite.

The contact unit is belemnite-bearing and radiolarian tests have been seen in thin section. Its lower contact is gradational; its upper contact is sharp. Contact unit mudstones are sedimentologically indistinguishable from interflow mudstone beds of the hangingwall andesite. It is thus defined as the mudstone between the upper surface of the rhyolite unit and the lowest andesite flow. The presence or absence of mineralization is not an essential parameter.

HANGINGWALL ANDESITE UNIT

This is a flow and sill complex in excess of 150 metres thick. It consists of rusty brown weathering, light grey to dark green pillow breccias with subordinate massive flows, dikes or sills, and hyaloclastite horizons. The andesite ranges from aphanitic to medium grained and locally carries fine feldspar phenocrysts. It is locally amygdaloidal. Matrix to the breccias is a mix of volcanic fragments, grey calcite, black chert and limy mudstone. Thin mudstone units occur as interflow sediments. Locally these are distinguished by radiating clusters of calcite, quartz, plagioclase, barite and prehnite. Mudstone interbeds appear to increase in both abundance and thickness to the northeast. Some fossiliferous and calcareous beds form local markers.

The andesite unit is truncated to the southwest by the Argillite Creek fault. It crops out in Mackay Creek but disappears to the northeast under a thick sequence of siltstones.

Northwest of the 21A deposit, within the andesite, is an isolated lens of massive white dacite or rhyolite first mapped by Whiting (1946). Rhyolite-andesite contacts are occupied by small gullies that may be the surface trace of faults.

UPPER SEDIMENTARY UNIT

This unit consists of a thick sequence of thin-bedded (turbiditic) siltstone, shale and fine sandstone. It includes strata of the lithologically similar Salmon River and Ashman formations. The unit has not been mapped in detail.

The only good stratigraphic markers in this monotonous sequence are sheets or lenses, up to 10 metres thick, of chert-pebble conglomerate and compositionally similar fine to coarse arenite. These crop out near the south end of the TOK claims, around the summit cairn on the Prout Plateau and between Tom Mackay and Little Tom Mackay lakes (Figure B-14-2). On lithologic grounds these markers can be assigned to the Ashman Formation of the Bowser Lake Group.

The Salmon River formation sediments are distinguished by the presence of volcanic material. For example, siltstones exposed in Mackay Creek have rare zones of andesitic debris apparently derived from the underlying hangingwall andesite unit.

From Mackay Creek south to Coulter Creek the basal contact of the upper sedimentary unit is the Argillite Creek fault.

AGE AND CORRELATION

Micro and macrofossils have been reported from many stratigraphic levels at Eskay Creek. The span of time indicated by them is Early to Middle Jurassic. The fossils may yield very precise biostratigraphic ages due to the overlap of ammonites and radiolaria (Smith and Carter, 1990). Drill-core samples are being processed. Figure B-14-4 shows a provisional correlation between lithologies, formations and ages

Smith and Carter found index fossils of the uppermost Pliensbachian (Carlottense Zone) immediately east of Calpine's camp. The fossils lie east of the Eskay Creek lineament and are thought to be stratigraphically below the "Calpine camp gossan" (*i.e.* #3 bluff of the footwall dacite unit). Hostrocks are assigned to the lower volcano-sedimentary unit which also contains the Early Jurassic bivalve *Weyla* (Donnelly, 1976). These rocks are correlated with the Betty Creek formation.

No index fossils have been observed in the footwall dacite unit although its upper horizons locally contain belemnites. Previous regional mapping (Alldrick *et. al.*, 1989) assigned this unit to the Mount Dilworth formation (Felsic Volcanic sequence). Recent drilling has shown that tuffs of this unit are intercalated with much sedimentary material. This is uncharacteristic of Mount Dilworth type sections (Alldrick, 1985). Also, there appears to be

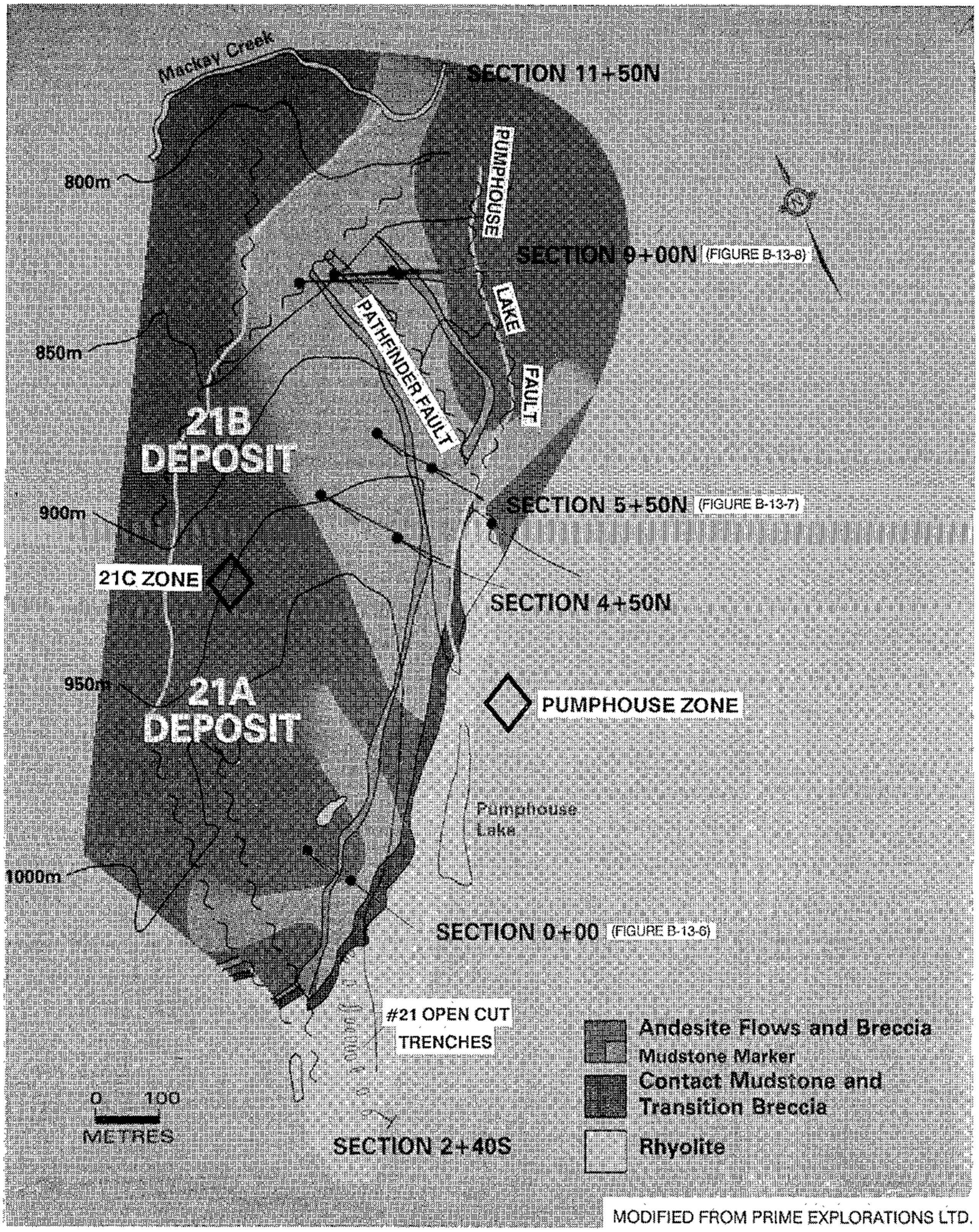


Figure B-14-5. Deposit plan, #21 zone, Eskay Creek.

considerable relief on the unit's upper contact suggesting that it may be a disconformity. It thus seems probable that the footwall dacite unit is instead a member of the Betty Creek formation.

The rhyolite unit is unfossiliferous. On the basis of stratigraphic position and lithology it can be correlated with the Toarcian Mount Dilworth formation (Alldrick, 1985). It differs from type sections in having minor siltstone interbeds and hyaloclastic and perlitic textures. These suggest a subaqueous environment of deposition for some or all of this unit.

The contact unit represents renewed sedimentation following cessation of felsic volcanism. It is fossiliferous (belemnites) but no diagnostic fauna have been reported. On the basis of stratigraphic position, if not lithology, it can be correlated with the unnamed lower member of the Salmon River formation (Anderson and Thorkelson, 1990). Present information suggests its age is Toarcian.

Fossils occur in areas underlain by the hangingwall andesite unit but so far have not been found in place. Radiolaria from limestone clasts in a conglomerate stratigraphically above the #21 zone but east of the Argillite Creek fault indicate a "late middle Toarcian to Early Bajocian age" (Smith and Carter, 1990). The sample was not found in place but is probably from the hangingwall andesite unit (P.L. Smith, personal communication, 1990). The middle Bajocian ammonite *Stephanoceras* reported by Donnelly (1976) was collected by R.J. Goldie in 1974. Anderson and Thorkelson (1990) do not consider the fossil sufficiently well located to be reliably tied to the hangingwall andesite unit.

The upper sedimentary unit matches lithologies of the Salmon River and Ashman formations. Belemnites (Toarcian to late Bathonian age) occur in chert-bearing arenite near the south end of Tom Mackay Lake (Gunning, 1986). Shales overlying these sandstones contain the Bathonian ammonite *Iniskinites* (Gunning, 1986) which provides good fossil correlation with the Bowser Lake Group (Smith and Carter, 1990). Closer to the Eskay property ammonites resembling *Monomorella* have been found along Mackay and Argillite creeks (Whiting, 1946) in areas underlain by the upper sedimentary unit. These sites have not been relocated.

INTRUSIVE ROCKS

Intrusive rocks are rare on the property.

Early workers interpreted resistant, weakly gossanous rocks at Battleship Knoll, 1 kilometre southwest of the Mackay adit, to be altered diorite (Mandy, 1934). Re-examination suggests these are altered andesite (tuff?).

One kilometre east of the #21 zone a small body of feldspar porphyry is weakly mineralized along its contact with lapilli tuff. This fairly massive unit crops out over an area 1000 metres long and 200 metres wide (Whiting, 1946). Donnelly (1976) named the rock granodiorite porphyry and gave this description: subhedral phenocrysts of oligoclase, up to 1 millimetre long, (36%), anhedral quartz, 0.3 millimetre diameter, (11%) and 1-millimetre, subhedral grains of orthoclase (8%), are set in a fine-grained quartz-feldspar matrix. Plagioclase is extensively replaced with chlorite and sericite. Its bulk composition is similar to dacitic pyroclastics seen higher in the section. It may represent a synvolcanic plug or a thick dacitic flow. Its age is not known.

Andesitic dikes and sills occur locally and are interpreted to be feeders to the hangingwall andesite unit.

STRUCTURE

FOLDS

The major structure on the property is interpreted to be an assymetric anticline which plunges gently to the northeast. Interbedded volcanic and sedimentary strata form its northwest limb and dip from 70° to 20°. The fold closes around the north end of the property near Mackay Creek.

Apart from the major anticline no other folds have been recognized. Soft-sediment deformation structures such as slumps are common in some siltstone layers.

FAULTS

The anticline is broken by a series of high-angle faults (Figures B-14-2, 3). Major faults strike north-northeast; minor ones north-northwest. Several northerly to north-easterly trending lineaments also traverse the property. Some of these are faults, some only fractures. Because they roughly parallel the strike of stratified rocks displacement on them is difficult to prove.

Displacement is demonstrable along the Argillite Creek fault which juxtaposes differing levels of the upper sedimentary unit against underlying volcanic units (Figures B-14-2 and 3). West of the #21 zone, hangingwall andesite is in fault contact with thinly bedded siltstone (Salmon River formation?). West of the Mackay adit felsic rocks (footwall dacite unit?) are in contact with conglomerate (Ashman Formation). The Argillite Creek fault continues south into the headwaters of Coulter Creek where an estimated 300 metres of siltstone stratigraphy is missing.

Another northeasterly fault, perhaps a splay off the Argillite - Coulter Creek structure, may be located along Eskay Creek and its headwaters. Bedrock along the creek is strongly foliated but similar lithologies crop out on both sides. Mapping has not demonstrated displacement.

Drilling has identified faults that have offset unit contacts and mineralized horizons (*e.g.* Pumphouse Lake and Pathfinder faults; Blackwell, 1990; Figure B-14-5). Some of these may be northerly extensions of the inferred Eskay Creek structure.

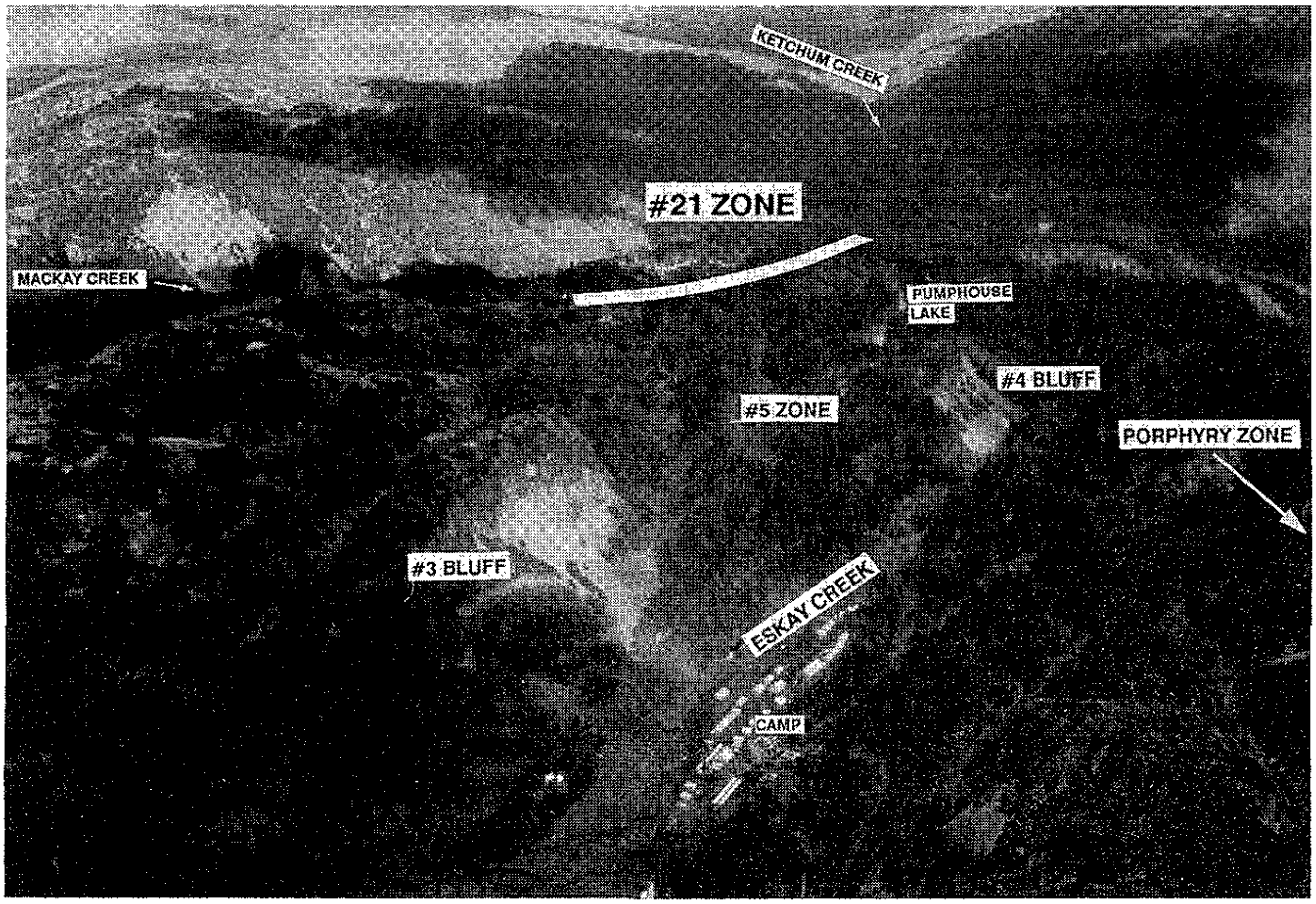


Plate B-14-1. Aerial view of Eskay Creek property, looking north-northwest (September, 1989).

