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COLUMBIA

Ministry of Employment and Investment
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Geological Survey Branch

EXPLORATION IN BRITISH COLUMBIA 1995

Part A - Overview of Exploration Activity

Part B - Geological Descriptions of Properties

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FOREWORD

During 1995 British Columbia exploration activity was primarily concentrated in the north and central parts of the province targeted at porphyry, vein and sedex deposits, such as the Red Chris, Akie, Mount Polley and Polaris-Taku. Fifteen metal mines were operating in the the province during the year, including two new mines, Eskay Creek and QR. After being in production since 1971, the Island Copper, Cu-Mo-Au mine, closed at the end of the year.

Solid mineral production in British Columbia for 1995 is forecast at $3.48 billion dollars, a 38% increase from 1994. Spending on mineral exploration declined slightly to about $83.45 million. Part of this record production increase is accounted for by significant improvement in base and precious metal prices. Gold production is forecast to be 19.8 million grams (636 600 oz) with a value of about $340 million, up over 7 million grams due primarily to the new production at the Eskay Creek and QR mines. Silver output is forecast at 392 million grams valued at $88 million, and up significantly due to the new production at Eskay Creek. Zinc and lead production are estimated to reach 120 million kilograms and 50 million kilograms respectively - worth an estimated $210 million. Production of industrial metals is estimated to have a value of $61 million while structural materials will account for a further $380 million.

In 1995 the British Columbia government allocated approximately $2.5 million in 71 grants, under its Explore BC program, to encourage mineral exploration and resource development. This program is designed to assist and promote private sector mineral exploration, to extend the economic lives of existing mines, and to contribute to community stability in existing mining regions.

The British Columbia Geological Survey Branch maintained an active program of fieldwork during the year, including a regional mapping program, mineral deposits studies, mineral potential evaluation, industrial minerals research, surficial geology and geological hazards investigations, regional geochemical studies, and joint projects with the GSC in geophysics and regional mapping. The results of some of these project activities are included in Part B of this publication, and comprehensive treatment is available in Geological Fieldwork 1995, Paper 1996-1, released in January 1996.

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Chief Geologist

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PART A

OVERVIEW OF EXPLORATION ACTIVITY

BRITISH COLUMBIA MINING, DEVELOPMENT AND EXPLORATION 1995 OVERVIEW

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INTRODUCTION

Relatively high prices of copper (US$1.30-$1.40 per pound), gold (US$380-$390 per ounce), molybdenum oxide (US$4-$4.50 per pound) and silver (US$5-$5.50 per ounce) have led to increased value of output (approximately 57%) at existing mines. The **Eskay Creek** high-grade silver-gold mine began direct shipping ore by rail and ocean freight in January 1995. It is the first new metal mine to open in western Canada in several years. The **QR** gold project began production in June 1995. At the **Golden Bear** gold mine, the focus has turned to the potential for heap leaching of lower grade material. Significant new discoveries of both refractory and oxide mineralization have been made. After being in production since 1971, the **Island Copper** copper-molybdenum-gold mine closed at the end of 1995. Although no exploration or development work was carried out on the **Red Mountain** gold-silver project during 1995, an aggressive program is planned for 1996.

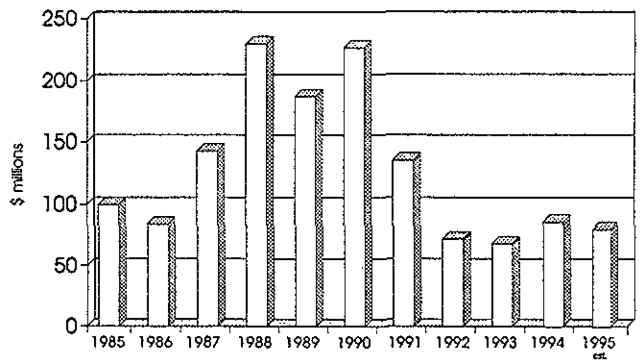
Production decisions were made in early 1996 for the **Mount Polley, Kemess, and Huckleberry** projects, all porphyry copper±gold±molybdenum deposits. Total exploration expenditures in 1995 are estimated to be approximately $83.45 million. Targets included many of the classic mineral deposit types for which British Columbia is known; for example, **Red Chris, Akie, Bralorne, Mount Polley, Polaris-Taku, Tsacha,** and porphyries in the **Babine Lake** area. Industrial minerals are receiving increasing attention with 1995 exploration expenditures estimated to be up slightly from 1994. The **Taurus** low-grade gold deposit is being explored for its heap-leach, bulk-mineable potential. The estimate for the number of claim units (approximately 32 768) recorded in 1995 also indicates an increase of about 8% in the level of activity over 1994; it is also the largest number since 1991. Several bulk sampling projects were carried out; some obtained revenue sales on a limited basis. A number of advanced projects in the Mine Development Assessment Process (now called Environmental Assessment Process) are in the feasibility stage. Some projects (*e.g.* Cirque, Mt. Milligan and Mount Polley) have received Mine Development Certificates and await production decisions.

In 1995 the British Columbia government allocated approximately $2.5 million for exploration under its **Explore B.C.** program. The program is designed to assist and promote private sector mineral exploration, to extend the economic lives of existing mines and contribute to community stability in existing mining regions. The projects supported in 1995 have produced positive and encouraging results. The government funded an airborne geophysical survey over three specific areas in the East Kootenay region, designed to locate more Sullivan-type targets, as well as others.

REGIONAL TRENDS

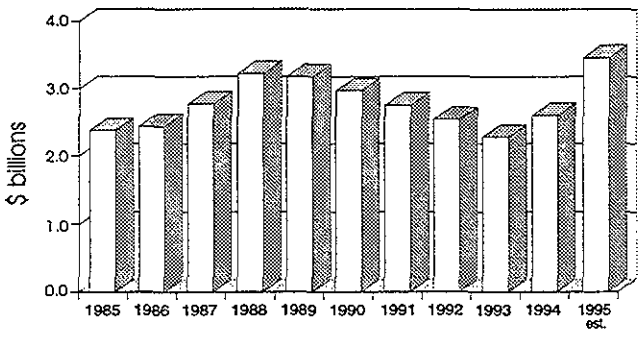
Preliminary estimates indicate that total expenditures on mineral exploration and development projects in British Columbia during 1995 will be approximately $83.45 million, a decrease of about 2% from 1994. As in previous years, it is estimated that over 40% of this total was spent in the northwest part of the province.

Figure 1 illustrates the fluctuation of exploration expenditures over the past decade. The peak year 1988, with expenditures of $225 million, coincided with the height of flow-through funding. In subsequent years, expenditures have shown a steady decline to a low of $66 million in 1993; however, a significant increase to $85 million was recorded in 1994. For the same ten-year period, the pattern of exploration spending is broadly similar to changes in the total



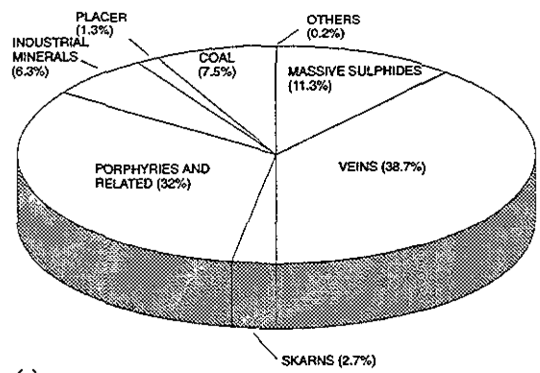
Source: MEI Resource Policy Branch

Figure 1. Mineral exploration expenditures in British Columbia: 1985 to 1995.

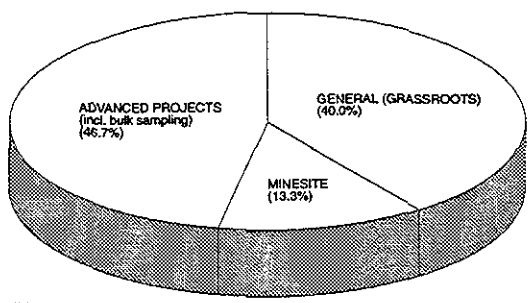


Source: MEI Resource Policy Branch

Figure 2. Solid mineral production value in British Columbia: 1985 to 1995.



(a)



(b)

Figure 3. Exploration targets - 1995 (a) by deposit type (%, expenditures); (b) by level or category of program (%, expenditures).

value of solid mineral production (Figure 2); although the latter increased sharply in 1995.

Exploration targets are varied and include: veins, massive sulphide deposits (volcanogenic, sedex and seafloor hydrothermal), porphyries and related deposits, skarns, industrial minerals, coal, placer deposits and others (Figure 3a).

Approximately 13.3% of exploration expenditures (including 7.2% at coal mines) were at minesites and 46.7% on advanced projects (including bulk sampling), including environmental studies and reclamation programs. An estimated 40% was spent on less advanced and grassroots ('general') exploration programs (Figure 3b). In total, there were approximately 240 projects with budgets in excess of $100 000, up slightly from the 225 projects in 1994. Figures 4a and 4b show the number of projects with expenditures in excess of this figure. The largest program was by American Bullion Minerals Ltd. on the **Red Chris** porphyry copper-gold project near Iskut, estimated at $6 million. **Red Mountain**, the project with the highest expenditure in 1994, was inactive during 1995 after Barrick Gold Corporation took over; an aggressive exploration and development program is planned for 1996.

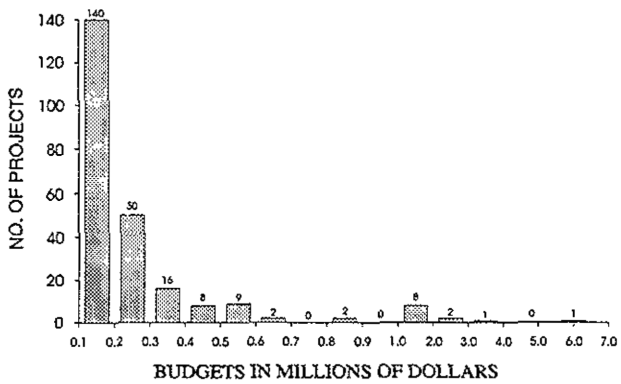
Grassroots programs were carried out in north-central British Columbia in the **Babine** and **Osilinka lakes** areas for porphyries, in southeastern and northeastern parts of the province for sedex deposits, in the **Interior Plateau** region of south-central British Columbia and the **Toodoggone** region of northwestern British Columbia for bonanza and bulk-mineable epithermal gold, in the **Stewart Camp** in the northwest for mesothermal and transitional gold deposits similar to Snip and Red Mountain, and in the **Wells-Barkerville Camp** for mesothermal veins and bulk-mineable gold. Exploration expenditures increased slightly for industrial minerals, and significantly for coal.

Estimates of the number of new mineral titles recorded (Figure 5) and the number of Free Miner Certificates issued indicate a slight increase over 1994. These indicators are positive, despite relatively constant exploration expenditures and increased global competition for risk capital.

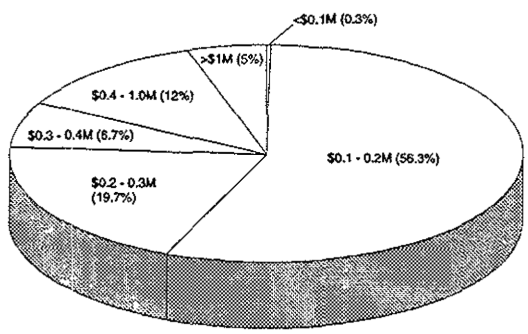
HIGHLIGHTS AT OPERATING MINES

PRODUCTION LEVELS

The locations of the 15 metal mines operating in British Columbia in 1995 are shown in Figure 6. Two new mines (**Eskay Creek** and **QR**) were opened during the year. One mine (**Island Copper**) closed at the end of the year. Most mines had significant exploration programs, some with good results. Several small high-grade projects (*i.e.*, **Elk, Iron Colt, Evening Star, Brett and Engineer**) have continued to produce, or plan to produce, using custom milling arrangements (Table 1; *see* also Operations). The **Table Mountain** gold mine continued to operate on a limited basis. The **Golden Bear** mine did not produce in 1995



(a)



(b)

Figure 4. Estimated number of major projects (>$1 000 000) (a) by incremental $0.1M; (b) by percentage of total expended.

but an aggressive exploration and development program was carried out (*see* Advanced Exploration and Development Projects).

The forecast value of solid mineral production for 1995 in British Columbia is $3.48 billion, a 38% increase from 1994 (Table 2). Copper represents 32.2%, at a projected value of approximately $1.12 billion, reflecting full production levels for **Similco**, **Gibraltar**, **Ajax** and **Myra Falls** mines (*cf.* 1994). Coal represents 28.4%, at a projected value approaching $1 billion. The production of gold is forecast to be 19.8 million grams (636 600 oz) valued at $340 million, up from 12.6 million grams (405 100 oz) last year, primarily due to significant new production from the **Eskay Creek** and **QR** mines. Silver output is forecast at 392 million grams (12.6 million oz) valued at $88 million, up significantly due to new production at the **Eskay Creek** mine. Zinc production in 1995 is forecast to be 120 million kilograms worth $175 million, lead output is forecast to be 50 million kilograms valued at $45 million. The total metals value is up approximately 57% from the 1994 estimate. Value of production of industrial minerals is forecast to be $61 million; structural materials are expected to account for another $380 million.

OPERATIONS

METAL MINES

The **Eskay Creek** gold-silver mine, operated by Homestake Canada Inc. through 50.6%-owned Prime Resources Group Inc., started commercial production in January 1995 with proven and probable reserves for the

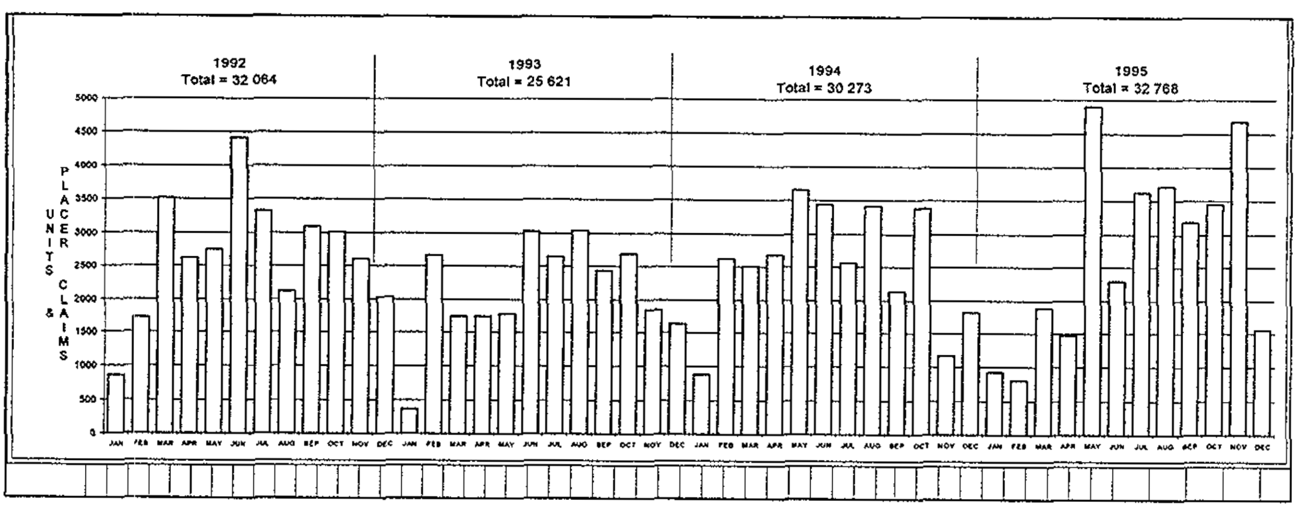


Figure 5. All mineral tenure recorded by month; 1992 to 1995. Note: High value for May 1995 reflects reverted Crown Grant sales and a release of a Regional Geochemical Survey by the Geological Survey Branch.

TABLE 1
ACTIVE AND POTENTIAL CUSTOM MILLING PROJECTS

Mill or Smelter/ Location	Project Name (Potential)	Commodity	Operator
Asarco/Helena, Montana	*Elk	Au	Fairfield Minerals Ltd.
Roberts Mill/Greenwood	(Brett)	Au	Liquid Gold Res. Inc./Huntington Res. Ltd.
Kettle/Republic, Washington	*Iron Colt, Evening Star, Midnight	Au	Pacific Vangold Res. Inc./ Int'l Silver Ridge Res. Inc.
Afton/Kamloops, B.C.	(Alwin)	Cu, Au	Claimstaker Res. Ltd.
Premier/Stewart, B.C.	(Debbie)	Au	White Hawk Ventures Inc.
Premier	(Greens Creek, Alaska)	Au, Cu, Ag, Pb,Zn	Kennecott Corp./Hecla Mining Co./ CSX Energy Corp./Exalas Res.
Premier	(Johnson River)	Au, Cu, Ag, Pb,Zn	Westmin Res. Ltd.
Premier	(Jualin)	Au	Coeur d'Alene Mines Ltd.
Premier	(Porcher Island)	Au	Westmin Res. Ltd.
Premier	(Red Mtn.)	Au, Ag	Royal Oak Mines Inc.
Premier	*Snip	Au	Cominco Ltd./Prime Resource Group Inc.
Premier	(SB)	Au	Tenajon Res. Ltd./Westmin Res. Ltd.
?	(Valentine Mtn.)	Au	Beau Pré Explorations Ltd.
Premier	*Skinner	Au	Ottarasko Mines Ltd.

* = Active

TABLE 2
1995 FORECAST VALUE OF MINERAL PRODUCTION IN B.C.

Commodity	Quantity (millions)	C$ Value (millions)	Percent of Total Value
Copper	278 kg	1 120	32.2%
Gold	19.8 g	340	9.8%
Zinc	120 kg	175	5.0%
Lead	50 kg	45	1.3%
Molybdenum	8.8 kg	275	7.9%
Silver	392 g	88	2.5%
Other		12	0.3%
Total Metals		**2 055**	**59%**
Structural Materials		380	10.9%
Industrial Minerals		61	1.8%
Metallurgical Coal	22.20 t	932	26.8%
Thermal Coal	2.25 t	54	1.5%
Total Solid Minerals		**3 482**	**100%**

Source: MEI Resource Policy Branch

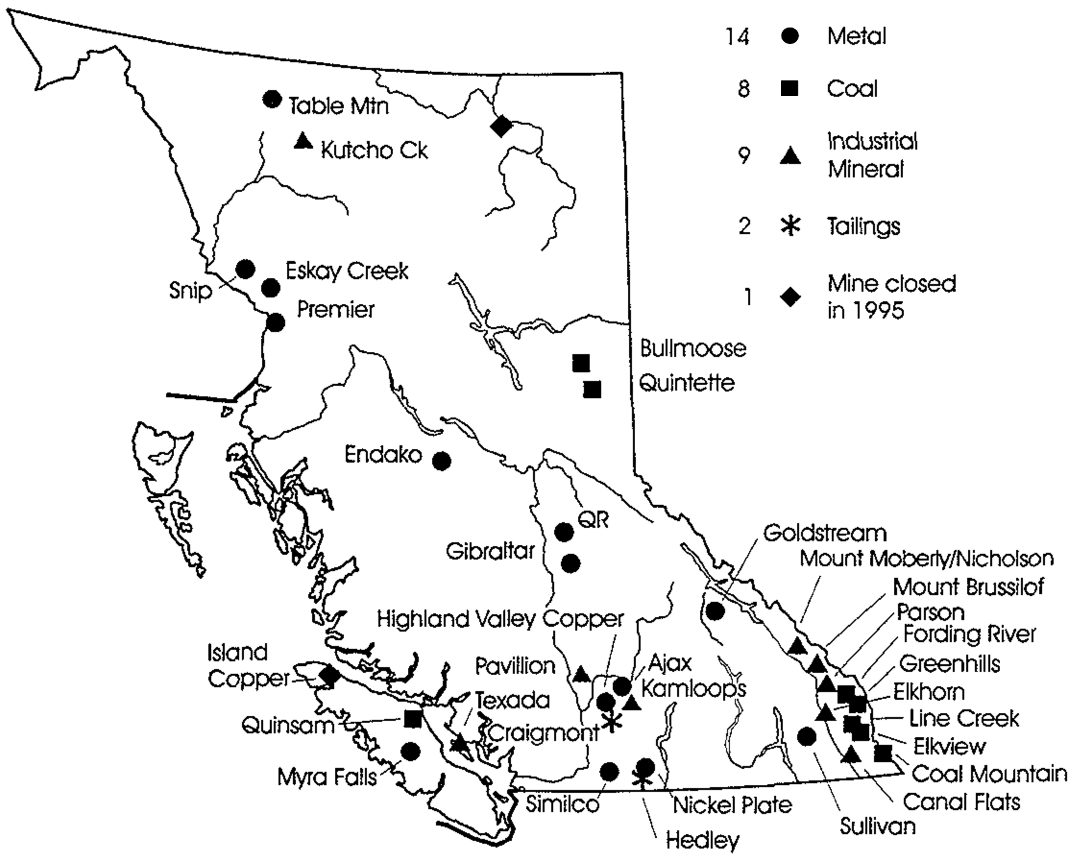


Figure 6. Operating mines in British Columbia - 1995.

21B zone estimated at 1.09 million tonnes grading 65.14 g/t Au, 2949 g/t Ag, 5.6% Zn and 0.77% Cu. Eskay Creek is the fourth largest silver producer in the world, and one of the highest grade gold and silver deposits ever discovered in North America. Ore is being blended on site, trucked to load-out facilities, and shipped directly to smelters in Quebec and Japan, by rail and ship, respectively. Production during 1995, at a mining rate of 275 tonnes per day, totalled 6113 kilograms (196 550 oz) of gold and 309 480 kilograms (9.95 million oz) of silver from 100 470 tonnes of ore milled. Cash costs are estimated at US$185 per ounce gold equivalent. In subsequent years, production is expected to average about 300 tonnes per day. Mining dilution, grades and production estimates have compared favourably with the feasibility predictions. An accelerated mine development program, implemented in April, has made more mining areas available, enabling Prime to optimize ore blending. Reserves estimated by Prime at January 1, 1996 were 1 019 468 tonnes grading 64.46 g/t Au, 2859.4 g/t Ag, 0.86% Cu, 3.07% Pb and 5.43% Zn.

Exploration drilling at the minesite resulted in the discovery of high-grade mineralization (NEX zone) in what appears to be an extension of the northeast end of the main 21B zone orebody. Additional drilling is planned to delineate this zone and underground development will be accelerated. Homestake Canada also completed a five-hole diamond drilling program on its Bonsai target, 10 kilometres west of the mine, to test for down-dip mineralization over a surface strike length of 580 metres.

Mill start-up at the **QR** gold mine, located 70 kilometres by road southeast of Quesnel, was June 1, 1995. Drill-indicated ore reserves were estimated at 1.3 million tonnes grading 4.5 g/t Au. Kinross Gold Corporation has spent over $20 million on construction to date. Operating cash costs are projected at US$220 per ounce gold. Gross revenue is estimated at $90 million in gold, and minor silver, over a five-year mine life, at a rate of about 1150 kilograms (37 000 oz) of gold recovered per year. Production during 1995, at an average milling rate of 1100 tonnes per day, totalled 659 850 grams (21 215 oz) of gold from 194 318 tonnes of ore milled. Reserves estimated by Kinross at January 1, 1996 were 1 287 239 tonnes grading 4.35 g/t Au. Three separate orebodies, hosted in a gold skarn, have been discovered to date; there is good potential for additional discoveries. Initially, the Main zone, which contains an estimated 616 760 tonnes grading 4.4 g/t Au, will be mined by open-pit methods; Kinross expects the zone to be depleted at the end of 1996. In 1996, Kinross plans to drive a ramp from the pit wall of the Main zone to the hangingwall of the Midwest zone, a few hundred metres to the west. Production from the Midwest zone, with probable reserves of 440 800 tonnes grading 4.32 g/t Au, is expected to begin in October 1996. The West zone, with probable reserves of 168 700 tonnes grading 6.64 g/t Au, will be mined underground during the latter years of the mine's life. The mill facility was designed for 800 tonnes per day; early operation has achieved rates up to 1200 tonnes per day. Up to 30% of recovered gold is expected to be from gravity concentration, the remainder by flotation and electrowinning methods. Kinross is testing and evaluating the possibility of lowering the cut-off grade to as low as 0.5 g/t Au for ore to be processed by heap-leach methods, which would add significant reserves and mine life to the operation. Preliminary tests are returning encouraging results. A 2000-metre drilling program to test for additional reserves to the east of the Main zone, across Wally's fault, and to the west of the West zone, was conducted in late 1995.

The **Snip** gold mine, owned and operated by Cominco Ltd. (60%) and Prime Resources Group Inc. (40%), produced 4000 kilograms (129 000 oz) of gold from 165 525 tonnes of ore milled in 1995. Mining is at a rate of 460 tonnes per day with a 12 g/t cut-off and operating costs are estimated at US$175 per ounce gold. Reserves estimated by Cominco at January 1, 1996 were 480 000 tonnes grading 25.8 g/t Au. Recoveries for gold are approximately 35% by gravity circuit and 56% by flotation, for an overall 91% recovery. Concentrate is shipped to the Premier mill near Stewart for further processing. Exploration of the Twin zone has been successful in locating ore up-plunge to the southeast. Exploration continues in that direction, as progressively higher exploration drifts are driven from the spiral ramp as it is developed.

Cominco began a 700-metre underground development program to evaluate the newly discovered Twin West vein on the west side of the Monsoon Lake lineament discovered during the past season. This vein has a northwesterly trend similar to the 150 vein that is currently being mined in the footwall of the Twin vein; it is narrow, but continuous and locally high grade. Ore grade mineralization has been indicated by surface drilling which is progressing towards the Sky fractional claim, part of the Bronson option from International Skyline Gold Corporation on the western boundary of the Snip claims.

In late March, 1996 Prime Resources agreed to purchase Cominco Ltd.'s 60% interest in the Snip mine for $55 million, Homestake Canada Inc. will be appointed as operator of the mine under a managerial arrangement similar to that which exists for Prime's Eskay Creek mine.

The **Highland Valley Copper** mine, a partnership among Cominco Ltd. (50%), Rio Algom Limited (33.6%), Teck Corporation (13.9%) and Highmont Mining Company (2.5%) milled 45 521 000 tonnes during 1995 at an average daily throughput of 124 715 tonnes. Production totalled 157 980 tonnes of copper contained in concentrate, 58 790 kilograms (1.89 million oz) of silver, 396.5 kilograms (12 745 oz) of gold and 1566.4 tonnes. The mine is one of the largest operations in the world and employs about 1160 people. During 1995, Highland Valley Copper completed deep-penetrating reconnaissance induced polarization and resistivity surveys over the Southwest Extension grid and over and adjacent to the JA deposit where a geologic resource of 286 million tonnes grading 0.43% Cu and 0.017% Mo has previously been defined. Anomalies were tested by diamond drilling. At the Valley pit, the east, southeast and southwest walls were pushed back in order to access deep ore in the southeast corner. Currently, 95% of millfeed at Highland Valley Copper is from the Valley orebody, 5% from Lornex.

The **Island Copper** mine produced 38 777 tonnes of copper, 1400 tonnes of molybdenum, 10 900 kilograms (350 800 0z) of silver and 661 100 grams (21 255 oz) of gold from 16 474 700 tonnes of ore milled at a daily throughput of 45 510 tonnes in 1995. BHP Minerals Canada Ltd. ceased mining operations in July 1995 and finished milling of surface stockpiles by the end of the year. BHP will continue to implement its closure plan and hopes to complete site reclamation in two years.

During 1994 the Westmin Resources Limited **Myra Falls** mine produced 21 770 tonnes of copper, 26 780 tonnes of zinc, 17 000 kilograms (546 570 oz) of silver and 819 kilograms (26 330 oz) of gold from 1 197 000 tonnes of ore, milled at a daily throughput of 3650 tonnes. Reserves estimated by the company at January 1, 1996 were 11 150 400 tonnes grading 1.6% Cu, 0.3% Pb, 6.1% Zn, 1.5 g/t Au and 27.5 g/t Ag. Reserves in the Battle zone, which is currently being developed and mined, are 2.5 million tonnes grading 2% Cu, 10.6% Zn, 1.0 g/t Au and 20.3 g/t Ag. There are two other high-grade zinc zones closely associated with the Battle: the Gopher and Gnu, which together total about 700 000 tonnes. The Gopher zone is the source of development ore which has been going to the mill since April 1995. Operating costs were down, during 1995 resulting in positive cash flow and a return to profitability.

In a separate program, underground drilling from the Lynx mine into the North Downdrop region, north of the Gap orebody, resulted in the discovery of the Marshall zone. It consists of high-grade ore within H-W stratigraphy. The implications are significant as this is the first discovery north of the North Downdrop fault in this region. It is also above the H-W haulage level about 900 metres northwest of the current Battle zone development. Surface exploration on the Trumpeter zone, located at the eastern end of the property, in late 1994 and January 1995, resulted in a significant increase in geological reserves. Follow-up drilling and underground development are planned for 1996.

At the Gibraltar Mines Limited **Gibraltar** (McLeese Lake) mine, production during 1995 totalled 27 795 tonnes of copper in concentrate and 2600 tonnes of cathode copper and 30.4 tonnes of molybdenum, from milling of 13 852 610 tonnes of ore at a daily throughput of 37 950 tonnes.

Reserves estimated by the company at January 1, 1996 were 162 302 200 tonnes grading 0.297% Cu and 0.009% Mo. Drilling during 1995, totalling 3150 metres in 23 core holes, focused on induced polarization targets on two zones: the Pollyana - GM zone immediately east of the Pollyana pit, and the Connector zone between the Pollyana and Gib East zones. The latter was tested for the presence of near-surface oxide ore. In 1995 Gibraltar approved an expenditure of about $1.3 million to recommission the molybdenum circuit. It was restarted in October and is expected to produce about 27 tonnes of molybdenum per month at a cash cost of about $3.40 per pound.

The Homestake Canada Inc. **Nickel Plate** open-pit gold mine produced 2842 kilograms (91 365 oz) of gold from 1 461 780 tonnes of ore milled in 1995, at a daily throughput of 3635 tonnes. Reserves estimated by the company at January 1, 1996 were 696 665 tonnes grading 2.84 g/t Au. Mining and milling are projected to cease towards the end of 1996. In 1995 Homestake drilled targets near Cahill Creek, testing a northerly trending zone extending from the French mine/Good Hope areas to the previously mined Canty open pit.

During 1995 the Princeton Mining Corporation **Similco (Copper Mountain)** mine produced 17 113 tonnes of copper, 736.5 kilograms (23 680 oz) of gold, and 2970 kilograms (95 565 oz) of silver from 7 371 190 tonnes of ore milled at a daily throughput of 19 140 tonnes. Reserves estimated by the company at January 1, 1996 were 123 742 000 tonnes grading 0.393% Cu, 0.155 g/t Au and 1.576 g/t Ag. During 1995 Princeton milled ore from the low-grade stockpile and from the Ingerbelle East (extension) pit (phase 1), with estimated reserves of 10.8 million tonnes grading 0.32% Cu and 0.24 g/t Au. It was planned that 75% of the millfeed would come from the Ingerbelle pit by the end of the year, and this should result in a significant rise in head grades. Elsewhere on the property, Princeton drilled the Alabama zone, and trenched and sampled an induced polarization anomaly on the P4 zone on Wolf Creek.

Production at the Westmin Resources Limited **Premier** gold mine during 1995 totalled 580 kilograms (18 665 oz) of gold and 6235 kilograms (200 495 oz) of silver from 179 500 tonnes of ore milled at a daily throughput of 490 tonnes. In addition, custom treatment, primarily of Snip mine concentrates, yielded additional gold and silver. Reserves estimated by the company at January 1, 1996 were 260 000 tonnes grading 4.65 g/t Au and 68.0 g/t Ag. Millfeed came two-thirds from Glory Hole fill recovered through a decline from 515-bench in the open pit, and one-third from pillars and ore on 4-level. Exploration targets underground include 5-level and the West zone above 3-level. Westmin also conducted an intensive assessment of all its holdings in the region. Development options are being considered to mine additional resources identified by a comprehensive compilation of all existing data.

At the **Goldstream** mine, Bethlehem Resources Corporation, which owns a 50% interest and is the operator, produced 10 220 tonnes of copper and 1043 tonnes of zinc from 302 835 tonnes of ore at a daily throughput of 1100 tonnes. Reserves estimated by the company were approximately 22 000 tonnes grading 3.5% Cu, and 2.15% Zn as of January 1, 1996. In mid- July, milling operations were temporarily shut down following slow ramp development and poorer than expected ore recovery in the 250-metre panel. Milling resumed in September and continued until January 31, 1996 when the economic limits of the existing orebody were reached. Underground exploration drilling was conducted on the 300-metre and 250-metre levels. A surface drilling program was carried out on the C-1 zone, approximately 10 kilometres west of the mine, where encouraging results were obtained in 1994 drilling.

At the Afton Operating Corporation **Ajax** copper-gold mine, production from the Ajax East pit, which contained approximately 3.63 million tonnes of ore grading 0.46% Cu and 0.34 g/t Au, totalled 10 586 tonnes of copper and 747.5 kilograms (24 033 oz) of gold and 1450 kilograms (46 620 oz) of silver from 3 110 000 tonnes milled at a daily throughput of 8770 tonnes. Reserves for the Afton-Ajax deposits estimated by the company at January 1, 1996 were 3 613 700 tonnes grading 0.48% Cu, 0.38 g/t Au and 0.86 g/t Ag.

In 1995 Afton announced that it will re-open the Ajax West pit, with about 9 million tonnes of the same grade as Ajax East, extending the mine life from December 1996 to about December 1998. Pushback stripping of the Ajax West pit is in progress, and some ore is already being milled. Definition drilling on the southeast side of the pit has yielded encouraging results. This may allow Afton to redesign and enlarge the final pit. Drilling was also carried out on the south side of the Ajax East pit. Teck Corporation has also outlined significant resources on the Rainbow and Galaxy porphyry projects, located between the Ajax mine and the Afton mill (*see* Advanced Exploration and Development Projects).

At the **Endako** molybdenum mine, Placer Dome Canada Limited produced 6536 tonnes of molybdenum in 1995, from 10 430 000 tonnes of ore milled at a daily throughput of 29 100 tonnes. Proven and probable ore reserves estimated by the company were 104 843 000 tonnes grading 0.077% Mo at January 1, 1996.

Cominco Ltd. production at the **Sullivan** underground zinc-lead mine in 1995 was 58 356 tonnes of lead, 113 024 tonnes of zinc and 21 118 kilograms (678 970 oz) of silver, from 1 616 000 tonnes of ore milled at a daily throughput of 6900 tonnes. Zinc concentrate production was the highest level achieved in the last 30 years. Reserves estimated by the company at January 31, 1996 were 11 435 200 tonnes grading 25.0 g/t Ag, 4.5% Pb and 8.0% Zn, sufficient for about another five years of operation. In 1995 Cominco conducted an exploration drilling program including one deep hole to test for the offset continuation of the Sullivan deposit north of the Kimberley fault.

At the **Table Mountain** underground gold mine, Cusac Gold Mines Ltd. produced 411 kilograms (13 220 oz) of gold in 1995 from approximately 21 500 tonnes of ore, milled intermittently at a daily throughput of 275 tonnes. During 1995 Cusac completed a decline to the Michelle high-grade zone and continued to develop the zone, producing about 45 tonnes of development ore per day for blending with the lower grade Bain vein material. The company also believes there is considerable potential both on strike and in well mineralized parallel structures. Drilling continues to explore this zone.

As a result of encouraging drilling results in the Michelle high-grade zone, Cusac is proceeding with completion of the 10-portal, a major underground development project with an estimated cost of approximately $1.3 million, to improve access to the orebody and, ultimately, to increase production. Cusac will advance the partially constructed adit (1570 metres) approximately 915 metres to the target area, with planned completion in the spring of 1996. Meanwhile, mining, development and exploration will continue through the existing decline. The mill processed high-grade material from both the Michelle high-grade zone and the Catherine vein open-pit.

COAL MINES

Total clean coal production in 1995 is estimated to be about 24.5 million tonnes, approximately 22.2 million tonnes metallurgical and 2.25 million tonnes thermal. This is a substantial increase over 1993. Prices for both types of coal rose in the early part of 1995 and the nine-month value of coal exported this year may exceed the previous maximum of about $1 billion, reached in 1985. Total expenditure on development and exploration at existing coal mines is forecast to be in excess of $4 million for 1995. There have also been major expenditures to increase plant capacities and total capital expenditures committed to increasing production probably amount to over $50 million.

At the **Quinsam** mine on Vancouver Island, Quinsam Coal Corporation produced about 600 000 tonnes of thermal coal in 1995, up from 550 000 tonnes in 1994. Production is planned to increase to 1.2 million tonnes in 1996. The wash plant expansion estimated to cost $2 million, originally scheduled for mid-1996, is currently in progress as a result of the strong demand from Asia Pacific countries. A successful exploration and drilling program in 1995 has increased reserves to more than 40 million tonnes from the previous level of 35 million tonnes. Next year, Quinsam plans to carry out a major exploration program on the Tsable River property and hopes to develop an underground coal mine.

Production by Fording Coal Limited at the **Fording River** mine is expected to increase to 7 million tonnes in 1995, following the addition of equipment to the plant and other capital expenditures. Over 120 holes totalling 16 000 metres were drilled in 1995 as part of a $750 000 exploration program on Henretta and Turnbull ridges. At the **Greenhills** mine, Fording Coal continues to increase production and plans to sell 3.8 million tonnes of metallurgical coal in 1995 and 4.2 million tonnes in 1996. The plant capacity has been increased by the addition of new heavy-media cyclone circuits. Eighty exploration drill holes, totalling 12 000 metres, were completed in the Raven and Cougar pits during 1995. Fording Coal has an aggressive expansion program at its **Coal Mountain** mine. Exploration in 1995, consisting of 80 drill holes totalling approximately 13 000 metres, has resulted in the definition of a reserve base of 40 million tonnes of clean coal. Expenditures on new mining equipment exceeded $15 million and extensive improvements are in progress in the plant, at a capital cost of $30 million. Production in 1995 is expected to reach 1.2 million tonnes and is projected to increase to 2 and 2.5 million tonnes in 1996 and 1997, respectively.

At the **Line Creek** mine, Line Creek Resources Ltd. is building a conveyor to move coal 10 kilometres from the raw coal stockpile to the plant. The conveyor will cost about $30 million and will have a capacity of 7 million tonnes per year. When commissioned, operating costs will be substantially reduced. Currently, clean coal production is 2.2 million tonnes metallurgical coal and 0.6 million tonnes thermal coal. A new pit is being developed on Horseshoe Ridge and the haul road to this area is under construction. Approximately 15 000 metres of exploration and development drilling were completed in 1995.

At the **Elkview** mine, Teck Corporation has submitted a new mine plan, encompassing Natal Ridge, for government approval. The plan will increase production from approximately 2.9 million tonnes per year to 5 million tonnes per year over a period of five to six years. In 1995 exploration was mainly in active pits and consisted of 77 drill holes totalling approximately 10 000 metres. Reserves estimated by the company at January 1, 1996 were 144.5 million tonnes.