North-northwesterly striking cross-faults have been recognized since the earliest exploration work (Whiting, 1946). They typically have left-lateral displacements in the order of 10 to 100 metres and are best illustrated by offsets on the basal contact of the hangingwall andesite. Several occur in the Emma adit area. Similar faults may form the presently defined southern boundary of the #21 zone.

Whiting (1946) named an easterly-trending structure that traverses the main grain of the property, from north of the #22 zone to the north end of the #3 bluff, the Mackenzie fault.

MINERALIZATION AND ALTERATION

Many zones of mineralization have been recognized on the TOK and KAY claims. These include the #5, #6, #10, #21, #22, #23, #28, and Porphyry zones; Mackay and Emma adit areas; and the #1 to #5 bluffs (Figures B-14-3, 4; Plate B-14-1). These prospects can be classified into seven general deposit types based primarily on geometry, secondarily on chemistry, mineralogy and texture.

STRATABOUND MINERALIZATION

(1) Stratabound gold and silver with antimony, arsenic and mercury minerals associated with intense hydrothermal alteration within the contact unit.
Example: 21A deposit.

(2) Stratabound sphalerite-rich mineralization with high-grade gold and silver in a tuffaceous facies of the contact unit.
Example: southern 21B deposit.

(3) Stratabound, gold and silver-rich base metal sulphide lenses within interflow mudstone beds of the hangingwall andesite unit.
Example: northern 21B deposit.

CROSSCUTTING MINERALIZATION

(4) Disseminated and fissure-vein gold-silver-lead-zinc mineralization, with minor antimony and arsenic, associated with variable muscovite and silica alteration within the rhyolite unit.
Examples: #6 and #22 zones (Emma adit); #21 open cut trenches; stockworks beneath stratabound mineralization of the 21A and 21B deposits.

(5) Disseminated to massive sulphides with low-grade gold and silver in veins and shears within the footwall dacite. Sphalerite, galena and iron sulphides are as-

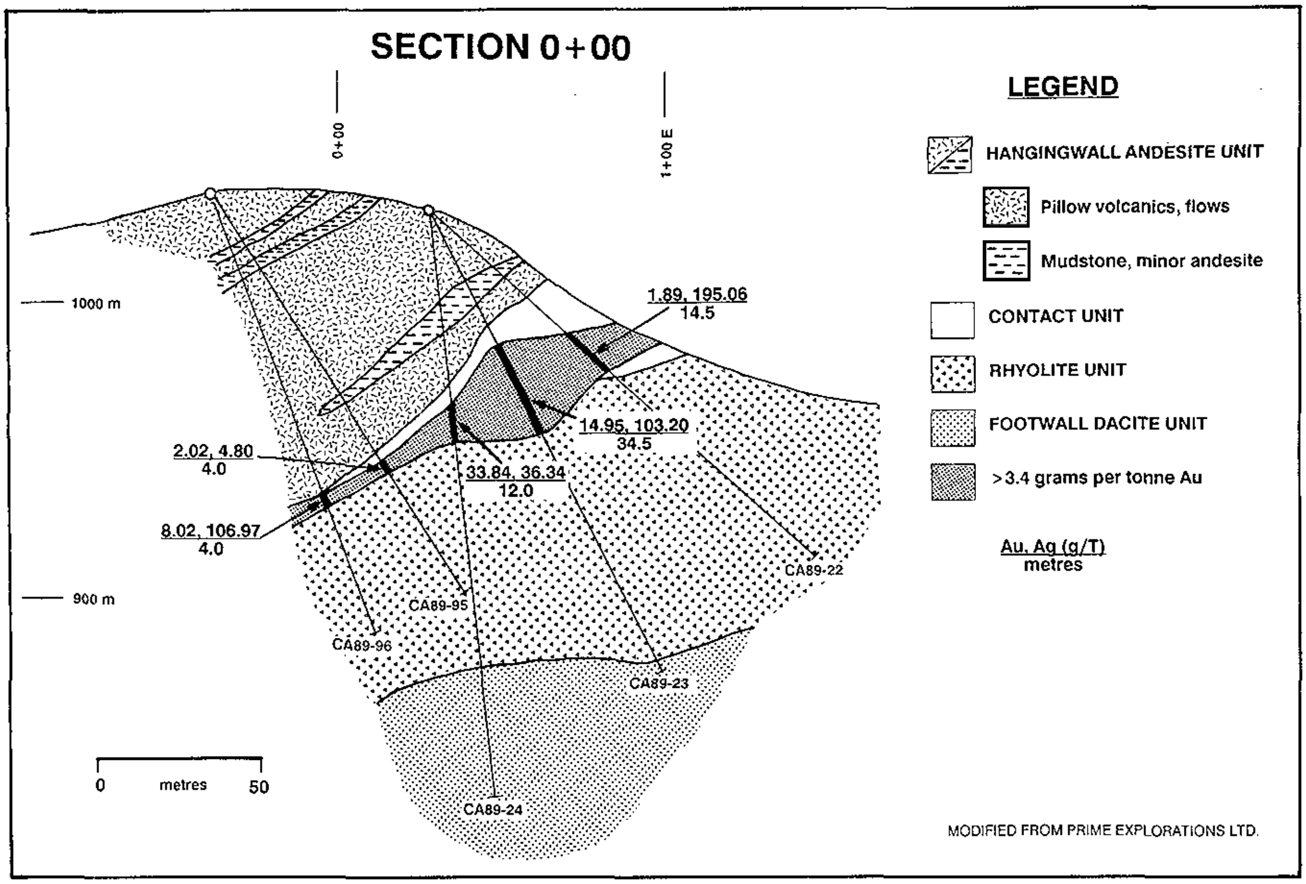


Figure B-14-6. Section 0+00, 21 A deposit, Eskay Creek.

sociated with moderate chlorite, muscovite and silica alteration.
Example: Mackay adit ("North End workings").

(6) Disseminated, geochemically anomalous gold and silver associated with iron sulphides in silicified zones in the footwall dacite.
Examples: #1 to #5 bluffs.

(7) Low-grade gold and silver associated with minor base metal (zinc, lead, iron) sulphides, chlorite and quartz in shears along the contact of a feldspar porphyry plug.
Example: Porphyry showing.

The #21 zone is the current focus of exploration, but other zones continue to be attractive targets.

#21 ZONE

Preliminary descriptions of #21 zone mineralization include Blackwell *et al.* (1989), Blackwell and Idziszek (1989), Blackwell (1990), Idziszek *et al.* (1990a, b), Barnett (1989a, b) and McMillan (1990).

The bulk of mineralization occurs as a stratabound sheet within carbonaceous mudstones of the contact unit and underlying rhyolite breccia, beneath mostly barren andesite flows. In the north sulphide layers also occur in the hangingwall andesite unit. As traced by diamond drilling the entire zone extends 1400 metres along strike, 250 metres down dip and is from 5 to 45 metres thick. It is open to the northeast and down dip.

Mineralization displays both lateral and vertical zoning. Antimony, arsenic and mercury-rich mineral assemblages in the south change to zinc, lead and copper-rich assemblages in the north. Vertical zoning is expressed as a systematic increase in gold, silver and base metal content up-section.

Based on mineral associations and continuity of grade the #21 zone has been divided into two deposits: the 21A (formerly called the South zone) and the 21B (which includes the former Central and North zones, now linked by drilling). The deposits are separated by 140 metres of weak mineralization. Figure B-14-4 shows the stratigraphic distribution of mineralization; figure B-14-5 is a generalized plan of the deposits; figures B-14-6 to 8 are schematic drill sections.

Ore reserves for the #21 zone have been estimated by Roscoe Postle Associates Incorporated on behalf of the Joint Venture and by Orcan Mineral Associates Limited on behalf of Stikine Resources Incorporated (Table B-14-1). Differences between the estimates stem from differing assumptions, methodology and the use of gold-equivalent assays by Orcan (George Cross News Letter No. 72/1990).

Two new mineral zones, the 21C and Pumphouse, have recently been announced (George Cross News Let-

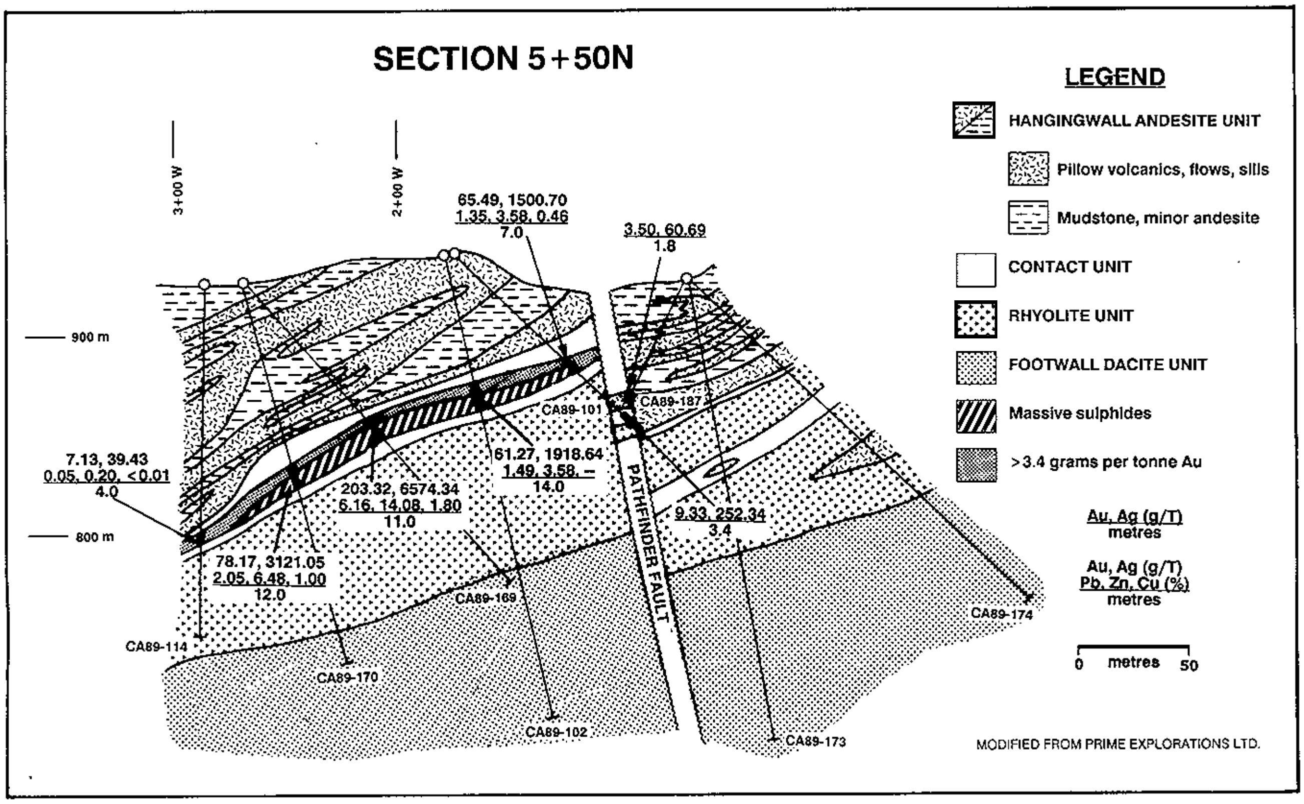


Figure B-14-7. Section 5+50, 21 B deposit, Eskay Creek.

ter No. 94/1990). They lie outside of the presently defined reserve. The 21C is centred about 450 metres due north of the 21A deposit. It is a discrete mineral zone 100 metres down dip from the 21B deposit and subparallel to it. The Pumphouse zone is located immediately northeast of Pumphouse Lake, east of the southern end of the 21B deposit. Both discoveries are currently being outlined by drilling.

21A Deposit

Initial drilling in the 21A area has outlined a mineralized zone approximately 280 metres long and up to 100 metres wide. Thickness is variable, averaging about 10 metres (Figure B-14-6). Locally much greater thicknesses are indicated. For example, drill hole CA89-23 returned a core length of 34.5 metres grading 14.9 grams per tonne gold and 103.1 grams per tonne silver.

The deposit is contained within the contact unit and underlying rhyolite unit. The upper limit of mineralization is sharp and generally coincides with the basal contact of the barren hangingwall andesite unit, the bottom 50 centimetres of which may show weak alteration. The lower assay wall is not defined by a lithologic contact. Instead it corresponds to a marked decrease in sulphide content and alteration intensity.

The deposit can be subdivided into an upper, stratabound zone of disseminated to near-massive stibnite and realgar within the contact unit, and a lower, stockwork zone of disseminated sphalerite, tetrahedrite and pyrite within the rhyolite unit.

Deeper in the section, in the footwall dacite unit, is a third style of mineralization that is not included as part of the 21A deposit.

Contact Unit Mineralization and Alteration

High-grade (>15 grams per tonne) gold and silver mineralization occurs in variably sheared, carbonaceous mudstone and mudstone-rhyolite breccia. A diverse suite of metallic minerals has been identified (Table B-14-2).

Zones of nearly massive stibnite, realgar and orpiment pass along strike and down dip into disseminated domains where sulphides occur in veinlets, as feathery masses, or as heavy impregnations along shears or in the mudstone matrix. The breccia matrix is variably pyritic. Both breccia matrix and clasts contain needles of stibnite and arsenopyrite. Gold occurs as native gold, amalgam and possibly in mercurian wurtzite. Silver occur as native silver, amalgam, tetrahedrite, and unnamed Ag-Pb-As-S minerals (Blackwell *et al.*, 1989).

Mineralization is associated with areas of intense alteration. Both members of the contact unit are overprinted with varying amounts of magnesian chlorite, muscovite, chalcedonic silica, calcite and dolomite;

TABLE B-14-2

METALLIC MINERALS OF THE 21A DEPOSIT

Stibnite	Sb_2S_3	Realgar	AsS
Native Gold	Au	Amalgam	Hg-Ag-(Au)
Native Silver	Ag	Aktashite	$Cu_6Hg_3As_5S_{12}$
Native Arsenic	As	Orpiment	As_2S_3
Hg-Wurtzite	(Hg,Zn,)S	Sphalerite	ZnS
Cinnabar	HgS	Galena	PbS
Arsenopyrite	FeAsS	Pyrite	FeS_2
Tetrahedrite	$(Cu, Ag, Fe)_{12} (Sb, As)_4 S_{13}$		

Mineral determinations by R.L. Barnett (1989a, b), the University of Western Ontario.

pyrobitumen is ubiquitous. The magnesian chlorite is locally rich in fluorine; the muscovite in barium.

Mineralized samples show a remarkable variety of textures. Thin sections commonly have co-existing zones of both high and low strain, despite a uniform mineralogy. Muscovite, chlorite and sulphides display schistose fabrics, with pressure shadows and rotated grains, as well as delicate, randomly oriented intergrowths. The zones mutually interfere. These textures suggest that mineral deposition spanned repeated episodes of shearing and alteration (Barnett, 1989a, b).

Rhyolite Unit Mineralization and Alteration

Disseminated to microfracture-filling mineralization in the rhyolite unit is characterized by low to moderate-tenor gold (1 to 15 grams per tonne) and locally high silver, associated with base metal sulphides and minor to trace antimony, arsenic and mercury minerals. Tetrahedrite, pyrite, sphalerite and galena predominate, with minor aktashite and chalcopyrite. Realgar and orpiment are rare to nonexistent. Carbon and graphite are absent.