In the northeast, the **Bullmoose** mine (Teck Corporation, 60.9%; Rio Algom Limited, 29.1%; Nissho Iwai Coal Development (Canada) Ltd., 10%) shipped 1.9 million tonnes of coal in 1995. This includes 400 000 tonnes transferred from the Quintette contract. The arrangement has been renewed for an additional two years, ensuring that Bullmoose stays at approximately the 2 million tonnes production level until at least 1998. During 1995, twenty development holes were completed in the South Fork pit. Reserves estimated by the company at January 1, 1996 were 13.5 million tonnes.

The **Quintette** mine, operated by Quintette Coal Limited, had a difficult year and shipped 3.7 million tonnes, down from the planned 4.3 million tonnes. Exploration expenditures, estimated at $1 million, were focused on developing reserves for beyond 1998 on Babcock Mountain (35 drill holes) and in the Mesa Extension area (35 drill-holes). Reserves of clean coal within existing pits, estimated by the company at January 1, 1996, were 12 million tonnes

INDUSTRIAL MINERALS MINES

British Columbia is endowed with a variety of industrial minerals. Interest in a number of commodities has increased in 1995. There are a nine major mines and more than thirty smaller quarries. These operations are mainly located in the southern half of the province, close to tidewater or major transportation routes. The most economically significant minerals produced in 1994 were sulphur, magnesite, gypsum, silica, barite, limestone and construction materials, with lesser production of jade, diatomite, magnetite, dolomite, dimension stone, pyrophyllite, scoria, slate, flagstone, zeolite, clay and fuller's earth. Sand and gravel pits are located throughout the province. The forecast value of production of industrial minerals in 1995 is $61 million (up from $47.1 million in 1994); structural materials are forecast to account for another $380 million (slightly higher than in 1994).

Sulphur, derived from natural gas, is produced at five extraction plants in the northeast of the province. Production during 1994 totalled 626 525 tonnes.

In the Rocky Mountains, Westroc Industries Limited moved production of **gypsum** from its Windermere quarry to its **Elkhorn** quarry. It has not yet started the proposed Elkhorn II development designed to sustain production at 450 000 tonnes per year. After restructuring for sale of the company, Domtar Gypsum continued to ship gypsum from a three-year stockpile mined from the **Canal Flats** (J4) quarry in 1994.

Baymag Mines Company Limited continued to mine **magnesite** at **Mount Brussilof** at an annual rate of approximately 175 000 tonnes. The magnesite is shipped to a processing plant at Exshaw, Alberta to produce high-quality calcined and fused magnesia. Construction of a new shaft kiln is in preparation at Exshaw and is expected to be in production in 1997, increasing Baymag's output by approximately 70%. The company plans to process and upgrade the lower grade magnesite (approximately 85%) presently wasted. The company also completed a drilling program over its claim block.

The **Mount Moberley** and **Nicholson** mines in the Golden area account for all of British Columbia's high-grade silica production. Mountain Minerals Company Ltd. is producing approximately 80 000 tonnes annually at Moberley for shipment to Springfield, Oregon. Bert Miller Trucking and Contracting Ltd. is producing approximately 60 000 tonnes annually and has started to process the undersize product, accumulating at a rate of some 10 000 tonnes annually, into a variety of fine to coarse aggregate products.

Limestone quarries at Gillies Bay and Blubber Bay on **Texada Island** ship some 5 million tonnes annually to pulp and paper mills, cement plants and lime producers along the coast from Alaska to northern California. White limestone is produced from deposits at **Benson Lake** (80 000 t), **Gillies Bay** (20 000) and **Lost Creek** (40 000 t, mostly from the lower adit) and used as a filler in paints and plastics produced in Surrey and Creston. The **Dahl Lake** operation, 30 kilometres west of Prince George, re-opened recently, processing approximately 20 000 tonnes of decorative aggregate from its 1994 stockpile. Kode-Jerrat Quarries Ltd. (**Giscome**) sells about 50 000 tonnes of limestone a year to customers in the central part of the province. The company plans to build its own kiln to calcine limestone on site and increase its market value four-fold. Limestone is processed by three cement plants and two lime production centres near Kamloops and Lillooet and in the Lower Mainland. The Continental Lime Ltd. Pavilion Lake plant produces up to 200 000 tonnes of lime per year from its quarry near Cache Creek. The majority of pulp and paper mills produce their own lime from nearby limestone quarries.

Mountain Minerals Ltd. operates the **Parson** mine, British Columbia's only **barite** producer. Current reserves are limited (one to two years); exploration drilling at Parson did not locate additional reserves. Dresser Industries may consider re-opening the **Fireside** property near Watson Lake.

Granite and **marble** are produced by a number of companies. Stone-processing plants are operated by Margranite Industries Ltd. in Surrey, Matrix Marble Corporation in Duncan and Westcoast Granite Manufacturing Inc. in Delta. Margranite is opening a new granite quarry (**Anderson-Bighorn**) near Boston Bar. Garibaldi Granite Inc. operates the Squamish quarry (Island white granite) and is preparing two sites on the **Ashlu River** for quarrying of granodiorite. In the Grand Forks area, "black" granite from the **San Pedro** property is being shipped to Korea; other potential granite quarry sites are being examined in the area. Granite Creations and Stone Works opened a quarry in black granite north of Harrison Hot Springs. Adera Natural Stone Supplies Ltd. is quarrying a granite on Granite Island, near Sechelt. Mammoth Geological Ltd. started production at its **Tsitika** grey granite quarry on northern Vancouver Island.

Franz Capital Corporation Ltd. has been delivering stone products from its **Kingfisher marble** quarry near Enderby to landscape and brick retail businesses and construction sites in British Columbia and Alberta. The company plans to improve productivity and increase production and sales to approximately 200 tonnes per month.

Products manufactured and stockpiled include split stone bricks and marble rock and chips.

Revelstoke Flagstone Quarries and Begbie Flagstone Ltd. are together producing approximately 200 tonnes of mica schist flagstone. Kootenay Stone Centre in Salmo is producing about 4000 tonnes of **quartzite flagstone**.

Clayburn Industries Ltd. of Vancouver is mining relatively small amounts of fireclay from **Sumas Mountain**, and processing **diatomite** and **pyrophyllite** from existing stockpiles. Clayburn plans to mine 200 tonnes of pyrophyllite from Princeton for its refractory brick plant in Abbotsford. Western Industrial Clay Products Ltd. in Kamloops supplies approximately half of the kitty litter market in western Canada, principally from its **Red Lake** property.

Dolomite quarried in the Crawford Bay, Creston and Rock Creek areas is used for soil conditioning, as a component in stucco and roofing materials, and as white, ornamental aggregate rock.

Jade was mined in the Kutcho Creek area by Jade West Resources Ltd. and recovered from the old Cassiar Asbestos dumps by Jedway Enterprises.

TAILINGS

Candorado Operating Company Limited operated the **Mascot Gold** tailings project at a designed rate of 36 000 tonnes per month. The project closed late in the fall. During 1995 production totalled 94 kilograms (3000 oz) of gold and 10 kilograms (320 oz) of silver from 42 640 tonnes processed. M. Seven Industries Inc. continues to produce about 60 000 tonnes per year of magnetite by processing the **Craigmont** tailings. The quality of the product has improved and the company is supplying most coal mines in western Canada (except Manalta and Line Creek). The company has filed a conceptual design to create a new tailings-storage dam (on top of the old one) which would allow the operation to continue for at least another 15 years.

ADVANCED EXPLORATION AND DEVELOPMENT PROJECTS

METALS

It is estimated that about 47% of total expenditures will be spent on advanced exploration and development projects, including bulk sampling, during 1995. A number of projects advanced to the development or bulk sampling stage. The locations of projects described in this section are shown on Figure 7 and listed, with reserves, in Table 3.

PORPHYRY (AND RELATED) DEPOSITS

At the **Mount Polley** copper-gold project, Imperial Metals Corporation (65%) and Sumitomo Corporation (35%) completed soil stripping on the mill site, road access route and tailings dam site, in anticipation of construction start-up in the spring of 1996. Results from 1995 metallurgical test work on fresh ore samples were positive, with improved gold recovery and better concentrate grades than achieved in 1988-1989 tests. A report on this recent metallurgical testing was prepared, together with a revised ore reserve estimate of 81 500 000 tonnes grading 0.30% Cu and 0.414 g/t Au with a stripping ratio of 1.12 to 1. The new estimate takes into account all drilling after the completion of the 1990 Wright Engineers' feasibility study, which calculated mineable reserves of approximately 49 million tonnes grading 0.38% Cu and 0.55 g/t Au. The company expected to make a final construction decision in the spring of 1996, on completion of financing arrangements. The overall geological resource is estimated at 230 million tonnes grading 0.26% Cu and 0.34 g/t Au. The capital cost of developing a 16 500 tonnes per day open-pit mine is estimated at $110 million. Annual production is projected at 15 000 tonnes of copper and 2180 kilograms (70 000 oz) of gold. Imperial, in receipt of a Mine Development Certificate issued in October, 1993, has been working on permitting for mine production, and has purchased mining and milling equipment from several sources, including the closed Brenda mine. The company also completed a modest program of widely spaced drill holes to test geochemical and geophysical anomalies peripheral to the main area of interest.

A detailed pre-feasibility study completed in 1995 on the Taseko Mines Ltd. **Fish Lake** porphyry copper-gold deposit was based on an open-pit "reserve" of 675 million tonnes grading 0.236% Cu and 0.435 g/t Au. The company has submitted an application for a Mine Development Certificate. The project, renamed Prosperity, is being reviewed under the Environmental Assessment Act. Taseko is planning to complete an angle drilling program in 1996, to confirm grade enhancements previously indicated.

On the **Kemess South** project, El Condor Resources Ltd. (60%) and St. Philips Resources Inc. (40%) are awaiting the granting of a Mine Development Certificate. Mineable reserves are estimated by the companies at 45.5 million tonnes grading 0.2% Cu and 0.75 g/t Au (supergene) and 155 million tonnes grading 0.23% Cu and 0.59 g/t Au (hypogene) for an overall reserve of 200.4 million tonnes grading 0.22% Cu and 0.63 g/t Au. Mill throughput is proposed at 40 000 tonnes per day, providing a mine life in excess of 15 years. In August 1995 Royal Oak Mines Inc. embarked on a program to acquire 100% ownership of the Kemess project, as part of an integrated package involving compensation and economic development for mining in British Columbia offered by the provincial government. The effective date for completion of the Plan of Arrangement between Royal Oak and El Condor, St. Philips and Geddes Resources Limited was January 11, 1996, to facilitate the ongoing review process. A 1993 pre-feasibility study on the Kemess South gold-copper deposit by Kilborn Engineering Pacific Ltd. estimated capital costs at $363 million, with annual metal production averaging 2600 tonnes of copper and 6625 kilograms (213 000 oz) of gold.

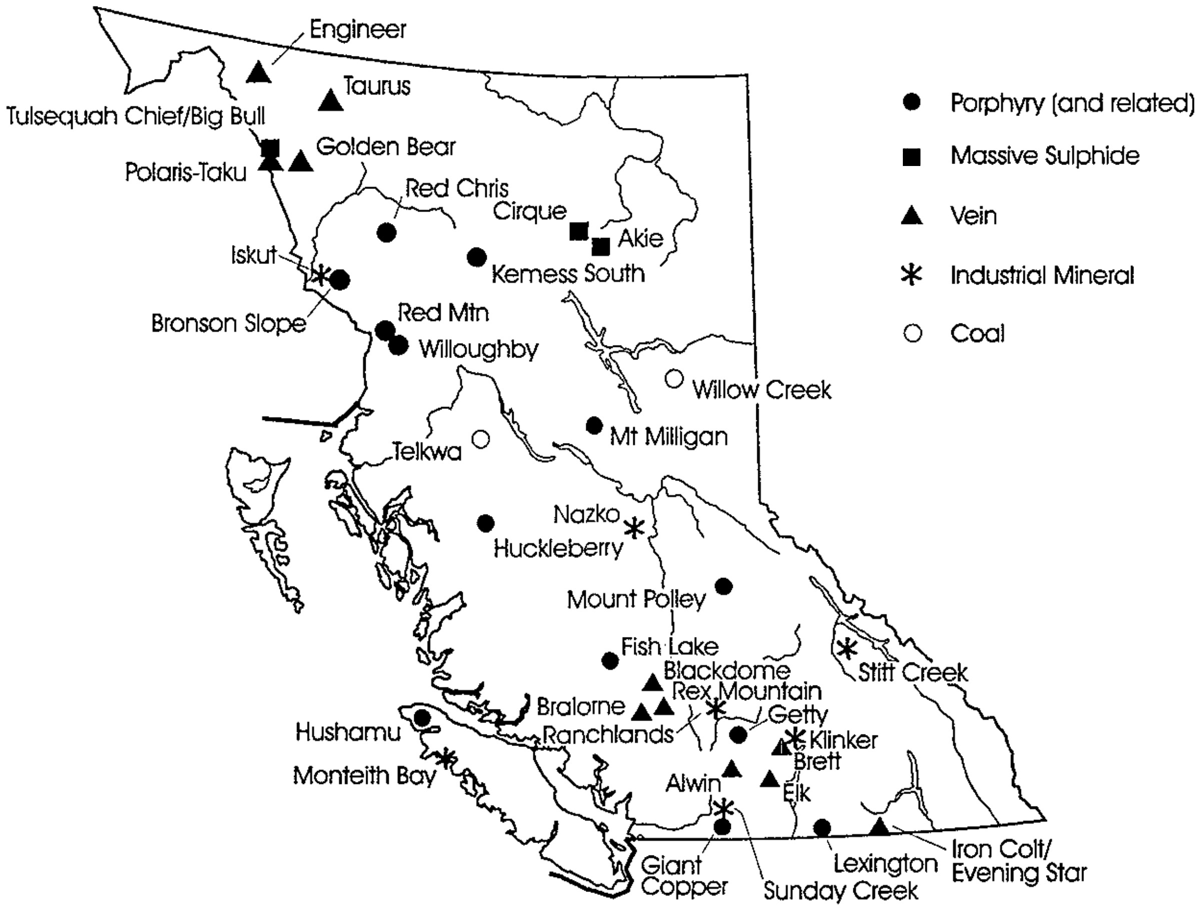


Figure 7. Advanced exploration and development projects in British Columbia - 1995.

Royal Oak extracted bulk samples from two pits (one in supergene, one in hypogene mineralization); metallurgical optimization testing is in progress. Initial results of bulk sample grades have correlated well with drill-hole and block-model grades. It has placed contracts with Kilborn, which has begun definitive engineering and procurement of equipment for the project. Royal Oak plans construction in the spring of 1996; start-up is planned for the middle of 1998.

Jordex Resources Ltd. continued evaluation of its **Hushamu** porphyry deposit located 25 kilometres west of the Island Copper mine.

On the **Huckleberry** porphyry copper-molybdenum project, Huckleberry Mines Ltd. (formerly New Canamin Resources Ltd.) received a project approval certificate for the development of the mine. Discussions with the Government of British Columbia are continuing with respect to an infrastructure loan. Current reserves are estimated at 93.9 million tonnes grading 0.50% Cu, with minor recoverable amounts of gold, silver and molybdenum. The deposit would be mined by two open pits, the Main zone and the East zone. Planned mill throughput is 15 500 tonnes per day for the East zone and 14 000 tonnes per day for the Main zone, producing a total of 27 300 tonnes of copper annually over the anticipated 17-year mine life. Project costs for development, including inventory and working capital, are estimated to be $137 million. In 1995 a consortium of Mitsubishi Materials Corporation, Dowa Mining Co. Ltd., Furukawa Co. Ltd. and Marubeni Corporation formed a strategic alliance, involving several detailed financial agreements, with Princeton Mining Corporation (which acquired the project by buying New Canamin Resources Ltd. on July 7, 1995) to develop the project. The partners anticipate an early production decision upon development approval, expected in the spring of 1996.

The Placer Dome Inc. **Mt. Milligan** porphyry copper-gold deposit contains resources estimated by the company at 298.4 million tonnes grading 0.22% Cu and 0.45 g/t Au. Capital costs were projected in the $500 to $600 million range in 1993. The company re-examined development options to lower capital costs.

During 1995 American Bullion Minerals Ltd. (80%) and Teck Corp. (20%) conducted the largest exploration program in the province on the **Red Chris** porphyry copper-gold property (112 holes totalling approximately 36 700 m of diamond drilling at an estimated cost of $6 million). Drilling has traced mineralization over a strike length in excess of 3 kilometres, adding approximately 400 metres

TABLE 3
NEW MINES. CLOSURES, DEVELOPMENT AND
ADVANCED EXPLORATION PROJECTS

Company Name	Project Name	Commodity	Estimated Tonnes (000s)	Estimated Grade	Reference
New Mines					
Prime Res. Group Inc.	Eskay Creek/ 21B Zone	Au, Ag	1019	64.46 g/t Au, 2859.4 g/t Ag, 5.43% Zn, 0.86% Cu	Homestake, 1995
Kinross Gold Corp.	QR	Au	1287	4.35 g/t Au	Kinross, MDC
Development					
Cominco Ltd./ Prime Res. Group Inc.	Snip/ Twin West Zone	Au, Ag	27.2	19.54 g/t Au	Prime, 1995
Westmin Res. Ltd.	Myra Falls	Cu, Pb, Zn, Ag, Au	11 150	1.6% Cu, 6.1% Zn, 27.5 g/t Ag, 1.5 g/t Au, 0.3% Pb	Westmin, 1995
Cusac Gold Mines Ltd.	Table Mtn./ Lily vein	Au	7700	20.6 g/t Au	Cusac, 1995
Advanced Exploration					
Porphyry (and related) Deposits					
Imperial Metals Corp.	Mount Polley	Cu, Au	81 500	0.3% Cu, 0.414 g/t Au	Imperial Metals, 1995
Taseko Mines Ltd.	Fish Lake	Cu, Au	675 000	0.236% Cu, 0.435 g/t Au	Taseko Mines, 1994
El Condor Res. Ltd./ St. Philips Res. Ltd./ Royal Oak Mines Inc.	Kemess South	Cu, Au	200 400	0.22% Cu, 0.63 g/t Au	El Condor, MDAP, 1992
Jordex Res. Ltd.	Hushamu (Expo)	Cu, Au, Mo	173 237	0.27% Cu, 0.34 g/t Au, 0.01% Mo	Jordex, 1992
Huckleberry Mines Ltd.	Huckleberry	Cu			
	Main Zone		30 900	0.48% Cu, 0.07 g/t Au, 2.17 g/t Ag, 0.013% Mo	New Canamin, MDAP, 1994
	East Zone		60 275	0.54% Cu, 0.06 g/t Au, 3.1 g/t Ag, 0.014% Mo	
Placer Dome Inc.	Mt. Milligan	Cu, Au	298 400	0.22% Cu, 0.45 g/t Au	Placer Dome, MDC, 1993

American Bullion Minerals Ltd.	Red Chris	Cu, Au	250 000	0.40% Cu, 0.30 g/t Au	Amer. Bull., 1995
Princeton Mining	Similco -	Cu, Au			Princeton, 1994
	Ingerbelle East		20 000	0.35% Cu	
	Alabama		20 000	0.31% Cu, 0.16 g/t Au	
Gibraltar Mines Ltd.	Gibraltar	Cu	9000	est. 0.3% Cu	Gibraltar, 1995
Royal Oak Mines Inc.	Red Mountain	Au, Ag	2540	12.8 g/t Au 38.1 g/t Ag	Lac Minerals MDAP, 1993
International Skyline Gold Corp.	Bronson Slope	Cu, Au, Ag	90 000	0.75 g/t Au, 0.16% Cu, 4.17 g/t Ag	International Skyline, 1995
Britannia Gold Corp./ Bren-Mar Res. Ltd.	Lexington	Cu, Au	162	8.9 g/t Au 0.96% Cu	Bren-Mar, 1995
Camnor Res Ltd./ Gold Giant Res./ Royal Oak Mines Inc.	Willoughby	Au, Ag			
Getty Copper Corp.	Getty North (Krain)	Cu			
	Getty South (Trojan)		> 50 000	0.5% Cu	
	Getty West (Transvaal)				
Getchell Res./	Galaxy	Cu, Au	3200	0.65% Cu,0.34 g/t Au	Getchell, 1995
Teck Corp.	Rainbow (No. 2 Zone)	Cu, Au	14 100	0.5% Cu	Getchell, 1995
Imperial Metals Corp.	Giant Copper (AM)	Cu, Au	20 700	0.75% Cu, 0.4 g/t Au, 12 g/t Ag	Imperial Metals, 1995
			3400	1.17% Cu, 0.5 g/t Au, 20 g/t Ag	

Massive Sulphide Deposits

Teck Corp./Cominco Ltd./ Samsung/Korea Zinc	Cirque	Pb, Zn, Ag	24 700	2.3% Pb, 8.5 % Zn, 50.8 g/t Ag	Curragh MDC, 1991
Redfern Res. Ltd.	Tulsequah Chief/ Big Bull	Cu, Pb, Zn, Au, Ag	7200	1.24% Cu, 1.18% Pb 6.32% Zn, 2.41 g/t Au, 99.33 g/t Ag	Redfern, MDAP, 1995
Ecstall Mining Corp./ Inmet Mining	Akie	Zn, Pb, Ag			

Vein Deposits

Bralorne-Pioneer Gold Mines Ltd./ Avino Mines and Res. Ltd.	Bralorne	Au,Ag			Bralorne-Pioneer, 1995
	Above 1000 level		432.5	10.6 g/t Au	
	Below 1000 level		673	8.2 g/t Au	
	51 vein		110.7	12.7 g/t Au	
	Loco veins		363	17.14 g/t Au	
Liquid Gold Res. Inc./ Huntington Res. Ltd.	Brett	Au			Huntington, 1993
	Bonanza Zone		12	39.12 g/t Au	
	R.W. vein			41.1 g/t Au	
Claimstaker Res. Ltd.	Alwin	Cu, Ag	390	2.5 % Cu	Claimstaker, 1995

Ampex Mining Ltd./ Winslow Gold Corp.	*Engineer*	*Au*	*27.5 to 45.3*	?	*Ampex, 1995*
Canarc Res. Corp.	Polaris-Taku	Au	3270	13.7 g/t Au	Canarc, 1996
Fairfield Minerals Ltd.	Elk (Siwash North)	Au	121	27.43 g/t Au,	Fairfield, 1995
Pacific Vangold Res. Inc./	Iron Colt	Au, Ag			
Int'l Silver Ridge Res. Inc.	Evening Star		90.7	10.3 g/t Au	Pacific Vangold, 1994
	Georgia		49	7.9 g/t Au	
Hera Res. Inc./ *International Taurus Res. Ltd./* Cyprus Canada Inc.	Taurus	Au, Ag	130 000	0.96 g/t Au	Hera, 1995
North American Metals Ltd./	Golden Bear	Au			
Wheaton River Min. Ltd.	Kodiak A		824	3.3 g/t Au	NAM, 1996
	Ursa		511	7.0 g/t Au	NAM, 1996
			153	23.39	NAM, 1995
Spokane Res. Ltd.	Rex Mountain	Au, Cu			
Claimstaker Res. Ltd.	Blackdome	Au, Ag	71	14.1 g/t Au	

Coal and Industrial Mineral Deposits

Mountain Minerals Co. Ltd.	Ranchlands	zeolite			
Canmark Int'l Res. Ltd.	Sunday Creek	zeolite			
Highland Talc Minerals Ltd.	Goldbridge	talc			
Anglo Swiss Ind. Inc.	Blu Starr	sapphire			
Okanagan Opal Inc.	Klinker	fire opal			
Quinto Mining Corp. Ltd.	Lumby	graphite, sericite			
Canada Pumice Corp.	Nazko	scoria			
New Global Res. Ltd.	*Monteith Bay*	*silica, pyrophyllite*			
Super Twins Res. Ltd.	Iskut	wollastonite	2000	80%	Super Twins, 1995
Manalta Coal Ltd.	Telkwa	coal	38 670	thermal	
Globaltex Industries Ltd.	Willow Creek	coal		thermal	

Note: MDC = Mine Development Certificate; MDAP = Mine Development Assessment Process.

of strike length to the Red Chris deposit, and identifying potential reserves in the Gully and Far West deposits (collectively referred to as the Yellow Chris zone) in the western part of the property. At the beginning of the year, Fluor Daniel Wright Ltd. calculated mining reserves, based on a cut-off grade of 0.3% Cu in an open pit 300 metres deep, at 157 million tonnes grading 0.48% Cu and 0.37 g/t Au. Two near-surface, higher grade stockwork copper-gold zones containing 100 million tonnes grading 0.58% Cu and 0.46 g/t Au are potential starter pits. Drilling in phase 1 of the 1995 program has increased the resource base estimated by American Bullion to in excess of 200 million tonnes. The company hoped to delinate an additional 80 million tonnes of ore in the Yellow Chris zone by phase 2 drilling in late 1995.

The phase 2 program included fill-in drilling in the western part of the Red Chris deposit to facilitate revision of mining reserve calculations for preliminary feasibility study purposes. On the Far West deposit, which occupies the northern part of the Yellow Chris zone, copper-gold mineralization has been intersected to a depth of 250 metres over a 300-metre length and a 200-metre width. This deposit has the highest gold-to-copper ratio so far encountered at the Red Chris project. Fill-in drilling was also carried out on the Gully deposit to the south, in order that this resource can be incorporated in preliminary feasibility study reserve calculations.

Geotechnical drilling was carried out in the fall for proposed tailings impoundment and open-pit design. American Bullion has retained Fluor Daniel Wright to complete a preliminary feasibility study on the Red Chris project by early 1996. American Bullion has filed an application for a project approval certificate, based on a resource of approximately 250 million tonnes grading 0.4% Cu and 0.3 g/t Au.

After evaluating bids on its **Red Mountain** gold-silver deposit near Stewart, Barrick Gold Corporation decided to keep it in its portfolio of properties. No further work was planned for 1995, a stark contrast to the previous owner's (Lac Minerals Ltd.) expenditures in excess of $15 million in 1994. Reserves previously reported by Lac in the Marc and AV zones were 2 539 000 tonnes grading 12.8 g/t Au and 38.1 g/t Ag at a cut-off grade of 3 g/t Au. In August 1995, Royal Oak Mines Inc. embarked on a program to acquire the Red Mountain gold project from Barrick Gold, as part of the same development initiative that led to its acquisition of the Kemess South project. Royal Oak's proposal involved a $3 million work commitment over three years, a 1% net smelter return royalty, payable to Barrick on the first 57 540 kilograms (1 850 000 oz) of gold recovered, and a $10 per ounce royalty on gold recovered in excess of that amount. Subject to completing a positive feasibility study, commercial production could start as soon as 1998. Capital costs of development of the orebody and construction of mining and processing facilities have been estimated at $100 million. Royal Oak completed the acquisition in January 1996 and created a B.C. Division, with headquarters and offices in northern British Columbia, to carry on exploration, development, construction and administration for the Kemess and Red Mountain properties

International Skyline Gold Corporation initiated several studies required for the preparation of a preliminary feasibility study on its **Bronson Slope** polymetallic porphyry property located adjacent to the Snip mine. In August 1995, the company estimated a drill-indicated and inferred inventory of 90 million tonnes grading 0.16% Cu, 0.75 g/t Au and 4.17 g/t Ag, plus the potential for recovery of molybdenum and iron from magnetite. A higher grade potential open-pit starter resource of 17 million tonnes grading 0.23% Cu, 0.72 g/t Au and 3.10 g/t Ag is indicated within this inventory. During 1995 Skyline completed a 610-metre drilling program in the spring and a 2400-metre program in the fall, both designed to confirm previous mineral inventory estimates. Skyline has also re-split and re-assayed over 1800 metres of drill core taken in 1988. New assays from the previously drilled core did not result in any material change in the overall grade or size of the deposit; however, higher grade gold in one hole has prompted the company to consider a reconnaissance drilling program to test the continuity of this possible vein target. The company has applied for a project approval certificate under the Environmental Assessment Act to develop a 12 000 tonne per day open-pit mine.

In the Greenwood camp, in southern British Columbia, Britannia Gold Corporation and Bren-Mar Resources Ltd. widened the Grenoble adit and commenced work on a 700-metre decline to the **Lexington** Main zone containing a drill-indicated reserve estimated at 162 000 tonnes grading 8.9 g/t Au and 0.96% Cu. The decline will provide access for a test mining program. Preliminary bulk metallurgical testing and a base-line environmental study are also planned. Mining of approximately 180 tonnes of material is proposed for testing purposes; a larger bulk sampling program may follow if results are positive. Material will be processed at the Roberts mill at Greenwood.

During 1995 Camnor Resources Ltd., under a joint venture agreement with Gold Giant Minerals Inc., drilled 27 core holes totalling 3013 metres on the **Willoughby** gold-silver project adjacent to the Royal Oak Mines' Red Mountain property. Gold Giant has entered into a subsidiary agreement with Royal Oak whereby Royal Oak has been granted the right to acquire up to a 35% interest in the property and the joint venture. The surface drilling program tested the North, Wilby, Willow, Kiwi, North/North and Icefall (Upper and Lower) zones. In order to better explore the North zone, Camnor completed 50 metres of a proposed 100-metre adit, before curtailing the planned excavation of underground drill stations due to a lack of water. This program is scheduled to restart in the spring.

In the northern part of the Highland Valley, southwest of Kamloops, Getty Copper Corporation conducted an induced polarization survey and drilling program (9150 m) on the **Getty North** (Krain) porphyry copper-molybdenum property. Drilling tested areas of known mineralization, favourable structural areas identified from a comprehensive remote sensing survey, and induced polarization anomalies. Results of the drilling and metallurgical studies will be used to re-evaluate the Krain oxide copper deposit for solvent extraction - electrowinning (leach) processing. The initial target is about 25 million tonnes grading 0.6% Cu (oxide). The degree of mixing of oxide and sulphide minerals will have a significant impact on copper recovery. Nearby sulphide copper deposits are also being examined for processing by conventional milling techniques. The drilling program is expected to continue through the winter; further metallurgical studies will be undertaken and a pre-feasibility study will be commissioned.

In the area between the Afton and Ajax deposits, Teck Corporation (70%) continued to drill-test the **Rainbow** porphyry copper-gold target, under a joint venture agreement with Getchell Resources Inc. (30%). The two-stage exploration and development program was focused on delineating an economic deposit in the previously drilled No. 2 zone (Rainbow zone). The higher grade core of this previously unrecognized, well zoned porphyry system has significant tonnage potential and is the initial priority target. Drilling results indicate mineralization is associated with a strongly altered zone of brecciation adjacent to a north-dipping intrusive dike. The dike is apparently wedge shaped, increasing from 30 metres wide near surface to greater than 100 metres at depth. Copper mineralization has been traced 650 metres along strike and to a vertical depth greater than 300 metres. Copper and gold grades generally increase with depth. The engineering department of Afton Operating Corporation completed a comprehensive review and analysis of substantial archival and recent, phase 1 drilling data on the Rainbow zone, identifying a potential pittable area and areas which require additional drilling information. Afton's engineering department continued to provide technical support during the phase 2 program. Teck and Getchell have completed approximately 6000 metres of drilling in 27 holes. A phase 3 program, comprising about ten diamond-drill holes, has been recommended to evaluate the new Rainbow No. 22 zone, southeast of the Rainbow No. 2 zone. Recent drilling and assessment of archival data has outlined a potential resource of 14.1 million tonnes grading 0.5% Cu to a depth of 300 metres.Teck continued negotiations with Getchell on the Galaxy property, 1.5 kilometres to the north of Teck's Ajax mine. Getchell reports that property hosts an estimated 3.2 million tonnes grading 0.65% Cu and 0.34 g/t Au. In early 1996 Teck completed a 32-hole diamond drilling program on the Galaxy. The results are being evaluated by Afton Operating Corporation.

In 1995 Imperial Metals Corporation conducted a surface diamond-drilling program on the **Giant Copper** deposit east of Hope. It focused on the expansion of the near-surface mineral resource in the AM Breccia zone. Previous drilling and underground development have outlined an open pittable reserve estimated at 20.7 million tonnes grading 0.75% Cu, 0.4 g/t Au and 12 g/t Ag. A small underground reserve of 3.4 million tonnes grading 1.17% Cu, 0.5 g/t Au and 20 g/t Ag is also estimated. The geological reserve estimated by Wright Engineers in a 1966 feasibility study is 57.8 million tonnes grading 0.55% Cu, 0.28 g/t Au and 6.9 g/t Ag. The 1995 program was designed to increase confidence in the resource calculations for the AM zone. There is significant exploration potential on the property outside the AM Breccia zone (*e.g.* No. 1 Breccia zone and Invermay deposit); however, no work was done on these zones in 1995. In September the provincial government announced the creation of the Skagit Valley Class A Provincial Park. The Giant Copper property straddles the northern boundary of the Skagit Valley area; future access to the site is guaranteed under the Park Act.

MASSIVE SULPHIDE DEPOSITS

During 1995 Redfern Resources Ltd. conducted on-going environmental and socio-economic studies associated with its application for a Mine Development Certificate for its **Tulsequah Chief** volcanogenic massive sulphide deposit. In July, Redfern reported positive results from a $1.5 million feasibility study conducted by Rescan Engineering Ltd. with contributions by a team of independent consulting engineers. The study is based on an initial mineable reserve of 7 200 000 tonnes grading 1.24% Cu, 1.18% Pb, 6.32% Zn, 2.41 g/t Au and 99.33 g/t Ag, which is part of the overall geological reserve of 8 900 000 tonnes. At a production rate ranging from 800 000 to 900 000 tonnes per year, the mine life is estimated to be about 8.3 years. Total capital investment includes preproduction capital of $125 million and ongoing capital costs of $35 million, mainly in the first three years. During full production, annual metal shipments will average 1770 kilograms (57 000 oz) of gold, 71 500 kilograms (2 300 000 oz) of silver, 10 000 tonnes of copper and 51 300 tonnes of zinc. Economic analysis is based on the year-round utilization of a 160-kilometre access road to be built from the minesite northwards to the existing road at Atlin, British Columbia. An alternative access option contemplates the seasonal use of barges on the Taku River, from its confluence with the Tulsequah River to its outlet at the ocean near Juneau, Alaska. Revisions to the feasibility study are anticipated, but Redfern hopes to file a project report under the B.C. Environmental Assessment Act early in 1996.

In the **Gataga** district, southeast of the Cirque zinc-lead-silver deposit, Inmet Mining Corporation (formerly Metall Mining) continued to explore the depth potential of the **Akie** zinc-lead-silver deposit it holds under an option agreement with Ecstall Mining Corporation. During 1994 Inmet traced the mineralized zone by drilling along a strike length of 1400 metres and to depths of 300 metres. This year the company drilled seven holes totalling approximately 4900 metres to depths in excess of 1000 metres, testing the down-dip extent of deposit. Ecstall currently estimates the dimensions of the deposit to be 1400 metres long by 800 metres deep by 20 metres thick. Considerable other surface exploration work was completed elsewhere on the property and several large lead-zinc soil anomalies were discovered on strike.

VEIN DEPOSITS

Bralorne-Pioneer Gold Mines Ltd., in a joint venture with International Avino Mines Ltd., plans to re-open the historic **Bralorne** mine encompassing the combined Bralorne, Pioneer and Loco properties, following issuance of a Mine Development Certificate in March 1995. Development and exploration work, together with final permitting application, are in progress. Initial underground mining will be from the formerly producing Bralorne 51-vein area where detailed exploration programs, in recent years, have outlined proven, probable and possible reserves of 570 000 tonnes grading 8.22 g/t Au. Proven and probable reserves above the 800 level and readily available for extraction total 432 500 tonnes grading 10.63 g/t Au. There are also reserves of 673 000 tonnes grading 8.23 g/t Au, proven and possible, between the 1000 and 2600 levels, accessible by dewatering the shaft. The nearby Countless vein on the Loco property has 110 000 tonnes probable and possible reserves grading 17.1 g/t Au. Mining and milling operations are forecast to start at about 225 tonnes per day, increasing to 400 tonnes per day at a later date. The initial capital cost is estimated between $5 and $7 million, based on a 225 tonne per day operation with annual output of 855 kilograms (27 500 oz) of gold at an average cash cost of US$250 per ounce. Over $2 million for underground vein development is included in this cost estimate. Milling machinery is being assembled at the property and the mill building has been rehabilitated.

During late 1994 and early 1995, an underground drilling program from the 400 level of the Bralorne mine intersected extensions of the Bralorne and Pioneer veins in the 610-metre gap between the two veins which has never been explored. Two of three veins intersected returned encouraging assays over mineable widths. A 13-hole drilling program in 1995 on the Peter, Millchuck and Big Solly veins on the Loco property also returned encouraging results. Bralorne-Pioneer has started to develop the Peter vein underground on the 800 level, 305 metres below the surface. Trenching on the northeast side of the Bralorne property uncovered a new gold-bearing zone, the Maddy zone, over an 850-metre length; follow-up drilling is in progress.

Huntington Resources Ltd. concentrated its 1995 work on surface mining in the high-grade R.W. gold vein on its **Brett** property. Closely spaced sampling of the vein returned an average grade of 34.35 g/t Au over a strike length of 51.3 metres and across a true width of 0.44 metre. Drilling in previous programs has tested the vein over a vertical range of at least 25 metres. Mining began in August and by the end of the year an estimated 225 tonnes of ore grading 34.18 g/t Au and 63.43 g/t Ag had been stockpiled. Surface mining is scheduled to recommence in the spring, concurrent with underground development on the Bonanza zone. Huntington is negotiating to custom mill ore off site.

Claimstaker Resources Ltd. signed an agreement with Afton Operating Corporation whereby it will ship high-grade copper ore from its **Alwin** mine in the Highland Valley to be custom milled by Afton. The company hopes to submit a mining plan and application to re-open the mine and commence underground mining at a proposed rate of 100 tonnes per day. Reserves estimated by the previous owners total 390 000 tonnes grading 2.50% Cu. In January 1995 the underground workings were re-opened to help prepare the No. 4 - North orebody for future production. During 1995, Claimstaker shipped a few thousand tonnes of oversize high-grade copper boulders to Afton.

At the **Engineer** gold mine, Ampex Mining Ltd., under an agreement with Winslow Gold Corporation, mined and milled approximately 345 tonnes of vein material from stopes on the Engineer and Double Decker veins during a bulk sampling program. Ampex installed tracks and mobilized equipment to improve mining efficiency. A further program of exploration, limited milling of material from near-surface veins and preparation for dewatering the lower levels on the Engineer vein is planned. The company hopes to bring the 27 500 to 45 300 tonnes of indicated reserves into the proven reserves category.

The Canarc Resource Corporation exploration program on the **Polaris-Taku** gold project in the Tulsequah area involved deep (up to over 730 m) drilling to test the potential of the C-vein and drilling on the North zone. Two new vein intersections were cut by the deep drilling. They are tentatively interpreted to be an extension of the C-vein system, 610 metres south and 90 metres below the deepest existing Y-vein reserves. Drill-indicated geological reserves, estimated by Montgomery Consultants Ltd. in early 1996, total 3.27 million tonnes grading 13.7 g/t, a 25% increase from previously calculated reserves. Drilling was also conducted on the North zone where the target is one or more gold-bearing quartz-carbonate vein systems within a favourable alteration zone up to 30 metres thick. A total of 27 drill holes have delineated the North zone over a strike length of 670 metres, with an additional 240 metres of strike length indicated by soil geochemical anomalies. The average width of the zone is about 7 metres grading 5.14 g/t Au. The 1995 program has shown that it has a gentle dip with similar gold grades throughout. Bulk underground mining and bioleaching are being investigated for this low-grade ore. The North zone resource is estimated at 204 000 tonnes grading 6.51 g/t Au. Fluor Daniel Wright Ltd. has been retained to carry out engineering, metallurgical, environmental and financial studies to assess the potential for a moderate tonnage, underground gold mining operation.

In 1995 Fairfield Minerals Ltd. sold 118.4 kilograms (3807 oz) of gold and 185 kilograms (5950 oz) of silver recovered from 1840 tonnes of ore from its bulk sampling program on the Siwash North vein on the **Elk** property and treated at the Asarco smelter at Helena, Montana. Reserves estimated by the company at January 1, 1996 were 122 800 tonnes grading 25.4 g/t Au and 35.3 g/t Ag. During 1995 Fairfield completed an in-fill program including 7620 metres (217 holes) of underground drilling and 6400 metres (98 holes) of surface drilling on a 10-by-10-metre grid. This work tested about 25% of the widely drilled (50-by-50 m) Siwash vein system along a strike length of about 335 metres, a width of 150 metres and a vertical depth of 130 metres. Many of the higher values intersected in the drilling are within four distinct shoots, two of which are within 60 metres of surface and may be amenable to open-pit mining. Five deep surface holes explored an area below the underground development; all five intersected the vein structure with gold values to a depth of 260 metres. Open-pit and a limited amount of underground mining between 1992 and 1994 netted Fairfield about 1586 kilograms (51 000 oz) of gold from ore averaging 97.7 g/t Au over 0.4 metre. Over the next several months, feasibility studies will determine the economics of an open-pit and/or underground operation. Fairfield estimates that it has approximately 2085 tonnes of ore stockpiled and estimated to contain 261 270 grams of gold. Reconnaissance drilling on five separate vein structures located 0.8 to 3.2 kilometres south of the mine obtained several high-grade but narrow intersections.

In the Rossland camp, International Silver Ridge Resources Inc. and Pacific Vangold Mines Ltd. have been conducting underground development work and mining on the Iron Colt and Evening Star properties. During January and June 1995, the companies shipped approximately 1414 tonnes of gold-bearing ore from the **Iron Colt** to the Kettle River mill at Republic, Washington for custom milling; 19.7 kilograms of gold were recovered. They plan to continue underground drilling throughout the winter. On the **Evening Star**, the operators have received a bulk sampling permit to extract 10 000 tonnes. They expect to produce approximately 70 tonnes of gold ore per day, at an average grade of approximately 17.1 g/t Au from drill-indicated reserves of 90 700 tonnes grading 10.29 g/t Au. Development work, including drifting on the vein, was carried out. Metallurgical testing has been completed and ore will be shipped to the Kettle River mill. During the summer 6585 tonnes of ore were processed at the Kettle mill yielding 250 kilograms of gold. Elsewhere in the Rossland district, Pacific Vangold and International Silver Ridge plan work on the **Gertrude** claim (surface drilling and drifting from existing workings to intersect the vein), where proven reserves are estimated at 49 000 tonnes grading 7.9 g/t Au, and on the Buckeye vein, exposed in old underground workings. Also, a four-hole drilling program targeted an untested section of the **Blue Bird/Mayflower** lead-zinc-silver-zone. LRX Capital Corporation is exploring the Baker vein system underground at the **Midnight** gold mine. An underground drilling program tested the extension of this system on strike to the west, and up dip. Drilling intersected mineralization which has been opened by drifting and raising. Bulk sampling is planned.

At the **Taurus** project in the Cassiar camp, Cyprus Canada Inc., under a joint venture agreement with International Taurus Resources Inc. and Cusac Gold Mines Ltd., completed a major drilling program (12 670 m in 78 drill holes) costing some $2.8 million and designed to delineate a large tonnage, low-grade, bulk-mineable (potentially heap-leachable) gold deposit in the vicinity of the Taurus, Sable and Plaza underground workings. International Taurus had completed an induced polarization survey on part of the property west of the mine workings in 1994. Two large anomalies were outlined; they were unlike those associated with the vein zones and their significance was not fully realized until diamond-drill hole 94-56 encountered altered pyritic volcanic rocks assaying 1.43 g/t Au across 45 metres. An additional 30 holes were drilled and numerous intersections, some with significant gold mineralization near the surface, were identified. The gold is contained in three zones (88 Hill, Taurus West and BM) of pyritic quartz veins and carbonate-altered, fine-grained pyritic volcanic rocks approximately 330 metres apart and extending westward onto the property of Cusac Gold Mines.

The discovery of low-grade gold mineralization attracted the attention of several major mining companies, and in April 1995 a joint venture agreement was made with Cyprus Canada Inc. Cyprus completed a winter drilling program (14 holes) to explore the outlying areas. At the same time, an induced polarization survey was completed over a 5 square kilometre area. Many of the initial 14 drill holes were near, but not in areas with high induced polarization anomalies. The Cyprus summer program started in May with additional induced polarization surveys and diamond drilling. Limited reverse-circulation drilling was conducted, mainly as a check of grades. The results indicate that the mineralization, which is concentrated between a hangingwall basalt and a footwall argillite, is present over a large area, 1.5 kilometres in an east-west direction and 800 metres wide. The mineralized zone, which ranges in thickness from 70 to 150 metres, strikes approximately 070° and dips 20° to the southeast. The quartz vein structures within it (which carry higher grades) trend northerly and are steeply dipping. The 'stratabound' zone includes a higher grade portion (2 to 3 g/t Au) within an average grade of 1 g/t Au, based on a cut-off grade of approximately 0.75 g/t Au. Based on results to date, a consultant to International Taurus estimates the size of the gold deposit to be at least 130 million tonnes grading 0.95 g/t Au. During late 1995 Cyprus completed metallurgical testing of different ore types. Follow-up drilling on induced polarization targets and closer spaced drilling to test and define a starter pit are planned for early 1996.

At the Golden Bear mine site, Wheaton River Minerals Limited and North American Metals Corporation carried out detailed surface diamond drilling on the Ursa zone, underground drilling on the Grizzly zone and comprehensive surface exploration on the Kodiak-Ursa area. Since the mine ceased production of refractory gold ore from the Bear Main zone in September 1994, the focus of exploration has been on the potential for heap leaching of lower grade, non-refractory material. The discovery of the Ursa zone in late 1994 confirmed the significant potential for carbonate-hosted gold (*i.e.* Carlin-type) deposits. The Ursa deposit is located 900 metres north of the Kodiak A zone, where the first two benches were mined in late 1994 and the ore stockpiled for future heap leaching.

During 1995 detailed surface drilling on the Ursa zone outlined mineable open-pit reserves of 511 000 tonnes grading 7.0 g/t Au, with a strip ratio of 6.6:1. Gold mineralization is associated with hypogene hematite and supergene limonite in the steeply dipping Ursa fault in a brecciated, thinly bedded graphitic limestone. Visible gold occurs in rare bonanza-grade intervals (*e.g.*, 100 g/t Au). In addition, a reserve estimate completed by Strathcona Mineral Services Limited for Wheaton River Minerals and North American Minerals outlined mineable open pit reserves in the Kodiak a deposit of 824 000 tonnes grading 3.3 g/t Au with a stripping ratio of 1:1. Extensive metallurgical testing of the ore has indicated a gold recovery of 87% by heap leaching methods.

Geochemical, geophysical and geological surveys, trenching and limited diamond drilling over an area approximately 200 to 300 metres west and north-northwest of the Kodiak A zone have identified several new gold-bearing zones (*e.g.*, Ridge zone). In March 1996 a feasibility study completed by Kappes, Cassidy and Associates of Reno, Nevada estimates that the mine will yield 5475 kilograms (176 000 oz) of gold over a 5-year period at a total cost of production of US $258 per ounce of gold. Capital costs are estimated at $8.3 million. It is anticipated that mining and leaching, beginning later in 1996 will be conducted during the summer and fall months only. The production start up will proceed in conjunction with a major exploration program in 1996. Priorities will include placing the Kodiak B and East Low Grade Stockpile resources into the long term mining plan and an extensive drilling program in the area of the Kodiak - Ursa deposits.

A 1-kilometre decline was driven on the Grizzly zone, during the fall of 1994 and the spring of 1995 approximately 300 metres below the mined out Bear Main zone. The deposit contains 152 945 tonnes grading 23.39 g/t Au based on a 12 g/t cut-off. Refractory gold ore, associated with heavily disseminated fine pyrite, occurs in a strongly silicified fault breccia, on the footwall side of a limestone lens 70 metres wide within the braided Ophir fault zone. Drilling was suspended in the summer due to high underground water pressure, potentially difficult mining conditions and lower than expected grades and widths of mineralization. The decline was allowed to flood; the zone is open to the north.

Spokane Resources Ltd. completed a 5800-metre drilling program, designed to extend the zone of gold-copper mineralization on its **Rex Mountain** property, 40 kilometres northwest of Lillooet, both laterally and at depth. The zone has been defined over a strike length of 700 metres, a width of approximately 6.5 metres and to a depth of 100 metres. Results confirm that the mesothermal gold-bearing vein system contains at least three quartz veins in a steeply dipping shear zone. The most significant gold-copper intersections occur within the quartz vein close to the contact with altered serpentinite (listwanite). Drilling is continuing to extend the system to the west and also at depth. Spokane Resources also plans to evaluate the nearby Shulap property which it recently acquired.

At the **Blackdome** gold mine, Claimstaker Resources Ltd. and joint venture partner Aurizon Mines Ltd. conducted a program of drilling and underground drifting in search of new reserves on veins identified by previous drilling and trenching. If successful, the operators believe the existing 200 tonne per day mill could be placed back in production very quickly. The main objective of the underground drilling program from the rehabilitated 1870 level is to test two areas on the No. 18, No. 19 and No. 11 veins, where a 1994 surface drilling program intersected high-grade gold mineralization. Prior to 1994, an independent study indicated a possible 70 800 tonnes grading 14.1 g/t Au; the 1994 and 1995 programs are expected to increase this tonnage.

Soil sampling and follow-up trenching on the southeast part of the vein system located several anomalies, and mineralized quartz float along fault structures. A bulk sample of approximately 2000 tonnes was taken from a trench 3 metres wide on the surface exposure of an ore shoot on the No. 11 vein. This ore has been stockpiled at the mill for future treatment. Aurizon has since terminated its agreement with Claimstaker.

INDUSTRIAL MINERALS

Exploration and market interest in industrial minerals continues to increase. In 1995 exploration expenditures are estimated over $4.5 million.

Zeolite beds have been identified in several areas throughout the interior of British Columbia. Mountain Minerals Company Ltd. mined 1000-tonne bulk samples from each of its **Ranchlands** Z-1 and Z-2 deposits near Cache Creek and will ship them to Alberta for test marketing for agricultural applications. The company has indicated its intention to begin limited production from the Cache Creek (Z-1) and McAbee (Z-2) pits at a proposed mining rate of 8000 to 9000 tonnes per year for each. The material would be shipped to Alberta for processing. Canmark International Resources Inc. is stripping overburden on its **Sunday Creek** zeolite property near Princeton, preparatory to mining a 10 000-tonne bulk sample for market development in the Lower Mainland. The zeolite is a high-quality clinoptilolite variety. Canmark has signed a contract with Sun-Ray Resources Ltd. to supply 2000 tonnes of zeolite with an option for an additional 3000 tonnes within a year.

Gemstones are attracting more interest in British Columbia as new discoveries are made. Anglo Swiss Industries Inc. has acquired the **Blu Starr sapphire** property in the Slocan Valley, where previous owners have extracted a large number of gem-quality star sapphires from a corundum showing in the Valhalla Complex. Many of these sapphires have been mounted in jewellery pieces which have been sold through retailers in Nelson. Anglo Swiss proposes to carry out detailed mapping and bulk sampling of its extensive land holdings. It will utilize its crushing, milling and laboratory facility located at its Kenville mine property, 30 kilometres by road from the Blu Star deposit.

Gem-quality **acquamarine** has been found in pegmatite dikes in the nearby **Airey Creek** area. High-quality black and smoky grey quartz crystals are also common. At the **Klinker fire opal** locality near Vernon, Okanagan Opal Inc. conducted test pitting and some rockhound sales transpired.

Canada Pumice Corporation continued to develop a market for **scoria** from the **Nazko** cinder cone located west of Quesnel. Bulk sampling (2900 t) was conducted

Continental Lime Ltd. filed for four limestone exploration projects - Vancouver Island, Crowsnest Pass, Giscome and Chetwynd.

Panorama Natural Stone Ltd. plans to quarry the **"Haddington Island" andesite** near Port McNeil. Quadra Stone Co. Ltd. has been sampling its **Beaverdell granite** property. Ava Resources Ltd. initiated road upgrading to access the **Babbette Lake/Wishaw** quartzite property preparatory to test quarrying and sampling, but the program was subsequently postponed until 1996. McBride **(Dome Creek)** Structural Slate Ltd. began clearing a test quarry site with potential to produce good roofing slate and other flagstone.

Modest exploration programs for **barite** were carried out on the **Dave-Wall** manto property north of Sirdar by Hunter Resources Ltd. and at **Jumbo Creek** next to the Mineral King lead-zinc property by Birch Mountain Minerals Ltd. The company lost the **Muncho Lake** white barite claims in a dispute over title.

Quinto Mining Corporation Ltd. continues to produce samples for marketing the product from its **Lumby** (Chaput) **graphite** and **sericite** deposit, 37 kilometres east of Vernon. Quinto proposes to renovate and upgrade its existing on-site mill. It is currently processing last year's 10 000-tonne bulk sample using an off-site mill. Industrial Mineral Park Mining Corporation mined a 3000 to 4000-tonne bulk sample from its **Black Crystal graphite** property near Slocan. It was shipped to a nearby site, where a flotation mill for the recovery of crystalline graphite will soon be built; start-up is forecast for late 1996.

Micro Minerals Resources Inc. sampled the **Millie Mack graphite** property south of Naskup. A graphitic shear zone containing an estimated 2 million tonnes of open-pittable graphitic sericite and sericite has been identified. Samples have been sent to research centres in the United States for testing. The company is focusing on developing a low-cost high-volume concrete additive to increase strength and resistance to severe temperature fluctuations.

Consolidated Ramrod Corporation Ltd., in a joint venture with Anvil Resouces Ltd., had planned a bulk sampling program for **diamonds** on their large **Ice** property which includes the Crossing Creek kimberlite near Elkford. Unfortunately, the program was postponed until 1996. Grassroots exploration was also carried out elsewhere in the Rocky Mountains and the Horsethief - Toby Creek area.

The New Global Resources Ltd. **Monteith Bay (geyserite) pyrophyllite-silica** project received a Mine Development Certificate in 1995; however, the company has not yet started commercial operation.

Highland Talc Ltd. continued to work on the northern extension of the Talc Group claims north of Boston Bar. Work on the prospect includes laboratory research and development, pilot-scale testing and a feasibility study.

Pacific Bentonite Ltd. has applied to the government for two bulk sample permits for its **red shale** and **bentonite** property in the Hat Creek coalfield. It proposes to mine 10 000 tonnes of bentonite and 10 000 tonnes of red shale for sale as landscape rock. Proceeds from the sale of the shale will be reinvested in on-going research and development on a bentonite-based geosynthetic liner that the company is developing.

Cassiar Coal Company Ltd. conducted a 25-hole drilling program totalling approximately 370 metres, to further test its **Stitt Creek** placer **garnet** deposit in the Goldstream mine area, north of Revelstoke. Preliminary results are encouraging.

Super Twins Resources Ltd. discovered and explored four **wollastonite** deposits and a possible fifth (**Iskut** property) on Zippa Mountain, 15 kilometres west of the Snip mine. Early results from sampling at the Cliff zone confirm the high purity of the deposit and its open-pit potential. The wollastonite is hosted by xenoliths and large screens in pyroxenite. The company is currently completing a deposit evaluation which will allow for a full feasibility study.

Due to delays in permitting and the lateness in the season, Great Pacific Pumice Inc. postponed its production of **pumice** from the **Pum** property near Mount Meager until June 1996. The property has possible reserves of 5 to 20 million tonnes. A 20-year mine and reclamation plan has been approved and a Mine Development Certificate granted in the spring of 1995.

Global Metals Ltd. drilled 29 shallow holes on its **Green jade** property on the north side of O'Ne-el Creek in north-central British Columbia. The company estimates that 2.8 million kilograms of nephrite jade and tremolite exist within the area tested.

COAL

Advanced exploration expenditures outside existing coal mine leases are estimated at $1.5 million in 1995. The increase in metallurgical and thermal coal prices has stimulated a number of companies to explore for additional coal reserves.

At the **Telkwa** thermal coal project, Manalta Coal Limited conducted an extensive exploration program south of the Telkwa River, designed to better define reserves in the Tenas Creek area, to better delineate the reserve potential of the license block as a whole and to explore the Cabinet Creek area. A total of 83 holes were drilled at a cost of around $1 million. Preliminary indications are that the Tenas Creek and Cabinet Creek areas are complicated by normal faulting; additional drilling will be required to fully evaluate these areas. Coal quality is very good, with high heat value, low sulphur content and locally clean enough not to require washing. The company continues to evaluate production feasibility. Geological reserves in the main deposit are estimated to be 38.7 million tonnes contained within four pit areas.

There was no exploration activity at the Globaltex Industries Inc. **Willow Creek** coal property. In February 1996 the company executed a joint venture agreement with Mitsui Matsushima Canada and BCR Ventures to develop the mine. A feasibility study will be undertaken before a production decision will be made. Preliminary estimates indicate that production levels would start at 600 000 tonnes per year, with a potential to increase later to 1 to 1.2 million tonnes annually. A new company, Pine Valley Coal, has been set up as the operator. The mine would produce metallurgical and low-volatile thermal coal for the export market.

In southeast British Columbia, McGillivray Mining Ltd. undertook exploration and test mining on its **Loop Ridge** metallurgical coal property in the Crowsnest Pass. A 10 000-tonne bulk sample was mined and trucked to the Elkview plant for washing. It is hoped that a minimum of 400 000 tonnes can be mined from the property over a period of two to five years, and sold raw to the Elkview mine.

HIGHLIGHTS OF GRASSROOTS METAL EXPLORATION

Gold-enriched porphyry copper and porphyry-related gold deposits, polymetallic massive sulphide deposits (volcanogenic, seafloor hydrothermal and sedex), and vein deposits (epithermal and mesothermal) accounted for approximately 82% of 1995 exploration expenditures in British Columbia. The remainder were directed to coal, industrial minerals, skarns and less traditional targets such as sedimentary copper and ultramafic-associated nickel. Of the total estimated $83.5 million exploration expenditures, approximately 40% fits into the less advanced to grassroots category addressed in this section. Although most of the programs were focused in and around areas with mines or known showings and existing infrastructure, several new, relatively low budget, regional programs were conducted throughout the province. The diversity of targets, their large size (some world class such as Highland Valley Copper and Sullivan), and the profitability of smaller, higher grade deposits such as Eskay Creek and Snip, continue to make British Columbia a good place to explore. The properties reported on are shown on Figure 8 and listed in Table 4, with estimated reserves, where available.

PORPHYRY AND PORPHYRY-RELATED DEPOSITS

The **Babine Camp** was very active in 1995. Hera Resources Inc. conducted a 43-hole diamond drilling program, totalling 9450 metres on the **Nak** porphyry copper-gold-molybdenum prospect, 30 kilometres northeast of the Bell mine, at an estimated cost of about $1.5 million. Much of the property was also covered by induced polarization surveys, resulting in the identification of several anomalous zones yet to be drill tested. At the **Hearne Hill** deposit, located close to the Bell mine, Booker Gold Explorations Ltd. continued to diamond drill high chargeability and low resistivity targets. The drilling encountered previously unknown mineralization in an area to the northeast of the mineralized zone explored by Texas Gulf Sulphur Company in the 1960s and by Booker Gold over the past few years. Copper and gold values are very encouraging. Drilling on this new zone continued throughout the winter. Elsewhere, Pacific Sentinel Gold Corp. and Northern Dynasty Minerals Ltd. have agreed to jointly explore the **Babs** property. A 2-hole diamond drilling program was completed in late 1995; drilling will resume in the spring of 1996. Also, Hera Resources Inc. optioned the **Trail Peak** prospect and plans work in 1996. Teck Corporation conducted a regional airborne geophysical survey over the Babine area in the fall.

On the **Lorraine** copper-gold-silver deposit, Lysander Gold Corporation, under an agreement subject to a back-in right held by Kennecott Canada Inc., conducted a 26-hole, 3850-metre drilling program focused on the Upper Main zone where previous operators had outlined a preliminary resource of 4.5 million tonnes grading 0.75% Cu and 0.34 g/t Au. Drilling indicates that mineralization occurs in steep irregular masses, rather than in a shallow west-dipping slab. Lysander envisages a small-tonnage, high-grade operation. The 1995 program also included the collection of seven bulk samples from the mineralized talus apron in the valley. The company believes that the talus may represent the eroded upper part of the Upper Main zone. Preliminary metallurgical testing has been initiated.

Spokane Resources Ltd., under an option agreement with Rio Algom Limited, completed a large program of geochemical, geophysical (induced polarization and magnetic) surveys and geological mapping during 1995 on the **Mac** porphyry molybdenum-copper deposit, 100 kilome-

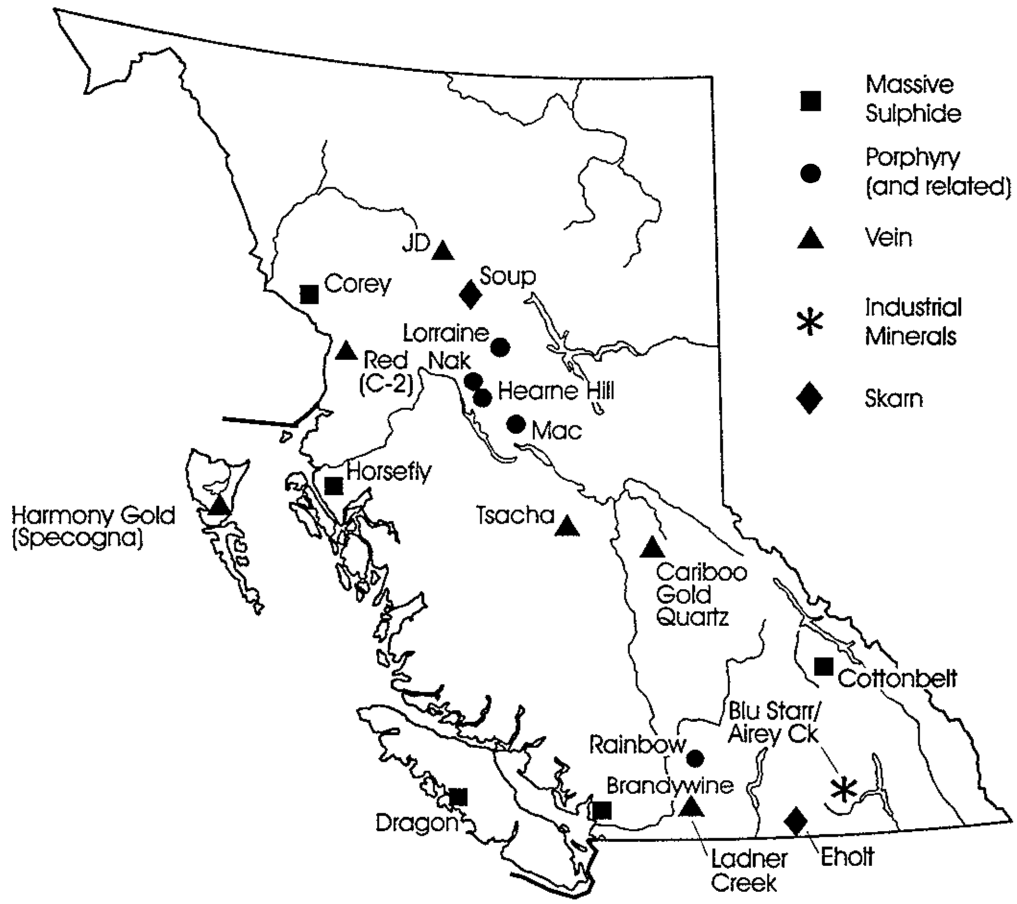


Figure 8. Major exploration projects in British Columbia - 1995.

tres east of Smithers. It confirmed the presence of a large mineralized porphyry system in excess of 3.5 kilometres long and up to 2 kilometres wide. Late in the fall, Spokane completed an eleven-hole drilling program totalling approximately 2000 metres, designed to extend and further test the mineralized zones discovered by previous diamond drilling on the Discovery or Camp zone, and within the Northern or Pond zone, and to test the Southern or Peak zone. During the winter of 1996 Spokane conducted further drilling in the Camp zone which outlined an area of significant molybdenum-copper mineralization approximately 700 metres in length, 300 metres in wide and tested to a depth of 150 metres. Additional drilling is planned.

PRECIOUS METAL BEARING VEINS AND BULK-MINEABLE DEPOSITS

Exploration targets in this category cover a broad spectrum of hydrothermal, epigenetic mineral deposits. They include high-level epithermal and deeper level mesothermal deposits.

In the northern Toodoggone district, AGC Americas Gold Corporation drilled in excess of 100 diamond-drill holes, totalling more than 8800 metres, most on the Finn zone on its **JD** polymetallic gold-silver property. Estimated expenditures totalled approximately $1.6 million. The Finn zone was partially delineated by closely spaced shallow drill holes; an open-pit resource will be calculated by the company over the winter months.

In the Blackwater River area in the Interior Plateau region of central British Columbia, Teck Corporation completed approximately 5200 metres of diamond drilling in a two-phase 35-hole program on its **Tsacha** epithermal gold-silver vein target. The main mineralized quartz-carbonate vein (Tommy) strikes north and is vertical; it has been traced along strike for approximately 650 metres, over widths ranging up to 8 metres, and down dip to approximately 150 metres. Hostrocks are Jurassic Hazelton Group welded rhyolitic tuffs. Several other quartz veins and stockwork zones are known to occur parallel to the Tommy vein. To the east, on ground now held by Phelps Dodge Corporation of Canada Ltd., a quartz vein up to several metres wide has been reported. To the south of the Blackwater River, Phelps Dodge has been exploring its extensive land holdings covering epithermal gold targets, including the **Clisbako** and **Baez** properties.

On the **Harmony Gold** project on Graham Island, Queen Charlotte Islands, which includes the Specogna (ex-Cinola) gold deposit, Romulus Resources Ltd. undertook a widespread multiparameter airborne geophysical survey and regional geochemical surveys under an arrangement

TABLE 4
1995 EXPLORATION HIGHLIGHTS

Company Name	Project Name	Commodity	Estimated Tonnes (000s)	Estimated Grade	Reference
Massive Sulphide Deposits					
Doromin Res. Ltd./ Westmin Res. Ltd.	Dragon	Cu, Pb, Zn, Ag, Au			
La Rock Mining Corp.	Brandywine/ Dave's Pond	Cu, Zn, Au			
Ecstall Mining Corp./ Atna Res. Ltd.	Horsefly Ecstall	Cu, Zn, Ag	6350	0.6% Cu, 2.5% Zn, 0.5 g/t Au, 20 g/t Ag	Atna, 1994
CanQuest Res. Corp.	Cottonbelt	Zn, Pb, Ag	725	11% (Pb + Zn), 58.3 g/t Ag	
Kenrich Mining Corp.	Corey	Au, Ag, Zn, Pb			
Porphyry (and related) Deposits					
Hera Res. Ltd.	Nak	Cu, Mo, Au			
Booker Gold Exploration Ltd.	Hearne Hill	Cu, Au	180	1.7% Cu	Prospectus MDAP, 1992
Spokane Res. Ltd./ Rio Algom Ltd.	Mac	Mo, Cu			
Lysander Gold Corp./ Kennecott Canada Inc.	Lorraine	Cu, Au	10 000	0.67% Cu, 0.34 g/t Au	Kennecott, 1993
Skarn Deposits					
Orvana Minerals Corp.	Eholt	Cu, Au			
Hemlo Gold Mines Inc./ Athlone Res. Ltd./ Vital Pacific Res. Ltd.	Soup	Au			
Vein Deposits					
AGC Americas Gold Corp.	JD	Au			
Teck Corp.	Tsacha	Au, Ag			
Romulus Res. Ltd.	Harmony Gold (Specogna)	Au	31 300	2.2 g/t Au	
Gold City Mining Corp./ International Wayside Mines Ltd./	Cariboo Gold Quartz - Sanders Zone	Au	690	3.84 g/t Au	Gold City, 1995
Mosquito Cons. Gold Mines	Rainbow Zone		907	4.53 g/t Au	
Athabasca Gold Res. Ltd.	Ladner Creek (Carolin)	Au	900	4.4 g/t Au	Athabasca, 1995

Note: MDAP = Mine Development Assessment Process. Estimated tonnes and grade are "resources."

with Misty Mountain Gold Ltd. Geological re-interpretation of the Gold Creek and Juskatla volcanic complexes has suggested many previously unrecognized exploration targets within the area. Since 1970, when the Cinola deposit was discovered, over $40 million has been spent on this property. This work has defined an open-pit mining resource of 31.3 million tonnes grading 2.2 g/t Au. Previous work focused almost entirely on outlining a bulk-mineable, low-grade gold deposit; the current focus is the potential for high-grade (bonanza) gold zones that could be mined underground. Initial follow-up surface diamond drilling, consisting of 7600 metres in 57 holes, will more clearly define the vein orientation to allow reassessment of this potential. Detailed clay analyses and fluid-flow regime studies have recently been conducted, to assist in the identification of higher grade targets.

In the **Wells-Barkerville** area, famous for both its lode and placer gold production, International Wayside Gold Mines Ltd., together with joint venture partners Mosquito Consolidated Gold Mines Ltd. and Gold City Mining Corporation, conducted an underground exploration drilling program from the 1200-level in the Rainbow zone of the **Cariboo Gold Quartz** mine. The main objective was to outline a zone of gold vein mineralization in the up-plunge projection of the Rainbow zone, which could be mined by open-pit methods. Drilling, from both underground and surface, tested the easterly strike extension of productive veins in the hangingwall of the Rainbow fault. Drilling during 1995 suggests that mineralized veins in the Rainbow zone (one of five zones and similar to the adjoining Sanders zone where previous surface drilling has outlined open pittable resources in excess of 690 000 t grading 3.84 g/t Au) extends to surface. Drilling also indicates that the limestone, host for the replacement ore (the mainstay of both the nearby Island Mountain and Mosquito Creek gold mines), extends to surface; the potential for development of this type of ore is now being examined. Exploration to date on the Rainbow zone has partially defined a zone 120 metres long and 36 metres wide, over a 60-metre vertical height from the 1300-level to the surface. The company estimates reserves at 907 000 tonnes grading 4.53 g/t Au. The Pinkerton zone and B.C. vein targets were also explored.

Elsewhere in the Wells-Barkerville area, Gold City Mining Corporation has assembled a very large land-holding (**WelBar** project) extending from the Cariboo-Hudson mine in the south to the Mount Tom area in the north. It plans to explore this ground for both high-grade gold reserves in and around existing deposits and for low-grade, bulk-tonnage deposits. Synthetic aperture radar and Dighem 1 Power airborne surveys were successful in identifying a number of geophysical anomalies not previously explored for lode gold. In particular, three very large radiometric anomalies coincident with historically rich placer gold deposits have been targeted for follow-up drilling. Numerous electromagnetic and magnetic anomalies have also been identified. Extensive trenching in previously unexplored or poorly explored areas has not resulted in any new discoveries fitting the company's low-grade, bulk-tonnage model. It will now concentrate on trenching and drilling (3400 metres) on known gold deposits such as the **Cariboo-Hudson** and **Black Jack (Williams Creek)**, and on new targets generated by the airborne geophysics and soil geochemical surveys. Deposit modelling and mine design, using data from prior operations, are part of the on-going pre-feasibility work.

South of Red Mountain in the Stewart Camp, Teuton Resources Corporation and Minvita Enterprises Ltd. have entered into an agreement with Homestake Canada Inc. and Prime Resources Group Inc. on their new **Red (C-2)** high-grade gold discovery. Disseminated native gold and minor amounts of chalcopyrite, galena, pyrite and erythrite are hosted by shear-controlled veins and stockworks. Eighty-one trenches tested a 150 by 570 metre portion of a northwesterly trending zone. A late-season diamond drilling program of 13 holes totalling 1067 metres tested both sulphide-rich and hematite-rich mineralization.

Athabasca Gold Resources Ltd. started underground development on the Idaho zone and surface drilling in the McMaster zone on its **Ladner Creek** (Carolin) gold property, 18 kilometres northeast of Hope. The targets are turbidite-hosted, mesothermal, epigenetic deposits, similar to those mined during 1982 to 1984. Preliminary results from both areas of drilling are encouraging. The initial drilling on the 800-level No. 3 zone has increased the resource in this area to 187 700 tonnes grading 3.77 g/t Au. Total underground resources are estimated at 900 000 tonnes grading 4.4 g/t Au. Drill testing of a tailings resource is continuing and a major metallurgical testing program is also in progress. Underground drilling in the western portion of the Idaho workings during the winter resulted in the discovery of new mineralization hosted in volcanic rocks (*cf.* turbidites). The company is very optimistic about recommissioning the permitted 1360-tonne-per-day mill and reactivating the mine as early as late 1996.

POLYMETALLIC MASSIVE SULPHIDE DEPOSITS

Base and precious metal rich (sedex, volcanogenic and seafloor hydrothermal) massive sulphide deposits were very important targets in 1995. The success of projects at **Myra Falls** (Battle/Gap zones), **Tulsequah Chief/Big Bull**, **Eskay Creek** and **Akie** over the past few years testifies to the exploration potential of these deposit types. The new Wolverine discovery in the southeastern Yukon and the re-opening of the Greens Creek mine west of Juneau, Alaska are reminders that the rocks which host these deposits project into British Columbia.

On the **Dragon** polymetallic 'Myra Falls-type' prospect, located near Gold River, which Westmin Resources

Limited holds under an option agreement with Doromin Resources Ltd., it conducted geological mapping and geochemical sampling of favourable Sicker Group rocks either side of the Muchalat River. Several new areas of massive sulphide mineralization and alteration associated with lead-zinc soil anomalies and airborne geophysical anomalies were identified over a length of 3.5 kilometres to the south of the Main showing and to the east for over 4.5 kilometres. Three drill holes totalling 722 metres tested coincident geochemical anomalies and alteration zones, approximately 2.5 kilometres south of the Dragon massive sulphide showings (Falls, North and Dragon).

During 1995, La Rock Mining Corporation focused its work on diamond drilling programs on the Dave's Pond zone on its **Brandywine** property, 110 kilometres north of Vancouver. This zone is one of seven geologically similar gold targets on the property, hosted by sheared rhyolitic and andesitic rocks of the Gambier Group. The drilling expanded the potential gold reserves in the Dave's Pond zone, and also tested a large gold geochemical anomaly (McKenzie zone) in soils, coincident with an electromagnetic anomaly, approximately 450 metres along strike to the southeast. After completing three holes in the McKenzie zone, south of the Daves' Pond zone, the drill was moved back to the latter zone.

Exploration on the **Horsefly** property, 80 kilometres southeast of Prince Rupert, by Atna Resources Ltd. under a joint venture agreement with Ecstall Mining Corporation, included a ground electromagnetic survey and follow-up diamond drilling. The geophysical survey indicates several strong conductive anomalies coincident with a sequence of mineralized rhyolitic volcanic rocks more than 2 kilometres long. The drilling (1075 m in eight holes) tested the Horsefly and Steelhead showings which lie immediately east of the Packsack deposit and approximately 15 kilometres southeast of the Ecstall (Red Gulch) deposit within the Ecstall River felsic volcanic belt. Disseminated, laminated and semimassive pyrrhotite, pyrite and chalcopyrite were intersected in altered volcanic rocks.

At the **Cottonbelt** lead-zinc-copper-silver-gold massive sulphide project in the Revelstoke area, CanQuest Resource Corporation drilled the Cottonbelt showing and the Bass showing, about 1 kilometre to the north. Encouraging results are reported. Mineralization has been traced on surface for a distance of 10 kilometres within both limbs of the west-dipping Mount Grace syncline. Drilling partially defined two stratabound zones of massive to semimassive sulphides in the west limb. Also, drilling around the old Cottonbelt workings is designed to increase the existing resource estimated at 725 000 tonnes grading 11% combined lead and zinc and 58 g/t Ag.

At the **Corey** property, 10 kilometres south of the high-grade Eskay Creek gold-silver-zinc-copper mine, drilling of 22 core holes by Kenrich Mining Corporation, resulted in the discovery of significant stratabound massive to semi-massive gold-silver-zinc-lead mineralization (Hutchings horizon) in the TV zone. Mineralization is hosted by a foot-wall rhyolite unit and overlying breccia and black mudstone, similar to the stratigraphy hosting the Eskay Creek deposits. Soil geochemical surveys have outlined significant anomalies coincident with induced polarization anomalies, over approximately 800 metres of the projected strike length of the mineralization. The TV zone has been traced 1500 metres on strike with widths over 90 metres. Other targets on the property include the Bench, Battlement and Cumberland zones. Two new high-grade gold veins were also discovered on the GFJ prospect, varying in width from 0.25 to 1.2 metres. Drilling programs are planned for all zones in 1996.

SKARN DEPOSITS

In the Greenwood camp, Orvana Minerals Corporation drilled the **Eholt** skarn target in the spring. Extensive, strong sulphide mineralization containing significant gold and copper values within the large (1 by 1.5 km) skarn system was encountered over a strike length of 750 metres and widths ranging from 10 to 40 metres. An eleven-hole, 3100-metre drilling program was completed in the fall on the Dead Honda showing and the east flank of Eholt Mountain. The geology is similar to that at the Phoenix deposit, 10 kilometres on strike to the southwest.

In north-central British Columbia, Hemlo Gold Mines Inc. drilled four holes on the **Soup** property, under an option agreement with Vital Pacific Resources Ltd. (75%) and Athlone Resources Ltd. (25%). Unfortunately, due to technical problems, none of the holes reached target depth. The holes were drilled on coincident airborne potassium radiometric and ground magnetic anomalies in an area of quartz-magnetite stockwork associated with diorite intrusive into andesitic flows, up-dip from a hole which intersected 5.4 g/t Au and 0.1% Cu over 40 metres and ended in mineralization grading 2.5 g/t Au. The fourth hole cut two sections of gold-copper mineralization within magnetite-silica stockworks, apparently above the target zone.

OTHER TARGETS

Both property-scale and regional exploration programs for sedimentary copper deposits were conducted in the southeast part of the province (*e.g.*, Junction property). Nickel and copper occurrences associated with ultramafic rocks were explored northwest of Fort St. James.

INITIATIVES IN BRITISH COLUMBIA

Several new or continuing government programs that will influence future mineral resource planning, exploration and development in British Columbia were active during 1995.