Beneath stratabound mineralization of the contact unit, the rhyolite unit is highly fractured and intensely altered. Fracturing, alteration intensity and metal tenor appear to increase toward the upper contact. Within 3 to 4 metres of the upper contact, rhyolite-hosted mineralization is characterized either by massive chlorite-gypsum-barite rock or by quartz-muscovite-sulphide breccia. Both associations may be strongly foliated and sheared, passing rapidly to open space filling vein-breccia textures. Beneath this zone three changes occur: fracturing in the rhyolite decreases dramatically; all alteration minerals are restricted to open joints and fractures; and sulphide minerals occur as crystalline aggregates on fracture surfaces.

Footwall Dacite Unit Mineralization and Alteration

Mineralization at this stratigraphic position does not contribute to currently stated reserves because drill penetrations are too widely-spaced to permit reliable estimates.

Mineralization commonly occurs in the datum dacite member. It consists of semimassive to disseminated, crystalline pyrite, sphalerite, tetrahedrite, galena and chalcopyrite in a pink to buff, feldspathized rock cut by chlorite and pyrite-filled fractures. Lodes carry geochemically anomalous to modest tenor gold and silver values.

The five gossanous bluffs, Mackay adit and the #5 and #23 zones all occur in the footwall dacite (Figure B-14-3; Plate B-14-1).

21B Deposit

The 21B deposit is approximately 900 metres long, from 60 to 200 metres wide and locally in excess of 40 metres thick. It is displaced on the east by the northeast-trending Pumphouse Creek fault and related north-trending splays (Figure B-14-5). The deposit is open to the northeast along strike, to the immediate east on fault-offset segments, and is partially open to the west at depth. It displays varied styles of mineralization and alteration.

The southernmost 600 metres of the 21B deposit (the former Central zone) is characterized by stratabound and *stratiform high-grade gold and silver-bearing base metal* sulphide layers. A drill cross-section (Figure B-14-7) through this portion of the deposit illustrates the distribution and richness of mineralization. Of note is hole CA89-169 which intercepted 11 metres grading 203.3 grams per tonne gold and 6574 grams per tonne silver, 14.08 per cent zinc, 6.16 per cent lead and 1.80 per cent copper.

Banded sulphide mineralization occurs in carbonaceous and tuffaceous mudstones of the contact unit. Sulphides form disseminated, semi-massive and massive laminae and bands, up to 12 metres thick, that appear to parallel bedding in the mudstones (Plates B-14-3, 4). Sulphide beds show an abundance of slump structures, grading and contain tuffaceous debris (Plate B-14-5).

In approximate order of abundance sulphide minerals include amber sphalerite, tetrahedrite, boulangerite and bournonite with minor pyrite and

Plate B-14-2. Tom Mackay's cabin built in 1936 (September, 1989).

Plate B-14-3. Sulphide layers in contact unit mudstone, southern 21B deposit, Eskay Creek (DDH CA89-68: 101 m).

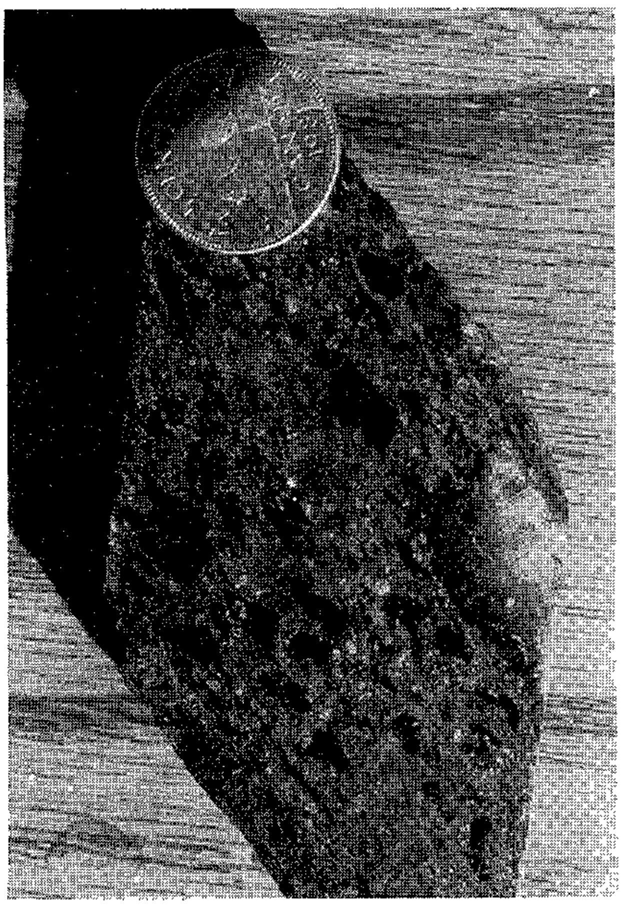


Plate B-14-4. Banded sphalerite, tetrahedrite, boulangerite and bournonite in contact unit pyritic mudstone, southern 21B deposit, Eskay Creek (DDH CA89-87: 97 m).

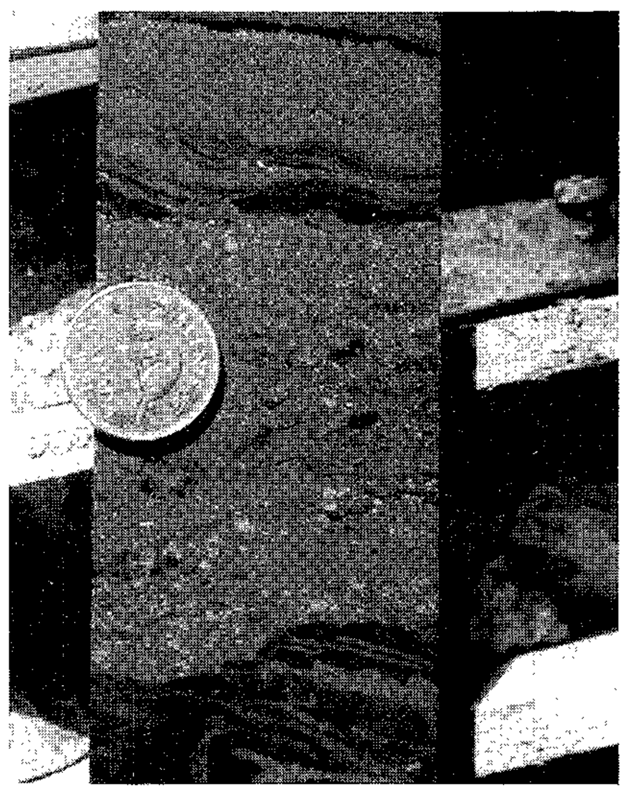


Plate B-14-5. Mudstone fragments in massive sulphide layer of the contact unit, southern 21B deposit, Eskay Creek (DDH CA89-87: 97 m).

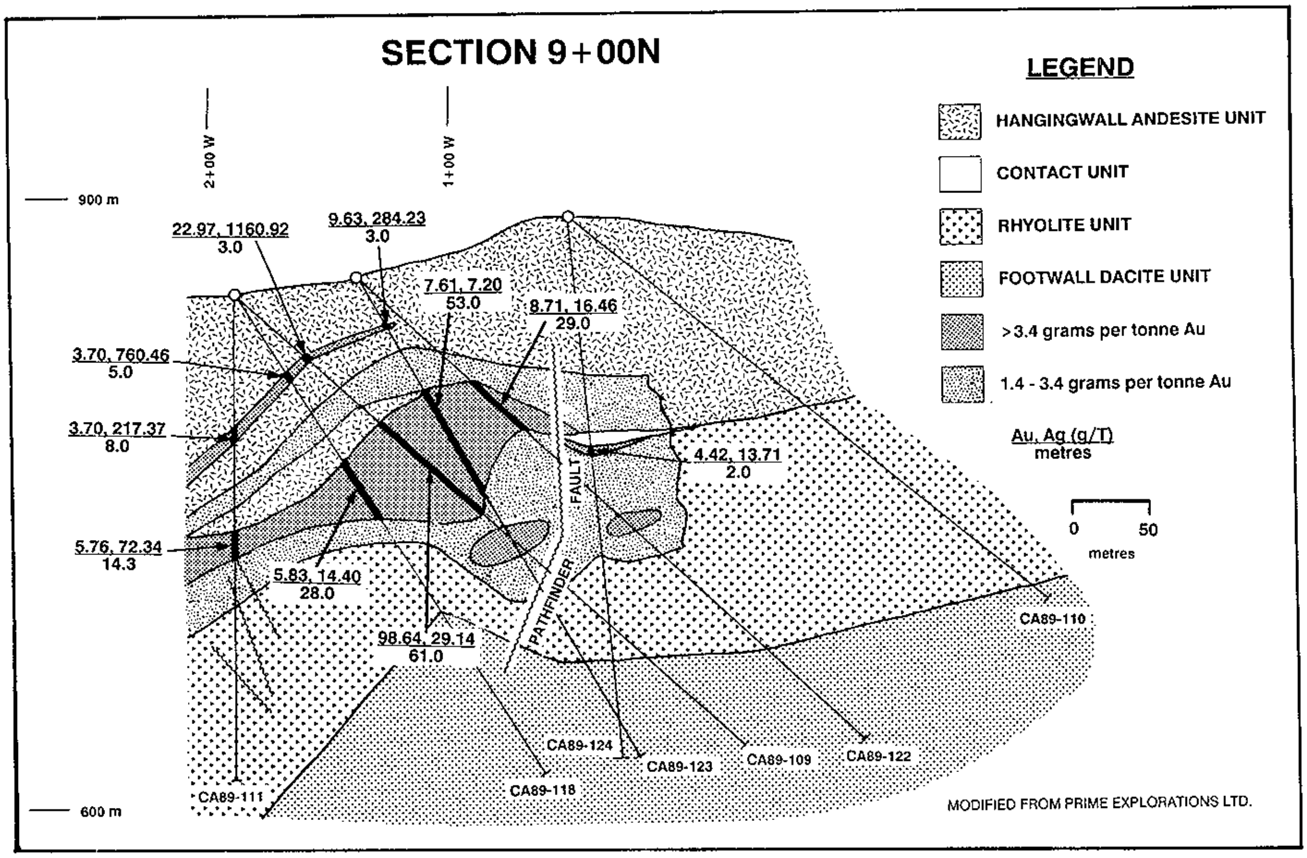


Figure B-14-8. Section 9+00, 21 B deposit, Eskay Creek.

galena. Gold and silver occur as 5 to 80-micron grains of electrum within fractured sphalerite, commonly in contact with galena. Realgar and stibnite are absent. Gangue minerals include magnesian chlorite, muscovite and quartz with lesser amounts of dolomite and calcite.

Peripheral to and beneath banded sulphide mineralization are areas of microfracture veinlets and disseminations of tetrahedrite, pyrite and minor boulangerite. Gangue minerals include magnesian chlorite, muscovite, potassium feldspar and calcite. Footwall, rhyolite-hosted stockwork mineralization is volumetrically insignificant in comparison with either the 21A deposit or the northern 21B deposit.

This portion of the 21B deposit has the most predictable geology, grade and best-defined, contact-controlled, assay boundaries. The bulk of published mineral reserves come from here.

In contrast, the northern 300 metres of the 21B deposit (the former North zone) exhibits considerable geological and structural complexity. Although hostrock stratigraphy is similar to that found to the south, mineralization occurs at several different stratigraphic levels (Figure B-14-8). Gold, silver and base metal rich lenses occur in hangingwall unit interflow mudstones as well as in the contact unit mudstone and underlying rhyolite unit breccias. Very high grade mineralization occurs deeper in the rhyolite unit in association with crosscutting zones of fracture-related alteration. The mineralized zone is thick (Figure B-14-8) and cut by zones of strong shearing.

Hangingwall mineralization is hosted by two mudstone beds near the base of the hangingwall andesite unit. Two partially stacked lenses have been intersected in widely spaced drill holes, and are characteristically composed of near-massive dark sphalerite, galena, and tetrahedrite with lesser amounts of pyrite and chalcopyrite. Mineralization is associated with pervasive chlorite alteration and locally heavy barite. Mineralized intervals vary from sulphide breccias to banded sulphide to sulphide mylonite.

Mineralization in the contact unit is similar to that encountered further south. Sphalerite, tetrahedrite and possibly boulangerite are the dominant sulphide species, plus varying amounts of galena and chalcopyrite. Alteration minerals are again chlorite, muscovite, quartz and calcite. Mineralized textures vary from crudely banded massive sulphides to thick and thin sulphide bands intercalated with mudstone, displaying a wide variety of clastic to laminated textures.

Crosscutting mineralization in the contact and rhyolite units occurs as siliceous (quartz-healed) and carbonate-rich breccias with anastomosing, crustiform veinlets and disseminations of coarse-grained iron-rich sphalerite, fine-grained pyrite, with minor galena, chal-

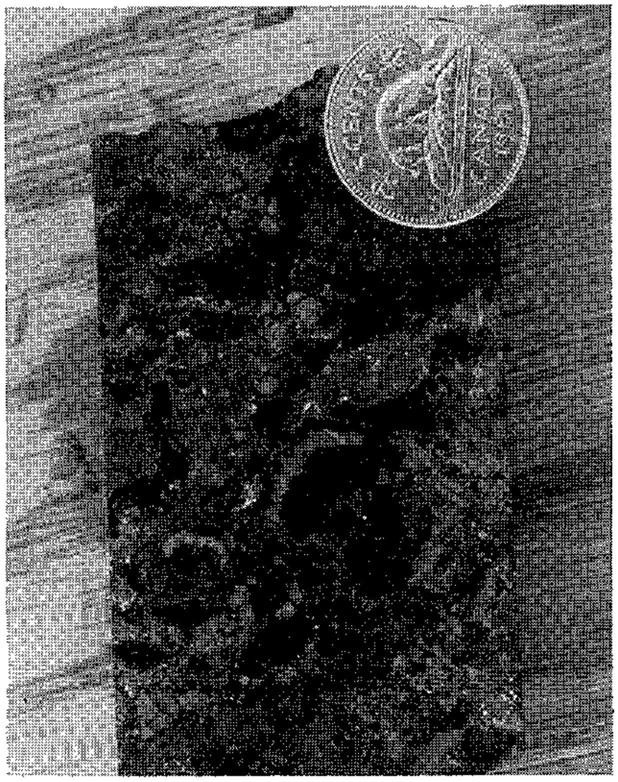


Plate B-14-6. Sulphide-rich vein with coarse-grained galena and zoned sphalerite, northern 21B deposit, Eskay Creek (DDH CA89-109: 90.5 m).

Plate B-14-7. Sulphide-silica-pyrobitumen(?) mineralization in rhyolite unit hostrock, northern 21B deposit, Eskay Creek (DDH CA89-109: 130.1 m)

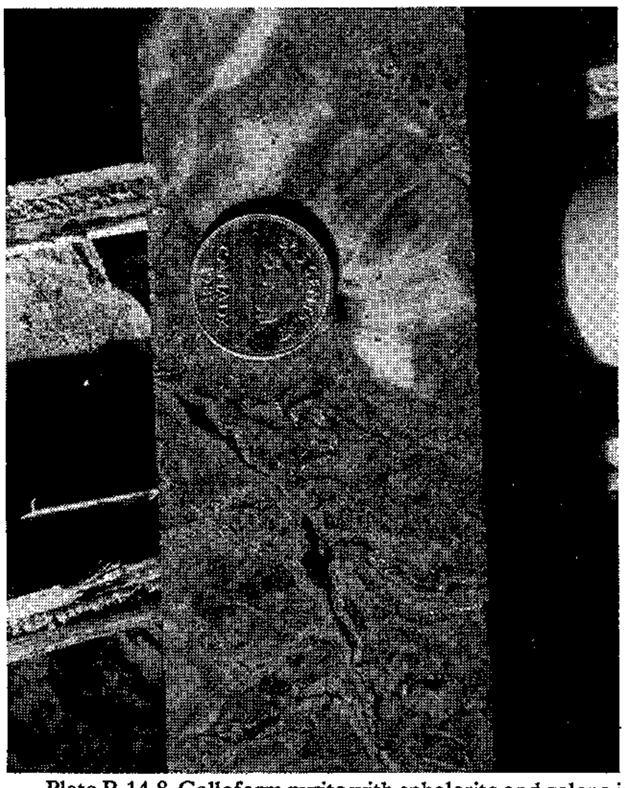


Plate B-14-8. Colloform pyrite with sphalerite and galena in quartz vein below massive sulphide horizon. Rhyolite unit, northern 21B deposit, Eskay Creek (DDH CA89-123: 172 m).

copyrite and tetrahedrite group minerals (Plates B-14-6, 7, 8). Gold occurs as spectacular films, wires or blebs associated with fractured sphalerite.