- **Explore B.C.**, part of a five-year $100 million program to provide significant tax reductions and exploration incentives to assist and promote private sector mineral exploration in British Columbia, continued in its second year of a three-year, $13.5 million program. The program, involving $2.5 million in 1995 expenditures, is designed to provide part of the risk capital required by mineral exploration companies to finance their programs, to extend the economic lives of existing mines and contribute to community stability in existing mining regions. It has three components:

(1) Mineral Exploration Incentive Program - (MEIP) provides grants to eligible exploration companies or individuals, to cover up to one-third of eligible exploration expenses on properties with identified economic potential. Maximum assistance is $150 000 per project. In July, 57 exploration and mining companies were awarded grants totalling $1.45 million under the MEIP program. This figure includes grants totalling approximately $235 000 to nine industrial mineral projects.

(2) Accelerated Mine Exploration Program - (AMEP) provides grants to mining companies to cover up to one-third of eligible exploration expenses at existing mines. Maximum assistance is $150 000 per project. Grants totalling approximately $415 000 were awarded to eleven projects under the AMEP program.

(3) Grassroots Mineral Incentive Program - (GMIP) provides grants to exploration companies or individuals to cover up to one-third of eligible expenses for grassroots exploration. Maximum assistance is $150 000 per project. Under the GMIP program seven grants totalling approximately $208 000 were awarded.

- The **Prospectors' Assistance Grant Program** is designed to promote grassroots prospecting for new mineral deposits in British Columbia. It will contribute up to 75% of eligible costs of an approved project to a maximum of $10 000. Sixty-eight grants were awarded in 1995 from a budget totalling approximately $500 000.
- This is the final year of the **Federal/Provincial Mineral Development Agreement**, which coordinates the efforts of Canada and British Columbia to strengthen and diversify the province's mineral industry. Activities sponsored under the agreement, most of which were in the write-up stage, include the funding of geological, market and technology studies.
- The new **Environmental Assessment Act** was proclaimed in 1995. It builds on the strengths of the previous Mine Development Assessment Act in establishing a process through which the potential effects of projects are identified and means of preventing or mitigating adverse impacts are developed and evaluated.
- A provincial initiative which includes a **partnership with B.C. Trade Development Corporation** to promote the marketing of industrial minerals in the province, Pacific Rim countries and Europe.
- Creation of an **Advisory Council on Mining**, a multi-stakeholder group of industry, labour, environmental and government groups, that advises the Minister on the implementation of the Whitehorse Mining Accord within British Columbia. The objective is to develop initiatives that will reverse the decline in the industry's competitive position.
- The **Geological Survey Branch** programs focused on regions where existing mines are expected to close in the next few years (northern Vancouver Island, East Kootenays and northern Selkirks) and in areas with significant identified potential (Interior Plateau, Gataga, Tatogga and Babine). Results of these programs are expected to encourage base and precious metal exploration in these areas and elsewhere.
- The **Mineral Potential Mapping Initiative** will see completion of 1:250 000-scale mineral potential maps for the province in 1996. These data are being used in many land-use decisions.
- A multi-year project to develop an inventory of sand and gravel resources will assist the Ministry in managing the aggregate resources in the province.
- Implementation of the joint strategic plan developed by the British Columbia Geological Survey Branch and the Geological Survey of Canada in 1994.
- Completion of part of the Geological Survey Branch **"Mineral Deposit Profiles"** project to describe the types of mineral deposits found around the world, with special emphasis on examples and deposit characteristics relating to British Columbia.
- Discussions continued with the First Nations, spearheaded through the Treaty Commission in British Columbia, designed to provide them with a more equitable role in mineral exploration and development decision making within their traditional territories.
- Initiation of a new five-year **Nechako Plateau - Babine Porphyry Belt NATMAP** program by the Geological Survey Branch and the Geological Survey of Canada in the Nechako River (93F), Fort Fraser (93K) and parts of Smithers (93L) and Prince George (93G) map areas. In addition, there will be a Regional Geochemical/National Geochemical Reconnaisance survey in parts of the project area. The project will capitalize on geological, geochemical and geophysical surveys conducted under the Canada/British Columbia Mineral Development Agreement (1991-1996).
- Initiation of a $600 000, multi-parameter **airborne geophysical survey**, funded by the provincial

government, over three specific target areas in the East Kootenay region of southeastern British Columbia. The objectives are to identify possible Sullivan-type orebodies and other targets.

- Completion of a **Regional Geochemical Survey of** the Cry Lake (104I) map sheet during 1995, with results to be released in 1996.
- Bill 13, which amends the **Mineral Tenure Act**, will streamline regulations, including those pertaining to bulk sampling and the acquisition of industrial mineral rights.
- As a result of the proclamation of the **Forest Practices Code of British Columbia** Act on June 15, 1995, the Ministries of Energy, Mines and Petroleum Resources; Forests; and Environment, Lands and Parks initiated a comprehensive review of mineral exploration practices and permitting procedures to develop standards compatible with Forest Practices Code.

SUMMARY AND OUTLOOK FOR 1996

Many of the signs that indicated an upswing in the mining industry in British Columbia in 1995 continue to be valid for 1996. Solid mineral production value in 1995 is estimated at $3.48 billion, the highest recorded in over 30 years. Exploration expenditures decreased very slightly to $83.5 million in 1995 from $85 million in 1994, even allowing for a significant decrease in exploration expenditures at the Red Mountain project. Claim staking in 1995 increased above 1994 levels; a further increase is expected in 1996. The number of valid Free Miners Certificates is up slightly in 1995 and is expected to rise again in 1996. Two new metal mines, Eskay Creek and QR, opened in 1995 and production decisions for several other advanced projects may be made in 1996 [*e.g.* Kemess, Huckleberry and Golden Bear (re-open)]. The Island Copper mine closed in late 1995. Successful exploration and development projects at several mines have increased reserves and mine life (*e.g.*, Snip, Table Mountain, Myra Falls and Ajax). Many smaller gold projects utilized custom milling facilities by obtaining the necessary permitting for bulk sampling; potential for other such projects will be important in the future. Production from southeastern coal mines increased significantly, with a strong demand for metallurgical coal. Several major expansions (*e.g.*, Quinsam, Fording River, Greenhills, Line Creek and Coal Mountain) were undertaken and bode well for the future of these operations. In general, the level of less advanced, grassroots exploration remained relatively high in 1995 at around 40% of total expenditures; this is expected to increase slightly in 1996.

Several advanced projects will receive further work in 1996, provided relatively high metal prices are sustained and uncertainties in land-use policies and First Nations' negotiations are dealt with in an orderly manner.

The many copper and gold-bearing porphyry deposits discovered during the 1960s and 1970s (*e.g.*, **Red Chris, Huckleberry, Lorraine**) will continue to be explored and developed. Sedex (*e.g.*, **Akie**) and volcanogenic polymetallic sulphide (*e.g.*,**Tulsequah Chief**) deposits offer small to medium tonnage and high-grade potential, particularly those enriched in precious metals. The stratiform, gold-enriched (seafloor hydrothermal) **Eskay Creek**-type deposits are examples of low-tonnage, but potentially extremely profitable, high-grade targets. The transitional setting, which includes vein and skarn deposits related to porphyry systems (*e.g.*, **Red Mountain, Willoughby, Snip**), offers similar small to medium tonnage and high-grade potential.

The potential for bulk-mineable (heap-leachable) gold deposits will continue to be examined. Current exploration and future development at the **Golden Bear** mine continue to be focused on the heap-leaching characteristics of recently discovered "no seeum" gold mineralization associated with silicified limestones and dolomites. In the Cassiar gold camp, the **Taurus** gold property will continue to be explored for its bulk-mineable potential. The potential for heap leaching low-grade material is also being investigated at the **QR** gold mine.

The completion of the access road into the Eskay Creek mine, and the infrastructure associated with the new mine development, will continue to assist other exploration programs (*e.g.*, Corey, Bonsai) in the region. The increase in exploration expenditures on industrial minerals is forecast to continue, with new discoveries made and new markets being developed. The release of results from both the Regional Geochemical Survey carried out in the Cry Lake map area and the airborne geophysical surveys in the East Kootenay region are expected to attract considerable attention. In general, the long-term outlook for mineral markets is very good throughout the Pacific Rim; British Columbia is well positioned to compete.

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EXPLORATION AND DEVELOPMENT HIGHLIGHTS NORTHWEST BRITISH COLUMBIA - 1995

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OVERVIEW

Mining industry highlights in northwest British Columbia in 1995 include the start of commercial production at the new Eskay Creek mine, certification of the Huckleberry project under the Environmental Assessment Act and advancement of three more projects; Tulsequah Chief, Red Chris, and Bronson Slope toward mine approval. An application for the Polaris-Taku project is expected in mid-1996. A compensation package for government's appropriation of the Windy Craggy resource in the Tatshenshini area was agreed to by Geddes Resources Ltd. and its controlling shareholder Royal Oak Mines Inc. and is expected to lead to development of the South Kemess copper-gold deposit (in the Prince George Region). This settlement is expected to restore a measure of confidence to the mining industry, in a fair reward for mineral exploration success in British Columbia.

Advanced exploration projects continued to be the focus in the northwest. Exploration activity, as measured by total drilling, dipped slightly in 1995 relative to 1994, but remains at a high level. Total expenditures showed a more substantial decrease in 1995, to $30.5 million. Grassroots activity is perceived to be increasing but is not reflected by any increase in the number of mineral claim units in good standing, which continues to decline. Exploration highlights include:

- American Bullion Minerals Ltd. continued to outline a large porphyry copper-gold deposit at Red Chris.
- North American Metals Corporation defined a small high-grade gold deposit in the Ursa zone at Golden Bear.
- The Table Mountain mine was returned to continuous gold production by Cusac Gold Mines Ltd.
- A large low-grade gold resource was indicated by drilling on the Taurus deposit by Cyprus Canada Inc.
- New gold discoveries were made in the Stewart area by Teuton Resources Corporation and Minvita Enterprises Ltd. and, at Hearne Hill, in the Babine camp, Booker Gold Explorations Ltd. extended the previously explored zone of copper mineralization.
- A northeast extension of the Eskay Creek 21B gold-silver deposit was discovered by Prime Resources Group Inc.
- Underground exploration is underway on the T-West gold vein discovered by Cominco Ltd. near its Snip mine.
- The Red Mountain gold prospect was acquired by Royal Oak Mines Inc. and a major exploration program is anticipated in 1996.

Three advanced projects received little or no exploration; Red Mountain was inactive due to a change in ownership, and Redfern Resources Ltd. and Huckleberry Mines Ltd focused their efforts on mine approval requirements for the Tulsequah Chief and Huckleberry projects, respectively.

Table 1 lists the 26 projects with expenditures in excess of $200 000 (compared to 30 such projects in 1994) and their locations are shown on Figure 1. Ten projects (versus nine in 1994) had budgets in excess of $1 million. Seven of these top ten projects were carried out by junior companies. Porphyry copper-gold targets received 32% of the $30.5 million in exploration spending, whereas 'gold-only' deposit types contributed 54%. Gold targets include shear-vein and mesothermal veins, 31%; Carlin-type, 10%; epithermal deposits, 9%; and intrusive-related and skarn deposits 4% of exploration dollars. Exhalative massive sulphides, including volcanogenic, Eskay and sedex types accounted, for 8% with the remainder, a diverse group of coal, industrial mineral and jade projects representing 6% of total expenditures.

Information contained in this report is derived from property visits by the Regional Geologist, news releases and other company reports and, most importantly, from mine and exploration project geologists whose work and ideas are acknowledged throughout the text.

TRENDS AND OPPORTUNITIES

Mineral exploration expenditures in northwest British Columbia fell 37% to $30.5 million in 1995 (Figure 2). The difference from 1994 can be attributed entirely to withdrawl of the large expenditure on the Red Mountain project. In 1995 there were 221 mineral Notices of Work in northwest British Columbia. Of these, at least 18 programs were not carried out, 34 were filed for reclamation work and 36 were second (or more) notices on a particular project. The remaining Notices of Work represent 107 minor exploration projects (less than $200 000 expenditure) and 26 major projects. Reclamation, primarily of camps and roads was carried out by several mid-size and major companies to eliminate liabilities, financial and moral, incurred by exploration up to twenty years ago. Some of this work is motivated by "good citizenship" in the British Columbia mining community rather than bond recovery. One example worthy of mention

TABLE 1
1995 MAJOR PROJECTS IN NORTHWEST REGION

PROPERTY	OPERATOR	MINFILE	MIN DIV	NTS	COMMODITY	TYPE	WORK DONE
Bonsai	Prime Resources Group Inc.	104B 383	Skeena	104B/10	Au, Ag	Epithermal msv sulphide	5 ddh, 1180 m
Bronson Slope	International Skyline Gold Corporation	104B 077	Liard	104B/11	Cu, Au	Porphyry	7 ddh, 2429 m
Corey	Canamera Geological Ltd.	104B 385, 011	Skeena	104B/8, 9	Au, Ag, Cu, Pb, Zn	Epithermal msv sulphide	Geol; geochem; IP, 18 km; trench; 22 ddh, 4118 m
Engineer	Ampex Mining	104M 014	Atlin	104M/8	Au	Epithermal vein	Install 600 m track; mine & mill 560 t
Eskay Creek	Prime Resources Group Inc.	104B 008	Skeena	104B/9	Au, Ag	VMS	21 ddh, 2400 m
Forrest	Abacus Minerals Corporation	104B 380	Liard	104B/15	Au, Ag, Cu, Pb, Zn	Shear vein	10 ddh, 1524 m
Georgia R/ Ashwood	Aquaterre Mineral Development Ltd	103O 013	Skeena	103O/16	Au	Vein	Geol; IP, 3 km; 19 ddh, 1838 m
Golden Bear (Ursa, West, Grizzly)	North American Metals Corp.	104K 079, 087, 088	Atlin	104K/1	Au	Carlin	Geol; geochem; EM, 27.8 km; trenching, 2300 m; drill access, 4.5 km; 49 sfc ddh, 6818 m; 16 u/g ddh, 2996 m
Hearne Hill	Booker Gold Explorations Limited	093M 006	Omineca	93M/1	Cu, Au	Porphyry, *breccia pipe*	Geochem; IP/ mag, 21 km; *drill access, 1600* m; 30 ddh, 5393 m
Horsefly	Atna Resources Ltd.	103H 014, 036	Skeena	103H/14	Zn, Au, Ag, Au	VMS	Geol; EM, 8.5 km; 8 ddh, 1076 m
Iskut Wollastonite	Super Twins Resources Ltd.	104B 384	Liard	104B/11	Wollastonite	Industrial mineral	Geol; trench; sampling
JD	AGC Americas Gold Corporation	094E 171,65 168	Omineca	94E/6	Au,Ag	Epithermal vein	Geochem; prosp; IP, 40 km; trenching, 4000 m; 103 ddh, 9150 m
Louise Lake	Global Mineral and Chemical Ltd.	093L 079	Omineca	93L/13	Cu, Au, Ag	Porphyry	Geochem; IP, 12 km
Nak	Hera Resources Inc.	093M 010	Omineca	93M/8,1	Cu, Au, Mo	Porphyry	Geol; IP, 20 km; 43 ddh, 9510 m
Polaris-Taku	Canarc Resource Corp.	104K 003	Atlin	104K/12	Au	Mesothermal (listwanite) vein	Seismic, 3 km; 19 ddh, 7810 m; metallurgical testing
Red (Clone)	Teuton Resources Corp.	103P new, 249	Skeena	103P/12,13	Au, Co	Shear vein	Geol; trenching, 345 m; 14 ddh, 1067 m
Red Chris	American Bullion Minerals Ltd.	104H 005	Liard	104H/12	Cu, Au	Porphyry	Geochem, 15 km; drill access, 3 km; 112 ddh, 36 760 m

Snip (Bronson)	Cominco Ltd.	104B 004, 264	Liard	104B/11	Au	Shear vein	12 ddh, 5875 m
Snip (mine site)	Cominco Ltd.	104B 250	Liard	104B/11	Au	Mesothermal (shear) vein	Access road, 1000 m; 61 ddh, 10 932 m; u/g development, 104 m
Strike	Navarre Resources Corporation	104A 061	Skeena	104A/4	Au, Ag	Vein	IP, 7 km; 20 ddh, 1923 m
Surf Inlet	Rupert Resources Ltd.	103H 027	Skeena	103H/2	Au	Mesothermal vein	U/g rehab (27 m u/g development, 5 ddh, 500 m)
Table Mtn	Cusac Gold Mines Ltd.	104P 070	Liard	104P/4	Au	"Cassiar" gold	IP, 22.4 km; 97 ddh, 5947 m; u/g development, 1145 m
Tatsi	Golden Hemlock Explorations Ltd.	093L 305	Omineca	93L/5	Ag, Au, Cu	Epithermal vein	Geol; 12 trenches; VLF-EM, 16 km; 15 ddh, 1820 m
Taurus	Cyprus Canada Inc.	104P 012, 013, 015	Liard	104P/5	Au	"Cassiar" gold	Geol; geochem; IP/Mag, 54 km; trenching; drill access, 4.1 km; 78 ddh, 12 670 m; 5 rdh, 820 m; metallurgy
Telkwa South	Manalta Coal Ltd.	093L156	Omineca	93L/11	Coal	Thermal coal	Drill access, 19.8 km; 80 rdh & 3 ddh, 9615 m; geophysical logs; ARD sampling
Willoughby	Camnor Resources Ltd.	103P 006	Skeena	103P/13	Au	Intrusive-related gold	Geol; geochem; 27 ddh, 3013 m; adit development, 55 m

is the voluntary contribution by Canamera Geological Ltd. to clean up of the Tide Lake airstrip north of Stewart.

The most accurate insight into health of the mineral exploration industry is considered, by the author, to be given by two statistics: the balance of claim holdings (a new statistic, discussed below) and the amount of exploration drilling. Conclusions drawn from statistics such as comparison of annual industry expenditures or the number of Notices of Work are less reliable. Expenditures are subject to inflation and budgets that include a growing list of non-exploration costs such as environmental studies and public consultation. Tracking the number of Notices of Work has many deficiencies: large and small projects count equally, staged projects submit several notices, some planned programs are not done and notices submitted only for reclamation should not be included as a measure of exploration activity.

Total exploration drilling decreased to 149 945 metres in 1995 (Figure 3) but remains far above 1992-1993 levels. The amount of drilling indicates a higher level of activity on intermediate and advanced exploration projects, during the past two years that statistics are available, but gives no insight into activity at the grassroots level of the exploration industry. A new statistic is introduced, the balance of claim holdings which is a tally of all new and forfeited mineral and placer claims. Mineral claims are staked and forfeited for a variety of reasons, but in a vibrant exploration industry there are at least as many new claims staked by optimists with new ideas as there are forfeitures by those who have been disappointed by their exploration programs or disillusioned in the market value of their mineral property. Claims acquired as 'insurance' to surround a mineral prospect, and subsequently permitted to lapse, indicate a decline in the perceived value of the prospect. Similarly, claims acquired for speculative reasons are forfeited because their worth in the market of exploration properties has declined.

Tenure data for northwest British Columbia from January to November 1995, inclusive, have been provided by Mineral Titles Branch. There were 11 454 mineral claim units recorded and 13 743 claim units forfeited yielding a net loss of 2289 units. The same period in 1994 showed an almost identical loss of 2356 mineral claim units. Figure 4 summarizes the results and compares 1994 data for Atlin

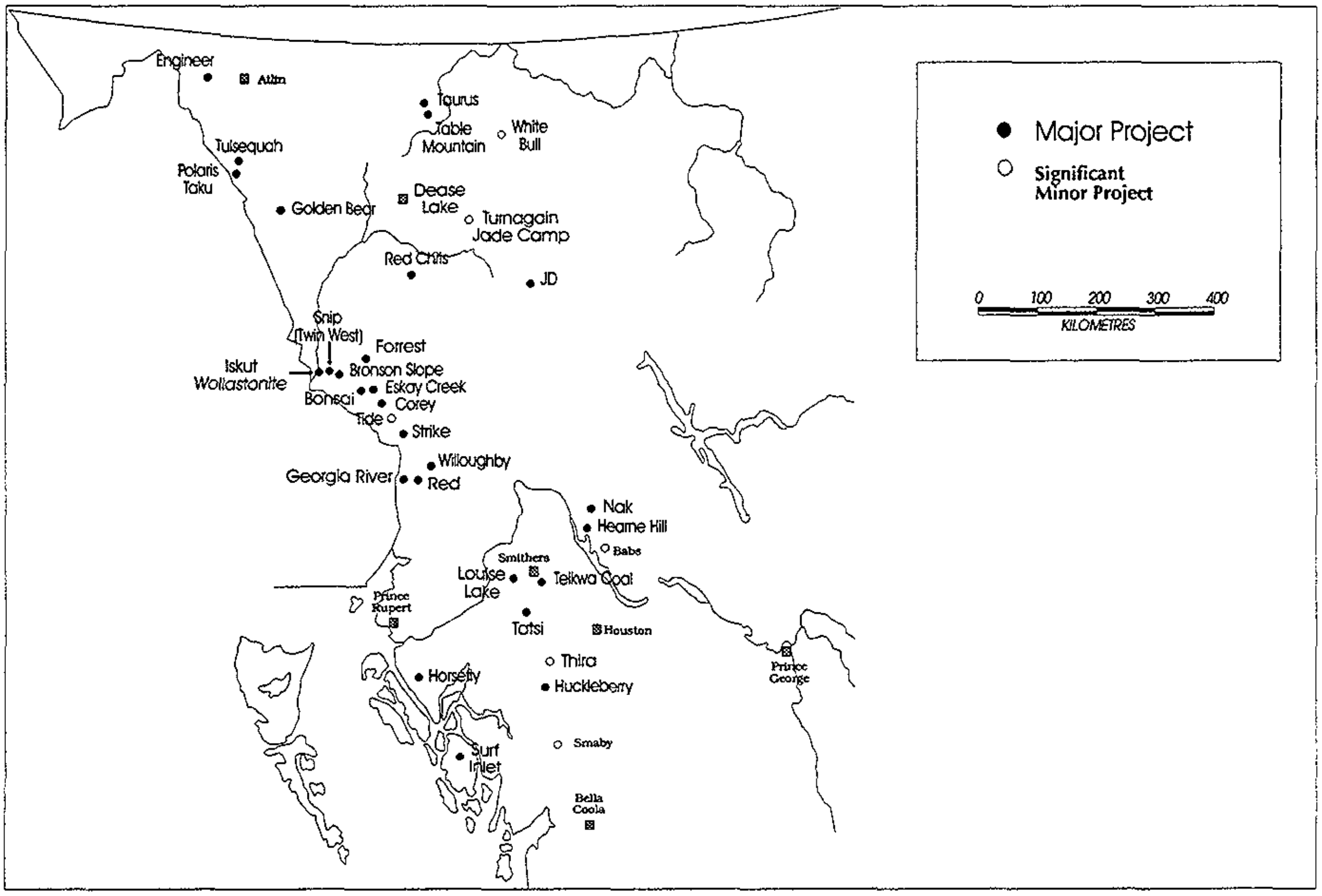

Figure 1. Location map, exploration projects in northwest British Columbia 1995.

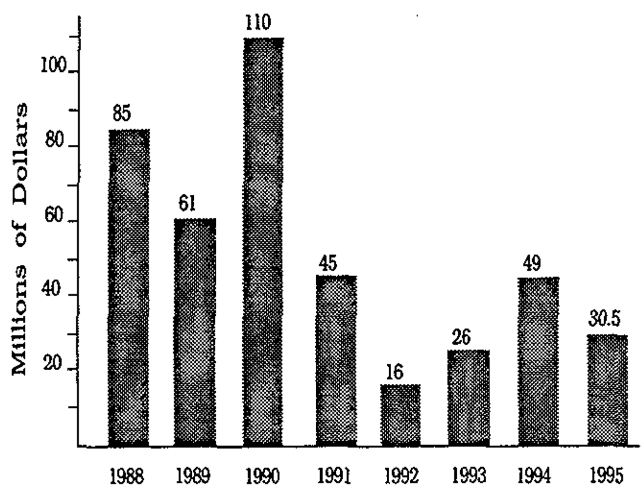

Figure 2. Mineral exploration expenditures in northwest British Columbia.

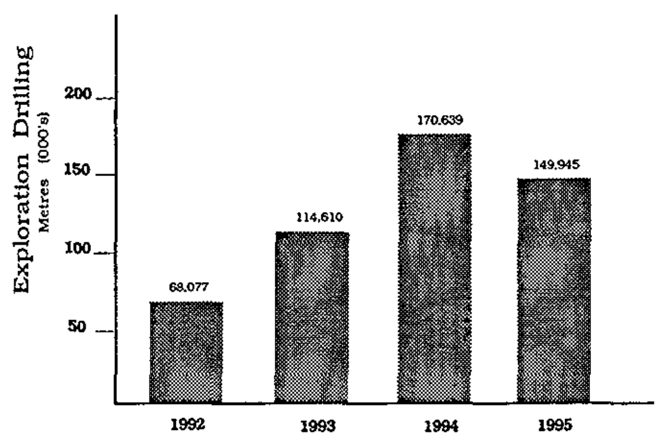

Figure 3. Exploration drilling in Northwest Region.

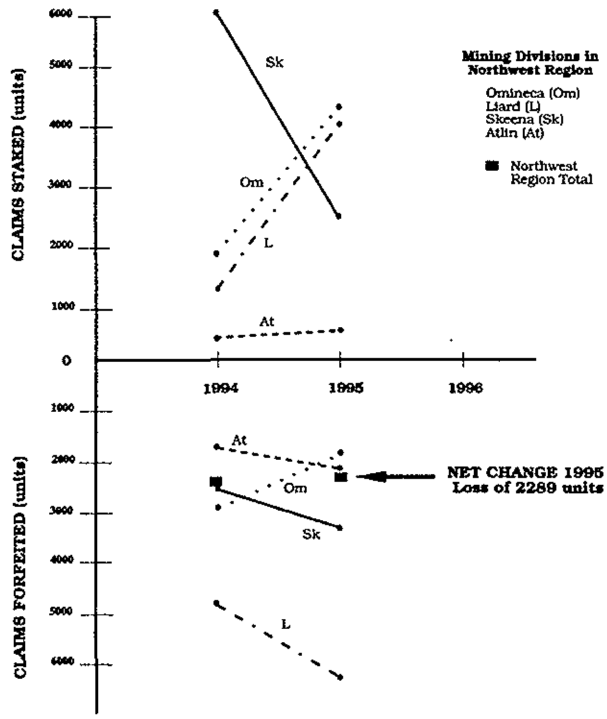

Figure 4. Summary of changes in mineral claim status, Northwest Region.

and the portion of Liard, Omineca and Skeena Mining Divisions that lie within Northwest Region. The most striking features are the sharp increase in new claims in Omineca and Liard Mining Divisions, due to activity in the Babine porphyry and Cassiar gold camps respectively, but offset by a precipitous drop in new staking in Skeena Mining Division and a sharp increase in forfeitures in Liard. The number of claim units forfeited also increased in Atlin and Skeena. Only in Omineca did the level of forfeitures decrease. New placer claims amounted to 308 units, balanced by 256 forfeitures, for a net increase of 52 units. By this analysis the depressed condition of the exploration industry persists at the grassroots level in northwest British Columbia. Several more years of mineral tenure and drilling data will give greater insight into trends in the exploration industry.

Gold continued to be the primary focus of mineral exploration in northwest British Columbia. Exploration for a bulk-tonnage gold deposit in the Cassiar gold camp by Cyprus Canada Inc. may be the advent of an important new trend in mineral exploration. Cyprus' U.S. parent is developing the Fort Knox gold deposit near Fairbanks, Alaska as a large-tonnage open-pit mine based on reserves of 158 million tonnes at 0.83 g/t Au. Mining industry observers are keenly interested in how this new operation performs. Although geologically quite different, economics of the Taurus deposit in the Cassiar gold camp may be comparable to Fort Knox, based on a resource of 145 million tonnes grading 0.95 g/t Au that is indicated by preliminary, wide-spaced drilling. Much more work needs to be done at Taurus to prove the resource and determine metallurgical recovery, and power costs and other aspects of feasibility, but the possibilities for further Cordilleran exploration are exciting.

The exploration success enjoyed by North American Metals Ltd at Golden Bear in discovery of the Kodiak A and Ursa gold deposits, both Carlin-type, ought to prompt more exploration of the Stikine assemblage for larger heap-leachable or refractory deposits. Exploration parameters are discussed below under Mineral Exploration in the Golden Bear camp.

Porphyry copper exploration expenditures have increased from less than $3 million in 1993 to nearly $10 million in 1995. This upsurge can be attributed to strong metal prices and the combined credits in base and precious metals (copper and gold) that many porphyry copper deposits offer. If development of the Huckleberry and Kemess projects proceeds, the latter in the Prince George Region, continued strong interest in porphyry exploration can be expected. Intensive exploration of old and new prospects in the Babine camp in 1996, by a number of major and junior companies can be anticipated with more certainty.

Start-up of mining at Eskay Creek appears to have spurred exploration for Eskay-type precious metal enriched massive sulphide deposits. Despite strong base metal prices, exploration for volcanogenic massive sulphide deposits continued at a modest level. This may change in 1996 as discovery of the rich Wolverine and Kudz Ze Kayah deposits in Yukon is expected to trigger exploration of possibly correlative terranes in northwestern British Columbia.

MINERAL LANDS ISSUES

Four sub-regional land-planning processes are underway in northwest British Columbia; Kispiox, Kalum, Bulkley and Lakes districts Land and Resource Management Plans (LRMP). This leaves a very large segment of Northwest Region (approximately one-sixth of the province) without any strategic land planning in progress. This results in a large element of uncertainty over access to mineral land that is not being resolved. Since the Cassiar Forest District annual allowable cut (AAC) was greatly increased in 1995, public pressure to begin land planning in the district has increased. There are also many large exploration projects and identified mineral resources whose development is hindered by a lack of infrastructure. Consequently, participation by the mining industry in Cassiar land planning will be very important.

Infrastructure required to develop mineral resources, specifically road access and power transmission lines into "wilderness areas" are pivotal land-use issues in northwest British Columbia. Access into the Tulsequah River valley, an area with high timber, fishery, wildlife, wilderness and mineral values, is the most difficult issue facing proponents of mine development at Tulsequah Chief and Polaris-Taku.

Access and power requirements appear to be the key issues for the Red Chris project. Early in 1995 Columbia Gold Mines Ltd. submitted a Notice of Work to conduct surface and underground exploration of the Spectrum gold prospect, 30 kilometres west of village of Iskut in the Mount Edziza Recreation Area. Road access through a few kilometres of Mount Edziza Park was considered necessary for advanced exploration of the resource, estimated at 615 000 tonnes of 12.34 g/t Au. Deadlocked in its efforts to gain work approval and advance the project, Columbia Gold Mines finally sold the property.

Native land claim negotiations are another area of uncertainty for the mining industry. Negotiations between the province and the Nisga'a government are advanced but it is premature to suggest that a settlement is at hand. Negotiations are ongoing with the Champagne-Aishihik, Wet'suwet'en and Gitxsan peoples. In addition, negotiations are expected to begin with at least nine other groups in 1996; the Gitanyow, Haisla, Heiltsuk, Oweekeno, Kaska Dene, Taku River Tlingit, Teslin Tlingit, Yekooche and Cheslatta Carrier.

The mining industry is well aware that effective working relationships can be developed with native governments and corporations that are knowledgeable of development and the mining industry. Toward this end a spectrum of mining and energy companies, together with the Ministry of Energy, Mines and Petroleum Resources, made presentations and participated in a mining and energy forum with the Wet'suwet'en, held in October. The cultural exchange was an important first step in building the respect and recognition that are necessary for successful business relationships. More such forums are anticipated with other groups in 1996 and the mining industry stands to benefit from participation.

OPERATING MINES

ESKAY CREEK MINE

The new Eskay Creek mine is owned by Prime Resources Group Inc. and operated by Homestake Canada Inc. Ore is mined at 270 tonnes per day and shipped directly to smelters in Japan and eastern Canada; there is no milling on site. The first shipment was made in January 1995. The Eskay Creek orebody is a gold-silver enriched exhalative massive sulphide deposit formed at the contact between rhyolite and overlying mudstone, near the top the Lower to Middle Jurassic Hazelton Group. The 21B deposit lies on the north flank of the thickest section of rhyolite. Clastic sphalerite, tetrahedrite, lead sulphosalts, galena and pyrite were transported northerly from the rhyolite dome and deposited as interbeds with mudstone (T. Roth, personal communication, 1995. In addition to precious metals, the deposit is enriched in deleterious elements; mercury, antimony and arsenic. Mercury correlates closely with gold and a prime requirement of grade control is to maintain mercury content of ore shipments to less than 1200 ppm by ore blending. Two ore blends are produced on site, to meet differing smelter terms. Poor ground conditions required that drift-and-fill stopes, be reduced from 3 by 3 metres to 2.4 by 2.4 metres. Cemented river gravel is used as fill. Stope development is planned to minimize rock exposure to air to a few days. Gold and silver production is ahead of schedule and, by extrapolating third quarter data, the writer estimates the mine will ship 325 000 gold-equivalent ounces in its first year. Cost of production, including shipping and smelting charges, is $183 per ounce. Reserves at start-up were 1.08 million tonnes at 65.5 g/t Au, 2930 g/t Ag, 0.77% Cu and 5.6% Zn, sufficient for about ten years of production. Discovery of the NEX extension of the deposit in 1995 may add another year of reserves (D. Kuran, personal communication, 1995). The cut-off grade was increased from an initial 13 g/t to 20 g/t Au and because there is no acceptable location for a stockpile, due to space and acid rock drainage concerns, this "low-grade" rock is dumped into Albino Lake along with acid-generating waste rock.

SNIP MINE

The Snip gold mine is a 460 tonne per day underground mine owned 60% by Cominco Ltd. and 40% by Prime Resources Group Inc., and operated by Cominco. The operation is based on the Twin zone, a quartz-carbonate-sulphide vein, 0.5 - 15 metres wide developed in a shear zone 1000 metres from a quartz monzonite stock, the Red Bluff orthoclase porphyry. The stock cuts Triassic feldspathic greywacke that has been metamorphosed to biotite hornfels. The Twin zone owes its name to a post-ore biotite lamprophyre dike which lies in the plane of the ore vein and commonly divides it in two. The vein extends 1000 metres along strike and 500 metres vertically, and plunges steeply northwest. Mine exploration continues in the up-plunge direction, from exploration drifts driven to the southeast from an ascending spiral ramp. Other exploration on the Snip property is described in the following section. Reserves as of January 1995 were 625 000 tonnes at 26.4 g/t Au (cut-off grade is 12 g/t Au), sufficient until late 1998. The 150 and 130 footwall veins constitute about 20% of the reserves. Ore is produced about 55% from mechanized and 45% from conventional cut-and-fill stopes. Snip will produce about 4350 kilograms (140 000 ounces) of gold in 1995 (T.W. Hodson, personal communication, 1995) as gold doré on site and an auriferous pyrite concentrate which is shipped to the Premier Gold CIL mill for gold recovery. Production costs are US$145 per ounce, exclusive of shipping and off-site treatment.

PREMIER GOLD MINE

Premier Gold is a 725 tonne per day underground mine and custom CIL milling operation owned and operated by

Westmin Resources Limited. Premier is an adularia-sericite epithermal deposit, following the classification of Heald *et al.* (Econ. Geol., 1987). Gold-silver ore is mined from a series of quartz-feldspar-calcite veins that exhibit pronounced zoning to base metal rich ore over a vertical range of 300 metres. The veins are related to sanidine porphyry dikes, high-level apophyses of the Early Jurassic Texas Creek granodiorite stock which intrudes coeval Hazelton Group andesite. Premier was a rich gold-silver producer from 1919 until 1963 and was re-opened as an open-pit mine by Westmin Resources in 1989. Currently all mining is underground with ore derived 65% from low-cost "Glory Hole" caved stopes accessed by adits from the open pit, and 35% from long-hole stopes and pillar recovery. Ore reserves, as of October 23, 1995, are 109 000 tonnes in caved stopes grading 2.91 g/t Au, 79 g/t Ag; and 79 000 tonnes in stoping blocks grading 7.10 g/t Au, 48 g/t Ag (R. Johnston, P.G. Lhotka, personal communication, 1995) The latter includes new reserves discovered by exploration of extensions to stopes on the lower levels of the old mine. A significant operating concern is the risk of Glory Hole muck freezing during cold weather. The Premier mine will produce about 22 350 gold-equivalent ounces in 1995. Premier Gold recovers gold from pyrite concentrate that is shipped by hovercraft and barge from the Snip mine to Stewart and then trucked to the mill site. Premier continues to aggressively seek additional ore and concentrate for custom milling.

TABLE MOUNTAIN MINE

Cusac Gold Mines Ltd. acquired the Cassiar gold camp holdings of Total Energold Corporation in 1993, including an operational 270 tonne per day mill. Gold ore on the Table Mountain property occurs in steeply dipping, east-northeast-trending quartz veins localized within basalt or listwanite immediately below overlying thrust-faulted argillite. Although gold grade correlates with total sulphide content, about 50% of the gold is recovered on site by gravity separation with the remainder shipped to Trail as a sulphide concentrate. Veins are typically 1 to 3 metres wide and 300 metres long with ore shoots having a maximum height of about 40 metres. Ore shoots are small and exploration and development must be maintained in order to sustain production. Ore from the Bain vein was milled in 1994, then the mill was shut down while the Michelle vein was accessed by a decline in 1995. Reserves of 22 675 tonnes at 27.4 g/t Au were defined in a rich shoot just 20 metres long by 14 metres high. Mining and milling, at 90 tonnes per day, were in progress from September 1995. A small tonnage of ore was mined from two other veins; the Big vein was developed from the Michelle decline and the keel of an ore shoot in the Katherine vein was recovered by an open cut. New ore veins are suggested by exploration drilling from the Michelle decline and late in 1995 Cusac resumed development of the 10-level adit, which was abandoned by predecessor Erickson Gold Mines Limited. This 2.4-kilometre adit will pass under the Michelle vein and allow more efficient mining of the Michelle ore shoot and any new zones that may be found, giving promise of sustained production at the Table Mountain mine.

MINERAL EXPLORATION

BABINE CAMP

Interest in the Babine porphyry copper camp increased throughout 1995. Hera Resources Inc. carried out a major drilling program on the Nak prospect, Booker Gold Explorations Limited drilled at Hearne Hill until late in the year and the Northern Dynasty Minerals Ltd - Pacific Sentinel Gold Corporation joint venture began drilling on the Babs property in December. A staking rush involving Booker Gold, Lucero Resource Corporation and Teck Corporation, which had conducted an airborne EM, magnetic and radiometrics survey, led to recording of 960 units in 93M/1 and 93M/8 during November. Acquisition agreements on several previously staked properties were also in negotiation at year end, so that new players and more projects are anticipated in 1996.

The Nak prospect, 35 kilometres north of Bell Copper, was discovered in 1964 by a syndicate controlled by Noranda Exploration Company Limited using silt geochemistry (R. Woolverton, personal communication, 1996). Following widespread shallow drilling by Noranda, Nak was largely inactive for more than 20 years prior to Hera Resources induced polarization survey in 1994 and subsequent 43-hole drilling program in 1995. Chalcopyrite and bornite occur in a weak to moderate stockwork developed in Babine biotite feldspar porphyry and biotite granodiorite dikes, associated with strong and extensive tourmaline, secondary biotite and argillic alteration. The porphyry system is large and mineralization is widespread but generally low tenor. Best drill intercepts were 0.425% Cu and 0.106 g/t Au over 104 metres and 0.409% Cu and 0.718 g/t Au over 119.5 metres.

At Hearne Hill, 20 kilometres northwest of Bell Copper along the Morrison fault, Booker Gold Explorations Limited sought to discover new zones of breccia mineralization by following mineralized float upslope to the east. The Chapman breccia zone contains 180 000 tonnes at 1.7% Cu (MDAP prospectus, 1992). Copper mineralization at Hearne Hill was discovered by Tro-Buttle Exploration Limited in 1967 and explored by a succession of companies, beginning with the Texas Gulf Sulphur Company in 1967. Porphyry copper stockwork and breccia chalcopyrite occur within a strongly altered Babine biotite feldspar porphyry intrusion and adjacent biotite hornfelsed Hazelton Group volcanic rocks. One exceptional 1995 drill hole returned 1.03% Cu and 0.43 g/t Au from the subcrop surface to a depth of 156 metres. Other holes have returned grades of 0.18 to 0.47 % Cu over lengths up to 300 metres. Subsequent drilling has limited the extent of copper mineralization.

Diamond drilling on the Babs property, 15 kilometres southwest of Bell Copper along the Morrison fault, was in progress at time of writing. Drilling by Pacific Sentinel Gold Corporation and Northern Dynasty Minerals Ltd. follows a 46-kilometre induced polarization survey. The objective is to locate the source of a focused glacial dispersion train comprising more than 100 mineralized boulders of Babine porphyry that assay up to 1.2% Cu and 1.3 g/t Au. Drilling by previous operators intersected Tertiary flow-banded rhyolite, with one drill intercept of 0.21% Cu over 10.4 metres. The rhyolite is similar to that on the Newman Pennisula south of Bell Copper and is probably preserved in downthrown Tertiary fault blocks.

TAHTSA CAMP

Activity at the Huckleberry porphyry copper deposit, 85 kilometres south of Houston, was limited to environmental studies and collection of a metallurgical sample by large-diameter core drilling. In December, Huckleberry Mines Limited, formed by merger of New Canamin Resources Ltd. and Princeton Mining Corporation received a Mine Development Certificate to develop a 15 500 tonne per day open-pit mine.

Cominco Ltd conducted percussion drilling on the Thira property 60 kilometres south of Houston. Feldspar porphyry, probably belonging to the Late Cretaceous Bulkley intrusions that are also responsible for mineralization at Huckleberry, is strongly argillized and pyritic over a 4 by 11 kilometre area. The zone follows a northeast-trending topographic depression and is exposed by new logging access roads. Near 'Copper Pond' at the southwest end of the zone, several exploration holes were drilled into a coarse biotite granodiorite in 1972, with poor results (J.R. Woodcock, 1973, AR 4181). Cominco's program of eight holes spaced 1 kilometre apart yielded sufficient encouragement for the company to return to drill three more diamond-drill holes late in the season (D. Wagner, personal communication, 1995).

On the Sibola property, 15 kilometres north of Huckleberry, Westley Technologies Ltd. drilled four holes to test a zone of porphyry copper-molybdenum mineralization discovered by Hudson's Bay Oil and Gas in 1976. The mineralized zone occurs at the contact between a coarse granodiorite to quartz monzonite and Hazelton Group volcanic rocks (G.D. Belik, personal communication, 1995).

SMITHERS CAMP

The Manalta Coal Ltd. program on the Telkwa thermal coal property comprised rotary holes on 200 to 300-metre centres to outline the Tenas Creek deposit, and more broadly spaced reconnaissance drilling to evaluate its extensive outlying coal licenses. A large area was eliminated from further consideration. Locally, glacial overburden up to 160 metres thick was encountered, precluding interest in any underlying coal-bearing stratigraphy. The Tenas deposit is an excellent addition to indicated resources in the Pit #3, #7 and #8 deposits; coal quality is very good and geometry is ideal for mining by a shallow open pit. Four trenches were excavated to test the acid rock drainage potential of the enclosing Skeena Group sandstone and shale, one of the requirements to satisfy government's Mine Development Review Committee. Improved prices for thermal coal give encouragement that this export-oriented project may proceed.

The Tatsi project, located 55 kilometres southwest of Smithers and explored by Golden Hemlock Explorations Ltd. comprises two zones. The Discovery zone was found in 1988 (Colin Harivel, 1988, AR 17971) and the Main zone, 1.5 kilometres to the south, was a new discovery in 1994. Both zones consist of a series of gently dipping comb-textured quartz-(barite) veins 10 to 20 centimetres thick, containing bornite, chalcopyrite, galena, possible tetrahedrite and native silver or electrum. The veins can be traced up to a few tens of metres east-west along strike and are arranged en echelon. This geometry, together with attendant buff-brown carbonate wallrock alteration, gives the impression of a wide, northerly striking zone that was interpreted initially to be steeply dipping.

Global Mineral and Chemical Ltd. continued a long history of exploration of the Louise Lake porphyry system, 35 kilometres west of Smithers. Discontinuous work since 1968 by Canadian Superior Exploration Limited, Granby Mining Corporation/ Noranda Exploration Company Limited, Lacana Mining Corporation/Corona Corporation and Equity Silver Mines Limited has outlined 50 million tonnes at 0.3% Cu and 0.3 g/t Au in a tabular zone 40 to 70 metres thick that strikes easterly and dips north. Tennantite and chalcopyrite occur in a pyrite-vein stockwork related to a feldspar porphyry, variously interpreted as a stock, sill or dike swarm that intrudes Skeena Group sedimentary rocks (Hanson and Klassen, CIM Special Volume 46). Mineralization occurs within a zone of intense clay-pyrite alteration, 4 kilometres long, that is controlled by a major fault and masks primary lithology. This year's work included a 12-kilometre induced polarization survey to extend definition of the sulphide zone east and west under overburden. Louise Lake has a high-level geochemical signature; arsenic is enriched in the copper-gold zone and antimony, as stibnite, is enriched above it. The property has potential to host a subvolcanic enargite-gold deposit, in addtition to a gold-enriched porphyry deposit.

Schufer Lake is a new gold showing discovered on Hudson Bay Mountain, 12 kilometres northwest of Smithers. Orequest Consultants Ltd. was contracted by Imperial

Metals Corporation to conduct a modest geological, geophysical and drilling program during the fall of 1995. Pyrite and arsenopyrite (with gold values) occur in a quartz vein within Red Rose Formation graphitic black argillite near a faulted contact with Telkwa Formation silicic volcanic rocks. A stock correlated with the Bulkley intrusive suite outcrops less than a kilometre to the north.

On the Burbidge Lake property, south of the idle Dome Mountain gold mine 30 kilometres east of Smithers, an induced polarization survey was conducted by D.C. (Bud) Plecash. The objective was detection of a vein or porphyry copper system.

NORTH COAST AREA

Atna Resources Ltd. drill tested the Horsefly and Steelhead volcanogenic massive sulphide showings within the Ecstall volcano-sedimentary pendant, 80 kilometres southeast of Prince Rupert. The Ecstall pendant, correlated with Alexander Terrane, is 10 kilometres wide by 75 kilometres long and, in the area of the showings, comprises (upper) greenschist-grade intermediate volcanic rocks, primarily non-clastic chlorite schist, with thin horizons of acidic volcanic rocks. Interbedded graphite and sulphide-bearing argillite units, typically 5 to 10 metres thick, are responsible for some of the better electromagnetic-conductors that were tested by drilling (U. Schmidt, personal communication, 1995). On Steelhead, an argillite unit contains thin interbeds of silica-carbonate-mariposite with 5 to 10% pyrrhotite and pyrite. At Horsefly, 900 metres north along strike, a 0.4-metre massive pyrite bed exposed in a creek was not intersected in drilling, but two holes cut patchy to disseminated pyrrhotite-chalcopyrite (1.68% Cu over 2.7 m) with associated chlorite alteration and quartz veinlets. This zone is suggestive of footwall volcanogenic mineralization and alteration. Further exploration is anticipated.

Abacus Minerals Corporation delineated a strong induced polarization chargeability response coincident with felsic fragmental volcanic rocks that host Cu-Zn-Au showings on the Smaby property, 150 kilometres south of Smithers (65 km southeast of Kemano). The andesite to rhyolite sequence lies on the eastern margin of the Coast Plutonic Complex and may correlate with the Jurassic Hazelton Group or Cretaceous Gambier Group. Association of chalcopyrite and sphalerite with epidote and magnetite suggest a skarn environment but volcanic stratigraphy, alteration and apparent stratagraphic control are consistent with volcanogenic mineralization. Epidote is extensively developed in felsic pyroclastic rocks and appears to be an early alteration event, unrelated to metamorphism or skarn development. Eight base metal showings occur over a 3 kilometres east-west strike length with the highlight of the 1995 season being return of high gold values from the new Ridge and Star copper showings.

At the former Surf gold mine at Surf Inlet, 100 kilometres south of Kitimat, Rupert Resources Ltd. has commenced a program on the 900 level to comprise rehabilitation, driving a short crosscut and diamond drilling to test for new ore shoots below stopes which produced 836 000 tonnes averaging 14.4 g/t Au in the 1940s. Free-milling gold is contained in quartz veins on a splay fault of the Grenville Channel lineament, a major structure in the Coast Range.

STEWART CAMP

The Stewart camp was much quieter than in the previous two years, with the important Red Mountain prospect being idle. However, several other projects in the Stewart area made significant progress and Royal Oak Mines Inc. has announced plans for a major surface and underground program at Red Mountain in 1996. Targets include the gently plunging Marc-AV-JW deposit trend to the northwest (J. Houle, personal communication, 1996).

Camnor Resources Ltd. continued surface drilling of gold zones on the Willoughby property, 25 kilometres east of Stewart. Gold mineralization is controlled by northwest-trending structures and associated with coarse pyrite or pyrrhotite and a geochemical association with As, Zn, Pb and Sb (J.J. Watkins, personal communication, 1994). Gold grade is highly variable and correlation of intercepts is problematic. The 1996 drill results range from 4.66 g/t Au over 6.1 metres in the Lower Icefall zone to 382.5 g/t Au over 2.9 metres in the North zone, but several holes returned negligible values from completed lithologies. The North zone, is controlled by a fault dipping 60° to 70° southwest, on the southwest margin of the Goldslide hornblende-feldspar-porphyritic diorite stock. The North zone is disrupted by northeast crossfaults and has a poorly understood plunge (A.L. Wilkins, D.A. Visagie, personal communication, 1995) which, combined with steep topography, makes exploration by surface drilling difficult. Camnor commenced a 100-metre adit to conduct a more effective drilling campaign. Weather conditions forced a shut-down and the adit will be continued in 1996.

Persistent prospecting in the Stewart area by Teuton Resources Corporation and Minvita Enterprises Ltd. resulted in discovery of the intriguing new Clone showing on the Red property in the Cambria Icefield. Four parallel, northwesterly trending shears within Hazelton Group volcanic rocks have been identified with three different gold associations. Low-sulphide shears contain hematite, chlorite and quartz with minor chalcopyrite, specularite(?) and fine visible gold. Surface sampling returned 28.8 g/t Au across 4.5 metres. Arsenopyrite and pyrite are the predominant minerals in sulphide-rich shears and surface sampling of two structures averaged 23.6 g/t Au over 3.0 metres and 26.7 g/t Au across 2.2 metres. The most intriguing association is gold with cobalt (*e.g.* 0.71% Co, 14.4 g/t Au over 1.5 m), but the relationship of this zone to the other shears is unclear. Hematitic shears exhibit striking cataclastic fabrics. Overall width of the zone is 50 to 70 metres and it has been traced 330 metres along strike. The Teuton - Minvita discovery prompted competetive staking in the area.

The Konkin silver showing, another new find by Teuton Resources and Minvita Enteprises, 30 kilometres east of Stewart, was drilled by Silver Standard Resources Inc. Recent ablation of the Cambria Icefield has exposed a coarse-grained pink carbonate-barite vein and breccia, mineralized with galena, pale sphalerite and trace pyrite, within green to maroon andesite breccia and tuff. High silver assays from surface sampling were not confirmed by drilling (M. Holtby, personal communication, 1995). Cockade banding indicates mineral deposition in open space, in an irregular 30-metre arc, but the cause of dilation of the massive andesite is not apparent. The absence of wallrock alteration suggests a low depositional temperature.

At the Georgia River gold prospect, 28 kilometres south of Stewart, Aquaterre Mineral Development Ltd. sought to identify high-grade gold ore shoots within an area of previous drilling on the Southwest vein. Quartz veins on the property occupy broad northwest-striking shears and northerly trending fault fissures in Unuk Formation volcanic rocks. The Southwest vein is one of the northerly trending vein set; it contains sparse base metal sulphides and visible gold. The program defined a reserve of 13 600 tonnes with 47.6 g/t Au. Potentially high-grade gold ore could be shipped to Premier Gold for custom milling. Extraction of a bulk sample is planned for 1996 (J.R. Kerr, personal communication, 1995).

The Tide property of Hemlo Gold Mines Inc. is underlain by Late Triassic to Early Jurassic Unuk River Formation near the coeval Summit Lake stock, 40 kilometres north of Stewart. Gold occurs where northeast-trending carbonate-sericite-pyrite shears, interpreted as splays of the East Gold fault, are mineralized with quartz and arsenopyrite (R.T. Kemp, personal communication, 1995). Hemlo Gold plans more work in 1996. Finally, Navarre Resources Corporation drill tested polymetallic quartz-carbonate veins on the Strike property, 20 kilometres north of Stewart.

ISKUT CAMP

Exploration drilling at the Eskay Creek mine by Prime Resources Group Inc. successfully located a northeast extension (NEX) of the 21B deposit where the ore horizon is folded around the nose of the Eskay anticline. The 1995 holes were oriented perpendicular to prior drilling, which missed the zone, and intersected ore-grade precious metals over significant widths in the hangingwall lens and/or the main ore lens at the rhyolite-mudstone contact (D.L. Kuran, personal communication, 1995). Follow-up drilling results and analysis have not been reported but it is fair to suggest that the discovery represents a modest addition to Eskay Creek mine reserves.

In the MacKay Lake synclinorium, west of the Eskay Creek mine, Prime Resources conducted detailed structural mapping of complexly folded and faulted Bowser Lake turbidites preparatory to exploration for underlying Eskay-type mineralization. On the western margin of the 10 kilometre wide synclinorium, Prime Resources explored the Eskay ore horizon where it is exposed on the Bonsai property. Intrusion of a rhyolite dome(s) has produced rhyolite - black mudstone breccia similar to rocks near the Eskay Creek deposit. The rhyolite is sericitic and anomalous in Eskay signature elements, Au, Sb, As and Hg (A. Kaip, personal communication, 1995). The Bonsai showing consists of bedded clastic pyrite, some clasts are laminated and others have radial structures suggesting the pyrite formed by alteration of marcasite.

Discovery of an Eskay-type deposit is also the objective of Canamera Geolgical Ltd., manager of the Corey project for Kenrich Mining Corporation. The Corey property is located 10 kilometres south of the Eskay Creek mine and underlain by similar strata. Rhyolite breccia in the TV zone is sericite altered, variably mineralized with base and precious metals and in contact with black mudstone containing bedding-parallel seams of pyrite. Drilling has intersected broad widths of low-grade gold and silver mineralization (*e.g.* 1.8 g/t Au, 32 g/t Ag over 34.4 m) with narrow intervals assaying up to 13.2 g/t Au and 170 g/t Ag over 1.0 metre. The tightly folded favourable horizon is inferred from geological mapping to extend to the Bench zone where the focus of interest is a rhyolite - black mudstone breccia (G. McRoberts, T. Drown, J. D. Blackwell, personal communication, 1995).

Several years of determined exploratory drilling by Cominco Ltd in the vicinity of the Snip mine led to the discovery of the T-West vein in 1995. The vein is a massive pyrite shear vein 0.1 to 2 metres wide, that has been traced 400 metres along strike and has a northwest trend similar to the Twin shear vein, the main source of gold ore at Snip mine (T.W. Hodson, personal communication, 1995). The T-West vein is highly auriferous, the only surface exposure is in a drill access road-cut where it assays 227 g/t Au over 30 centimetres (S. Metcalf, personal communication, 1995). A modest addition to Snip ore reserves is indicated by surface drilling and exploration is continuing by means of an adit that was collared in November. Its purpose is to evaluate the T-West zone in detail while surface drilling in 1996 will continue to follow the vein to the west. Four 800-metre holes were also drilled east of the mine, on claims optioned from International Skyline Gold Corporation. The target was a pyrite-sphalerite vein with higher gold grade at depth, but a non-auriferous pyrrhotite-sphalerite ductile shear was intersected (J. Garratt, personal communication, 1995).

International Skyline Gold Corporation continued work on the Bronson Slope porphyry gold-copper deposit located less than 500 metres east of the Snip mine. A quartz-magnetite stockwork containing pyrite and chalcopyrite is developed within the Early Jurassic (195 Ma) Red Bluff stock, an orthoclase-porphyritic quartz monzonite. The deposit contains an inferred resource of 101.9 million tonnes containing 0.72 g/t Au and 0.15% Cu. International Skyline has applied under the Environmental Assessment Act to develop a 12 000 tonne per day mine, to commence operation after closure of the Snip mine. Gold mineralization at Snip is also genetically related to the Red Bluff stock.

Pamicon Developments Ltd. conducted a drilling program on the Forrest property, 30 kilometres southwest of Bob Quinn, for Abacus Minerals Corporation. Gold occurs in Paleozoic Stikine assemblage but may be related to Early Jurassic intrusions on the property and is controlled by northerly trending structures, possibly related to the nearby Forrest Kerr fault (C.C. Scott, personal communication, 1995). Prior drilling has intersected wide zones of gold-copper mineralization (C.K. Ikona, personal communication, 1995).

Super Twins Resources Ltd. carried out detailed mapping and surface sampling on the Iskut wollastonite property, 13 kilometres west of Snip mine. Wollastonite is a fibrous pyroxene-structure calcsilicate mineral with attributes that allow it to substitute for asbestos. On Zippa Mountain, skarn zones are associated with a nepheline syenite body 4 kilometres long, intrusive into Stikine assemblage strata. Wollastonite, with associated diopside and titaniferous andradite, comprise a thin stratigraphic unit that can be traced about 300 metres (B.A. Slim, B. Gowarski, personal communication, 1995). Beneficiation and product testing were in progress at year-end.

TOODOGGONE CAMP

AGC Americas Gold Corporation delineated the Finn zone by close-spaced drilling on the JD property, 290 kilometres due north of Smithers, but just 12 kilometres from the Cheni gold mill and the Omineca Mine Access Road. Gold-silver mineralization occurs in a quartz-carbonate healed fault zone that dips at 30 to 40°. Precious metals are associated with base metals but correlate poorly (B.D. Game, personal communication, 1995). The fault, probably a thrust, separates distinctly different members of the Jurassic Toodoggone Group; an upper light-coloured, feldsparphyric dacite tuff breccia (McClair Creek formation?) and a lower, dark green and calcareous andesite ash tuff (Tuff Peak formation?). Hematite is prominent in both units. The Finn zone has a zinc geochemical halo but no arsenic, antimony or mercury enrichment commonly associated with epithermal mineralization. Prior to the 1995 program, AGC estimated the Finn zone to contain 148 000 tonnes grading 4.40 g/t Au, open along strike and amenable to open-pit mining. A new resource estimate was not available at time of writing. The idle Cheni mill and camp facilities, that might have been used to mine the Finn zone, were sold late in the year by Meota Resources Inc. (formerly Cheni Gold Mines Inc.). The camp will be used by Royal Oak Mines Inc. during construction of the Kemess mine and the mill is destined for re-assembly in South America.

STIKINE PORPHYRY CAMP

The American Bullion Minerals Ltd. drilling program on the Red Chris porphyry copper-gold deposit 80 kilometres south of Dease Lake was the largest exploration project in northwest British Columbia in 1995. Mineralization is contained within the Red stock, an Early Jurassic monzodiorite emplaced into mafic volcanic and clastic sedimentary rocks of upper Triassic to lower Jurassic age assigned to the Hazelton Group by C.J. Ash *et al.* (BCGS Geological Fieldwork, 1995) near the north margin of the Bowser Basin. The Red stock is elongate parallel to the Ealue Lake fault, a major, arcuate east-west strike-slip fault. East-northeast faulting that controlled plutonic emplacement is interpreted by American Bullion geologists to have occurred prior, during and after mineralization (J.D. Blanchflower, 1995, J.R. Deighton, personal communication, 1996). Pulses of magma were also emplaced during mineralization, resulting in two principal phases which are indistinguishable except for copper grade (J.R. Deighton, T.M. Fraser, personal communication). The relationship of the Main phase and Late phase is enigmatic, contacts vary from chilled margins to gradational or faulted (J.R. Deighton, personal communication, 1996). Sheeted veins in the East zone are aligned parallel to the intrusion but veining grades to a stockwork without prominent preferred orientation to the west in the Gully zone. Metal zonation from east to west in the East, Main, Gully and Far West zones of the Red Chris deposit shows a decrease in bornite, increase in pyrite and decrease in Cu:Au ratio from 1:0.8 to 1:3. Mineralization extends beyond the Red stock into the volcanic host rocks in the Gully and Far West zones. Potassic alteration is more prevalent in the East zone and gives way to phyllic alteration westward. These changes are attributed to a series of normal faults which step the deposit down to the west, exposing progressively higher levels of the porphyry system (J.D. Blanchflower, personal communication, 1995). A revised resource estimate was released in March 1996. At a net smelter return cut-off of Cdn$7.00 per tonne the measured and indicated resource at Red Chris is 398 million tonnes of 0.41% Cu and 0.36 g/t Au. American Bullion Minerals initiated government's mine approval process in November 1995 by proposing a 50 000 tonne per day open-pit mine based on a 245 million tonne deposit.

KUTCHO DISTRICT

In the Kutcho jade camp, 80 kilometres east of Dease Lake, both Jade West Resources Ltd. and Glenpark Enterprises Ltd. conducted trenching, drilling and on-site cutting to locate and evaluate nephrite jade lenses. Jade is developed within metasomatized antigorite serpentinite of the Cache Creek Terrane, in an area bounded by the King Salmon and Kutcho faults (H. Gabrielse, GSC Open File 2262). Locally, resistant jade blocks are preserved in the overburden.

On the White Bull property, 130 kilometres northeast of Dease Lake, Atna Resources Ltd. explored a massive barite horizon, thought to be within the Cambro-Ordovician Kechika Group, for exhalative zinc-lead mineralization. A massive pyrite horizon was discovered (P.R. DeLancey, personal communication, 1995).

CASSIAR CAMP

Cyprus Canada Inc. undertook exploration on the Taurus project, a property formed by a joint venture with International Taurus Resources Inc. and Cusac Gold Mines Ltd. The possibility of identifying a very large, but low-grade gold resource amenable to open-pit mining was recognized first by M.H. Gunning (Exploration in British Columbia 1987) and tested by International Taurus in 1994. The target area comprises the underground workings of the Taurus, Plaza and Sable mines, and other quartz-vein gold showings. Stacked thrust sheets in the Paleozoic Sylvestor Group imbricate basalt, which hosts gold mineralization in the Cassiar camp, with graphitic argillite (Figure 5). Gold occurs with disseminated pyrite in both a myriad of high-angle quartz veins and in altered basaltic rock. The alteration zones are thought to be both stratabound and crosscutting, the former may be permeable tuffaceous horizons and the latter are vein envelopes (M. Mason, personal communication, 1995). Cyprus tested the bulk-tonnage potential by drilling at 100-metre intervals on lines spaced 200 metres apart and, at year end, is determining gold recovery by both conventional milling and heap leaching. Based on drilling results to date, International Taurus and Cusac Gold Mines have estimated the gold resource in the 88-Hill, Taurus Portal and Taurus West zones to be 32.5 million tonnes at 1.55 g/t Au (1.5 million contained ounces). Alternatively the resource can be stated as 145 million tonnes at 0.95 g/tonne Au (4 million contained ounces of gold). Continuation of a major drilling program is anticipated in early 1996.

At the Table Mountain gold mine, Cusac Gold Mines Ltd. completed a decline to access and explore the Michelle High Grade zone. The Michelle vein was discovered by Total Erickson Resources Limited, a predecessor company, in

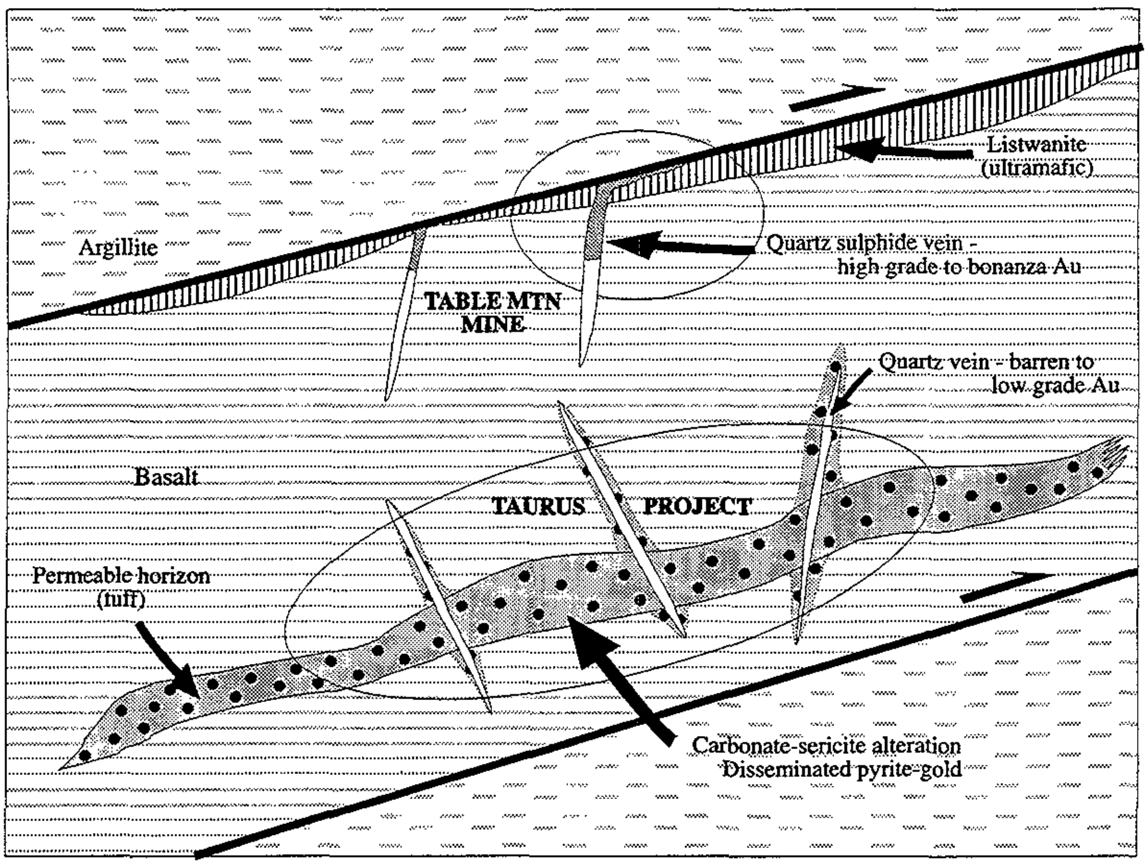

Figure 5. Schematic diagram of Cassiar gold camp.

1985, but its underground development was abandoned due to excessive water flow. Development and underground drilling by Cusac in 1995 identified an ore reserve of 22 675 tonnes grading 27.4 g/t Au in the Michelle vein Underground drilling of the Lily vein, northeast of the Michelle vein, will continue in 1996. Table Mountain gold ore occurs in quartz - base metal veins that strike at 070° and are contained in basalt or listwanite immediately beneath argillite (Figure 5). Ore shoots are restricted to within a few tens of metres of the argillite "cap". The argillite was impermeable to gold-bearing fluids and could not sustain fractures (J. Nelson, BCGS Bulletin 83).

Gold deposits in the Cassiar camp are assigned to the class of mesothermal ore deposits for the purpose of categorizing exploration expenditures. However, Cassiar gold deposits show significant differences from such classic mesothermal gold veins such as the California Mother Lode, Bralorne and Giant mines. As pointed out by J. Nelson (BCGS Bulletin 83) classic mesothermal gold deposits occur in major (crustal scale) fault zones and have notable vertical continuity, whereas Cassiar veins are within fractures of short strike length and without significant offset. Instead, Nelson lists several lines of evidence to suggest Cassiar gold deposits are related to the cupola of a cryptic granitic intrusion. The author refers (in Table 5) to these deposits as 'Cassiar-type' until an appropriate classification is determined.

Attracted by the activity of Cyprus Canada Inc. and Cusac Gold Mines Ltd in the Cassiar gold camp, Nicholson and Associates staked approximately 1000 claim units for the Cassiar Syndicate early in 1994. Further north, the high level of interest in Yukon-Tanana and correlative terranes in Yukon for volcanogenic massive sulphide deposits prompted KRL Resources Corporation to reevaluate the Ace Mountain showing 10 kilometres south of the Yukon border. Claims were also staked south of Watson Lake, giving promise of increased grassroots exploration next year.

At the former Cassiar mine, B.C. Chrysotile Corporation contracted recovery of jade to Jedway Enterprises Ltd. Nephrite jade, associated with chrysotile asbestos, was discarded with waste rock during open-pit mining at Cassiar. Best quality jade is in the west dump although it is more abundant on the east dump (J. Doucet, personal communication, 1995). The large size of waste blocks and blast damage to jade are operating problems.

GOLDEN BEAR CAMP

At the Golden Bear mine site, North American Metals Corporation carried out underground drilling on the Grizzly zone, detailed surface drilling on the Ursa zone and comprehensive surface exploration on the Kodiak - Ursa area. At the conclusion of 1995 drilling, Ursa ore reserves were reported as 209 000 tonnes grading 23.3 g/t Au. Gold mineralization at Ursa occurs within 100 metres of surface, in the steeply dipping Ursa fault in a brecciated, thinly bedded graphitic limestone. Below 100 metres the fault breccia is healed by calcite and contains little gold. Massive dolomite/chert in the footwall of the fault is barren, perhaps because it did not brecciate during faulting to provide open space (L.C. Pigage, A. Hamilton, personal communication, 1995). Gold is associated with hypogene hematite and supergene limonite which, together with brecciation, are the only visual guides to gold mineralization (L.C. Pigage, personal communication, 1995). Rare bonanza-grade intervals (*e.g.*, 100 g/t Au) contain fine visible gold. A feasibility study, scheduled for completion in late December, is expected to favour open-pit mining followed by a combination of wet milling of the high-grade ore and heap leaching of the low-grade component of the Ursa deposit. Studies indicate gold is readily leachable, like the Kodiak A deposit which contains an ore reserve of 542 600 tonnes at 4.4 g/t Au. Open-pit mining and heap-leach recovery of gold from Kodiak A is planned for 1996. Exploration at Golden Bear has been very successful during the past two years and is expected to continue in 1996. For example, the Ridge zone is a new target area identified by soil geochemistry, trenching and drilling.

The Grizzly zone is located 300 metres below the Bear open pit, on the footwall side of a limestone lens 70 metres wide within the braided Ophir fault zone. It consists of a series of anastomosing faults within the carbonate lens (R. Smallwood, personal communication, 1995). Highest gold values are correlated with heavily disseminated fine pyrite (*i.e.* refractory ore) in a strongly silicified fault breccia. Geological reserves are estimated at 153 000 tonnes grading 20.5 g/t Au, using a 12 g/t Au cut-off. The Grizzly zone is approximately 100 metres below the elevation of Muddy Lake, resulting in high underground water pressure and potentially difficult mining conditions. It is open to depth but underground drilling was halted and the decline allowed to flood.

Discovery of the Kodiak A and Ursa gold deposits at Golden Bear has contributed to a better understanding of gold mineralization in the camp. Deposit characteristics were summarized by Lehrman and Caddy (1989) in a private report for Homestake Canada Inc. and are augmented by more recent findings. These are listed below and clearly indicate the Golden Bear deposits are Carlin-type:

- Hostrocks are Paleozoic carbonates, in particular a thin-bedded graphitic limestone at Ursa
- Ore is localized on steep normal faults; thrust faults exist in the area but their importance is uncertain due to poor understanding of Paleozoic stratigraphy (D.A. Brown, personal communication, 1995)
- Brecciation and gouge are important ore controls
- Metallic minerals are very fine grained, 0.5-5 microns
- Sulphide ore is refractory; gold occurs in pyrite (in arsenian rims on pyrite in the Bear Main deposit, J.L. Oliver, personal communication, 1996)

- Oxide ore is readily amenable to cyanide heap-leaching; gold is associated with hematite and limonite
- Main gangue minerals are replacement dolomite and quartz; veins (at any scale) are absent
- Geochemical signature is Au, As (both >1000 times background) together with Ag, Hg, Sb (100-1000 times background). Partial data suggest Te is highly anomalous
- Low Ag:Au ratios are characteristic
- Fluid inclusion studies indicate ore deposition at 180°C from fluids with 1 to 3% NaCl
- Mineralization was a single-stage event
- Some zones (Kodiak B, Ursa) contain felsite dikes that are altered and mineralized (L.C. Pigage, R. Smallwood, personal communication, 1995)

TULSEQUAH CAMP

Canarc Resource Corporation explored two areas in its 1995 drilling program at the former Polaris-Taku gold mine. On the North zone, discovered last year by Canarc geologist J. Moors, a deeper tier of holes tested for better gold grade at depth and secondly, a new vein intersection was sought southeast of known mineralization, deep below the Tulsequah valley. Gold at Polaris-Taku is associated with disseminated arsenopyrite in conjugate, shear-controlled quartz-ankerite vein stockworks developed within Devonian mafic volcanic rocks. The shear zone is a splay of the Llewellyn fault, shown by M.G. Mihalnyuk to be an important regional control of gold mineralization. On surface and in shallow 1994 drillholes, the North zone dips gently and contains 2 to 5 g/t Au over widths up to 15 metres. Drilling in 1995 demonstrated that it continues to dip gently at depth and maintains similar gold grade. Because the gold at Polaris-Taku is refractory, a grade of 2 to 5 is considered insufficient to be viable and no further work is planned on the North zone.

The higher grade deep target at Polaris-Taku is a new zone of intersection of two shear veins; the northwesterly AB shear and the family of northerly Y veins. These intersections, spaced about 300 metres apart, produce the rich C-veins, historically termed "junction arcs". Prior to drilling, Canarc completed a seismic reflection survey to elucidate the subcrop surface below an estimated 300 metres of overburden in Tulsequah River valley and then utilized wedges and a directional drilling tools to maintain holes on target. The company was rewarded with several 2.5 to 7.5 metre intercepts of 12 to 15 g/t Au at 400 to 700 metres below surface, confirming that the ore zone continues undiminished to depth. Previous drilling at Polaris-Taku indicates a geological resource of 2 587 000 tonnes of 14.56 g/t Au.

No exploration work was done at the Tulsequah Chief Cu-Zn-Ag-Au volcanogenic massive sulphide prospect, located 6 kilometres from Polaris-Taku on the opposite side of Tulsequah River. Redfern Resources Ltd. focused its efforts on mine certification requirements.

ATLIN CAMP

Exploration activity in the Atlin camp was subdued in 1995. Placer mining continued at recent levels on Spruce, Pine, Birch, Boulder, Ruby, Otter, Wright and McKee creeks and O'Donnel River, but the area was not visited by the Regional Geologist.

At the former Engineer gold mine, Ampex Mining, a private company, in partnership with Pelly Construction completed installation of a gravity mill, complete with a jig and Deister tables. A 565-tonne sample was mined from eight areas on the Engineer and Governor veins, selected on the basis of a study of old mine records, and run through the mill. The Engineer and Governor veins belong to a series of epithermal quartz-calcite veins that fill tensional fractures perpendicular to a prominent northwest-striking shear zone, a splay of the Llewellyn fault, that cuts folded Laberge Group sedimentary rocks. Mine track was installed and other steps taken preparatory to pumping out the flooded 600, 700 and 800 levels in 1996. Old records suggest continuation of an ore shoot on the 700 level.

EXPLORATION AND DEVELOPMENT HIGHLIGHTS CENTRAL REGION - 1995

By K.F. MacDonald
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HIGHLIGHTS

- Exploration expenditures totalled almost $14 million, more than double 1994 expenditures.
- Increased number of exploration projects; several companies conducted major programs.
- QR gold mine opened near Quesnel with mill start-up in May.
- Kemess project entered Environmental Assessment Process, project approval may be granted in early 1996.
- Nazko Pumice entered the Environmental Assessment Process with large-scale production planned for 1996, once permitting is secured.
- Drill intersections from the Akie property continue to generate interest in the sedex potential of the Gataga belt.
- Revised ore reserve estimate casts favourable light on Imperial Metals' Mount Polley project.
- Placer Dome initiates redesign of the mine plan at Mt. Milligan; changes include simpler water management.
- Land-use planning well advanced in seven of the eight LRMPs in the Prince George Forest Region.
- Implementation of the Cariboo-Chilcotin Land Use Plan underway.

INTRODUCTION

Mining activity in the Northeast-Central region rebounded significantly from the levels of the past several years. Mineral exploration and pre-production development expenditures in 1995 more than doubled from 1994. Advanced exploration activities were particularly evident and included diamond drilling, trenching, underground development and bulk sampling. The opening of the **QR gold mine**, near Quesnel, by Kinross Gold Corporation, was overshadowed by the start-up of the Eskay Creek mine in Northwest British Columbia. Nonetheless, by year's end the mine was quietly producing approximately 3000 ounces of gold per month from a throughput of 20 000 tonnes. The mining industry was given a major boost with the announcement that the provincial government had reached an agreement with Royal Oak Mines Inc. that would link compensation for the expropriation of the Windy Craggy copper deposit to the development of two new mines, **Kemess South** and **Red Mountain**.

TRENDS

The upward turn in mineral exploration activity in 1995 was reflected by the increased number of Notices of Work submitted to the Prince George office (Figure 1). A total of 220 mineral Notices of Work were filed, compared to 197 one year ago. Expenditures on exploration and development programs increased to approximately $13.7 million; the 1994 total was just over $6 million (Figure 2).

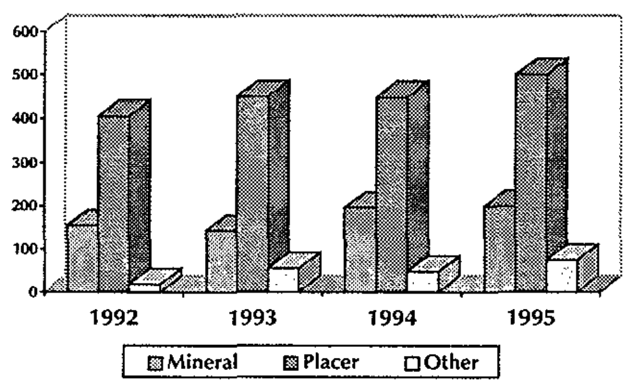

Figure 1. Notices of Work 1992-1995.