The different stratigraphic levels of mineralization are illustrated by hole CA89-109 (Figure B-14-8) which intersected a cumulative core length of 208 metres grading 29.96 grams per tonne gold, 33.2 grams per tonne silver, 2.26 per cent zinc, and 1.12 per cent lead. Within this interval is a hangingwall unit intercept of 3.0 metres grading 22.97 grams per tonne gold, 1160.92 grams per tonne silver, 16.13 per cent zinc, 5.99 per cent lead and a combined contact unit - upper rhyolite unit intercept of 61 metres of 98.60 grams per tonne gold, 29.14 grams per tonne silver, 3.44 per cent zinc and 1.86 per cent lead.

A zone of shearing and fracturing up to 60 metres wide (the Pathfinder fault zone) transects the northern 21B deposit. It is marked by intense silica and carbonate alteration that obliterates most original rock textures. Mineralization in hangingwall, contact and rhyolite units is spatially, and perhaps temporally related to this structure.

AGE OF MINERALIZATION

The contact unit is host to most of the mineralization in the #21 zone. On paleontological grounds the age of this unit is late Early to early Middle Jurassic (probably Toarcian). If textures such as slumped, graded and bedding-parallel massive sulphide seams reflect synsedimentary mineralization, then this is also the age of the deposit.

Lead isotope analyses of galena samples collected from Eskay Creek veins and massive sulphide lenses coincide with early Jurassic lead ratios from the Kitsault, Stewart, Sulphurets and Iskut mining camps (Alldrick *et al.*, 1987b, 1990b). Isotopic data are taken to indicate a widespread, early Jurassic mineralizing event. The Eskay Creek deposits are also products of this event.

DISCUSSION

The discoveries at Eskay Creek add a new and exciting dimension to the Stewart-Iskut camp. Previous exploration has concentrated upon structurally controlled lode gold and silver (Snip, Johnny Mountain, Brucejack Lake) or large porphyry copper systems (Kerr, Galore Creek). The 21A and B deposits demonstrate the potential for large-tonnage, high-grade polymetallic sulphide deposits with exceptional gold and silver tenor. The nature of the mineralization, an essentially stratabound sheet occurring in a restricted stratigraphic interval (the transition between the regionally extensive Mount Dilworth and Salmon River formations), offers useful guidelines for further exploration.

Sophisticated scientific study of these deposits has yet to be undertaken. In the absence of fluid inclusion data and deposit chemistry much about the nature of the hydrothermal system (or systems) that produced them remains conjecture. The following comments are based on field observations of drill cores and a limited amount of advanced petrology (Barnett, 1989a, b).

#21 zone mineralization is unusual. There is a close spatial, and apparently temporal, relationship between what conventional models describe as low-temperature epithermal and volcanogenic massive sulphide deposit types. Epithermal mineralization, characterized by gold, silver, arsenic, antimony and mercury mineral suites, forms massive and stratabound lodes as well as more usual crosscutting veins and disseminations. Massive sulphide mineralization shows typical "syngenetic" ore textures but atypical mineralogy and precious metal enrichment. The deposits thus resist easy classification. Explanations of ore genesis must account for the complex textural, paragenetic and compositional features displayed in these rocks.

One hypothesis is that the deposits are the product of a single, complex, evolving, shallow hydrothermal system initiated during the last stages of felsic volcanism and continuing through subsequent sedimentation and the early stages of intermediate (andesitic) volcanism. Such a system could be thermally driven by synvolcanic felsic plutons, perhaps akin to the feldspar porphyry plug located east of the #21 zone. Metals could be scavanged from the volcanic pile by deeply circulating seawater or derived from the intrusion. In this scenario possible geologic settings for ore deposition are a small rift basin within a mature island arc or a submarine felsic caldera undergoing cauldron subsidence following the cessation of volcanism. Either interpretation is compatible with current understanding of the geology of the Hazelton Group.

If this model is valid it is tempting to suggest that mineralization observed in the northern part of the 21B deposit is related to a vent area. High-grade, intensely silicified zones could represent stockworks in the underlying rhyolite pile. Layered sulphides in the southern part of the 21B would thus represent more distal accumulations of clastic material vented onto the sea floor. If 21A deposit mineralization was also exhalative it could be deposited by the coolest, farthest-travelled fluids or else be the product of a separate vent.

The 21A deposit might alternatively be the result of a separate, epithermal mineralizing system. Fluids would have risen through the rhyolite and encountered an anoxic, carbonaceous sediment (the contact unit), which served as both a chemical and hydrologic barrier, trapping and precipitating the volatile-element-rich mineral suite characteristic of this deposit.

The 21A and B deposits occur in a simple, apparently undisturbed stratigraphic sequence. There is, however, some evidence that this sequence has been tectonically thickened by early, low-angle thrust or décollement faults. Evidence includes a lens of rhyolite in the hangingwall andesite unit; gouge and foliation fabrics along unit contacts, especially between lithologies with high competency contrast; and low-angle (relative to bedding) foliations in sedimentary strata. Local duplication of stratigraphy is fairly common elsewhere in the Iskut-Sulphurets area with repetition in the order of 10 to 100 metres of section. Similar faulting at Eskay Creek may account for massive sulphide lenses in the hangingwall unit, which otherwise imply a diachronous mineralizing event.

Other genetic hypotheses can be proposed. The deposits may represent separate but contemporaneous hydrothermal systems. In this model the 21A deposit would result from a lower temperature, shorter-lived system; the 21B deposit from a higher temperature, longer-lived system. Another possibility is that epithermal mineralization has been superimposed on earlier syngenetic mineralization. Alternatively, the deposits are entirely epigenetic, perhaps telescoped epithermal veins that have selectively replaced favourable stratigraphic horizons.

It is anticipated that future studies at Eskay Creek will resolve and clarify the nature and ultimate origin of the #21 zone deposits.

ACKNOWLEDGMENTS

We wish to thank Chet Idziszek, President, Prime Explorations Limited, and Dave Mallo, Project Manager, for permission to sample and photograph core as well as to publish proprietary information. Gerry McArthur, Field Manager, gave freely of his encyclopedic knowledge of the property and was an invaluable help in locating samples and explaining down-hole geology. Ron Fenlon, Field Manager, generously made time and space available for his visitors. The diligence and enterprise of numerous site geologists is also gratefully acknowledged.

This report includes data collected by B.C. Geological Survey Branch geologists Dani Alldrick, Ian Webster, Colin Russell, Mary MacLean, Kirk Hancock, Betsy Fletcher and Steve Hiebert with the 1988 field assistance of Malcolm Smith and Todd Kemp. Their cheerful diligence in adverse conditions so often carried the day.

The critical review of a draft of this report by Dani Alldrick and John Newell is much appreciated.

REFERENCES

Alldrick, D.J. (1985): Stratigraphy and Petrology of the Stewart Mining Camp (104B/1); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Geological Fieldwork 1984, Paper 1985-1, pages 316-341.

________ (1987): Geology and Mineral Deposits of the Salmon River Valley, Stewart Area (104A, 104B); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Open File 1987-22.

Alldrick, D.J. and Britton, J.M. (1988): Geology and Mineral Deposits of the Sulphurets Area (104A/5, 12; 104B/8, 9); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Open File 1988-4.

Alldrick, D.J., Brown, D.A., Harakal, J.E., Mortensen, J.K. and Armstrong, R.L. (1987a): Geochronology of the Stewart Mining Camp (104B/1); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Geological Fieldwork 1986, Paper 1987-1, pages 81-92.

Alldrick, D.J., Gabites, J.E. and Godwin, C.I. (1987b): Lead Isotope Data from the Stewart Mining Camp; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Geological Fieldwork 1986, Paper 1987-1, pages 93-102.

Alldrick, D.J., Britton, J.M., Webster, I.C.L. and Russell, C.W.P. (1989): Geology and Mineral Deposits of the Unuk Area (104B/7E, 8W, 9W, 10E); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Open File 1989-10.

Alldrick, D.J., Britton, J.M., MacLean, M.E., Hancock, K.D., Fletcher, B.A. and Hiebert, S.N. (1990a): Geology and Mineral Deposits of the Snippaker Area (104B/6E, 7W, 10W, 11E); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Open File 1990-16.

Alldrick, D.J., Godwin, C.I., Gabites, J.E. and Pickering, A.D.R. (1990b): Turning Lead Into Gold - Galena Lead Isotope Data from the Anyox, Kitsault, Stewart, Sulphurets and Iskut Mining Camps (Abstract); *GAC-MAC Program With Abstracts,* Volume 15, page A2.

Anderson, R.G., (1989): A Stratigraphic, Plutonic and Structural Framework for the Iskut River Map Area (NTS 104B), Northwestern British Columbia; *in* Current Research, Part E, *Geological Survey of Canada,* Paper 89-1E, pages 145-154.

Anderson, R.G. and Bevier, M.L. (1990): A Note on Mesozoic and Tertiary K-Ar Geochronometry of Plutonic Suites, Iskut River Map Area, Northwestern British Columbia; *in* Current Research, Part E, *Geological Survey of Canada,* Paper 90-1E, pages 141-147.

Anderson, R.G. and Thorkelson, D.J. (1990): Mesozoic Stratigraphy and Setting for some Mineral Deposits in the Iskut River Map Area, Northwestern British Columbia; *in* Current Research, Part E, *Geological Survey of Canada,* Paper 90-1E, pages 131-139.

Armstrong, J.E. (1949): Fort St, James Map-area, Cassiar and Coast Districts, British Columbia; *Geological Survey of Canada,* Memoir 252.

B.C. Minister of Mines, Annual Reports (for the year ended December 31st, 19--): 1932, pages A61-A62, 1933, pages A60-A61; 1934, pages B30-B33; 1935, pages B9 and B27; 1936, page B3; 1939, page A65; 1940, page A51; 1941, page A53; 1946, page A85; 1953, pages A82-A83 and A87-A89; 1963, page 10; 1964, page 20; 1965, page 44; 1967, pages 30-31.

B.C. Department of Mines and Petroleum Resources, Geology, Exploration and Mining in British Columbia: 1970, pages 64-65; 1971, page 36; 1972, pages 516-517; 1973, page 499.

B.C. Ministry of Mines and Petroleum Resources, Exploration in British Columbia: 1975, pages E182-E183; 1976, page E182.

B.C. Ministry of Mines and Petroleum Resources, Geology in British Columbia: 1976, pages 121-122, and Figure 51.

Barnett, R.L. (1989a): Petrographic and Electron Microprobe Study of Selected Samples from the Eskay Creek Project, British Columbia; unpublished report for *J.D. Blackwell Mineral Exploration Consultants Limited, Prime Explorations Limited, Calpine Resources Incorporated* and *Consolidated Stikine Silver Limited*, May 15, 1989, 114 pages.

______ (1989b): Petrography and Mineral Chemistry of Selected Samples from the Eskay Creek Gold Prospect, Stewart, British Columbia; unpublished report for *J.D. Blackwell Mineral Exploration Consultants Limited* and *Prime Explorations Limited*, July 4, 1989, 367 pages.

Blackwell, J.D. (1989): Eskay Creek Project Exploration Review 1932 to 1989; unpublished report for *Calpine Resources Incorporated* and *Consolidated Stikine Silver Limited*, 42 pages.

______ (1990): Geology of the Eskay Creek #21 Deposits, *Mineral Deposits Division, Geological Association of Canada*, The Gangue, Number 31, April, 1990, pages 1-4.

Blackwell, J.D., Downing, B.W., Fenlon, R. and McArthur, G.F. (1989): Report on the Eskay Creek Gold Project, Fall 1988 and Winter 1988-89 Exploration Programmes; unpublished report to *Calpine Resources Incorporated, Consolidated Stikine Silver Limited*, and *Prime Explorations Limited*, July 17 1989, 38 pages.

Blackwell, J. and Idziszek, C. (1989): Exploration Update - Eskay Creek Project (Abstract); *in* Mining Environment in the '90s, *Northwest Mining Association*, 95th Annual Convention, December 1989, Spokane, Washington.

Britton, J.M. (1988): Stratigraphy and Mineral Deposits in the Unuk-Sulphurets Map Area, Northwestern B.C. (Extended Abstract); *in* Geology and Metallogeny of Northwestern British Columbia, *Smithers Exploration Group- Geological Association of Canada, Cordilleran Section*, pages A22-A28.

Britton, J.M. and Alldrick, D.J. (1988): Sulphurets Map Area (104A/5W, 12W, 104B/8E, 9E); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Geological Fieldwork 1987, Paper 1988-1, pages 199-209.

Britton, J.M., Webster, I.C.L. and Alldrick, D.J.(1989): Unuk Map Area (104B/7E, 8W, 9W, 10E); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Geological Fieldwork 1988, Paper 1989-1, pages 241-250.

Britton, J.M., Fletcher, B.A. and Alldrick, D.J. (1990): Snippaker Map Area (104B/6E, 7W, 10W, 11E); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Geological Fieldwork 1989, Paper 1990-1, pages 199-209.

Brown, D.A. (1987): Geological Setting of the Volcanic-hosted Silbak Premier Mine, Northwestern British Columbia (104A/4; 104B/1); unpublished M.Sc. thesis, *The University of British Columbia,* 219 pages.

Donnelly, D.A. (1976): A Study of the Volcanic Stratigraphy and Volcanogenic Mineralization on the KAY Claim Group, Northwestern British Columbia; unpublished B.Sc.thesis, *The University of British Columbia,* 59 pages.

Gasteiger, W.A. and Peatfield, G.R. (1975): Report on Geophysical Surveys and Supporting Work on the S.I.B., T.O.K. and KAY Claims (SIB Supplement Group); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Assessment Report 5638, 4 pages.

George, R.H. (1983a): Geochemical Report TOK 1-6 and 7-22, Skeena Mining Division; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Assessment Report 11160, 14 pages.

______ (1983b): Geochemical Report S.I.B. Claims, Skeena Mining Division; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Assessment Report 11228, 13 pages.

Grove, E.W. (1969): The Bowser Basin; *B.C. Minister of Mines and Petroleum Resources,* Annual Report 1968, pages 42-44.

______ (1971): Geology and Mineral Deposits of the Stewart Area, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Bulletin 58, 219 pages.

______ (1986): Geology and Mineral Deposits of the Unuk River - Salmon River - Anyox Area; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Bulletin 63, 152 pages.

Gunning, M.H. (1986): Late Triassic to Middle Jurassic (Norian to Oxfordian) Volcanic and Sedimentary

Stratigraphy and Structure in the Southeastern Part of the Iskut River Map Sheet, North-central British Columbia; unpublished B.Sc. thesis, *The University of British Columbia,* 85 pages.

Hancock, K.D. (1990): Geology of Nickel Mountain and the E & L Nickel-Copper Prospect, (104B/10E); *B. C. Ministry of Energy, Mines and Petroleum Resources,* Geological Fieldwork 1989, Paper 1990-1, pages 337-341.

Harris, C.R. (1985): Report on KAY and TOK Claims, Eskay Creek, Unuk River, British Columbia, Skeena Mining Division (104B/9W); unpublished report for *Golden Coin Resources Ltd.*, 15 pages.

______ (1987): Report on TOK and KAY Claims, Eskay Creek, Unuk River, British Columbia, Skeena Mining Division (104B/9W); unpublished report for *Consolidated Stikine Silver Limited.*, 12 pages.

Idziszek, C., Blackwell, J., Fenlon, R., McArthur, G. and Mallo, D. (1990a): The Eskay Creek Discovery; Abstract of Talk to Mineral Exploration Group, Vancouver, 28 February, 1990; *Prime Explorations Limited*, 1 page.

______ (1990b): The Eskay Creek Discovery; *Mining Magazine,* March 1990, pages 172-173.

Kerr, F.A. (1948): Lower Stikine and Western Iskut River Areas, British Columbia; *Geological Survey of Canada,* Memoir 246, 94 pages.

Kuran, V.M. (1985): Assessment Report on the Unuk River Property, KAY, TOK and GNC Claims, Skeena Mining Division; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Assessment Report 14099, 17 pages.

Logan, J.M., Koyanagi, V.M. and Drobe, J.R. (1990a): Geology and Mineral Deposits of the Forrest Kerr Map Area (104B/10, 15); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Geological Fieldwork 1989, Paper 1990-1, pages 127-139.

Logan, J.M., Koyanagi, V.M. and Drobe, J.R. (1990b): Geology, Geochemistry and Mineral Occurrences of the Forrest Kerr - Iskut River Area, Northwestern British Columbia (104B/10, 15); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Open File 1990-2.

MacLean, M.E.: (1990): Geology of the Colagh Prospect, Unuk Map Area, (104B/10E); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Geological Fieldwork 1989, Paper 1990-1, pages 343-346.

McMillan, W.J. (1990): British Columbia's Golden Triangle: Report on Iskut Field Conference; *Geoscience Canada*, Volume 17, Number 1, pages 25-28.

Mallo, D.W. (1989a): Assessment Report on the Lakewater Property Airborne Geophysical Program, LAKE 1-2 and WATER 1-2 Claims; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Assessment Report 18957, 6 pages.

______ (1989b): Assessment Report on the Eskay Creek Property Drill Exploration Program, KAY 15 Claim, Skeena Mining Division; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Assessment Report 18958 (Part 1), 8 pages.

Mallo, D.W. and Dvorak, Z. (1989): Assessment Report on the Eskay Creek Project Airborne Geophysical Program, TOK 1-22 and KAY 11-18 Claims, Skeena Mining Division; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Assessment Report 18958 (Part 2), 6 pages.

Mandy, J.T. (1934): Unuk River Section; *B.C. Minister of Mines*, Annual Report for 1933, pages A60-A61.

Panteleyev, A. (1983): KAY (Eskay Creek Property) (104B/9W); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Geology in British Columbia 1976, pages 121-122, and Figure 51.

Peatfield, G.R. (1975): Eskay Creek Option, Final Report, 1975 Geology-Geophysics Program; unpublished report for *Texasgulf Inc.*

______ (1976): Eskay Creek Property, Final Report, 1976 Diamond Drilling Program; unpublished report for *Texasgulf Inc.*

Read, P.B., Brown, R.L., Psutka, J.F., Moore, J.M., Journeay, M., Lane, L.S. and Orchard, M.J. (1989): Geology, More and Forrest Kerr Creeks (Parts of 104B/10, 15, 16 and 104C/1,2); *Geological Survey of Canada*, Open File 2094.

Schink, E.A. and Peatfield, G.R. (1976): Report on Diamond Drilling Programme on the S.I.B., T.O.K. and KAY Claims, Skeena Mining Division; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Assessment Report 6075, 2 pages.

Smith, D. and Gerath, R.F. (1989): Iskut Valley Road Option Study; unpublished report for B.C. Ministry of Energy, Mines and Pretroleum Resources, *Thurber Consultants Ltd.*, Vancouver, B.C., 49 pages.

Smith, P.L. and Carter, E.S. (1990): Jurassic Correlations in the Iskut River Map Area, British Columbia: Constraints on the Age of the Eskay Creek Deposit; in Current Research, Part E, Geological Survey of *Canada,* Paper 90-1E, pages 149-151.

Stasiuk, M.V. and Russell, J.K. (1990): Quaternary Volcanic Rocks of the Iskut River Region, Northwestern British Columbia; *in* Current Research, Part E, *Geological Survey of Canada,* Paper 90-1E, pages 153-157.

Tipper, H.W. and Richards T.A. (1976): Jurassic Stratigraphy and History of North-central British Columbia; *Geological Survey of Canada,* Bulletin 270, 73 pages.

Webster, I.C.L. and McMillan, W.J. (1990): Structural Interpretation of Airborne Synthetic Aperture Radar Imagery in the Sulphurets-Unuk-Iskut River Area, Northwest British Columbia (104B); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Open File 1990-7.

Wheeler, J.O., Brookfield, A.J., Gabrielse, H., Monger, J.W.H., Tipper, H.W. and Woodsworth, G.J. (1988): Terrane Map of the Canadian Cordillera; *Geological Survey of Canada,* Open File 1984.

Whiting, F. (1946): Unuk River Exploration; unpublished report for *Canadian Exploration Limited,* 43 pages.

Woodcock, N.H. and Fischer, M. (1986): Strike-slip Duplexes; *Journal of Structural Geology,* Volume 8, Number 7, pages 725-735.

NOTES

McLYMONT

By Victor M. Koyanagi

(Fig. B1, No. 15)

LOCATION:	Lat. 56°50′ Long. 130°57′	(104B/15)
	LIARD MINING DIVISION. North of the Iskut River, in the headwaters of McLymont Creek, 15 kilometres northeast of Bronson strip, 100 kilometres east of Wrangell, Alaska.	
CLAIMS:	McLYMONT 3.	
ACCESS:	Access by fixed-wing aircraft from Smithers, Terrace or Wrangell to Bronson strip and then by helicopter to the property.	
OWNER/OPERATOR:	GULF INTERNATIONAL MINERALS LIMITED.	
COMMODITIES:	Gold, silver, copper.	

NORTHWEST ZONE, McLYMONT PROPERTY, NORTHWESTERN BRITISH COLUMBIA

The McLymont Creek area was first explored in the early 1960s by Newmont Mining Corporation of Canada Limited. In 1980 Dupont Canada Explorations Limited staked the Warrior claim group and initiated an exploration program in 1981. Skyline Explorations Limited and Placer Development Limited continued explorations on the Warrior claim group in 1983. The Warrior claims expired and were restaked as the McLymont claims by Gulf International Minerals Ltd. A program to explore quartz-carbonate veining cutting granitic rocks on the McLymont claims was then initiated in 1986. Three short diamond-drill holes intersected several veins carrying significant gold and silver values. Mapping and prospecting in 1987 led to the discovery of the Northwest zone which was subsequently tested by 25 core holes. A further 96 holes were drilled on this zone in 1988 and 1989.

REGIONAL GEOLOGY

The region is underlain by the Stikine Terrane comprising a mid-Paleozoic to Mesozoic island arc succession. This stratigraphy is overlapped by Middle to Upper Jurassic sediments of the Bowser Basin to the east and intruded by rocks of the coast plutonic complex to the west. The Paleozoic are Stikine Assemblage metasediments and metavolcanics of Devonian, Carboniferous and Permian age. The Mesozoic is represented by Upper Triassic sediments and volcanics of the Stuhini Group overlain by Jurassic volcanic and sedimentary rocks of the Hazelton Group. The stratified rocks are intruded by early Jurassic to Cretaceous and Tertiary plutons (Logan *et al.*, 1990).

PROPERTY GEOLOGY

The Northwest zone is underlain by Mississippian volcanics and sediments of the Stikine assemblage and Hazelton Group volcanic and sedimentary rocks. The Jurassic rocks previously thought to be Permian are preserved within the Newmont Lake graben (Logan *et al.*, 1990). The Mississippian package structurally overlies Jurassic stratigraphy along a northeast-trending steeply dipping reverse fault. The Mississippian stratigraphy is a several hundred metres thick thin-bedded clastic marine succession, comprising distinctive coarse crinoidal calcarenite, indurated siltstone, sandstone, turbidites, lesser chert and polymictic conglomerate. Jurassic stratigraphy consists of hornblende-plagioclase porphyritic, maroon andesite flow breccia, maroon lahar, lapilli tuff and associated volcanic sediments. A middle(?) Jurassic quartz-rich granite pluton intrudes the stratified rocks and is the source of dikes along pervasive northeast-trending faults.

THE NORTHWEST ZONE

Mineralization in the Northwest zone is hosted by Mississippian sedimentary rocks along their faulted contact with Hazelton Group volcanics and sediments. It occurs both in veins and replacements along steep fractures and in stratabound replacement bodies adjacent to steeply dipping, north-easterly trending major structures. Although significant mineralization is restricted to Mississippian sedimentary rocks, principally marble and chert, gold is also present in quartz-carbonate veins cutting Jurassic strata east of the main fault zone; such veins are ubiquitous throughout the region.

Locally the Mississippian marble is extensively replaced by barite and barite-pyrite breccia. Drilling has intersected gold-bearing barite-pyrite mineralization in veins, breccias and replacements controlled by steep fractures in chert and sandstone and extending along shallow-dipping marble beds and chert-marble contacts (Figure B-15-1). Gold and silver are associated with copper, lead and zinc sulphides in a gangue of pyrite, magnetite, specular hematite, calcite, quartz and barite. There is a strong correlation between gold grade and

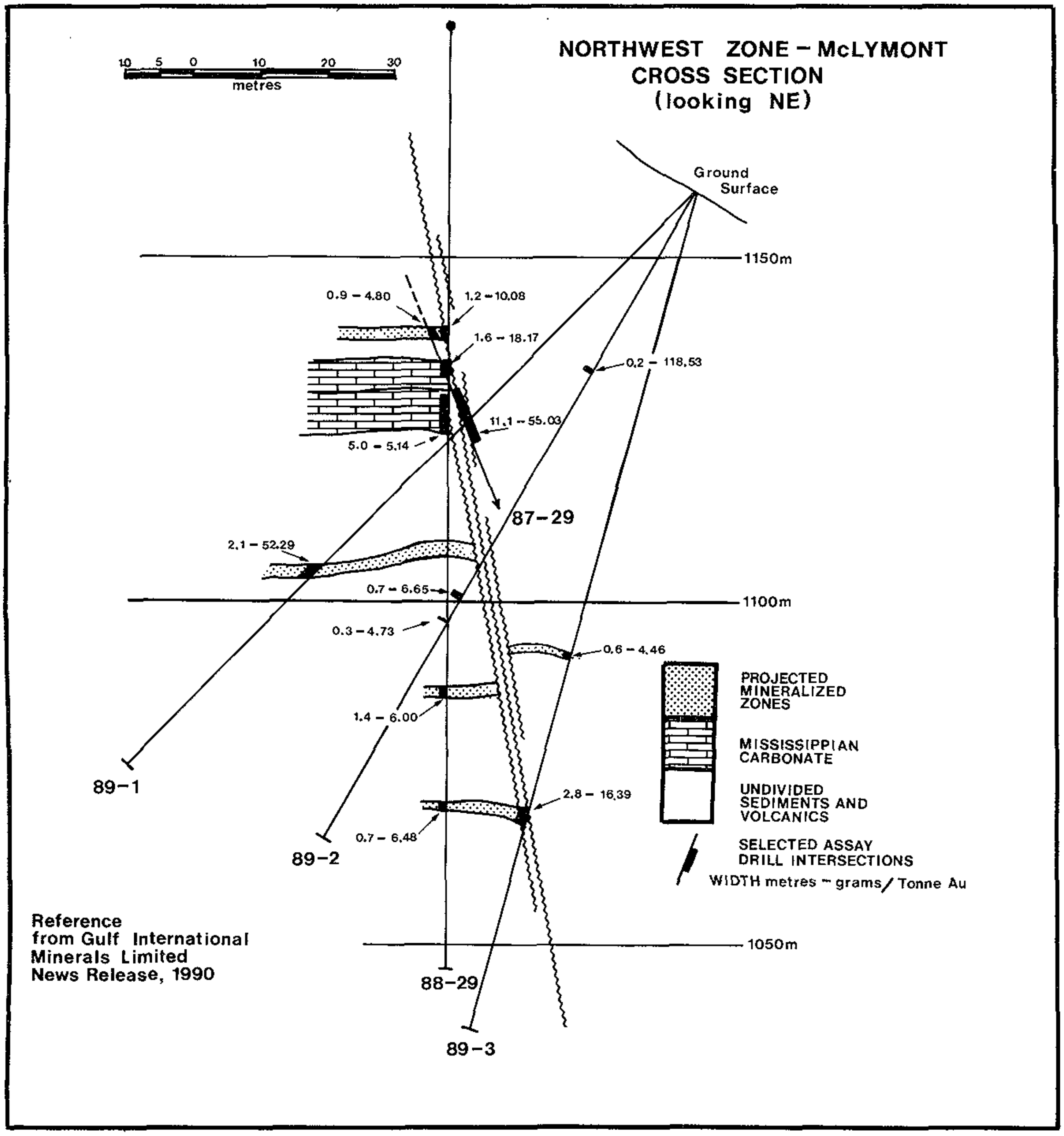


Figure B-15-1. Cross-section through the Northwest zone showing general geology, selected drill hole intersections and gold assay data.

coarse euhedral pyrite (Grove, 1989 and personal communication).

The underlying Jurassic granite pluton is proposed as the source of mineralizing fluids migrating upwards along fault zones and outwards along bedding planes in the Mississippian sediments. The deposit has been previously classified as a skarn due to the association with marble, but the absence of calcsilicate alteration other than minor garnet within the mineralized zones (H. Smit, personal communication, 1990) suggests simple replacement and open-space filling.

REFERENCES

Grove, E.W. (1989): Geological Report and Development Proposal on the McLymont Creek Property in the Iskut River area, N.W. British Columbia; *Gulf International Minerals Limited* report.

Logan, J.M., Koyanagi, V.M. and Drobe, J.R. (1990): Geology of the Forrest Kerr Creek Area, Northwestern British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1989, pages 127-139.

NOTES

WIDESPREAD GLACIAL DISPERSAL OF PLACER GOLD FROM THE ERICKSON CAMP, CASSIAR MOUNTAINS, BRITISH COLUMBIA (104P)

(Fig. B1, No. 16)

By Joanne Nelson, John Knight, Ken McTaggart and Heather Blyth

INTRODUCTION

Placer gold is found directly downstream from the Erickson-Taurus gold-quartz mining camp near Cassiar, B.C. (Nelson and Bradford, 1989), and also in drainages isolated from the bedrock gold mineralization - Dennis, Rosella, Spring and Tame creeks, shown on Figure B-16-1. Although it was proposed by Gabrielse (1963) that this gold had been glacially transported from the area of Erickson veins, an alternate hypothesis, that it was derived from unknown sources within the drainage, had led to extensive staking in 1985. That the Rosella-Spring Creek drainage is underlain in part by Lower Cambrian carbonates of the Rosella Formation lends credibility to the idea that it may contain Ketza River-type gold manto mineralization, particularitly as there are small Eocene intrusions with associated skarns on Mount Haskins and Mount Reed.

This study was undertaken to evaluate the two hypotheses for the origin of the placer gold in the Rosella/Spring Creek drainage. It combines bedrock geologic mapping and prospecting (Nelson), a brief survey of glacial geology in the field (Knight), air-photo interpretation (Blyth) and electron microprobe analyses of gold grains for gold, silver, mercury and copper in order to compare bedrock and placer signatures (Knight and McTaggart). Most of the samples were collected by Knight during the 1989 field season; others were donated by companies or individuals.

Because the results of the microprobe analysis and the glacial geology point so strongly to a derivation of all of the placer gold from the Erickson-Taurus camp, only a general treatment of the bedrock geology appears in this report; a full description will be included in Nelson (in preparation).