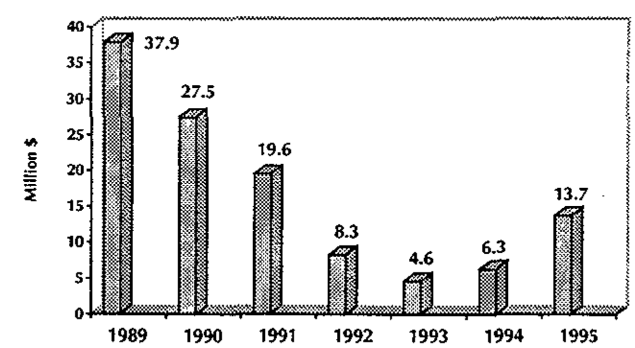

Figure 2. Exploration Expenditures 1989-1995.

A total of 32 exploration and development projects reported expenditures greater than $100 000; a nearly two-fold increase from 1994 when only 15 such projects were reported (Table 1). Of those projects, more than half targeted porphyry copper-molybdenum deposits. Precious metal vein and transitional targets, respectively, were the next targets of preference (Figure 3). However, only 30% of the total exploration dollars spent in the region were directed toward porphyry targets. This discrepancy is explained by the disproportionately large costs associated with exploration of non-porphyry targets in more remote and often less accessible areas. The non-porphyry targets include sedex, vein, transitional, coal and industrial minerals (Figure 4).

Placer Notices of Work applications increased by 11% to 499 from 1994. Notices of Work for coal, quarry and aggregate (sand and gravel) also increased in 1995, from 48 to 74.

Although mineral exploration expenditures have risen and the number of major projects has increased, the focus of activity has not changed from the Gataga belt, the Quesnel Trough, the Nechako Plateau, and the Likely and Barkerville-Wells areas. Other early-stage programs were completed in remote areas and these included several industrial mineral projects.

Drilling completed on exploration and development projects in 1995 totalled approximately 51 000 metres (Figure 18). This represents an increase of 40% over the previous year. Almost 60% tested porphyry copper-molybdenum-gold targets, with the next largest percentage aimed at precious metal vein and transitional deposits.

TABLE 1
EXPLORATION PROJECTS - NORTHEAST-CENTRAL REGION

Operator	MINFILE	Mining Division	NTS	Commodity	Deposit Type	Work Done
Inmet Mining Corp.	094F 031	Omineca	93F/7W	Pb,Zn	Sedex	7 ddh, 4950 m; geophys
Royal Oak Mines Inc.	094E 094	Omineca	94E/2	Cu,Au	Porphyry	bulk sample; camp setup
Quintette Operating Corp.	093P 019	Liard	93P/3	Coal	Sedimentary	71 dhh, 11 254 m
Gold City Mining Corp.	093H 010	Cariboo	93H/4E	Au	Replacement	24 ddh, 3400 m; geochem
Lysander Gold Corp.	093N 002	Omineca	93N/14W	Cu,Au	Porphyry	27 ddh, 3984 m; bulk sample
Teck Exploration Ltd.	093F 055	Omineca	93F/3E	Au	Epithermal	35 ddh, 5100 m; trenching
Imperial Metals Corp.	093A 008	Cariboo	93A/12E	Cu,Au	Porphyry	23 ddh, 3589 m; site prep
Spokane Resources Ltd.	093K 097	Omineca	93K/13E	Mo,Cu	Porphyry	11 ddh, 2100 m; IP/mag
Big Valley Resources Inc.	093A 160	Cariboo	93A/12	Cu,Au	Porphyry	31 ddh, 4650 m; IP/mag
International Wayside Gold Mines Ltd.	093H 019	Cariboo	93H/14E	Au	Replacement	u/g & surface drilling
Phelps Dodge Corp. of Can. Ltd.	093C 016	Cariboo	93C/9E	Au,Ag	Epithermal	4 ddh, 800 m; IP
Ava Resources Inc.	093H 131	Cariboo	93H/16E	Quartzite	Metamorphic	road building
Hera Resources Inc.	093K 067	Omineca	93K/13E	Cu,Au	Porphyry (?)	5 ddh, 893 m; geochem
International Focus Res. Inc.	093N 079	Omineca	93N/2W	Cu,Au,Mo	Porphyry	5 ddh, 838 m; IP
Gibraltar Mines Ltd.	093B 012	Cariboo	93B/9W	Cu,Mo,Ag	Porphyry	37 ddh, 4962 m
Placer Dome Canada Ltd.	093K 006	Omineca	93K/3E	Mo	Porphyry	49 ddh, 5023 m
Canada Pumice Corp.	093B 060	Cariboo	93B/13E	Pumice	Volcanic	site prep
Phelps Dodge Corp. of Canada Ltd.	093C 015	Cariboo	93C/9E, 16	Au	Epithermal	4 ddh, 800 m; trenching
Columbia-Yukon	093K 078	Omineca	93K/6E	Cu,Au	Porphyry	4 ddh, 961 m
Consolidated North Coast Ind. Ltd.		Omineca	94D/9W	Cu,Au	Porphyry	geol; geophys
Hemlo Gold Mines Ltd.	094D 025	Omineca	94D/8E	Au,Cu	Skarn	4 ddh, 318 m
Kinross Gold Corp.	093A 121	Cariboo	93A/12W	Au	Skarn	8 ddh, 2500 m
Westmin Resources Ltd.	093N 164	Omineca	93N/2E	Cu	Porphyry	3 ddh, 301 m; IP
Consolidated North		Omineca	94D/9E	Cu,Au	Porphyry	geol; geophys
Global Metals Ltd.	093K 005	Omineca	93K/14W	Jade	Metamorphic	29 drill holes, 500 m
Hemlo Gold Mines Inc.	094D 027	Omineca	94D/9W	Au,Cu	Porphyry	geol; geophys
Hudson Bay Ex. & Dev. Ltd.	093F 061	Omineca	93F/12W	Au,Cu	Epithermal	trenching; IP
Canasil Resources Inc.	094E 147	Omineca	94E/2E, 7W	Au, Cu	Porphyry	3 ddh, 478 m; trenching
Durfield Geol.	094C 138-140	Omineca	94C/4E	Cu,Au	Porphyry	geol; geophys
26 BT Resources Dev. Co. Ltd.		Cariboo	93I/4E	Ti,Ma	Igneous	3 ddh, 275 m
Phelps Dodge Corp. of Can. Ltd.	093F 044	Omineca	93F/10	Au	Epithermal	geol; geochem; IP
Phelps Dodge Corp. of Can. Ltd.	093F 058	Omineca	93F/6E, 11E	Au	Epithermal	trenching; geol

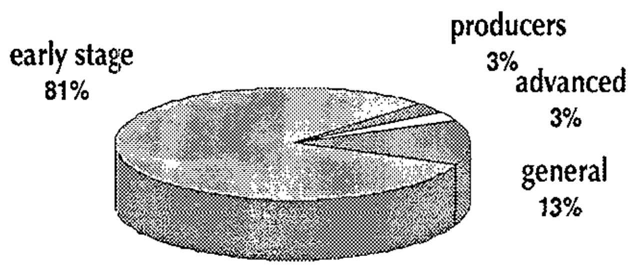

Figure 3. 1995 Exploration programs by type.

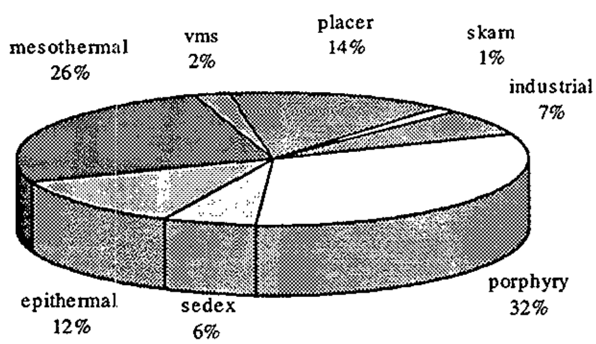

Figure 4. 1995 Exploration targets by deposit type.

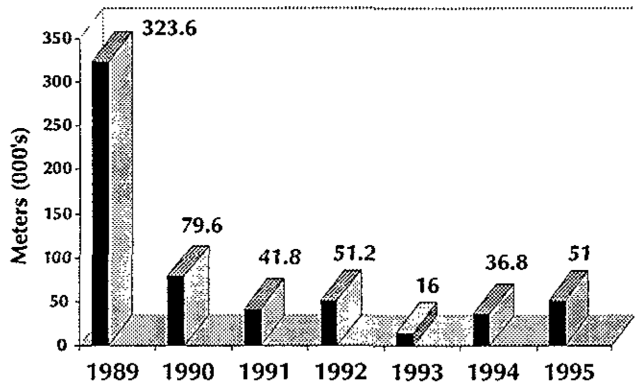

Figure 5. Exploration drilling 1989-1995.

Production from the region's operating mines increased significantly from the totals recorded during 1994. **Gibraltar** achieved a full year's production compared to the previous year when mining was suspended due to low copper prices. Possibly the brightest news for the region was the opening of the **QR** gold mine in May. The **Kemess South** project was given strong support by both the provincial government and the new owner, Royal Oak Mines Inc., with news that the Windy Craggy compensation issue would include support for economic infrastructure. The bulk-tonnage **Nazko** pumice project entered the Environmental Assessment process. The **Wishaw** quartzite quarry project had unforeseen road building delays, deferring development until the arrival of favourable spring weather in 1996 (Figure 6).

LAND USE

1995 was the first full year of implementation of the **Cariboo-Chilcotin Land Use Plan,** with progress made toward resolving issues of access and harvesting in sensitive management zones. A total of seven **Land and Resource Management Plan** (LRMP) tables were active in the Prince George Forest Region. Each table made significant gains toward reaching consensus on the Protected Area Strategy (PAS). Moreover, negotiations on proposed protected areas were given momentum by the Land Use Coordination Office which directed the tables to work toward meeting the reduced regional PAS target (which fell from 12% to 9%). Several planning tables are now close to completion and will probably present to government their recommended land and resource management plans by early summer of 1996.

OPERATING MINES

Steady coal production in the Northeast coalfield continued from the two large open-pit operations near Tumbler Ridge. At Quintette, managed by Teck Corporation and operated by Quintette Coal Limited, an estimated 4.166 million tonnes of clean metallurgical coal was produced during 1995. A rotary drill program conducted during the year on the Quintette coal lease focused on developing new reserves. A total of 11 254 metres of drilling was completed in 71 holes in the Babcock and Mesa Extension areas. Reserves in these areas are scheduled for mining beginning in 1998.

At Bullmoose, the Bullmoose Operating Corporation trucked an estimated 1.865 million tonnes of clean metallurgical coal for shipment by rail to Prince Rupert. A limited program of development drilling was completed at the South Fork Pit.

Placer Dome Canada Limited produced an estimated 6.626 million kilograms of molybdenum from the Endako mine near Fraser Lake. An exploration program supplemented by an Explore BC grant, was undertaken to expand the reserve base. It included just over 5000 metres of diamond drilling in 49 holes. Results are reported to be mixed.

At the Gibraltar mine near McLease Lake, both the copper and molybdenum circuits operated to capacity during 1995, mainly due to continued strong prices. A total of 13.852 million tonnes was milled, from which 30 394 tonnes of copper and 30.4 tonnes of molybdenum were recov-

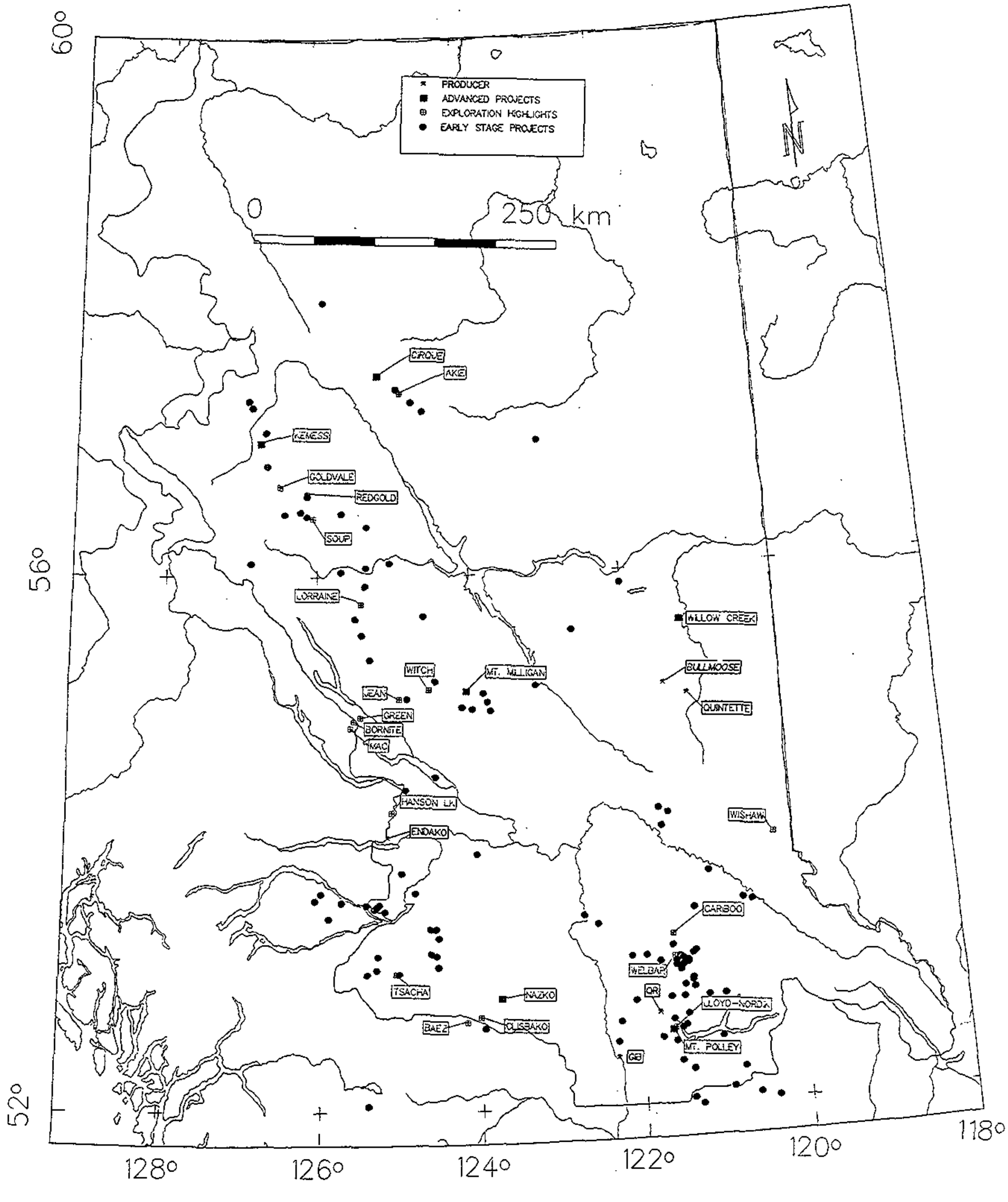

Figure 6. Map of Northeast - Central Region showing locations of mines and major exploration and development projects in 1995.

ered. A program of diamond drilling totalling 4962 metres in 37 holes was completed which resulted in the discovery of a new zone of copper-molybdenum mineralization. This zone has the potential to add 2.7 to 3.6 million tonnes to ore reserves, which at the end of the fourth quarter of 1995 totalled at 162.3 million tonnes grading 0.297% Cu and 0.009% Mo.

The QR gold mine, owned and operated by Kinross Gold Corporation, opened in June and brought dignitaries and government officials alike to the Quesnel area. The deposit is situated 60 kilometres southeast of Quesnel and is accessible by an all-weather forestry road. The deposit was discovered in 1975, and to date has a mineable reserve of 1.354 million tonnes grading 4.68 g/t Au. The reserves are in three discrete orebodies: Main, Midwest and West zones. They are expected to provide the operation with 5 years of mill feed.

The deposit is within the southern Quesnel Trough near the eastern edge of the Intermontane Belt. The property is underlain by Takla Group volcanics and fine-grained sediments that have been intruded by the alkalic QR diorite stock. Gold is associated with pyrite stockworks in both weakly and strongly propylitized fragmental basaltic rocks, and with disseminated pyrite in massive epidote skarn. Pyrite content varies from 2% to massive stringers and lenses with up to 80%.

Mining is by open pit, but will eventually switch to underground methods after depletion of the reserves in the Main zone. Development of the Main zone pit was started in 1994. Mill construction was completed in May with an official mill start-up on June 1, 1995. By mid-summer, the milling rate had increased from the design capacity of 800 tonnes per day to 1000 tonnes per day. Gold is recovered primarily by electrowinning, but with up to 30% of the gold recovered by gravity concentration prior to the cyanide-leach CIP process. The mine has been able to maintain a production rate of between 93 and 155 kilograms of gold per month at a mining rate of between 8000 and 10 000 tonnes per day. Kinross expects to produce 1370 kilograms of gold in 1996.

The potential for discovery of additional reserves on the property is considered high. An exploration program, conducted around the mine site in 1995, was partly funded by the Accelerated Mine Development Program, a component of the provincial government Explore BC program. The eight-hole, 2500-metre diamond drilling program tested for additional reserves at the extremities of the three known zones. Three deep holes explored along strike to the east of the Main zone and confirmed that the alteration and mineralization does extend. Five holes targeted at the western margin of the West zone were barren. The 1996 drilling program will follow-up encouraging results and will test the Hillside anomaly, as well as areas west of the West and Midwest zones.

ADVANCED EXPLORATION AND DEVELOPMENT PROJECTS

The British Columbia government announced in August that it had reached an agreement with Royal Oak Mines Inc., the principal shareholder of Geddes Resources Ltd., to resolve Geddes' claim for compensation for the expropriation of the Windy Craggy deposit.

Work undertaken by Royal Oak at the Kemess South deposit during 1995, included the extraction of two 200-tonne bulk samples for metallurgical testing, one taken in hypogene ore and one in supergene ore. A fully winterized camp was established on site, to begin construction on the airstrip to serve the mine. Issues facing the development are related to access management, engineering and design plans for the tailings facility, and compensation for loss of fisheries habitat. Royal Oak is planning for construction start-up in early spring of 1996. Reserves at the Kemess South deposit, in the measured category, are reported as 200 million tonnes grading 0.63 g/t Au and 0.220% Cu.

At the Mount Polley copper-gold project, diamond and percussion drilling completed during 1995 totaled 3589 metres in 23 holes. Metallurgical testing indicated better metal recovery than anticipated in an earlier feasibility study. Exploration drilling tested several soil anomalies and helped revise ore reserve calculations. Imperial Metals reports ore reserves now stand at 81 529 000 tonnes grading 0.30% Cu and 0.414 g/t Au. The earlier feasibility study, by Wright Engineers Ltd., reported measured reserves of 48 983 400 tonnes grading 0.54 g/t Au and 0.380% Cu. Revised project economics have reduced the stripping ratio to 1.12 to 1 from 1.76 to 1.

Road construction, soil stripping of the mill site area and tailings dam site preparation were also initiated in 1995. Imperial Metals anticipates that all financing for the open pit and mill will be completed by January 1996. Construction could begin as early as the spring of 1996.

At the Mt. Milligan copper-gold project, a design review was undertaken by owner Placer Dome Canada Limited to determine whether the project would be feasible in light of continued strong copper prices. With a projected 10 to 20% reduction in capital costs due to proposed design changes, the dormant project may yet become a mine. Providing that a feasibility study could be completed by the end of 1996 followed by a 20-month construction period, production could start as early as the first quarter of 1999. Placer Dome has begun a preliminary technical evaluation of the proposed changes to try to meet that timeline.

The original concept called for a 60 000 tonne/day open-pit mine, based on an indicated reserve of just under 300 million tonnes grading 0.22% Cu and 0.45 g/t Au. Geostatistical analysis of the ore reserve indicates a previously high-grade core in the Main zone, allowing in a lower cut-off grade and an additional 4 years of mine life.

Marked improvements to the original design include: change the steepness of the Main zone pit walls from 40-41% to 44-45% grade; reduce the number of grinding circuits from three to two; and implement a coarser primary grind circuit to save power costs. A power line, possibly linked to Kemess, would replace the original plan for a gas line with back-up hydroelectric power. A revised water management plan would simplify spill-control measures and localize the disturbance from tailings to the immediate pit area. A closer tailings disposal site would eliminate the requirement for a long conveyor system and reduce environmental impacts on Limestone Creek.

At the Nazko cinder quarry, owner Canada Pumice Limited is awaiting issuance of project approval after having completed the environmental assessment review necessary to increase production to 100 000 tonnes per year of pumice. A bulk sampling program was implemented in preparation for large-scale production in 1996. Ongoing quarry development brought an unexpected anomaly - both base and precious metal mineralization have been encountered throughout the cone.

The Giscome limestone quarry, located immediately north of Prince George, was limited to intermittent production throughout the year. Owned by Pacific Lime Ltd. and operated by Kode-Jerrat Quarries Ltd., the operation produces high-calcium limestone used as a neutralizing and digestive agent at several pulp mills in the region.

A bulk sampling program was planned by Ava Resources Ltd. to quarry quartzite blocks from the Wishaw site for sale overseas to decorative stone buyers. Road building, preparatory to extraction, was halted due to poor weather. Given favourable road building conditions in the spring of 1996, Ava hopes to be able to remove about 350 blocks from the site, at an average of 20 tonnes per block. The blocks are expected to be shipped to Montreal where container shipping will deliver the product to developed markets in Italy.

Development at the Willow Creek coal project, owned by Globaltex Industries Inc., was halted as the company sought joint venturing opportunities with Mitsui Matsushima Co. Ltd. and BCR Ventures Inc. (a wholly owned subsidiary of BC Rail Ltd.). A planned and permitted 25 000-tonne bulk sample was not extracted during 1995. An extensive drilling and sampling program is planned for early 1996. If the mine proceeds, initial production levels could reach 600 000 tonnes per year. Measured, indicated and inferred reserves at Willow Creek are reported at 72.56 million tonnes.

EXPLORATION

GATAGA BELT

A major program of deep drilling was conducted by Inmet Mining Corporation on the Akie property. Work at Akie dominated the exploration news in the region for much of the 1995 season. A second drill was mobilized to the property early in the season to accelerate progress hampered by delays caused by the Fort Ware forest fire. At the time of writing 18 holes have been completed on widely spaced step-outs and have confirmed the continuity of the bedded and massive sulphide mineralization tested in 1994. Drilling on the nineteenth hole was abandoned, at a depth of 1175 metres, due to inclement weather.

The stratiform sedimentary exhalative deposit is hosted in the distinctive lithologies of the Upper Devonian Gunsteel Formation. It is inferred from drilling to measure 1400 metres long by 800 metres deep by 20 metres thick, with several intersections grading 10% combined Zn-Pb. Mineralization is comprised of massive and semimassive pyrite-sphalerite-galena-barite and is locally interbedded with argillaceous sediments locally. Assays reported included an intersection of 9.06% combined Zn-Pb over 9.5 metres, at a depth of 983 metres. Soil sampling, VLF-EM, linecutting and mapping was also conducted on the property during 1995, and several large lead-zinc anomalies are reported on strike with the deposit.

Teck Corporation and Inmet Mining were active on several other properties located within the prospective Gataga belt, notably the Muskwa, Elf, Fluke and Rift properties. Late Devonian barite-sulphide deposits extend in a linear belt northwestward from the Akie River to Driftpile Creek. With the significant mineralization intersected at Akie and the previously defined resources, the Gataga Belt should generate interest again in 1996.

NORTHERN QUESNEL TROUGH

The majority of the major programs conducted in the region were located in the northern Quesnel Trough. Apart from the development work at Kemess, much of the work was early to middle-stage exploration on several established porphyry copper-gold properties. International Focus Resources Inc. conducted a program of induced polarization and other surface exploration, together with limited drilling, at the Jean property.

A 300-metre excavator-trenching program was completed on the Indata property by Eastfield Resources Ltd. and focused on two largely unexplored porphyry copper targets. The property had previously been explored for its lode gold potential. Recent work indicates copper mineralization is comprised of disseminations and quartz stockworks of bornite, chalcopyrite and magnetite, within a sequence of propylitically altered mafic volcanic and related intrusive rocks. One trench sample from the Lake zone returned 0.36% Cu over 75 metres. A new zone of mineralized quartz diorite, located 300 metres from the Lake zone, returned up to 2.76% Cu in grab samples. A follow-up program of diamond drilling is planned for early 1996.

Lysander Gold Corporation continued a major program of exploration on the Lorraine copper-gold property north of Fort St. James. Much of the work concentrated on the untested Upper Main zone, where precipitous terrain made drill staging a difficult process, even for a fly-weight drill. A total of 3984 metres of drilling was completed in 27 holes of which 24 holes were collared on the Upper Main zone. A program of metallurgical bulk sampling was also undertaken on the mineralized talus apron in the valley below.

Drilling results from the Upper Main zone included several multiple copper-gold intersections including 26.0 metres in hole 95-11 grading 1.23% Cu and 0.86 g/t Au, and 18.0 metres in hole 95-12 grading 1.42% Cu and 0.51 g/t Au. The company envisions a small-tonnage, high-grade deposit at Lorraine rather than the more traditional large-tonnage, low grade deposit. Lysander was also active at the Cat property, where it conducted a limited drill program.

Consolidated North Coast Industries Ltd. explored three properties south of Kemess. Airborne and ground geophysics and mapping targeted porphyry copper-gold systems in the Takla Group volcanics. Extensive biotite hornfels and skarn are reported from the Redgold property and appear to be associated with a dioritic stock intruded into volcanics and volcaniclastic sediments. Massive quartz veining mineralized with coarse chalcopyrite and bornite has also been reported.

At the Westmin Resources Ltd. Witch property, located near Chuchi Lake, limited drill testing and an induced polarization survey were completed by year end. Due to a late start, the drilling program did not test all the proposed targets.

At the Soup property, Hemlo Gold Mines Inc. drilled four holes in a 318-metre program to help define a gold-copper prospect. The drilling indicated gold-copper values associated with narrow magnetite and pyrite-mineralized quartz veins. The veins are structurally controlled and steeply dipping. The best intersection returned 7.02 g/t Au and 0.4% Cu over a true width of 3.56 metres. Hemlo was also active at the Goldway/Mariposite property, where surface exploration delineated a sheeted quartz-vein system hosted in altered andesite tuffs and epiclastics, close to a diorite stock. Selected vein samples returned better than 0.5 g/t Au. Results from programs at the Darb Creek and Granite Basin properties were largely disappointing, and Hemlo has no plans to return to either in the coming year.

Canasil Resources Inc. followed up on work completed earlier on the Brenda copper-gold property with a four-hole drill test of targets trenched in 1994. Results are said to be encouraging, with the best intersection taken from hole 95-3 which returned 50.6 metres grading 0.75 g/t Au and 0.10% Cu. Limited trenching exposed a 2.3-metre interval that returned 3.68 g/t Au. At the Hawk gold-copper property, Durfield Geological completed surface exploration that extended the three known mineralized zones and helped define targets for drill testing in the summer of 1996. Limited drilling at the Hanson Lake polymetallic prospect, owned by Columbia-Yukon Gold, indicated more work is justified.

One major and several early stage programs were completed in Cache Creek Terrane rocks west of the Quesnel Trough. Spokane Resources Ltd. conducted a major program of drilling, soil sampling, induced polarization and magnetic surveys on the Mac property, to further evaluate the porphyry molybdenum-copper potential. The property is located about 160 kilometres east of Smithers and was originally worked by Rio Algom which drilled twelve holes within the Camp zone. A porphyry molybdenum-copper system, has been defined by mapping, ground geophysics and soil sampling, measuring more than 3 kilometres long and 1.5 kilometres wide. Three discreet zones of mineralization have been defined within the system, and all appear open in several directions.

An eleven-hole, 2100-metre program of diamond drilling was completed in 1995: one hole tested the southern Peak zone; four tested the central Camp zone; and six tested the northern Pond zone. This drilling confirmed earlier indications of core areas of higher grade mineralization within each zone. At the Camp zone, higher grade molybdenite and chalcopyrite are associated with silicified volcanics at the contact with a quartz monzonite porphyry. The best intersection in the Camp zone returned 137 metres (hole 95-15) with an average grade of 0.125% Mo and 0.176% Cu. The northern subzone within the Camp zone was tested by hole 95-16, and returned 93 metres with an average grade of 0.13% Mo and 0.122% Cu. Road construction and a winter drilling program, 2000-metre are scheduled for early 1996.

Hera Resources began a reconnaissance drilling program on the Bornite property, northwest of Fort St. James. Three copper-in-soil anomalies were tested, and there are reports of porphyry-related mineralization on the property.

NECHAKO PLATEAU

Exploration on the Nechako Plateau focused on epithermal gold deposits, and to a lesser extent on porphyry-related precious and base metal systems. Industry interest has been spurred on by a greatly improved understanding of the regional geology facilitated by the joint provincial-federal mapping and geochemical sampling projects initiated by the Interior Plateau Project. With a better database and encouraging results from the past two seasons, 1995 marked the third successive year that major expenditures were committed to the plateau. More than $6 million has been spent by industry since the Canada - British Columbia Mineral Development Agreement began funding the project in 1992.

Hudson Bay Exploration and Development was active on several properties, including the Loon gold-silver property where an early-stage program of trenching, induced polarization surveys and mapping was completed. Lucero Resources Corporation discontinued exploration of the Wolf gold prospect until uncertainty over local land-use issues is resolved. In-fill drilling planned for 1996, to test the continuity of two zones at depth, could realize the potential for a medium-sized open-pitable deposit.

Teck Corporation conducted a major program of diamond drilling and trenching at the Tsacha gold-silver property located near the Blackwater River. Several gold and silver bearing quartz-carbonate veins, hosted by felsic volcanics of the Hazelton Group, have been discovered. The main Tommy vein has been delineated for 600 metres along strike and 150 metres down dip, with an average width of 3 to 4 metres. A total of 5100 metres of drilling in 35 holes and 300 metres of trenching was completed. One of the better 1995 drill intercepts was 13.4 g/t Au over a true width of 4.3 metres. Trench results from late 1994 include 38 g/t Au over 1.4 metres, 3.4 g/t over 8.8 metres and 7.3 g/t Au over 3.1 metres.

Phelps Dodge Corporation of Canada Ltd. was clearly the most active company on the plateau. Fox Geological conducted preliminary exploration on a total of 15 properties owned by Phelps Dodge. The largest expenditure was at the Clisbako gold prospect, where 800 metres of drilling was completed in four holes. Similarly, four holes tested the Baez prospect. More surface exploration was conducted at the Cutoff property, where Cogema Resources Inc. drilled the Trout prospect and several other targets during 1994. The Yellow Moose and Tonka properties were revisited, as were the Bako, Taken, Holy Cross and several others in the Laidman Lake and Lucus Lake areas. Typical of the plateau, results have been variable, from encouraging to disappointing.

Arnex Resources Ltd. completed exploration on the Tan, Kuy, and Chu prospects owned by Orvana Minerals Corporation. Results are reported to be encouraging. Kennecott Canada Inc. reports sulphidized and hornfelsed sediments and felsic pyroclastic rocks have been discovered along the eastern contact of an intrusive on its porphyry copper-gold prospect on the Kuyakuz property.

CARIBOO

Surface and underground drilling were performed at the historic Cariboo Gold Quartz mine by 50/50 joint venture partners, International Wayside Ltd. and Mosquito Consolidated Gold Mines Ltd. A comprehensive program of percussion, surface and underground drilling was initiated in an attempt to increase the known gold reserves in several vein-hosted zones on the property, and to explore the potential for bulk-mineable replacement ore. To date seventeen underground BQ holes have been completed, with assays pending from twelve. In addition, six percussion and five surface diamond-drill holes have been completed together with surface trenching and refurbishing of underground workings.

The program explored the up-plunge projection of the Rainbow zone for new ore reserves that would be amenable to open-pit mining. Underground drilling was conducted from the 1200-level adit up to 90 metres below surface in the Rainbow zone. Drilling has intersected pyrite mineralization similar to the replacement orebodies mined at several operations in the immediate area. Previous work on the Sanders zone outlined 1.1 million tons grading 4.11 g/t Au and the operators see similar potential in the Rainbow zone. Underground drilling, scheduled for January, will attempt to test the near-surface potential of the Pinkerton zone, one of nine zones known in the area.

At the Welbar project, Gold City Mining has continued its ambitious and comprehensive exploration program in the hope of developing bulk-tonnage, low-grade gold deposits in the Wells-Barkerville camp. To increase the chance for exploration success, the company has assembled, a large land holding in excess of 13 000 hectares, mainly under option agreements. The holding includes four former producing mines: Island Mountain, Cariboo Hudson, Mosquito Creek and a minority ownership position in the Cariboo Gold Quartz mine. Historically, gold production from the area's underground mines has been from narrow, high-grade quartz veins and thin lenses of massive pyrite. While there is still untested potential for development of high-grade veins, the Welbar project has focused mainly on conceptual targets where potential for large tonnages of open-pitable low-grade gold may exist peripheral to the veins.

High-resolution synthetic aperture radar and a multi-array airborne geophysical surveys was completed by Gold City to identify bedrock targets and resolve the major structures that control mineralization. Three large anomalies were identified that have high-potassium radiometric signatures coincident with high bulk-resisitivity and a high density of lineaments. In addition, ground geophysics, mapping, 3.5 kilometres of trenching and 3400 metres of drilling in 24 holes was finished before the onset of winter. Drilling was divided evenly between step-out and in-fill targets associated with the known resources, and new targets generated by the geophysical surveys. Results from some trench samples have been reported. At the Morning Star Crown grant, trenching of a large quartz-vein stockwork has returned favorable results, including 23.4 g/t gold over 1.4 metres in trench WC95-01.

The Lloyd-Nordik property, owned by Big Valley Resources Inc., was the focus of a program of detailed surface exploration and drilling. The property, adjacent to the Mount

Polley project, is believed to host a number of under-explored copper-gold targets peripheral to the Mount Polley stock. To date, five exploration targets have been identified. Drilling during 1995 comprised 4650 metres in 31 holes, with about 1000 metres of trenching also completed. Two new copper-gold soil geochemical anomalies have been identified, and are coincident with either an induced polarization chargeability high or magnetic low, or with both. Measuring about 500 metres wide by 2.5 kilometres long, the Lloyd Three zone will be drilled in 1996. Drilling on the Nordik Southeast zone returned 18 metres grading 0.09% Cu and 0.05 g/t Au in hole 95-31.

A program of surface exploration and limited drilling was undertaken by Noble Metal Group Inc. on the J1 mineral claims north of the company's placer deposits near Keithley Creek. Several drill targets, based upon high induced polarization anomalies, have been identified. Drilling was suspended late in the year due to weather conditions.

INDUSTRIAL MINERALS

Development work planned for the Dome Creek slate property by Dome Creek Structural Slate Ltd. was halted due to unforeseen delays in the issuance of forestry permits. 26BT Resource Development Co. Ltd. completed limited drilling in search of magnetite and titanium on the BT claims. Continental Lime met with mixed results at the Glen limestone property west of Dawson Creek. Possibly the best results were achieved at the optioned Green jade property northwest of Fort St. James where Global Metals Ltd. has now completed 27 shallow holes to quarrying depth. The holes are reported to have returned both foliated and massive occurrences of tremolite and nephrite. A positive response to the hardness, polishability and desirability of the stone intersected in core has resulted in a sales and distribution arrangement with Definity Marketing Inc. A bulk sample of approximately 60 tonnes of sandstone was taken from the Sam property near Fort. St. John. R.B. Masonry hopes to develop a quarry at the site in the near future.

OTHER

The board of directors of Cheni Resources Inc. resolved to close the Lawyers mine in the Toodoggone region of north-central British Columbia. The mine had been on a care and maintenance basis since December 1992.

Sable Resources Ltd. continues to evaluate the possible methods for extraction of the remaining gold ore at the Shasta property, adjacent to the closed Baker mine.

ACKNOWLEDGMENTS

The author also wishes to acknowledge the contribution of ideas and the critical review, provided by Ministry staff, particularly Bob Lane, David Pow and Ed Beswick. Klaus Brueckl kindly provided estimated mineral production statistics.

EXPLORATION AND DEVELOPMENT HIGHLIGHTS SOUTH-CENTRAL REGION - 1995

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Energy and Minerals Division

HIGHLIGHTS

- The region's base metal mines were generally profitable due to high metal prices and the low Canadian dollar.
- Exploration and development spending was **$12.4 million**, down by 25% from $16.5M spent in 1994. Junior companies were responsible for over 80% of spending. Most exploration work was done at existing minesites or advanced projects with only about 21% of spending going to grassroots prospects.
- The majority of exploration funds were directed to **porphyry Cu-Mo-Au-Ag** and **vein Au-Ag** deposits.
- The **Getty North** (Krain) oxide-sulphide copper project was the largest in the region in 1995. A major drilling program was directed toward evaluating the potential for SX-EW copper production from oxide ore and the tenor of deeper hypogene copper mineralization.
- The **Bralorne** gold mine received a mine development certificate in March, 1995 and is being readied for production in 1996.
- Teck Exploration Ltd. and Getchell Resources Inc. redrilled the **Rainbow #2** porphyry Cu-Au deposit near Afton, defining a potential reserve of 14.1 million tonnes grading 0.5% Cu. A new extension of the zone was discovered late in the program.
- The outlook for 1996 is bright. Several advanced projects should see large exploration programs and a number of promising grassroots prospects will be drilled. Interest in **porphyry Cu-Mo-Au-Ag and vein Au-Ag** deposits is expected to remain strong. There may be a possible revival of interest in **polymetallic massive sulphide** and **bulk tonnage** Au targets as a spillover from discoveries in the northern cordillera.

TRENDS IN EXPLORATION ACTIVITY

Total exploration and development spending in the South-Central Region during 1995 is estimated at $12.4 million, down 25% from 1994. This figure is 38% lower than the $20 million spent in 1989 (Figure 1). This reduction can be attributed to strong competition for exploration dollars from jurisdictions outside of British Columbia, uncertainty related to land-use planning and native land claims, and the absence of any very large development projects. In previous years, huge projects such as Fish Lake ($7 million in 1993) were major contributors to overall spending totals.

Nevertheless, as in previous years, a few prominent projects accounted for a large proportion of the spending. The two largest projects were **Getty North** (Krain) and **Siwash North** (Elk) which together accounted for about $3.8 million.

The number of major exploration programs ($100 000 in spending) dropped by over 30% from the 34 projects in 1994 to 23 in 1995. By comparison, in 1989, there were 42 major projects in the region (Figure 2).

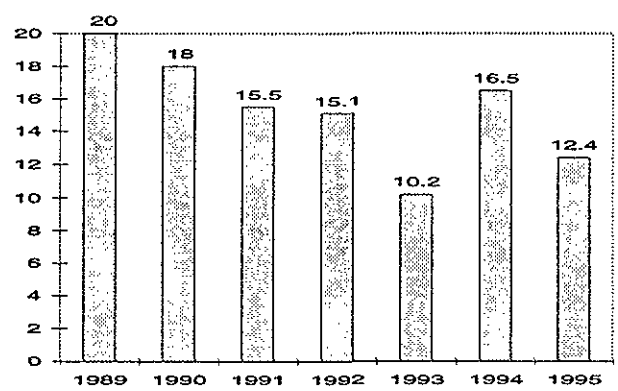

Figure 1. Annual exploration and development spending in millions of dollars, South-Central Region, 1989-1995.