BEDROCK GEOLOGY

The area near Cassiar is part of the McDame synclinorium (Gabrielse, 1963; Nelson and Bradford, 1989), the core of which is occupied by the oceanic Sylvester allochthon that was overthrust on autochthonous North American strata in Mesozoic time. These strata are exposed on the limbs of the synclinorium. The Spring Creek drainage is underlain by Late Precambrian to Lower Cambrian units - the Espee, Stelkuz, Boya and Rosella formations (Figure B-16-2), that form a series of thrust imbricates. A later north-trending fault that crosses Poorman Lake and upper Rosella Creek shows dextral offsets of thrusts and fold axial surfaces of about 2 kilometres. Secondary high-angle faults, particularily significant on Mount Haskins, are truncated by it. Skarn, associated with the Eocene intrusion on Mount Haskin, occurs along some of these faults where they cut Rosella limestones.

Other than Mount Haskin and Mount Reed, the only apparent bedrock mineralization within the Spring Creek drainage is evidenced by a zone of lead-zinc geochemical anomalies on the mountain north of Rosella Creek, described in a 1969 assessment report (Cody, 1969). The highest lead and zinc anomalies in stream sediments in this area were 770 ppm and 1250 ppm respectively. Neither we nor the authors of this report discovered visible sulphides associated with these anomalies, although the mountain is cut by a number of topographic and air photo linears that should be prospected in detail.

GLACIAL GEOLOGY: FIELD ASPECTS

The Spring Creek drainage shows evidence of extensive continental as well as valley glaciation. The valleys are broad, with truncated spurs extending up to 300 metres below the height of most summits. Outwash terraces underlie the flat valley floors, in which modern creek channels are incised. All placer gold occurrences are located well below the upper level of valley glacial features. The Dennis Creek, Tame Creek and some of the Rosella Creek placers lie directly below banks of outwash gravels. The gravels range from poorly to well sorted, and from crudely to well-stratified. On the north bank of Rosella Creek, crudely stratified, poorly sorted deltaic gravels dip steeply to the north (Figure B-16-3). They may be an ice-front margin deposit. At the Tame Creek placer, outwash gravels are essentially flat-lying and consist mostly of well-sorted, well-rounded pebbles. One layer near the base of the incised terrace consists of coarse, subrounded to subangular cobbles of local derivation and also exotic clasts in a clay-rich matrix. This may have been deposited as a slump from a moraine.

One of the most revealing glacial features in the Spring Creek drainage is the ubiquitous presence of greenstone and lesser ultramafic erratics and clasts in outwash. Greenstone erratics were observed near the

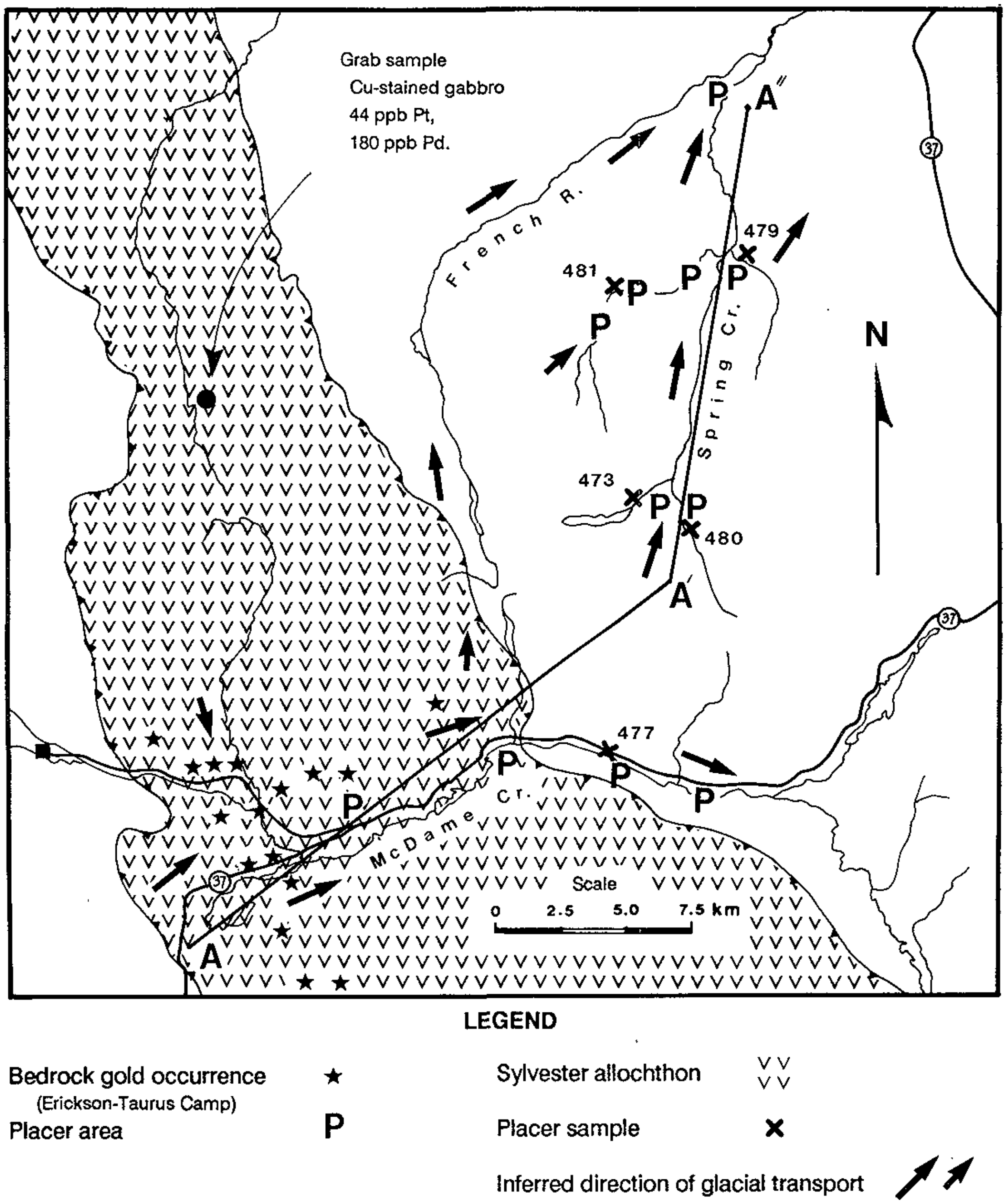


Figure B-16-1. Location of the Spring Creek drainage and the Erickson gold camp.

height of land south of Rosella Creek. Very large boulders of greenstone, diabase and serpentinized harzburgite are present in the creek bottom. At Tame Creek, greenstone clasts form up to 5 per cent of some gravel layers. Some of the richest pans come from these layers (P. Hadrava and Serge Hrbinic, personal communication, 1989). These lithologies do not outcrop anywhere within the drainage, and thus must have been transported into it from the Sylvester allochthon. The large ultramafic boulders may have come from major ultramafic exposures in the Cassiar and Zus Mountain bodies that lie west of Long Lake (Nelson and Bradford, 1989). The greenstones are typical of those that occur throughout the allochthon. Some of them show the swarms of hairlike chorite veinlets that are present in many basalts in the Erickson camp.

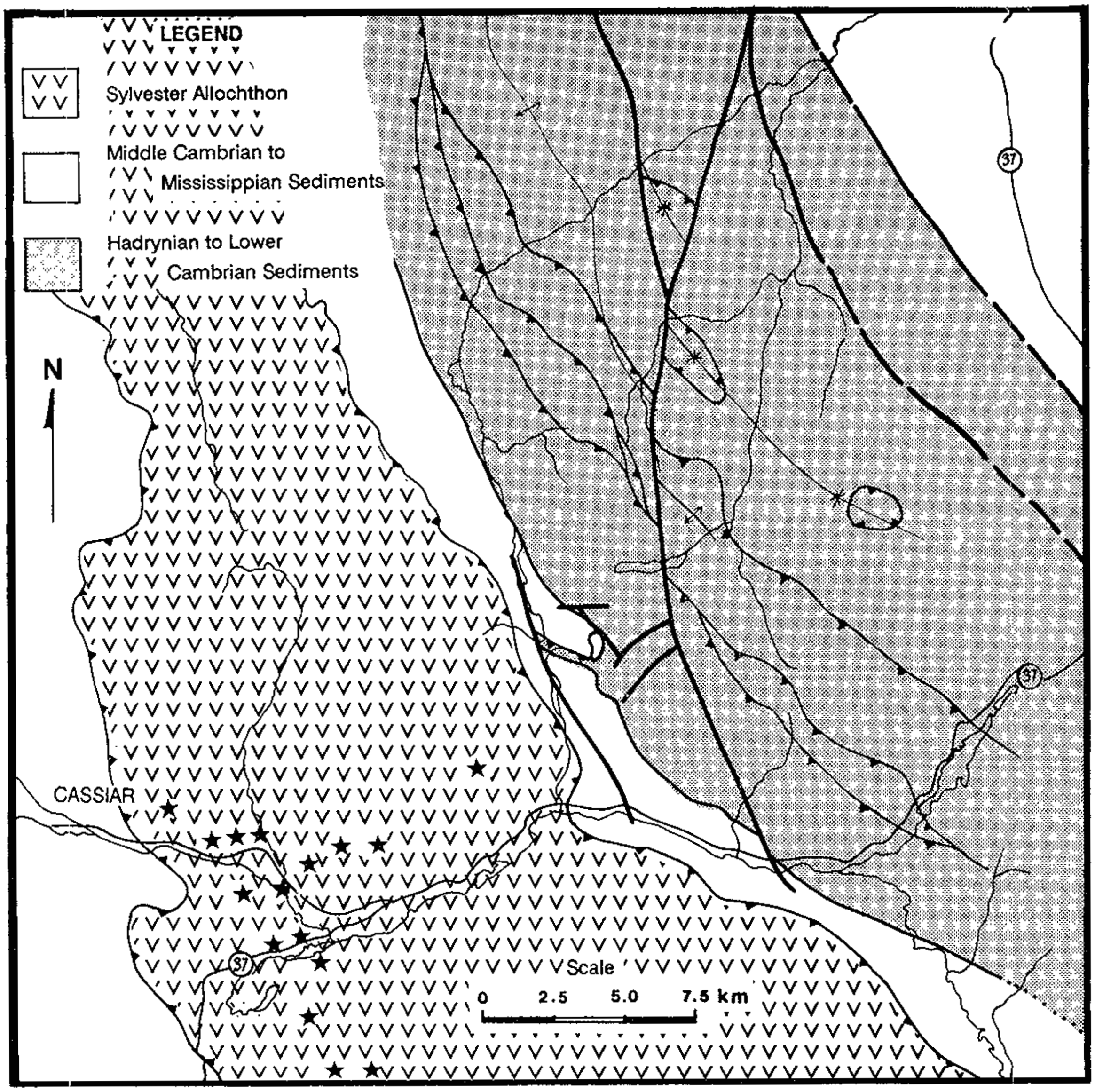


Figure B-16-2. Simplified bedrock geology of the Spring Creek drainage.

GLACIAL GEOLOGY: AIR PHOTO INTERPRETATION

irectional glacial indicators were identified on 1:25 000 air photos covering the Erickson mine and the drainage basins of the French River, McDame, Rosella and Spring creeks. Local valley glacial features can be distinguished from regional-scale continental features. This distinction provides evidence of at least two glacial events in the area (respective terraces marked by 1 or 2 in Figure B-16-4). Due to the alpine nature of the terrain, indication of ice flow direction comes mainly in the form of converging kame-terraces, glacial striations and drumlinoid structures (*see* Figure B-16-4). The converging kame-terraces on the French River, northeast of its main bend, show a clear ice terminus of possible Late Wisconsinan age. In addition the striations and stoss side rounding, evident northeast of Tame Creek, are indications of the northeasterly flow of an earlier, pre-Late Wisconsinan ice advance (Peter Bobrowsky personal communication, 1990). The pro-glacial delta evident in the southwest corner of Figure B-16-4 is related to a Late Wisconsinan ice stand. These features, combined with the drumlinoids, eskers and upland grooves, suggest a generally northeasterly trend in both the pre-Late and Late Wisconsinan glaciations. Minor exceptions to the prevailing flow direction, for example, west of Hot Creek, can be attributed to low valley and cirque glaciers.

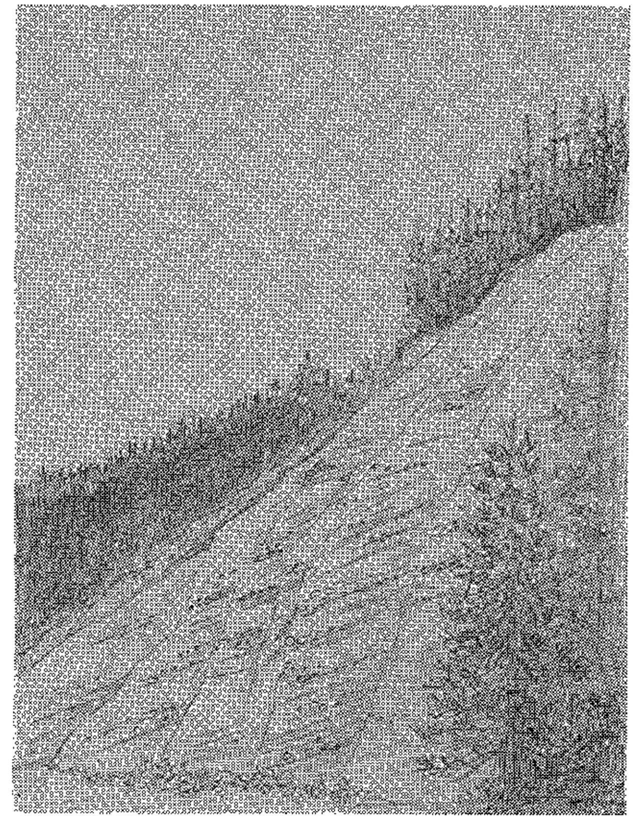


Figure B-16-3. Outwash-delta deposit at Rosella Creek placer; sketch from photograph.

A southwest to northeast trend is interpreted for both glaciations, controlled by the topography of the northwesterly to southeasterly trending Cassiar mountains. Previous glacial movement in this area is not solely parallel to present day drainage patterns as is evident at Tame Creek and Hot Lake (Figure B-16-4). The controlling factors for ice movement are whether or not ice thickness and height are great enough to overcome topographic controls and how much the glacial retreat or on-set changed topographic controls, either by deposition or erosion. It is also clear that glacial features related to the first glaciation are well above the height of the passes between the McDame and the Spring Creek drainage basins. Although unique directional indicators are not present throughout (Poorman Lake) the inferred general flow direction is consistent with the transport of ice in a northeasterly direction, across low intervening passes and into the Spring-Rosella Creek drainage basins. Inferred directions are summarized on Figure B-16-1.

RESULTS OF MICROPROBE ANALYSIS

SAMPLE DESCRIPTIONS

All of the placer samples, from the McDame placer as well as those in the Spring Creek drainage, have similar shape characteristics. The particles are flat and smooth, indicating considerable deformation during transport (Figure B-16-5A). In cross-section, rims of high fineness are seen on a varying number of particles in all samples. Such rims are a common feature of placer gold and are believed to form in the surficial environment by the removal of silver (Knight and McTaggart, 1986, 1989). In the study area most rims are generally less than 2 microns thick and are generally incomplete. Most form less than 10 per cent of the particle's circumference, although a few particles are completely rimmed. The rims show folding and pitting. These features are believed to indicate that the present rims are remnants of once-complete rims, formed prior to transport of the particles to their present location. They were subsequently smeared, abraded and partly removed during transport. The rims thus show that the placer gold has undergone a multistage history of deposition, re-erosion and re-deposition in the surface environment. There is no indication that any of the gold is newly liberated from a lode, as would be shown by features such as angular outlines, more equant morphology or euhedral crystal forms. A few grains of platinum-iron alloy were recovered from the Tame Creek placer by the owner, R. Bergeron. Their composition was verified by qualitative SEM analysis (Figure B-16-5B). The only known source of platinum in the Sylvester allochthon is a single platinum-group element anomaly of 44 ppb platinum, 180 ppb palladium from a lithogeochemical sample of highly fractured, copper-stained gabbro within the Zus Mountain body, collected in 1988 (Figure B-16-1).

ANALYTICAL RESULTS

Samples consisting of several individual grains were mounted and polished and analysed for gold, silver, mercury and copper using the CAMECA SX-70 electron microprobe at the University of British Columbia. Details on analytical procedures and data reduction can be found in Knight and McTaggart (1986, 1989). The detection limit for copper is .025 weight per cent; for mercury .065 weight per cent at 99 per cent confidence (3X background error).

The results are shown as fineness versus mercury diagrams in Figure B-16-6 and in Table B-16-1. For comparison purposes, the samples in Figure B-16-1 are projected onto the topographic cross-section line A-A' in Figure B-16-6. On this line, the Erickson-Taurus bedrock veins appear first, followed by the McDame placer and then, separated by a topographic high in the pass east of Mount Haskin, the samples in the Spring Creek drainage. The effects of progressive addition of gold from different sources, if they exist, should increase sequentially from left to right along the cross-section.

The source of the placer gold can be deduced by comparing the its signature with that of the lodes. The 5 by 10 kilometre Erickson gold camp is the only known

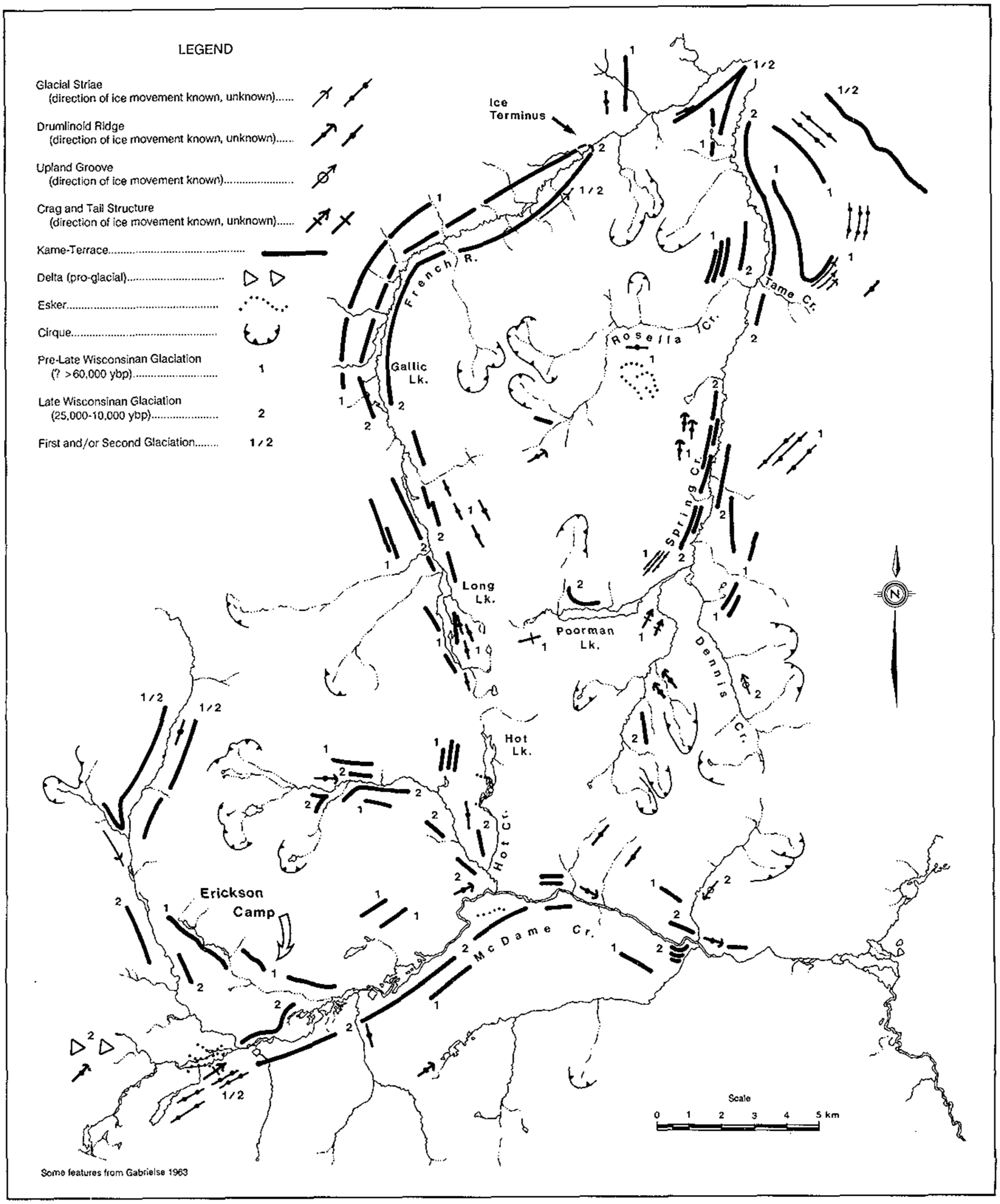
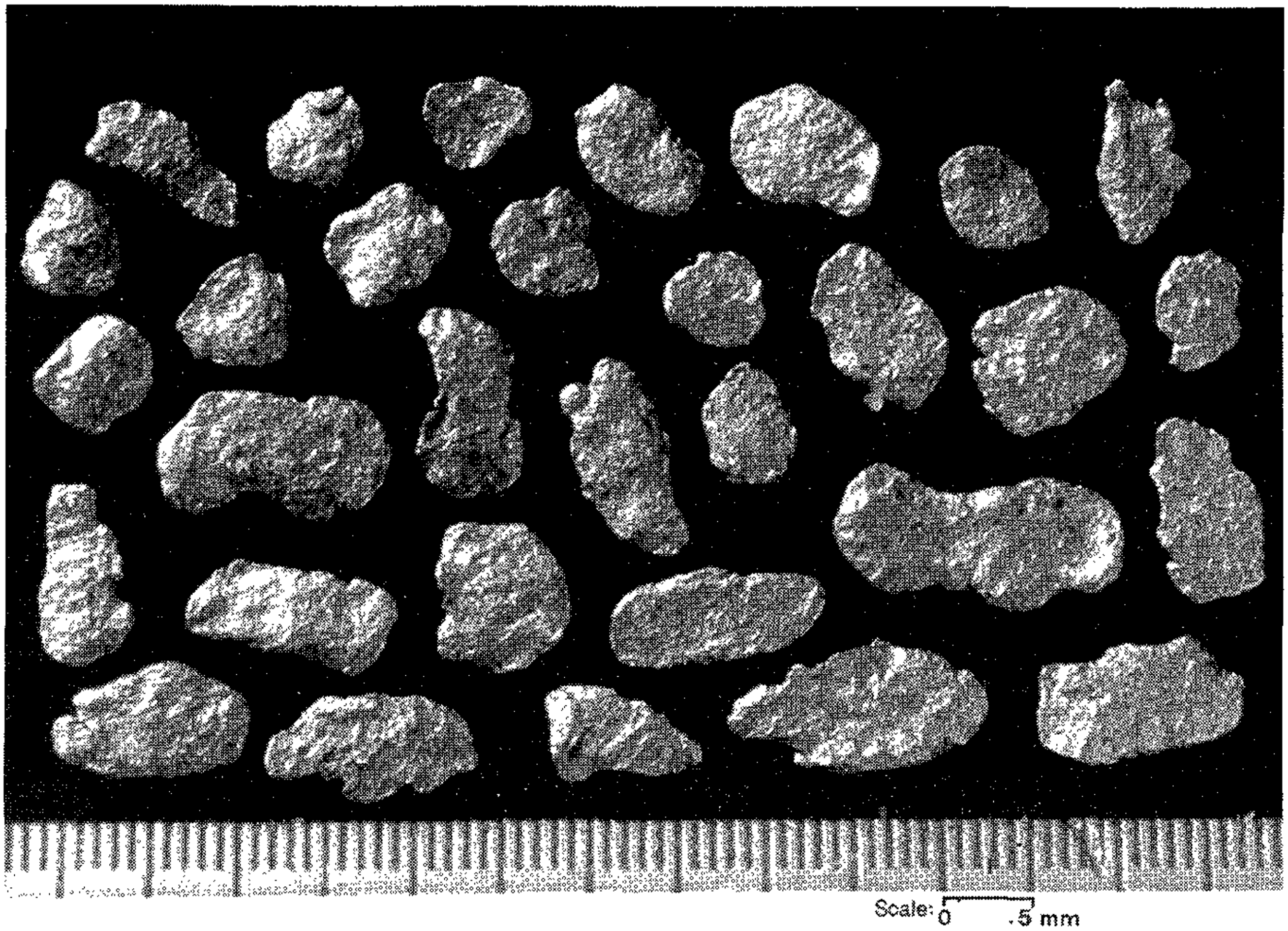


Figure B-16-4. Glacial features in the McDame and Spring Creek-French River drainages.



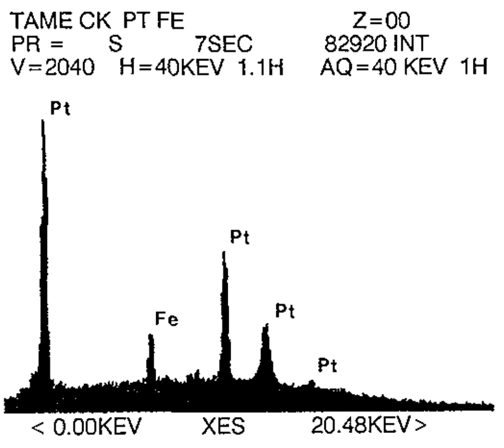


Figure B-16-5A. Photo of typical placer gold particles. 5B. SEM trace of Tame Creek platinum grain.

source of lode gold in the area (Nelson and Bradford, 1989). The camp is characterized by numerous small gold-quartz veins, a few of which are economically significant. The Erickson and Taurus gold mines were the main producers. The majority of the data points in the "Erickson all data" plot of Figure B-16-6 came from the economic veins in the Erickson camp; they show two prominent maxima at 770 and 880 fine, and mercury values to 1.2 per cent (15 points not shown on plot). The cluster at 770 fine is nearly all derived from the Eileen vein: thus this strongly bimodal signature is probably not representative of the camp as a whole.

The gold from the McDame Creek placer near Centreville provides an important datum, the signature of placer gold almost certainly derived from the Erickson-Taurus veins, gold which has travelled less than 10 kilometres downstream from the camp. The McDame signature shows a single cluster centered on 880 fine, 0.2 ppm mercury. It is like the northern Erickson data, but lacks the bimodality shown by the southern data. This may be due to extensive dilution by material derived from the uneconomic veins, as discussed above.

In the Spring Creek drainage, the samples from Dennis, upper Spring, Tame and Rosella creeks show signatures that are indistinguishable either from each other or from the McDame placer (Figure B-16-6 and Table B-16-1). The only notable difference is the presence of particles with a fineness of about 950 and about 0.1 weight per cent mercury. Particles with this signature make up about 10 per cent of the Spring Creek drainage samples. Aside from this difference, all the placers on

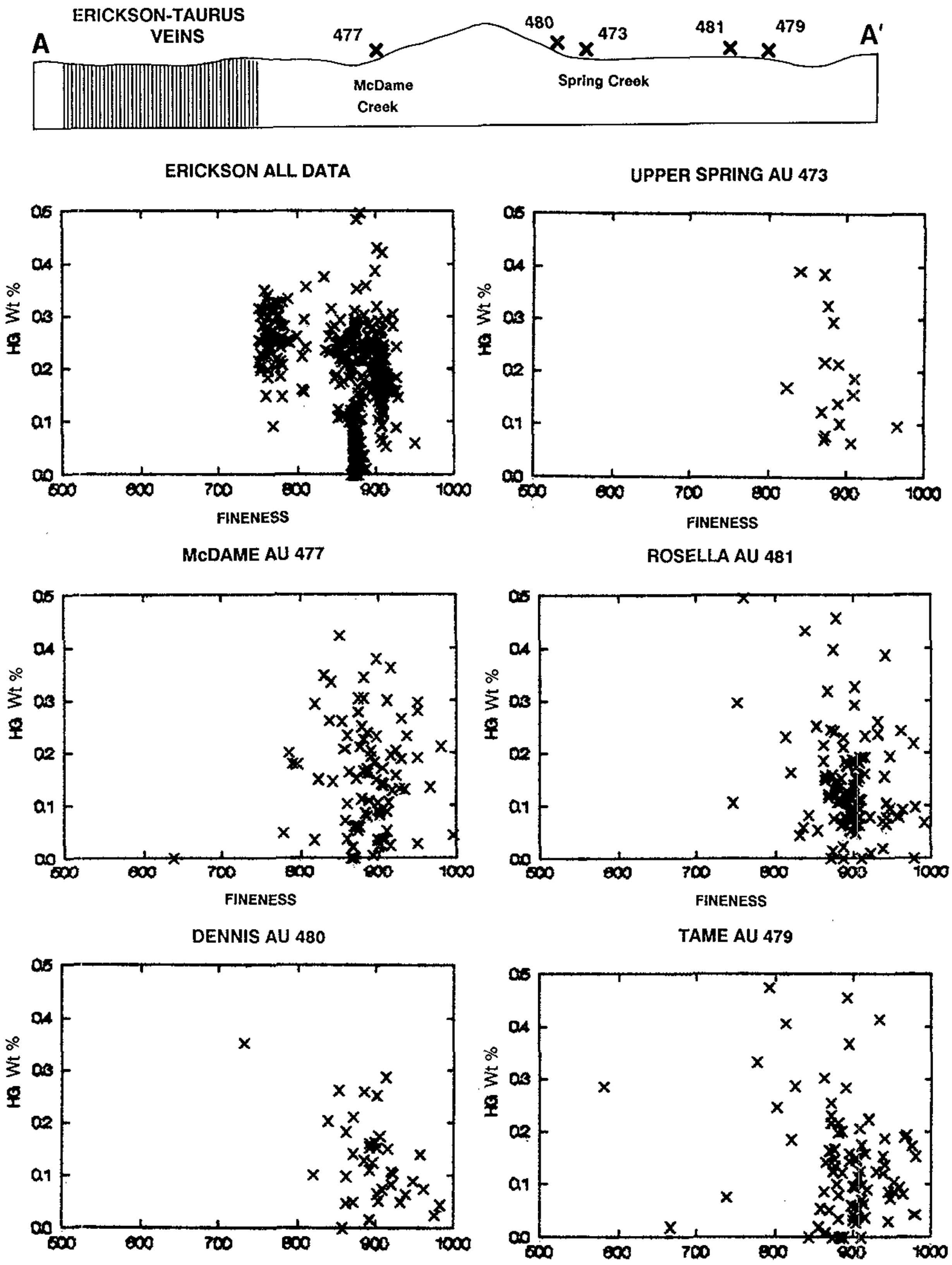


Figure B-16-6. Mercury-fineness signatures of bedrock and placer gold samples.

TABLE B-16-1
AVERAGE ANALYTICAL DATA FROM PLACER SAMPLES

Sample #	# of particles	Hg wt%	Hg sigma	Cu wt%	Cu sigma	Fineness wt%	Fineness sigma	Total wt%	Total sigma
477	91	.194	.18	.023	.019	878.3	58.7	99.8	.32
480	39	.163	.176	.030	.026	894.7	45.2	99.8	.38
473	16	.189	.108	.021	.021	884.1	31.8	100.2	.30
481	93	.147	.101	.028	.018	894.4	43.1	99.5	.25
479	80	.201	.225	.028	.023	879.0	69.4	100.0	.24

Spring Creek bear the Erickson geochemical signature. It is not modified by gold from other sources, such as manto deposits within the drainage. If there were additional sources within the Spring Creek drainage it would be expected that their signatures would not match the Erickson signature, and that in consequence the signatures in the placer gold would become more diffuse downstream. An example of such a broadening of the population was illustrated by Knight and McTaggart (1986) for the Bridge River - Fraser River drainage.