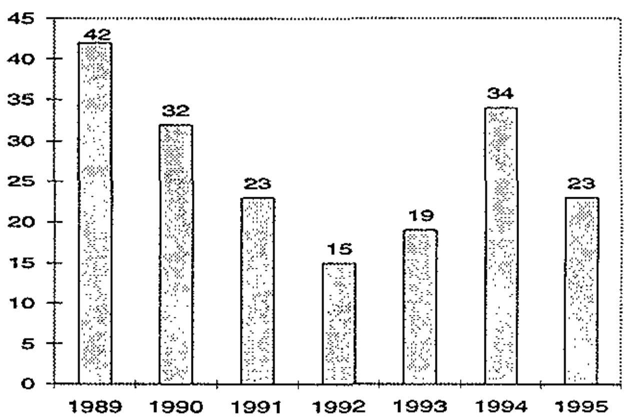

Figure 2. Number of major exploration projects per year,

The number of major exploration programs ($100 000 in spending) dropped by over 30% from the 34 projects in 1994 to 23 in 1995. By comparison, in 1989, there were 42 major projects in the region (Figure 2).

Claim staking activity was down slightly from 1994, to about 4600 units, and down substantially from nearly 14 000 units staked in 1991 (Figure 3). The number of claims forfeited per year shows a similar decline, from over 18 000 in 1991 to nearly 8000 in 1995. Of particular concern is that for each of the last five years the number of claims forfeited has substantially exceeded the number of new claims staked. This has resulted in a net decrease of about 30 000 claim units over the five-year period. On the positive side, the annual net decrease in tenure held appears to be slowing, and more importantly, prospective ground is becoming available for new staking.

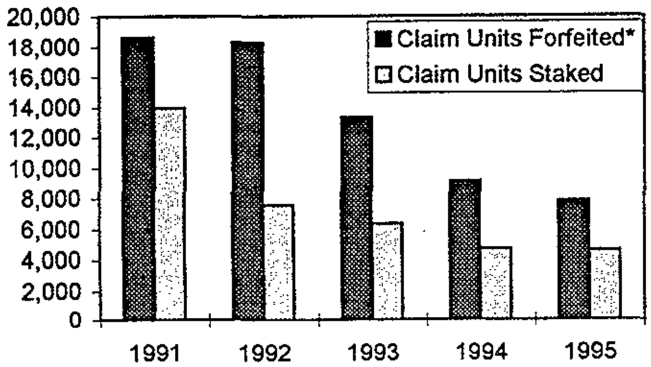

Figure 3. Number of mineral claim units forfeited* and staked per year, South-Central Region**, 1991-1995. (*Forfeited includes surrendered, abandoned and cancelled claims. ** For the purposes of this analysis, "South-Central Region" includes all of the Clinton, Kamloops, Lillooet, Nicola, Osoyoos, Revelstoke, Similkameen and Vernon Mining Divisions.)

Metres of drilling is perhaps the best indicator of advanced exploration and development activity. In 1995 there was about 72 000 metres of drilling in the region, about the same as 1994 (Figure 4). This is up substantially from just 28 000 m drilled in 1993, but still short of the average of over 100 000 metres per year from the period 1989-1992.

Figure 5 shows the breakdown of spending between minesite, advanced and grassroots project categories. Roughly 44% of all spending was at minesites (operating mines, temporarily closed mines or projects with an approved mine development certificate). A further 35% went to advanced exploration or development projects and included mainly definition drilling, underground development, bulk sampling and environmental, processing and marketing studies. Unfortunately only 21% of spending was on grassroots projects, defined here as including mainly geological, geochemical or geophysical surveys or early stage drilling on new or poorly explored targets. The low percentage of grassroots work is disturbing and reflects continuing weakness in this critically important part of the industry.

In terms of broad exploration targets, most funds were directed to deposit types and commodities for which the region is renowned (Figure 6). As expected, porphyry and related deposits of copper-molybdenum-gold-silver and high-grade gold-silver veins accounted for most of the spending, about 44% each. Stratiform base metal targets accounted for just 6%, despite the well documented high potential in the region, particularly in Eagle Bay, Shuswap and Kootenay Arc rocks. Industrial mineral targets make up another 6% of spending.

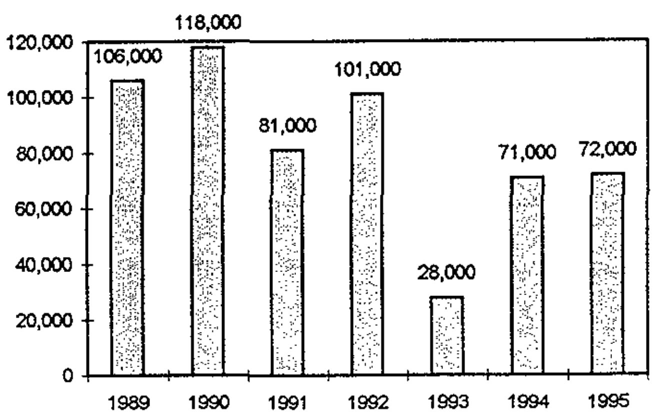

Figure 4. Metres of exploration and development drilling per year, South-Central Region, 1989-1995.

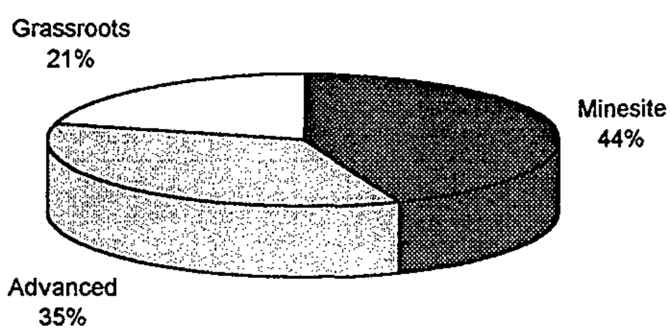

Figure 5. Percentage breakdown of spending in 1995 by category of work program.

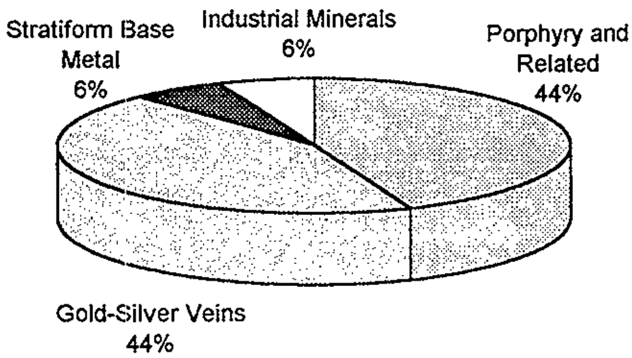

Figure 6. Percentage breakdown of spending in 1995 by exploration target.

It is interesting that more than 80% of all exploration and development funds were spent by junior companies or individuals this year. With a the exception of minesite exploration, the major mining companies invested very little in exploration in the region in 1995.

PRODUCING METAL MINES

1995 was a better year at most of the producing metal mines in the region, mainly as a result of strong copper and molybdenum prices and the low Canadian dollar. The operating mines are listed in Table 1 and their locations are shown on Figure 7. Exploration and development work at individual minesites is detailed in the following section.

The **Similco** mine of Princeton Mining Corporation produced mainly from its low-grade stockpile during the year, gradually bringing on production from the Ingerbelle pit expansion. After re-opening the **Ajax** East pit in the fall of 1994, Afton Operating Corporation began mining again

TABLE 1
OPERATING MINES AD QUARRIES, SOUTH-CENTRAL REGION, 1995

MINE	OPERATOR	COMMODITY	COMMENTS
Large Metal Mines			
Ajax	Afton Operating Corp.	Cu, Au, Ag	Re-opened Ajax West pit in February, 1995
Goldstream	Imperial Metals Corp./Goldnev Resources Inc.	Cu, Zn, Ag	Ceased mining in January, 1996
Highland Valley	Highland Valley Copper	Cu, Mo, Au, Ag	
Nickel Plate	Homestake Canada Inc.	Au, Ag	Closure planned for October, 1996
Similco	Princeton Mining Corp.	Cu, Au, Ag	Produced mainly from low-grade stockpile; began mining from expanded Ingerbelle pit during the year
Small Mines and Quarries			
Craigmont tailings	M Seven Industries Inc.	Magnetite	
Harper Ranch	Lafarge Canada Inc.	Limestone	
Mascot Gold tailings	Candorado Operating Co. Ltd.	Au	Ceased mining in November, 1995; heap leaching to continue in 1996
Moberly	Mountain Mineral Co. Ltd.	Silica	
Nicholson	Bert Miller Contracting Ltd.	Silica	
Parson	Mountain Mineral Co. Ltd.	Barite	
Pavilion Lake	Continental Lime Ltd.	Lime	
Red Lake	Western Industrial Clay Products	Fullers Earth	

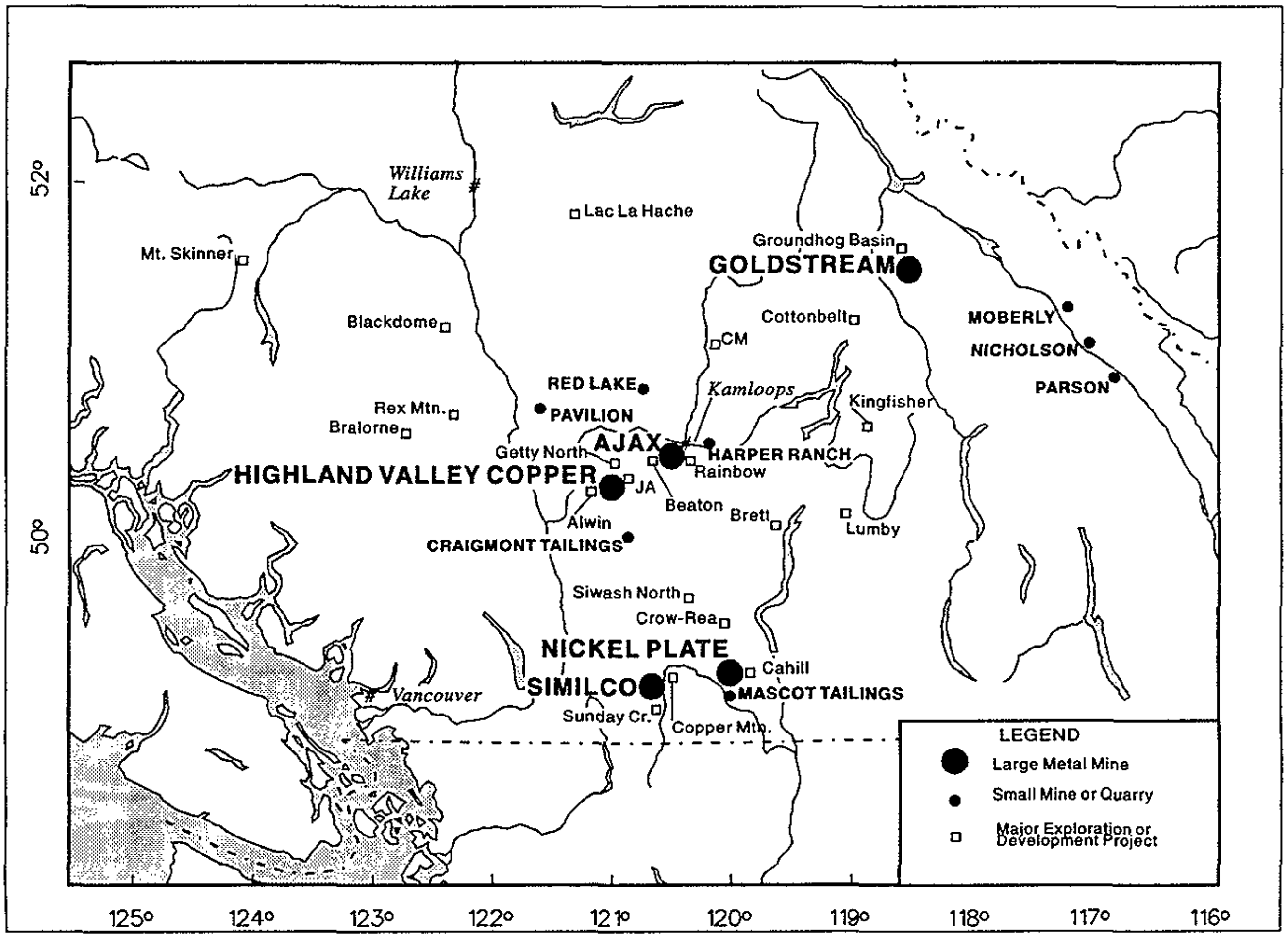

Figure 7. Map of South-Central Region showing locations of operating mines and major exploration and development projects in 1995.

in the Ajax West pit in February of 1995. **Highland Valley Copper** had an excellent year, reporting profits of $258 million for the calendar year. Production was mainly from the Valley pit. The **Goldstream** underground copper-zinc mine suffered from increasing underground haulage distances and announced it would close in January 1996 due to the exhaustion of ore reserves. Homestake Canada Inc. announced that the **Nickel Plate** gold mine will close permanently in late 1996 after operating since 1987. Also in the Hedley area, the **Mascot Gold tailings** heap-leach operation of Candorado Operating Co. Ltd. announced closure in late 1995. Leaching and reclamation will continue in 1996.

EXPLORATION AND DEVELOPMENT ACTIVITY

There were numerous positive developments in the region in 1995. Figure 7 shows the locations of major exploration projects. Details of each project are listed in Table 2.

GUICHON CREEK BATHOLITH

Highland Valley Copper explored various targets on its large property this year. The company conducted high-power, deep-penetrating induced polarization surveys and drilling at the JA deposit, induced polarization surveys southwest of Lornex, near Roscoe Lake and north of Bethlehem, and drilling in the Valley pit area. The company's goal is to locate and delineate additional reserves for the operation, which is currently slated to be depleted in the year 2008.

The **Getty North** project of Getty Copper Corporation was one of the largest projects in the region in 1995. The project area covers the partially oxidised Krain porphyry copper deposit located 8 kilometres north of the Bethlehem minesite. Getty conducted remote sensing analysis, a large induced polarization survey and diamond drilling totalling 7627 metres in 33 closely spaced holes. The objective of this work was to better define resources of oxide copper which are potentially amenable to low-cost solvent extraction-electrowinning (SX-EW) processing, and to evaluate under-

TABLE 2
MAJOR EXPLORATION AND DEVELOPMENT PROJECTS
SOUTH-CENTRAL REGION, 1995

Property	Operator	MINFILE Number	Mining Division	NTS	Commodity	Deposit Type	Work done
Ajax & Pothook pits	Afton Operating Corp.	92INE012	Kamloops	92I/09W	Cu, Au	Alkaline porphyry	33 ddh, 5782 m
Alwin (OK mine)	Claimstaker Resources Ltd.	92ISW 010	Kamloops	92I/06E	Cu	Vein/Porphyry	Shipped approx 2000 t to Afton mill
Beaton Group	Lakewood Mining Co. Ltd.	None	Kamloops	92I/10E	Au, Cu	Porphyry/Vein?	7 ddh, 1845 m; 1 pdh, 57.3 m
Blackdome mine	Claimstaker Resources Ltd./Aurizon Mines Ltd.	92O 051	Clinton	92O/08W	Au, Ag	Epithermal vein	960 m u/g drilling; u/g devel; 1800 t bulk sample; geol; geochem
Bralorne mine	International Avino Mines Ltd. / Bralorne-Pioneer Gold Mines Ltd.	92JNE001	Lillooet	92J/15W	Au, Ag	Mesothermal vein	Approx 400 m u/g devel; 15 u/g & sfc ddh, approx 2100 m; trench
Brett	Huntington Resources Inc./Liquid Gold Res. Ltd.	82LSW110	Vernon	82L/04E	Au, Ag	Epithermal vein	U/g dev, 173 m; u/g rehab; bulk sample; 1 trench
Cahill	Homestake Canada Inc.	None	Osoyoos	92H/08E	Au	Vein/Skarn	7 ddh, 947 m
CM	Inco Exploration and Technical Services Inc.	92P 101	Kamloops	92P/08E	Cu, Zn, Au, Ag, Pb	Massive sulphide	7 ddh, 1181 m
Copper Mountain (Alabama, P4, WR)	Princeton Mining Corp.	92HSE013	Similkameen	92H/07E	Cu, Au	Alkaline porphyry	29 rcdh, 5186 m; trenching, 344 m; geol; IP
Cottonbelt	CanQuest Resource Corp.	82M 086	Kamloops	82M/07W	Zn, Pb, Cu, Ag	Sedex	24 ddh, 1937 m; geol; mag
Crow-Rea (Lori)	Verdstone Gold Corp./Amcorp Industries Inc.	92HNE138	Osoyoos	92H/09E	Mo	Porphyry	19 ddh; trenching; geochem; geol
Getty North (Krain)	Getty Copper Corp.	92INE038	Kamloops	92I/10W	Cu, Mo, Au, Ag	Calc-alkaline Porphyry	33 ddh, 7627 m; geophys
Goldstream mine	Imperial Metals Corp./Goldnev Resources Inc.	82M 141	Revelstoke	82M/10E	Cu, Zn, Pb, Au, Ag	Besshi-type Massive Sulphide	2 sfc ddh, 804.4 m; 4 u/g ddh, 807.4 m; geochem
Groundhog Basin	Orphan Boy Resources Inc.	82M 167	Revelstoke	82M/09W	Au, Ag	Mesothermal vein	12 ddh, 1449 m
JA, Valley, Lornex, Bethlehem	Highland Valley Copper	92ISW012	Kamloops	92I/06E	Cu, Mo, Au, Ag	Calc-alkaline Porphyry	13 ddh, 5653 m, IP, 349 km
Kingfisher	Franz Capital Corp.	82LNE023	Vernon	82L/10E	Marble	Industrial mineral	Approx 10 000 t bulk sample; drilling; trenching; site prep
Lac La Hache	Regional Resources Ltd.	92P 002	Clinton	92P/14E	Cu, Au	Porphyry, Skarn	28 ddh, 3489 m; road; IP, mag
Lumby	The Quinto Mining Corp.	82LSE006	Vernon	82L/07W	Graphite/ Sericite	Industrial mineral	Processing and marketing studies; rehab of old mill
Mt. Skinner	Ottarasko Mines Ltd.	92N 039	Clinton	92N/09W	Au, Ag	Mesothermal vein	U/g development; 350 t bulk sample
Rainbow	Teck Exploration Ltd./Getchell Resources Inc.	92INE028	Kamloops	92I/09W	Cu, Au, Ag, Mo	Alkaline porphyry	27 ddh, approx 6000 m
Rex Mountain (Spokane Group)	Spokane Resources Ltd.	92JNE034	Lillooet	92J/16W	Au, Cu	Mesothermal vein	20 ddh, 2531 m; geol; geochem
Siwash North (Elk)	Fairfield Minerals Ltd.	92HNE096	Similkameen	92H/16W	Au, Ag	Mesothermal vein	98 sfc. ddh, 6406 m; 217 u/g ddh, 7568 m; 645 m u/g dev
Sunday Creek	Canmark International Resources Inc.	92HSE168	Similkameen	92H.028	Zeolite	Industrial mineral	1000 t bulk sample; roads, 2000 m

included metallurgical testing as leachability, copper recovery and acid consumption will be critical factors in the economics of the oxide deposit.

The 1995 work indicates that the North zone (Krain) has dimensions in the order of 300 to 350 metres in length, 150 to 250 m in width and at least 300 metres in depth with grades of 0.3 to 0.7% Cu (D. Blann, personal communication, 1996). The oxide zone is know to extend as deep as 150 metres and is thickest to the north where it is overlain by Tertiary basalts of the Kamloops Group. A 1972 grade and tonnage calculation by Quintana Mineral Corporation estimated a total reserve of 14 million tonnes grading 0.56% Cu and 0.01% Mo using a cut-off grade of 0.3% Cu. Of this total, about 4.9 million tonnes were defined as oxide with a grade of 0.64% Cu (Christie, 1976). A new reserve calculation, to be completed in early 1996, is expected to improve the reserve base. In addition, step-out drilling will evaluate other showings and new targets generated by the induced polarization survey.

At the **Alwin** project (OK mine) located a few kilometres west of the Highland Valley Copper mine, Claimstaker Resources Ltd. shipped a few thousand tonnes of high-grade copper ore to the Afton mill near Kamloops. The ore consisted of boulders of vein material which were too large to be milled by previous operators. Claimstaker also evaluated the feasibility of reopening the underground mine to extract and direct ship 100 to 200 tonnes of high grade copper ore per day. Underground reserves estimated by a previous operator total about 390 000 tonnes grading 2.5% Cu.

IRON MASK BATHOLITH

Southwest of Kamloops, in the Iron Mask batholith, Teck Corporation was busy trying to find and define copper resources for the **Afton-Ajax** operation which is approaching exhaustion of reserves. On the mine property, 5782 metres was drilled in 33 holes on the margins of the Ajax West and East pits, with two holes in the area of the former producing Pothook pit. Previous drilling around the West pit was widely spaced and the current program was successful in locating mineralization that may increase the tonnage and/or grade of the remaining reserves.

At the nearby **Rainbow** property, a joint venture of Teck Exploration Ltd. and Getchell Resources Inc. conducted a substantial program of relatively tightly spaced, angle drilling in an attempt to define an open-pittable orebody on the Rainbow #2 zone. The work defined a potential resource of 14 100 000 tonnes of 0.5% Cu to a depth of 300 metres. The zone is open at depth where previous drilling intersected grades of 4 to 5% Cu. In addition, an extension of the zone, named the Rainbow #22 zone, was discovered to the southeast of the known deposit. The best hole in this zone intersected 66 metres grading 0.88 % Cu and 0.23 g/t Au. It remains open and further drilling is planned in 1996. Copper mineralization at Rainbow occurs in a complex faulted zone containing slivers of Nicola volcanic rocks interleaved and intruded by several phases of the Iron Mask batholith.

PRINCETON-HEDLEY AREA

At **Copper Mountain**, Princeton Mining Corporation, conducted reverse circulation drilling and trenching on the Alabama Cu-Au deposit in an attempt to increase known reserves. Prior to the 1995 drilling, a preliminary probable reserve, based on 130-metre section spacing, indicated 19.6 million tonnes grading 0.312% Cu and 0.16 g/t Au with a low stripping ratio (Princeton Mining Corp., 1995). Mineralization is controlled by a large, well mineralized vertical fault zone. Trenching of induced polarization anomalies at the P4 target uncovered only disseminated pyrite in Nicola volcanic rocks. Similco also trenched on the WR 1-6 claims optioned from Westmin Resources Ltd.

Drilling was also conducted on the nearby **Whipsaw** porphyry Cu-Mo-Au target, located southwest of the Similco mine. The project was managed by Richardson Geological Consulting on behalf of private company Martech Industries Inc.

On the **Cahill** claims east of the Nickel Plate mine, Homestake Canada Inc. drilled seven widely spaced holes to test for gold mineralization. The area is east of the Cahill Creek fault. Several of the holes intersected thick sections of an unmapped, poorly consolidated heterolithic breccia which may be part of the mid-Eocene Springbrook Formation. One hole returned a narrow gold intercept from a fault zone cutting skarn (W. Wilkinson, personal communication, 1995).

LILLOOET-GOLD BRIDGE AREA

The historic **Bralorne gold** mine, jointly owned by International Avino Mines Ltd and Bralorne-Pioneer Gold Mines Ltd., received a mine development certificate in March 1995. During the year the partners focused on financing, refitting the mill, design and stripping of the tailings impoundment site and permitting.

Exploration and development work at Bralorne included rehabilitation of workings on the 400 and 800 levels, thirteen trenches and seven surface holes on the newly discovered Maddy zone, and underground diamond drilling of the Taylor and 52 veins from the 400 level. Most significantly, a drift 233 metres long on the 800 level was driven on the suspected down dip extension of the Peter vein. An average grade of 15.8 g/t Au was returned over a true width of about 2 metres and a strike length of 33 metres. This drift is nearly 300 m down dip from a 1992 adit which returned an average grade of 13.0 g/t over a width of 1.1 metre and a strike length of 70.5 metres. The 1995 work also included crosscuts on the 800 level and underground drilling to test the Peter vein and adjacent Big Solly vein. Work in 1996 will consist of stope development and mill construction.

At the **Minto** and **Olympic** gold property, northeast of Bralorne, International Wayside Gold Mines Ltd. completed seven diamond-drill holes late in the year.

On the **Rex Mountain** (Spokane Group) Au-Cu property in the Shulaps Range, Spokane Resources Ltd. completed a twenty- hole, angle diamond-drilling program. The holes tested a shear zone hosting a series of mesothermal, listwanite-related quartz veins containing pyrite, pyrrhotite, chalcopyrite and bismuthinite (A. Boronowski, personal communication, 1995). To date the vein system has been tested over a strike length of 700 metres and to a depth of 75 metres. The company released a resource estimate of 190 000 tonnes grading 8.6 g/t Au and 0.92% Cu for the zone.

Closer to Lillooet, Homestake Canada Inc. optioned the **Ample-Goldmax** claims from prospectors Gary Polischuck and Dave Javorsky. An interesting new showing of high-grade gold in quartz veins beneath a thrust fault is hosted by strongly folded sediments mapped as Upper Jurassic-to Lower Cretaceous Brew Group. The prospect is located on a steep hillside above the Duffy Lake road. Drilling of this grassroots prospect is planned for early 1996.

OKANAGAN VALLEY

The high-grade **Siwash North** gold mine (Elk claims) of Fairfield Minerals Ltd. was the largest exploration and development project in the region in 1995. In order to finance part of this work, the company shipped about 1800 tonnes of stockpiled ore containing about 118 kilograms gold and 184 kilograms silver to the ASARCO smelter in Montana. The underground decline was extended and a large program of surface and underground diamond drilling totalling 13 203 metres in 287 holes was completed. This program was successful in defining total diluted underground and open-pit reserves of 121 400 tonnes at a grade of 27 g/t Au in the probable and possible categories . Elsewhere on the Elk property, five other gold vein targets were tested by 28 holes totalling 1826 metres.

Fairfield also conducted soil sampling, trenching, overburden drilling and diamond drilling on gold targets on the nearby **Bank**, **Crest**, **Pen** and **Swan** claims located to the south and east of the Elk claims.

At the **Brett** epithermal gold vein deposit west of Okanagan Lake, development work was slowed by an ownership dispute between partners Huntington Resources Inc. and Liquid Gold Resources Inc. In late 1994 and early 1995 an adit and raise were driven towards the Bonanza zone in order to extract a bulk sample for shipment to a custom mill. Later in 1995 a 225-tonne bulk sample, grading 34.2 g/t Au and 63.4 g/t Ag, was mined on surface from the R.W. vein.

West of Summerland, the **Crow-Rea** (Lori) molybdenum property of Amcorp Industries Inc. and Verdstone Gold Corp. was tested by soil geochemistry, trenching and 19 diamond-drill holes. Following up on surface sampling which returned up to 2.66% Mo, the company reported several short, high-grade drill intercepts such as 9 metres grading 0.256% Mo. The work will continue into 1996.

At the **Munro Lake** Cu-Mo-Au-Ag property of Almaden Resources Corp., induced polarization surveys were conducted to define extensions of anomalies discovered in 1994. This zone is underlain by intrusive rocks which may be part of the Pennask batholith, which also hosted the now-depleted Brenda porphyry Mo-Cu orebody 12 kilometres to the north. The area has thick till cover making exploration difficult. A limited drilling and trenching program in the 1970s identified low-grade porphyry-style mineralization on the property. The induced polarization anomalies are reported to be located directly up-ice from a large area with anomalous Au-Ag-Cu-Mo-Zn in the heavy mineral fraction of basal till from overburden drillholes. Drilling of this promising, grassroots bulk-tonnage target is planned for 1996.

KOOTENAY TERRANE AND SHUSWAP COMPLEX

Despite well documented potential for polymetallic massive sulphide deposits, the Kootenay Terrane received relatively little exploration attention in 1995. This was the first year in perhaps a decade when the Paleozoic Eagle Bay assemblage north of Kamloops had no significant exploration programs.

At the **Goldstream** Cu-Zn mine north of Revelstoke, exploration consisted of underground drilling to test for parallel mineralized zones beneath the main massive sulphide lens, and surface drilling to test for mineralization west of the mine. The mine closed in January, 1996; however, it is worth noting that the massive sulphide deposit is not entirely depleted. Mining has simply become uneconomic due to the long haul distance to surface and the resultant inability of the mine to keep the mill fed at an optimum rate. High-grade Cu-Zn mineralization is still present in the deepest stopes and is open at depth.

The **Groundhog Basin** property of Orphan Boy Resources Inc. received drilling totalling 1449 metres in twelve holes. The property is located at the head of McCulloch Creek, north of the Goldstream mine, and hosts gold-bearing quartz veins in metasedimentary and metavolcanic rocks of the Lardeau Group.

North of Barriere, Inco Exploration and Technical Services Ltd. tested geophysical anomalies on the **CM** property with seven drillholes. Results were disappointing. Small showings of Cyprus-type massive sulphide Cu-Zn mineralization are known on the property and are similar to the Chu Chua deposit is hosted by the Mississippian-Triassic Fennell Formation.

In high-grade metamorphic rocks of the Shuswap Complex, the **Cottonbelt** massive sulphide Zn-Pb-Ag deposit was explored by CanQuest Resource Corp. Twenty-four holes were drilled to test for structurally thickened "rods" along a thin, persistent stratiform layer which occurs on both limbs of the Mount Grace syncline. The company has recognised similarities of the mineralization with the huge metamorphosed massive sulphide deposits at Broken Hill, Australia.

CARIBOO-CHILCOTIN PLATEAU

The large **Lac La Hache** property operated by Regional Resources Ltd. was active again this year. The property covers numerous alkaline porphyry, skarn and vein Cu-Au prospects hosted by mafic volcanic and dioritic intrusive rocks of the Nicola Group and granodiorite of the Early Jurassic Takomkane batholith. The company conducted induced polarization surveys and completed 28 drill holes on several targets. The most encouraging results came from a chargeability anomaly on the TT claims south of Murphy Lake. This area is heavily drift covered and is underlain by Takomkane batholith.

At the past-producing **Blackdome** gold mine, located west of the Fraser River, Claimstaker Resources Ltd. entered an option agreement with Aurizon Mines Ltd. and began exploration, development and rehabilitation in order to put the mine back into production. Work included drifting, crosscutting and raising on the #11 vein, a 2000-tonne bulk sample from the #11 vein on surface, diamond drilling on the #18, #11 and #19 veins, partial rehabilitation of the 1870 and 1920 levels, soil sampling and reconnaissance prospecting. Aurizon dropped the option late in the year but Claimstaker will proceed with more work in 1996.

Ottarasko Mines Ltd. completed an underground bulk sampling program at the **Mt. Skinner** property. About 350 tonnes of quartz vein material containing 18.5 kilograms of gold and 19.0 kilograms of silver were mined and shipped to the Trail smelter and the Premier mill.

INDUSTRIAL MINERALS

Industrial minerals quarries and mines in south-central British Columbia are shown on Figure 7 and listed in Table 1. Exploration and development activity for industrial mineral commodities was steady this year, with most interest directed to graphite-sericite, absorbent minerals, bentonite, dimension stone, landscape rock, garnet and talc.

At the **Craigmont tailings** magnetite operation of M Seven Industries Inc., production continued at a rate of about 60 000 tonnes of magnetite per year. The operation recovers magnetite from tailings derived from the Craigmont copper skarn deposit. The product is sold to many of the coal mines in western Canada for use in coal beneficiation. During 1995, the company submitted a conceptual plan to the provincial government to increase its tailings storage capacity and to access additional old tailings for re-processing. This plan would increase the life of the operation by 15 years. A formal proposal is expected in 1996.

On the **Lumby** graphite-sericite project, Quinto Mining Corporation continued processing and marketing studies, began expanding the existing mill building on site, and submitted a mine development proposal under the **Environmental Assessment Act**. The company proposes to mine graphitic shale from a shear zone and produce very fine grained mixtures of sericite-graphite for use as a filler in specialty plastics. After deciding that a smaller operation was more appropriate, the company withdrew this EA application late in the year and plans to apply for a small mine permit (<25 000 tonnes per year) under the **Mines Act**.

Western Industrial Clay Products Ltd. conducted auger drilling at the **Red Lake** quarry to define additional reserves of fullers earth. Existing production from this quarry supplies about half of the kitty litter market in western Canada.

Several zeolite properties were advanced toward commercial production this year. At **Sunday Creek**, near Princeton, Canmark International Resources Inc. took a 1000 tonne bulk sample. Near Cache Creek, Mountain Minerals Co. Ltd. submitted applications to quarry 8000 to 9000 tonnes per year from each of the Z-1 and Z-2 sites on the **Ranchlands** claims. The material would be trucked to a plant in Rocky Mountain House, Alberta for crushing and sizing. It is being tested for use as a feed additive for pigs.

The **Kingfisher** marble quarry east of Lumby continued small-scale production during the year. Operated by Franz Capital Corp. Ltd., the quarry produces split and crushed white marble for decorative and landscaping uses.

Near Princeton, Clayburn Industries Ltd. took a 230-tonne bulk sample of pyrophyllite from the **CIL** property for use in its refractory bricks which are manufactured in a plant at Abbotsford.

On **Stitt Creek** north of Revelstoke, Cassiar Coal Company continued evaluation of a placer garnet deposit. Work included 25 drillholes, four test pits and bulk sampling.

Okanagan Opal Inc. continued testing on its unique **Klinker** precious opal property near Vernon. Fire opal occurs in cavities and veins in basalt of the Eocene Kamloops Group. The company took a 52- tonne bulk sample for market testing of jewellery made from the material. Other prospectors are looking for similar deposits of opal and agate in the area.

OPPORTUNITIES AND OUTLOOK FOR 1996

It is expected that bulk-tonnage **porphyry Cu-Mo-Au-Ag** deposits and small, **high-grade Au-Ag veins** will continue to be the most attractive targets in the year ahead. Interest and exploration for **industrial minerals** continues to grow steadily.

Although interest in **stratiform base metal targets** has waned in this region recently, it is expected that activity will revive soon. Numerous claims have lapsed in recent years and ground with good potential is available for staking. In particular, the **Eagle Bay assemblage** has excellent potential for Devono-Mississippian precious metal enriched, Kuroko-type, volcanogenic massive sulphide deposits and is similar in many respects to the Yukon-Tanana Terrane in the southern Yukon. The discovery of the Kudz Ze Kayak and Wolverine deposits in the Yukon-Tanana rocks has created excitement over these types of deposits and Devono-Mississippian volcanic rocks in general. It is only a matter of time until explorationists "rediscover" the promising deposits and targets in the Eagle Bay rocks such as the Homestake, Kamad, Rea, Twin, Birk Creek, Harper Creek and Mila.

Exploration interest in **bulk-tonnage gold** targets in this region may also increase due to the recent discoveries of large low-grade deposits in the northern Cordillera, such as **Taurus, Fort Knox and Dublin Gulch**. Promising targets in this area include intrusion-hosted stockwork or porphyry-style mineralization (*e.g.* **Munro Lake**), and sediment-hosted, disseminated or stockwork, epithermal Au-Ag-As-Sb-Hg mineralization such as that in the **Watson Bar** area north of Lillooet.

ACKNOWLEDGMENTS

This review was made possible by the generous contributions of ideas and data by prospectors and geologists in the minerals industry throughout the region. The editorial suggestions of Rick Meyers are greatly appreciated.

EXPLORATION AND DEVELOPMENT HIGHLIGHTS KOOTENAY REGION - 1995

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TRENDS AND HIGHLIGHTS

An upward trend in the level of exploration and prospecting activity was evident in the Kootenay Region in 1995 (Figures 1, 2 and 3). A total of 280 mineral, placer and coal Notices of Work (permit applications) were submitted, an increase of 27% over the number in 1994. Although not all permitted programs were carried out, due to funding or other problems, an estimated total expenditure of $8.8 million for the region in 1995 represents a substantial increase over the $5.6 million estimate for 1994. A total of 6877 mineral claim units were recorded in 1995, an increase of 22% from 1994.

The major focus of interest continued to be the search for Sullivan-style sedimentary exhalative lead-zinc-silver deposits in the Purcell Anticlinorium between Kootenay Lake and the Rocky Mountain Trench. This effort received a boost by the British Columbia government through the funding of a $600 000 airborne geophysical survey over three critical areas in the Purcells. Two of the three areas were surveyed in late 1995: the third area will be surveyed as soon as possible in the spring of 1996. Data from the 1995 flying will be released July of 1996. Several companies and individuals have already begun to acquire tenure and carry out preliminary work in anticipation of the release of the new data. Meanwhile, Cominco Ltd. has been drilling two deep holes in the vicinity of the Sullivan mine in an on-going effort to extend reserves close to the orebody. Other companies aggressively involved in the Purcell activity include Consolidated Ramrod Gold Corporation, Chapleau Resources Ltd., White Knight Resources Ltd., Sedex Mining Corporation and Abitibi Mining Corporation Other types of deposits, including replacement and Mississippi valley type lead-zinc-silver, redbed copper, gold-rich quartz veins and possibly Olympic Dam type gold, also occur in the Precambrian rocks of the anticlinorium and will be targeted using the new geophysical data.

Another focus of exploration activity in 1995 was the Greenwood Mining Division where interest in skarn-hosted gold-copper mineralization was stimulated by impressive early-season drilling results announced by Orvana Minerals Corporation at its Eholt prospect. Epithermal gold (Tam O' Shanter) and replacement copper-gold (Lexington) were among other targets of interest at Greenwood. The Greenwood area is expected to remain very active in 1996 with renewed interest in skarn-hosted and epithermal gold in the Rock Creek area by Phoenix Gold Resources Ltd. and its

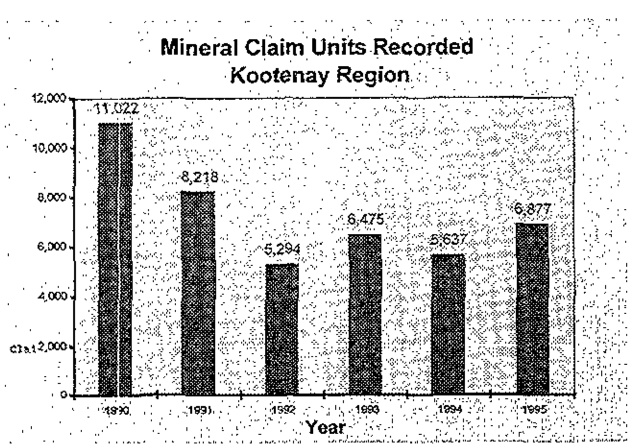

Figure 1. Mineral claim units recorded, Kootenay Region.

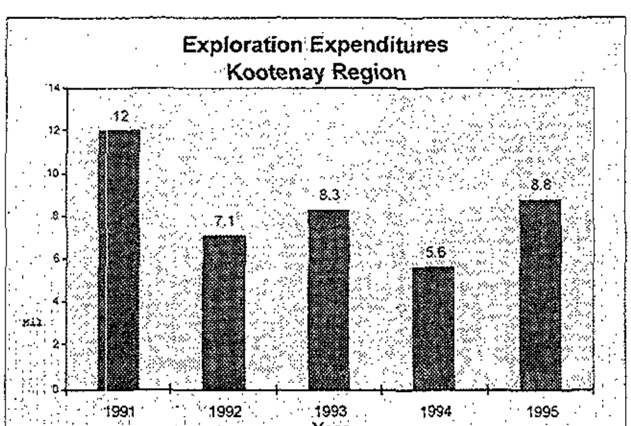

Figure 2. Exploration expenditures, Kootenay Region.