CONCLUSIONS

A number of lines of evidence lead to the conclusion that the placer gold in the Spring Creek drainage was derived from veins in the Erickson camp and glacially transported into the basin. The chemical signatures of placer gold in the Spring Creek drainage are remarkably similar to one another and to the Erickson signature. The mechanism of glacial transport of the gold is required due to the present drainage divides that separate Spring Creek from the area of geochemically similar bedrock gold mineralization; it is confirmed by the ubiquity of greenstone and ultramafic erratics in the Spring Creek drainage, which must have come from west or southwest of the drainage divides. Air photo study of glacial features associated with higher ice levels shows that a continental ice sheet filled all of the passes and moved, locally, in northerly to northeasterly directions from the McDame Creek into the Spring Creek drainage. Finally, the abraded rims on the placer gold particles show a long and complex surficial history, possibly involving fluvial, then glacial, then further fluvial transport.

The widely distributed placer gold derived from the Erickson-Taurus camp provides a clear example of the persistence of a single geochemical signature far from its site of origin. The Tame Creek placer is located 30 kilometres from the camp, and yet the Erickson signature in it is perfectly preserved. This close correspondence between bedrock gold and far-travelled placer points to the usefulness of placer gold geochemistry as a tracer of its source. It provides a model for more complex systems involving several sources, and encourages the use of gold geochemistry to unravel them.

ACKNOWLEDGMENTS

The authors wish to acknowledge the kind cooperation of placer miners Peter Hadrava, Serge and Moshe Hrbinic, Kennedy Melville and Barry Rollins; as well as Total Energold Corporation for samples from the Erickson camp and permission to publish the results. Ed Montgomery photographed the placer gold. Peter Bobrowsky and Vic Levson provided cogent advice on the interpretation of glacial features.

REFERENCES

Cody, R.W. (1969): Geochemical Report, Rose Claims 1-140, Liard Mining Division, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 2399.

Gabrielse, H. (1963): McDame Map-area, Cassiar District, British Columbia; *Geological Survey of Canada*, Memoir 319, 138 pages.

Knight, J. and McTaggart, K.C. (1986): The Composition of Placer and Lode Gold from the Fraser River Drainage Area, Southwestern British Columbia; *Canadian Institute of Mining and Metallurgy*, Geological Journal, Volume 1, Number 1, pages 21-30.

______ (1989): Composition of Gold from Southwestern British Columbia: A Progress Report; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1 pages 387-394.

Nelson, J. and Bradford, J. (1989): Geology and Mineral Deposits of the Cassiar and McDame Map Areas, British Columbia (104P/3, 5); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 323-338.

Nelson, J. (1990): Exploration in B.C. 1989; *B.C. Ministry of Energy, Mines and Petroleum Resources*, in preparation.

ASSESSMENT REPORTS - A SOURCE OF VALUABLE INFORMATION

(Fig. B1, No. 17)

T.E. Kalnins and A.F. Wilcox

INTRODUCTION

Results of mineral exploration programs are submitted to the Ministry in compliance with the Mineral Tenure Act Regulations and provide an invaluable record of exploration work in the province.

Assessment reports submitted and approved in 1989 numbered 1233[1] with a total declared work value of $60 856 206, a 12 per cent decrease in number and 23 per cent decrease in value from 1988.

Most reported exploration occurred in NTS 82, 92 and 104 areas (Table B-17-1, Figures B-17-1 and 2). Drilling accounted for about 40 per cent of the expenditures, followed by geochemical (30%) and other surveys (Figure B-17-3).

Average exploration project unit costs by work type are shown in Table B-17-2. These values are based on statements of costs declared in assessment reports, including labour, consulting, food, accommodation, transport, equipment rentals and supplies, laboratory analysis, report preparation and direct administration - management of the project.

The reports indicate that most exploration was directed toward polymetallic base and precious metal deposits (53%), followed by precious metal deposits (5%) and industrial minerals (2%).

EXPENDITURE TRENDS

Figure B-17-4 depicts point values and trends in annual exploration expenditures[2]. The "Value Applied to Claims Tenure" graph shows the upward trend best (about 7% annually), because the unit cost of applying assessment work to claims has not changed in this period and shows less inflation than the other graphs.

Of the Estimated Total Exploration expenditures, about half are submitted in assessment reports to the public database, and a third are filed as assessment work to extend the tenure of minerals claims. Submission of extra information in assessment reports is encouraged by the Portable Assesment Credit (PAC)system introduced in 1977.

Table B-17-3 compares exploration project costs by work type for 1981, 1988 and 1989. Only those work types are included that have clearly apportioned costs, including support costs, declared in selected assessment reports. The Table shows a surprising downward trend of unit costs (except non-core drilling), indicating that the exploration industry has become more efficient in doing more work at less cost.

USING THE DATABASE

Assessment reports are the primary source of detailed technical data in the public domain. The Geological Survey Branch maintains a library of approximately 20 000 reports dating from 1947 (Figure B-17-5). More than 1200 new reports are submitted annually. The reports may be viewed or copies purchased after expiry of a confidentiality period (usually one year). A computer index called ARIS (Assessment Report Indexing System) provides help to users wishing to locate

TABLE B-17-1
SUMMARY OF ASSESSMENT WORK, 1989

NTS	No. of A.R.	Value ($)	Geological (ha)	Geophysical Airborne (km)	Geophysical Ground (km)	Geochem No. of Samples	Drilling Core (m)	Drilling Non-core (m)	Prospecting (ha)	Trenching (m)	Access Roads (km)	Line/grid (km)	Tunnel (m)
82/83	331	13 992 319	83 516	7 866	2 428	90 855	45 011	13 308	10 297	9 988	110	1 334	227
92/102	400	19 618 545	40 773	11 157	4 063	129 490	80 692	5 719	32 299	21 247	40	2 297	2 900
93	197	8 451 809	54 842	4 434	2 198	67 413	37 914	12 268	8 053	7 668	58	1 500	—
94	39	2 811 022	22 205	3 200	262	9 688	7 668	2 844	3 650	1 000	7	119	—
103	36	2 348 767	9 556	—	111	6 935	8 464	—	620	426	2	37	603
104/114	230	13 633 744	53 481	10 099	1 389	58 771	27 762	—	69 597	1 696	5	634	231
TOTALS													
1989	1 233	60 856 206	264 373	36 756	10 451	363 152	207 511	34 139	124 516	42 025	222	5 921	3 961
1988	1 403	79 018 639	322 187	20 172	15 294	481 245	344 262	52 524	61 076	67 782	425	9 285	4 723
1987	1 181	42 736 000	—	16 607	10 686	284 332	160 011	16 592	—	25 609	294	7 202	554

1 308 reports required amendments and 57 reports were rejected. Rejection of reports may result in forfeiture of title to the claims.

2 Mineral Policy Branch, Mineral Titles Branch and Assessment Report statistics. The values have not been adjusted for inflation.

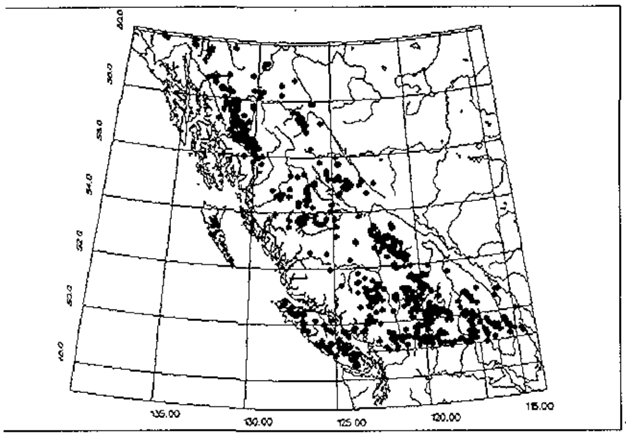


Figure B-17-1. Assessment Reports 1989.

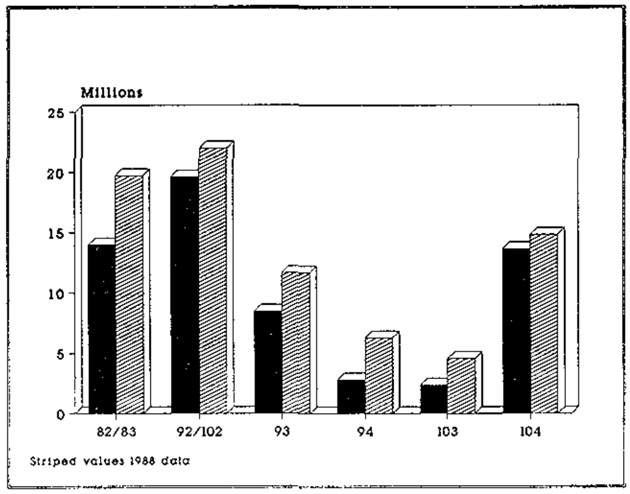


Figure B-17-2. Value of exploration by NTS 1988-89.

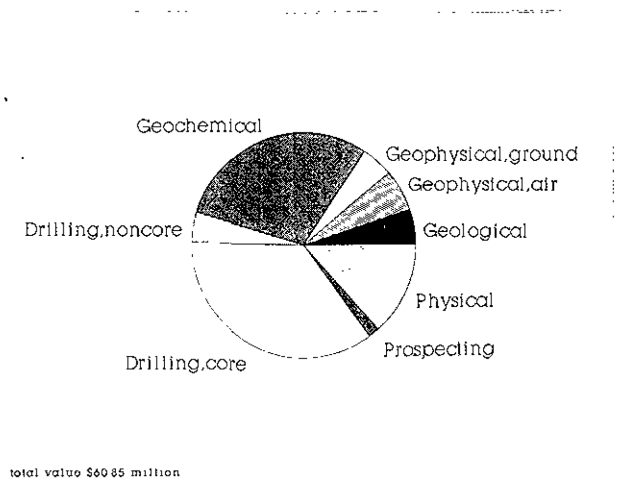


Figure B-17-3. Value of exploration by work type 1989.

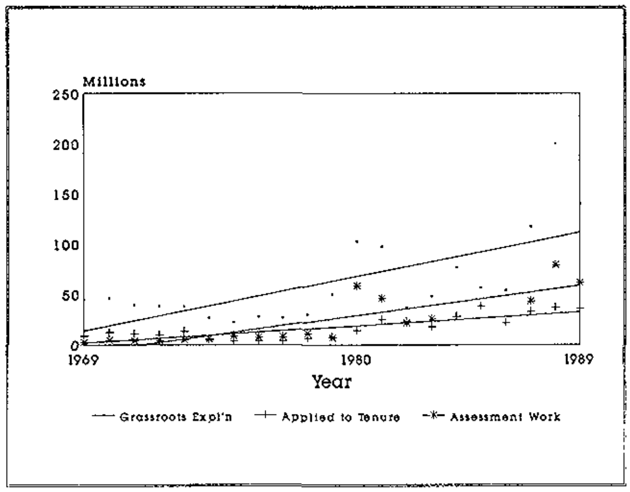


Figure B-17-4. Trend analysis of annual expenditures.

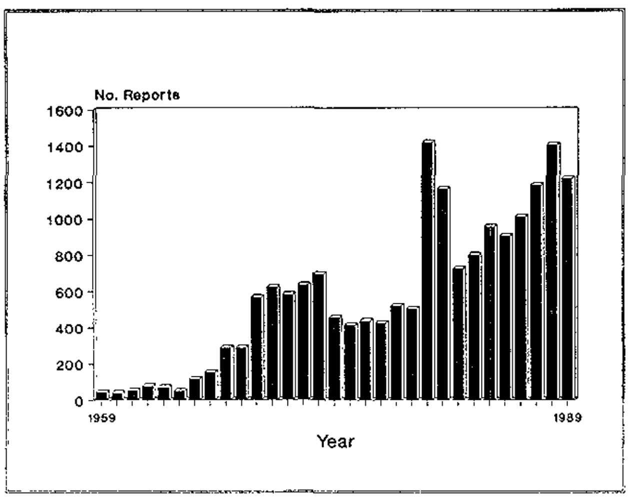


Figure B-17-5. Assessment Reports received 1959-1989.

TABLE B-17-2

EXPLORATION PROJECT COSTS, 1989

TYPE OF WORK	AMOUNT	UNITS	VALUE $	AVERAGE COST $	NUMBER OF SURVEYS
Geological Mapping	105 460	ha	1 257 663	12 per ha	88
Photo Interpretation	10 850	ha	18 430	2 per ha	7
Petrography	95	samples	8 963	94 per sample	10
Magnetrometer, airborne	13 846	km	624 965	45 per km	40
Electromagnetic airborne	13 371	km	596 610	45 per km	38
Magnetometer, ground	2 060	km	498 565	242 per km	89
Electromagnetic, ground	2 624	km	793 066	302 per km	101
Induced polarization	448	km	707 943	1 580 per km	34
Resistivity (alone)	16	km	8 180	511 per km	2
Seismic	5	km	47 586	8 978 per km	3
Self Potential	12	km	9 165	751 per km	2
Soil	101 002	samples	2 338 739	23 per sample	169
Stream sediment	604	samples	52 188	86 per sample	34
Rock chip	8 229	samples	377 630	46 per sample	91
Heavy minerals	220	samples	43 561	198 per sample	14
Sampling and assaying	20 428	samples	649 144	32 per sample	67
Metallurgy	4	samples	13 466	3 366 per sample	2
Diamond Drilling	49 985	metres	4 965 163	99 per metre	49
Rotary drilling	2 282	metres	181 952	80 per metre	
Prospecting	38 981	ha	263 339	7 per ha	55
Linecutting	2 658	km	770 428	290 per km	108
Road work	60	km	136 846	2 288 per km	17
Trenching	19 924	metres	379 748	19 per metre	21
Underground development	950	metres	1 575 959	1 659 per metre	
Topographic mapping	22 500	ha	37 580	2 per ha	2
Reclamation	1 300	ha	50 758	39 per ha	6

TABLE B-17-3

EXPLORATION PROJECT COSTS

($ per unit of work)

TYPE OF WORK	1981	1988	1989
Geological mapping	17/ha	15/ha	12/ha
Magnetic ground	383/km	225/km	242/km
Electromagnetic ground	774/km	321/km	302/km
Mag./EM, airborne	145/km	94/km	90/km
Induced polarization	1720/km	1986/km	1580/km
Seismic	9810/km	-	8978/km
Soil sampling	36/samp	25/samp	23/samp
Silt sampling	87/samp	71/samp	86/samp
Rock sampling	74/samp	49/samp	46/samp
Drilling, core	128/m	111/m	99/m
Drilling, non-core	44/m	71/m	80/m
Prospecting	-	10/ha	7/ha
Line/grid estab.	-	244/km	290/km
Topographic mapping	-	2/ha	2/ha

specific information for planning new exploration programs, resource management/land use studies, or conducting geoscience research.

Paper Index maps at a scale of 1:250 000 (or 1:125 000 in southern B.C.) show the approximate centre of exploration reported. Page-size, photo-reduced copies of these maps are included with the Index printout.

A basic bibliographic **Index printout** is sorted by NTS map sheet. For each report the index provides latitude, longitude, UTM co-ordinates, claim names, operator, author, type of work reported and report year. The same data fields included on the paper index are organized as a series of flat ASCII files on **diskettes** to facilitate access by a variety of commercial software programs. The index is also available on **COMfiche** and the index maps on **microfiche** as 35mm images. For further information contact Gerri Magee or Lois Pollard:

Geological Survey Branch Tel: (604) 356-2278
Rm. 121 - 525 Superior Street Fax (604) 387-3594
Victoria, B.C.
V8V 1X4

A complete library of **original reports** is located in the Branch's headquarters in Victoria. Partial libraries are located in Kamloops, Prince George, Smithers and Nelson.

Complete libraries of **microfiche reports** are available in all District Geologists' offices and Vancouver. Partial libraries are maintained in nineteen Gold Commissioners' offices throughout British Columbia.