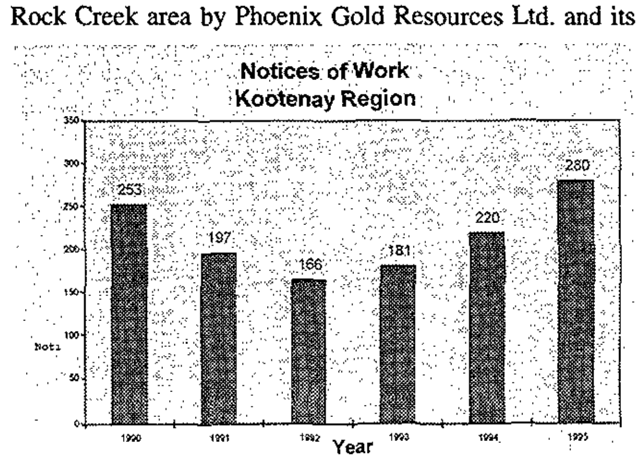

Figure 3. Notices of Work, Kootenay Region.

partners and a proposal by Guy F. Atkinson Holdings Ltd. to explore and develop the Old Nick nickel-cobalt deposit near Bridesville.

Major bulk sampling projects were underway in 1995 at the Lexington property, the Black Crystal graphite prospect and the McGillivray coal property east of Sparwood. Pacific Vangold Mines Ltd.'s Evening Star property at Rossland evolved into a small but high-grade producing gold mine, and a large quarry is being developed by CP Rail at Swansea Ridge west of Cranbrook, to produce railway track ballast by mining and crushing gabbro from one of the larger Moyie sills.

EXPLORATION HIGHLIGHTS

(Figure 4, Table 1)

METALS

PURCELL ANTICLINORIUM

The top priority exploration target in the Kootenay Region was, and will continue to be for the next few years, Sullivan-style sedimentary exhalative zinc-lead-silver mineralization in the Middle Proterozoic Aldridge Formation siliciclastic rocks of the Purcell (Belt) Supergroup. Remaining reserves in the giant Sullivan orebody, a major contributor to the economy of the region and of the province for almost a hundred years, are projected to be exhausted by the year 2001. In spite of many decades of increasingly sophisticated exploration, no mineable deposit to replace the Sullivan has yet been identified. As described above, the British Columbia government is currently financing a multi-system airborne geophysical survey over three priority areas in an attempt to stimulate further exploration for Sullivan-type deposits in the Purcell Mountains. Considerable claim staking and preliminary prospecting have already taken place in anticipation of the release of the new data in 1996.

Cominco Ltd., owner and operator of the Sullivan mine, is drilling a deep drill hole on the **Hope** claims, about 6 kilometres northwest of the mine, in what is described as a final attempt to test a missing piece of the Sullivan orebody, believed to have been relocated westward and downward by movement on the Kimberley fault. Drilling was

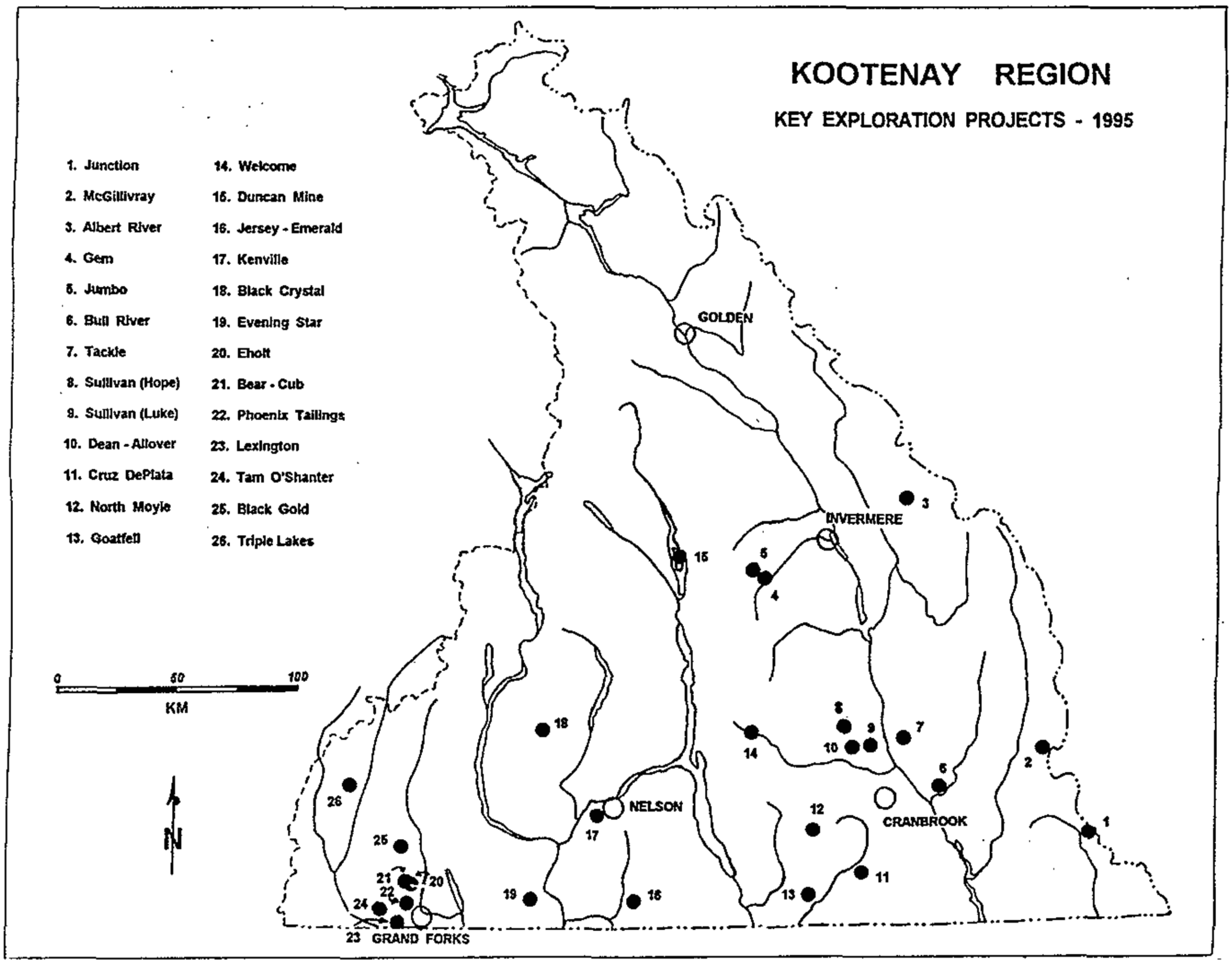

Figure 4. Kootenay Region, key exploration projects - 1995

TABLE 1
EXPLORATION PROJECTS - KOOTENAY REGION 1995

Property (Operator)	MINFILE Number	Mining Division	NTS	Commodity	Deposit Type	Work Done
Black Crystal (I.M.P. Industrial Mineral Park Mining Corp.)	082FNW260	Slocan	82F/13W	Graphite	Metamorphic hosted	13 ddh, approx. 800 m: bulk sample approx. 4000 t
Bull River (RH Stanfield & Associates)	082GNW002	Fort Steele	82G/6W, 11W	Au, Cu	Veins	2460 m diamond drilling
Coal Mountain (Fording Coal Ltd.)	082GSE052	Fort Steele	82G/7E, 10E	Coal	Organic	80 rdh, approx. 13 000 m
Cruz De Plata (Chapleau Resources Ltd.)	082GSW066	Fort Steele	82G/4W	Pb, Zn, Ag	Sedimentary exhalative	4 ddh, 2106 m: mapping
Dean - Allover (Consolidated Ramrod Gold Corp.)	082FNE135	Fort Steele	82F/9E	Pb, Zn, Ag	Sedimentary exhalative	7 ddh, approx. 2900 m: mapping
Duncan mine (Cominco Ltd.)	082KSE023	Slocan	82K/7W	Pb, Zn	Kootenay Arc type Pb - Zn	3 ddh, 1932 m
Eholt (Orvana Minerals Corp.)	082ESE239	Greenwood	82E/2E	Au, Cu	Skarn	15 ddh, 3100 m
Elkview (Elkview Coal Corp.)	082GNE015	Fort Steele	82G/10W, 15W	Coal	Organic	77 rdh, approx. 10 000 m
Evening Star (Pacific Vangold Mines Ltd.)	082FSW102	Trail Creek	82F/4W	Au, Ag	Subvolcanic shear-hosted veins.	10 000 t bulk sample
Fording River (Fording Coal Ltd.)	082JSE009, 010, 012	Fort Steele	82J/2W	Coal	Organic	52 rdh, approx. 9700 m
Goatfell (White Knight Resources Ltd.; Inmet Mining)	082FSE107	Fort Steele	82F/1E	Zn, Pb, Ag	Sedimentary exhalative	6 ddh, approx. 2000 m; geophysics
Greenhills (Fording Coal Ltd.)	082JSE007	Fort Steele	82J/2W	Coal	Organic	80 rdh, 12 000 m; 46 test pits
Iron Colt (Pacific Vangold Mines Ltd., International Silver Ridge Resources)	82 FSW100	Trail Creek	82F/4W	Au, Ag	Subvolcanic shear-hosted veins	u/g raising and drilling; bulk sampling, approx. 2500 t
Kenville (Teck Corporation)	082FSW084, 085, 086	Nelson	82F/6W	Au, Ag, Cu	Veins, Porphyry	7 ddh, 1140 m; geophysics
McGillivray (*McGillivray Mining Ltd.*)	*082GNE009*	*Fort Steele*	*82G/10W*	*Coal*	*Organic*	*10 000 t bulk sample*
Sullivan / Hope (Cominco Ltd.)	082FNE052	Fort Steele	82F/16E	Zn, Pb, Ag	Sedimentary exhalative	1 ddh, 1755 m
Sullivan / Luke (Cominco Ltd.)	N.A.	Fort Steele	82G/12W	Zn, Pb, Ag	Sedimentary exhalative	1 ddh, 1313 m; geophysics
Tam O'Shanter (Kettle River Resources Ltd.)	082ESE130	Greenwood	82E/2E	Au	Epithermal Veins	9 ddh, approx. 1500 m

suspended late in the year at a depth of 1937 metres and will resume in 1996. Target depth is reported to be in excess of 2100 metres. The company also drilled a deep hole on the **Luke** claims, about 7 kilometres east of the Sullivan mine, to test a geophysical-geological target in Aldridge stratigraphy. The hole was completed at 1313 metres but no results of the work have been reported. Consolidated Ramrod Gold Corporation drilled seven holes totalling approximately 2900 metres on a property called **Dean-Allover** on North Star Mountain. The work was centred about 2 kilometres southeast of the Sullivan orebody between the former North Star mine and the Stemwinder deposit, within the "North Star - Sullivan Corridor" of intense alteration. The objective was to investigate the deeper parts of the stratigraphy in an area of extensive near-surface alteration and sulphide enrichment. Results of the work have not been released.

In the Sunrise Creek area south of Moyie Lake, Chapleau Resources Ltd., drilled four core holes totalling 2106 metres on a property called **Cruz DePlata**, . The program resulted in the discovery of a Sullivan-type hydrothermal vent structure with brecciation and intense alteration believed to extend from high in the Middle Aldridge Formation down to at least the Sullivan horizon. One of the drill holes is reported to have intersected a sub-ore grade mineralized zone 4 metres thick, adjacent to the vent and underlain by 3 metres of tourmalinite. This newly recognized vent is only about 10 kilometres south of the Fors vent which was discovered and outlined by Consolidated Ramrod Gold Corporation on its combined Fors and Vine properties in 1993. The property is also immediately south of the former St. Eugene mine, a lead-zinc-silver sulphide vein occurrence in Middle Aldridge rocks.

At **Goatfell**, just west of Yahk and about 50 kilometres south of Cranbrook, an area long known for its abundance of float and bedrock occurrences of tourmalinite, Inmet Mining Corporation completed 50 kilometres of pulse electromagnetic survey on the Goat claims optioned from White Knight Resources Ltd. Inmet dropped the option but White Knight immediately proceeded to drill six core holes totalling about 2000 metres to test geophysical anomalies located by the Inmet survey. BHP Minerals International Inc. contributed 60% of the drilling cost in a joint venture arrangement with White Knight. The target was stratabound Sullivan-style mineralization in Middle Aldridge strata. There has been no public release of information on the results of the work. In the **North Moyie** Creek and upper Moyie River area, Sedex Mining Corporation (formerly Otis J Exploration Corp.) drilled two short vertical holes as preliminary stratigraphic tests in an area believed to be another alteration corridor. Sedex also drilled eight short holes on the nearby **David** claims where a gold resource of 96 000 tonnes averaging 13.1 g/t has previously been outlined. The gold occurs in a northeast-trending silicified shear zone. Sedex Mining Corporation, Abitibi Mining Corporation and other affiliated companies of the Hastings Management Group have put together mineral holdings totalling over 2300 claim units in a number of properties throughout the Purcells and are expected to undertake very aggressive exploration work in 1996, primarily for Sullivan-type deposits.

Not all of the significant projects in the Purcell anticlinorium were targeted on Sullivan-type mineralization. At the **Jumbo** claims on Black Diamond Creek, in the upper Toby Creek area west of Invermere, Birch Mountain Minerals Ltd. carried out detailed mapping and some backhoe trenching to investigate zinc-lead-barite mineralization occuring in quartz-barite stockworks and shear zones cutting dolomite breccia. The mineralization and its geological setting are believed to be similar to that of the former Mineral King mine which produced more than 1.2 million tonnes of ore grading about 11% combined lead-zinc, as well as barite as an industrial mineral commodity, prior to 1964. In the same area, the partnership of Chuck Downie, Tim Termuende and Rick Walker, assisted by an Explore BC grant from the provincial government, investigated the **Gem** prospect on the north side of Toby Creek, east of the confluence of Jumbo Creek. The target mineralization is shear-hosted quartz veins with high-grade lead-zinc-silver and minor gold associated with the Black Diamond regional fault structure. Four short holes were drilled with encouraging results reported. At the **Welcome** property on upper St. Mary River, Abitibi Mining Corporation drilled four short core holes to test polymetallic vein mineralization in a north-trending shear cutting Kitchener Formation sedimentary rocks. Aldridge Resources Ltd. drilled seven holes totalling 654 metres on its **Tackle** gold prospect on Tackle Creek, a tributary of Wildhorse River northeast of Cranbrook. The holes tested coincident induced polarization and gold-in-soil anomalies in an area of poorly exposed Aldridge Formation argillites, looking for low-grade gold mineralization associated with alkaline syenite dikes cutting the argillites. The company reported that no significant gold values were encountered. R.H. Stanfield and Associates completed 2460 metres of surface diamond drilling in their continuing program to firm up mineable underground reserves at the former **Bull River** open pit mine east of Cranbrook. Gold-copper-silver mineralization is hosted by east striking quartz-ferrocarbonate veins cutting Middle Aldridge metasedimentary rocks.

GREENWOOD CAMP

The Greenwood camp, including the Rock Creek and Grand Forks areas, was another focus of aggressive exploration and prospecting in 1995. The most advanced program in the area is the **Lexington** project of Britannia Gold Corporation and Bren-Mar Resources Ltd. located adjacent to the international border about midway between Greenwood and Grand Forks. The main activity in 1995 was the rehabilitation of the Grenoble adit and driving of a 650-metre decline into the Main Zone orebody. A 200-tonne sample was collected from a small zone near the portal of the decline for preliminary metallurgical testing. When the decline reaches the Main Zone orebody in mid-1996, larger scale bulk sampling and underground drilling will be carried out. The bulk sample will be processed at the Bow Mines mill at the former Roberts Creek mine near Greenwood. The copper-gold ore occurs as stockwork veins and disseminated and locally massive pyrite-chalcopyrite within a strongly altered porphyritic dacite intrusive rock. The full nature and origin of the mineralization is still somewhat unclear as it has characteristics of both porphyry and replacement mineral deposits. A mineral inventory for the entire Main Zone has recently been recalculated at 146 000 tonnes grading 1.01% Cu and 7.5 g/t Au. There are reported to be four or five more similarly mineralized zones still to be explored on the property.

The target for many of the other projects in the Greenwood area is structurally controlled, skarn-hosted, gold-copper mineralization like that of the former Phoenix mine which produced a total of 30 million tonnes grading 0.8% Cu and 1 g/t Au. Orvana Minerals Corporation, generated some excitement early in the year at its **Eholt** property, when it reported the results of a four-hole drilling program including a 27.8-metre intersection of massive sulphides grading 2.7 g/t Au and 0.28% Cu in a zone called the Dead Honda. Eleven more holes were drilled in October, giving a total for the year of 3100 metres of diamond drilling in 15 holes. Seven of the holes in the fall program further tested the Dead Honda zone and found consistent grades over a strike length of 210 metres, open in both directions. On the **Bear-Cub** claims which adjoin Orvana's property to the north, Teck Corporation drilled six core holes in a similar setting around the Rambler adit. Results of that work have not been reported.

Kettle River Resources Ltd., partly supported by an Explore BC grant, drilled two short sonic holes into the **Phoenix tailings**. The material recovered was assayed and tested to determine the feasibilty of recovering gold, copper and possibly magnetite or garnet from the tailings. A preliminary estimate of the resource was 11.8 million tonnes of tailings averaging 0.15% Cu and 0.38 g/t Au. Kettle River's major project in the camp in 1995 was on its **Tam O'Shanter** gold prospect, joint ventured with Dentonia Resources Ltd. and located just west of Greenwood at the head of Buckhorn Creek. Nine diamond-drill holes were completed totalling about 1500 metres. The prime area of interest straddles the east margin of the Toroda graben and exploration focused on a steep vein structure known as the Wild Rose zone. The geology is complex and several stages of gold mineralization have been identified. They include epithermal veins and alteration superimposed on mesothermal veins and listwanitic alteration of serpentine and intrusive diorite.

OTHER AREAS

In the Rocky Mountains, two metal projects of note were active. On the **Albert River**, east of Radium Hot Springs, Dia Met Minerals Ltd. completed further geological mapping, geochemical and geophysical surveys, but was unable to begin a planned drilling program due to early snow. The drilling is expected to be done as soon as conditions permit in 1996. The claims were originally staked on the basis of a heavy mineral tungsten anomaly, but further exploration has revealed very high gold and rare earth element anomalies in heavy minerals. Present speculation is that the anomalies are associated with an alkaline intrusion into Chancellor Group calcareous rocks with resulting auriferous skarns. At the **Junction** property, east of the Flathead valley, optioned by Hudson Bay Exploration and Development Company Ltd. from Ecstall Mining Corporation, two short diamond-drill holes were completed to test a 700 metre long zone of anomalous copper in soils, with showings of stratabound copper mineralization hosted by dolomites of the Precambrian Sheppard and Kintla formations.

In the Kootenay Arc, a very promising project is the **Jersey-Emerald** gold prospect being explored by Sultan Minerals Inc. under an option agreement with two Nelson-based prospectors. The property is centred on the closely adjoining Jersey lead-zinc and Emerald tungsten mines, both major producers in the Salmo camp prior to the early 1970's. The gold-rich zones being explored are, in most cases, actually part of the base metal orebodies and are exposed in the old mine workings, but were ignored by the former mine operators. The highest grade gold values are reported to be associated with massive pyrrhotite zones in the skarn-hosted Emerald orebodies and in a bismuth and arsenic-rich vuggy quartz zone which immediately overlies part of the Jersey lead-zinc orebody. A 1300-metre surface diamond drilling program begun in late 1994 was completed at the beginning of 1995. Further work in 1995 included extensive geochemical and geophysical surveys as well as ongoing geological studies. Three main target areas have now been identified on the property and aggressive programs of both surface and underground drilling are anticipated in 1996. Farther north in the arc at Duncan Lake, Cominco Ltd. drilled three holes totalling 1932 metres at the **Duncan mine** site where a drill-indicated resource of about 9 million tonnes grading 2.7% lead and 2.9% zinc is reported.

At the **Kenville** project, located 13 kilometres west of Nelson on Eagle Creek, Teck Corporation drilled seven core holes totalling 1140 metres and carried out further indued polarization and geochemical surveys. The property being explored includes the Kenville mine (formerly known as the Granite-Poorman mine) optioned from Anglo Swiss Industries Inc. and a former producer of gold from several parallel quartz-vein systems. Adjoining claims to the south have been acquired under other options. Teck's objective is to locate a bulk-mineable porphyry copper-gold system. The 1995 drilling intersected a new set of quartz veins with local concentrations of gold-rich pyrite-chalcopyrite mineralization but provided sufficient encouragement that the porphyry target is still a viable objective that work is expected to continue in 1996. At Rossland, Pacific Vangold Mines Ltd. mined a 10 000-tonne bulk sample of gold-silver ore from the former-producing **Evening Star** mine and about 2500 tonnes from the nearby Iron Colt claim. Work on the Iron Colt is a joint venture with International Silver Ridge Resources Inc. The ore mined from both properties was trucked to the Echo Bay Mines Limited custom mill at Republic, Washington. On both properties, the ore recovered represented new reserves outlined by exploration programs over the last few years. No significant new exploration was conducted during 1995 but more is planned in several areas within Pacific Vangold's extensive holdings in the Rossland camp. In the **Triple Lakes** area at the head of Canyon Creek, east of Beaverdell, Phelps Dodge Corporation completed 20 kilometres of induced polarization and extensive geochemical surveys followed by three short diamond-drill holes. The target was epithermal gold mineralization associated with northeast-trending faults and breccia zones on the west flank of the Toroda graben. Results of the work have not been reported.

INDUSTRIAL MINERALS

Two industrial minerals projects included significant sampling and testing programs in the region in 1995. At the **Black Crystal** graphite prospect on Hoder Creek in the Valhalla Mountains, northeast of Nelson, Industrial Mineral Park Mining Corporation mined a bulk sample of about 4000 tonnes of high-grade flake graphite and moved it to a site on the Little Slocan River where a pilot mill is under construction. When the mill is operational in 1996, the sample will be tested and market evaluations undertaken. The graphite occurs disseminated in thick marble beds, and to a lesser degree in quartzites and gneisses, of the Valhalla gneissic complex. Exploration drilling to better define the extent of the resource, and more sampling are expected in 1996. On the **Black Gold** claims at the head of Almond Creek north of Grand Forks, San Pedro Stone Inc. continued to extract and transport, mainly to Korea, small test shipments of its "Black Gold" dimension stone. The stone is a distinctive coarse-grained, dark grey to black diorite or gabbro with abundant, very large biotite phenocrysts. The company reports that marketing has been sufficiently encouraging that it plans to acquire a full quarry permit.

The potential for discovery and profitable marketing of a large variety of industrial mineral commodities in the Kootenays is increasingly attracting the attention of prospectors and companies. There was active prospecting by several individuals in 1995 for commodities such as wollastonite, barite, gemstones (particularly in the Slocan Valley and the Valhalla Mountains), dimension stone, slate, talc, rhodonite and others.

COAL

At the **McGillivray** coal property on Loop Ridge, southeast of Sparwood, a private company, McGillivray Mining Ltd., extracted a 10 000-tonne sample of metallurgical coal and trucked it to Elkview Coal's plant for test processing. The property has a proven reserve of 800 000 tonnes with potential for considerably more to the north of the sampling pit. The owners have submitted a proposal to the provincial government for the mining of 200 000 tonnes/year for four years and are attempting to secure markets for the coal.

All five of the operating coal mines in the southeast coalfield carried out major exploration drilling programs at their mine sites in 1995, and all five are expanding their annual rates of production. Fording Coal Limited is reported to have drilled more than 120 holes totalling 16 000 metres at the **Fording River** mine, 80 holes totalling 12 000 metres at **Greenhills** and 80 holes totalling 13 000 metres at **Coal Mountain**. Line Creek Resources completed about 15 000 metres at the **Line Creek** mine and **Elkview** Coal drilled a total of about 10 000 metres in 77 holes. Most of the drilling done by the coal mines is rotary drilling for the purpose of reserve definition and quality testing, and much of it is in active pits.

PLACER ACTIVITY

The level of placer testing and mining activity showed little change in 1995 with 61 permit applications submitted, compared to 62 in 1994. The areas of most concentrated activity were the Rock Creek, Wildhorse River and Pend D'Oreille River areas. Moyie River, Perry Creek and the Grand Forks areas also saw activity.

The largest placer operation was the **Moyie River** mine operated by Weaver Creek Placer Ltd., a subsidiary of Fiorentino Bros. Contracting Ltd. of Cranbrook. The company is recovering abundant coarse gold from a deep Tertiary channel which has an overall average grade of 3.66 g/m^3. The washing plant, which operates only intermittently, processes about 920 cubic metres in a 10-hour shift and typically recovers an average of 930 grams per shift.

PRODUCING MINES AND QUARRIES
(Figure 5)

COAL

All five of the coal mines were expanding, or preparing to expand, their production rate and, as detailed in a previous section, they all carried out major exploration drilling programs in 1995. At the **Fording River** mine, Fording Coal Ltd. reported total 1995 clean coal production of 7.25 mil-

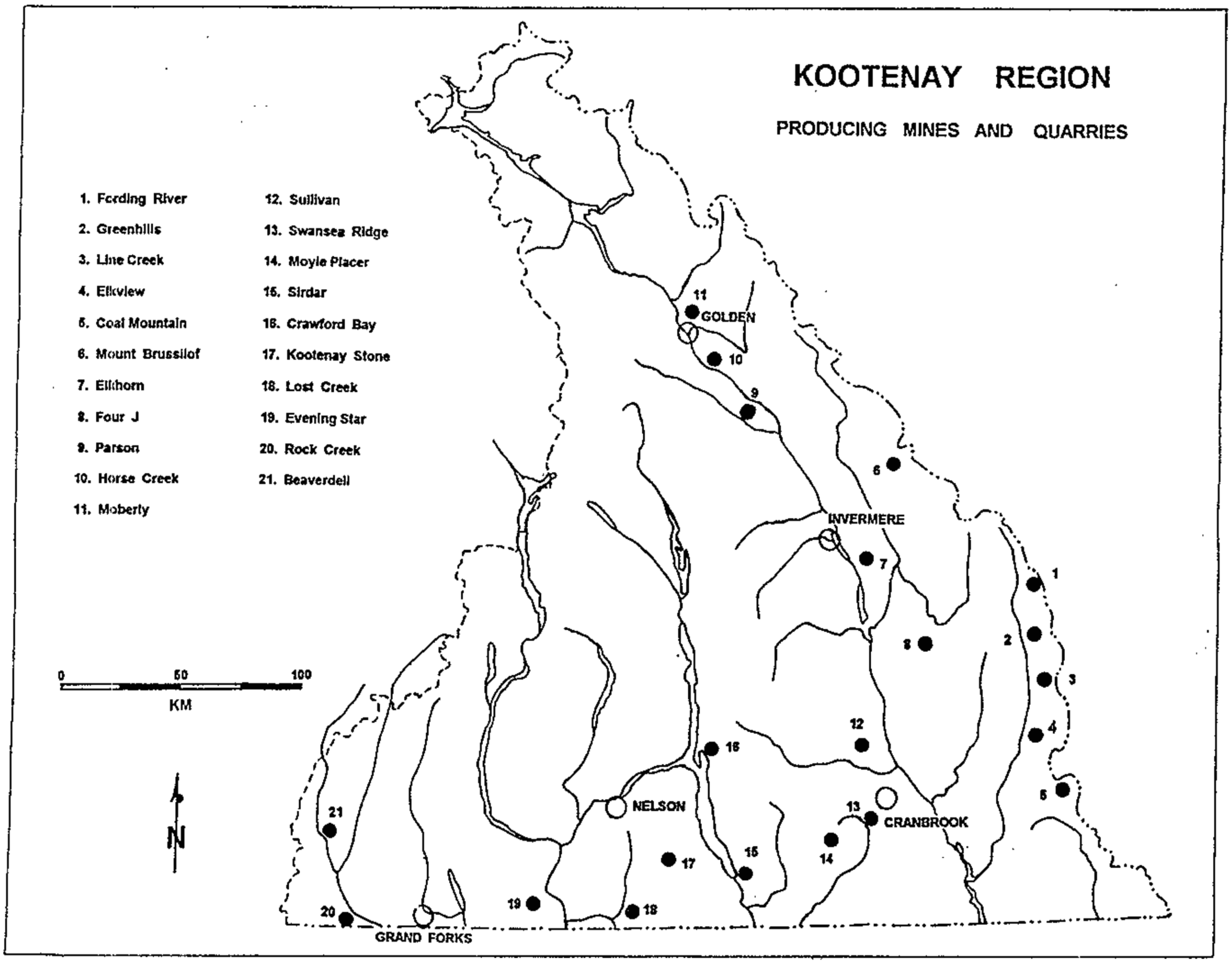

Figure 5. Kootenay Region, producing mines and quarries.

lion tonnes. Total production at **Greenhills** was 3.8 million tonnes with a projection of about 4.2 million tonnes in 1996.

At the **Coal Mountain** thermal coal mine, Fording reported production of 1.1 million tonnes, with expansion underway to an annual rate of 2.5 million tonnes per year. Line Creek Resources Ltd. reported 1995 production at the **Line Creek** mine of 3.6 million tonnes. A 10-kilometre conveyor to move raw coal down Line Creek canyon to the plant was under construction. When operational it is expected to be able to move 7 million tonnes of coal per year. A major new pit is also being developed on Horseshoe Ridge. The **Elkview** mine at Sparwood, operated by a subsidiary of Teck Corporation, reported 1995 production of 2.9 million tonnes and expects to increase its annual production to about 5 million tonnes in the next few years as it brings an expanded pit on stream on Natal Ridge.

METALS

At the **Sullivan** mine, Cominco Ltd. continued to mine and mill lead-zinc-silver ore at a rate of 8000 tonnes per day for an annual total of about 1.6 million tonnes. Remaining reserves reported at the end of September, 1994, were 13 million tonnes averaging 7.91% Zn, 4.53% Pb and 25.69 g/t Ag. Mine closure is scheduled for the year 2001

INDUSTRIAL MINERALS

At **Mount Brussilof**, Baymag Mines Company Limited mined approximately 175 000 tonnes of magnesite and shipped it to a processing plant at Exshaw, Alberta. Westroc Industries Limited transferred its production of gypsum from its Windermere quarry to the **Elkhorn** quarry while sustaining an annual production rate of 450 000 tonnes. Domtar Gypsum continued to ship gypsum from a stockpile at its **Four J** quarry on Lussier River near Canal Flats. Mountain Minerals Ltd. continued to produce barite at **Par-**

son but has reserves available to sustain production for only about one more year. High-grade silica products are produced in the Golden area by Mountain Minerals at **Moberly** and by Bert Miller Trucking and Contracting Ltd. at **Horse Creek**.

In the West Kootenays, IMASCO operates an underground dolomite mine at **Crawford Bay** and mines limestone intermittently at **Lost Creek**. The material is processed at the company's plant at **Sirdar**, where it also produces crushed granite. Mighty White Dolomite Ltd. quarries and processes dolomite at **Rock Creek** and **Kootenay Stone Centre** produces about 4000 tonnes of multicoloured flagstone from several quarries in flaggy quartzite, mainly in the Porcupine Creek area.

CP Rail is developing a large quarry at **Swansea Ridge** south of Cranbrook, which will supply about 360 000 tonnes of railway ballast for about 50 years The material to be quarried and crushed is massive gabbro from a flat-lying Moyie sill 60 metres thick.

EXPLORATION AND DEVELOPMENT HIGHLIGHTS SOUTHWESTERN BRITISH COLUMBIA - 1995

By R.H. Pinsent, P.Geo.
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Energy and Minerals Division

INTRODUCTION

The Southwest Regional Geology office, in Vancouver, monitors exploration and other geoscience activity on the Queen Charlotte Islands, Vancouver and the Off-shore Islands and in the Coast Mountains southeast of Bella Coola (Figure 1). It also handles land-use issues on the Lower Mainland.

HIGHLIGHTS

- BHP Minerals Canada Limited closed the Island Copper mine after twenty-five years of operation.

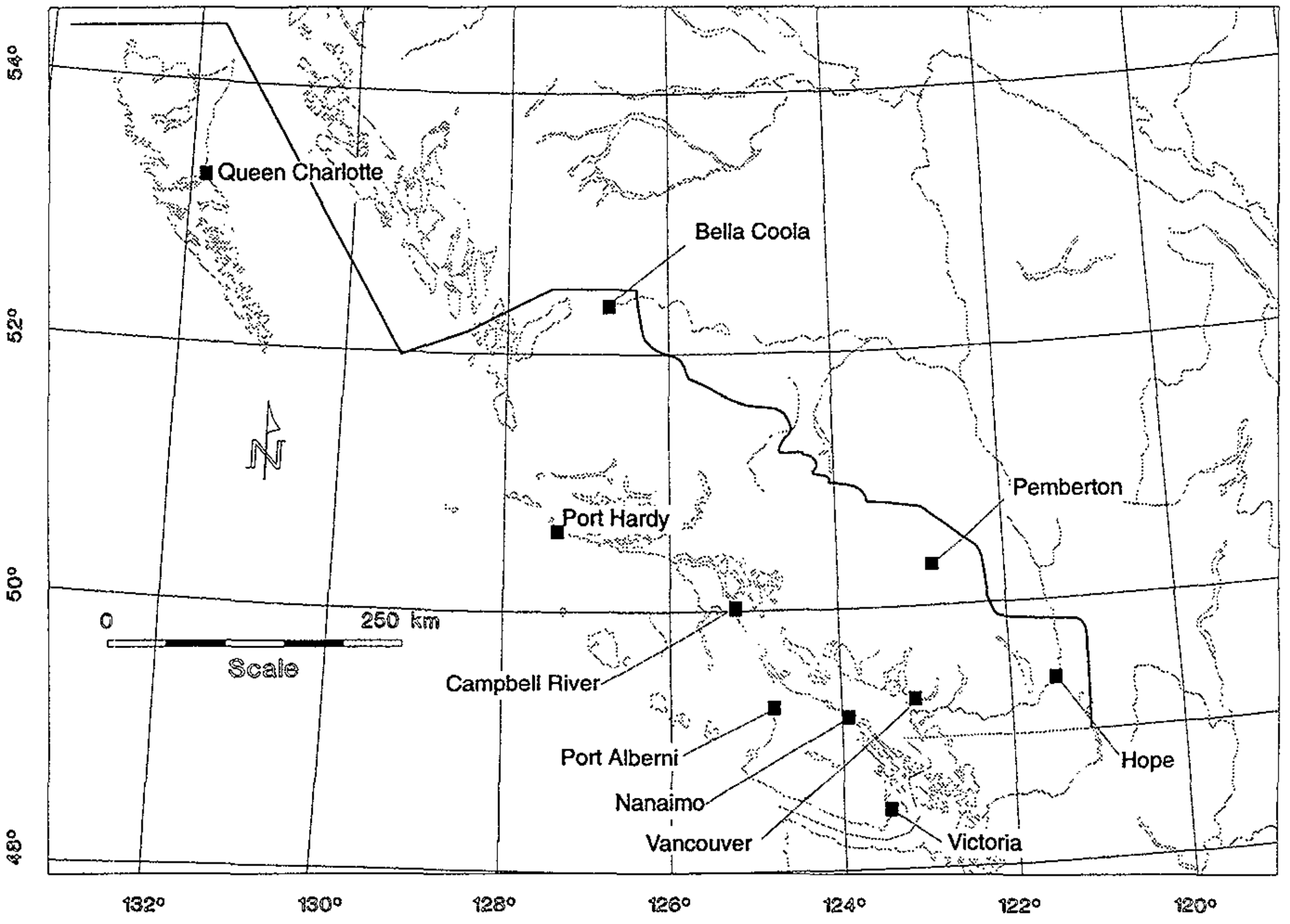

Figure 1. Southwestern Region location map.

- Westmin Resources Limited had its first full year of production at Myra Falls since 1992.
- Quinsam Coal Corporation undertook a major expansion of the Quinsam coal mine.
- Misty Mountain Gold Limited ran a major exploration program on and around the Specogna (Cinola) deposit, in the Queen Charlotte Islands.

Athabasca Gold Resources Limited ran a major underground exploration program at the Ladner Creek (Carolin) mine, near Hope.

EXPLORATION TRENDS

The level of mine-related activity in the region was similar to that in 1994. No new major mines or quarries came on stream but three of the four existing operations increased their production and improved their competitive position. The fourth also had a good year, albeit its last. The Island Copper mine took advantage of an improved copper price as it finished production and prepared for closure.

The level of exploration activity was, again, similar to that in 1994. Only a few companies allocated funds for major programs but those that did were encouraged by the results. Several of the more advanced properties have considerable potential to go to feasibility in the foreseeable future.

The total investment in exploration in 1995 is estimated at $6.0 million; which is considerably higher than the $4.0 million and $5.0 million dollar estimates made for the previous two years. However, it is still well below the $8.5 million figure for 1992. Most of the expenditure was on relatively few "high-profile" projects and much of the increase reflects the very large expenditures made by Misty Mountain Gold Limited, on and around the Specogna deposit, in the Queen Charlotte Islands, and Athabasca Resources Limited, in the Ladner Creek gold camp, on the Lower Mainland.

The number of major projects (arbitrarily defined as those likely to have incurred costs in excess of $100 000) dropped from sixteen in 1994 to twelve in 1995 (Table 1; Figure 2). The drop reflects a noticeable trend over the past

TABLE 1
1995 EXPLORATION PROJECTS - SOUTHWESTERN REGION

Property (Owner)	MINFILE Number	Mining Division	NTS	Commodity	Deposit Type	Work Done
Argonaut (Aurizon Mines Ltd.)	092F 075	Nanaimo	92F/13E	Garnet	Skarn	bulk sample of tailings
Brandywine (La Rock Mining Corp.)	092JW001	Vancouver	93J/3E	Au, Ag, Pb	Shear/vein	26 ddh, 2286 m
Ladner Creek (Athabasca Gold Corp.)	092HNW007	New West.	92H/11W	Au,Ag	Vein	u/g devel. 280 m; metall; 92 u/g ddh, 7010 m
Dragon (Westmin Resources Ltd.)	none	Alberni	92E/15W	Cu, Pb, Zn, Ag, Au	Massive sulphide	3 ddh, 722 m; geol; geochem
Giant Copper (Imperial Metals Corp.)	092HSW001	New West.	92H/3W	Cu, Au	Breccia	8 ddh, 1389 m
Specogna (Misty Mountain Gold Ltd.)	103F 034	Skeena	103F/9E	Au	Vein	airborne geophys; geol; geochem; 31 ddh, 7110 m
Knob Hill (First Choice Industries)	102I 005	Nanaimo	102I/16E	Cu, Au	Porphyry	geol; geochem
Lucky/Toq (Consolidated Logan Mines Ltd.)	none	Alberni	92F/3W	Cu, Au	Porphyry	geol; geochem; 5 ddh, 826 m
McMaster/Lorraine (Athabasca Gold Corp.)	092HNW018	New West.	92H/11W	Au, Ag	Vein	10 ddh, 827 m
Myra Falls (Westmin Resources Ltd.)	092F 330 092F 073	Alberni	92F/12E	Cu, Pb, Zn, Ag, Au	Massive sulphide	3 ddh, 1323 m; 3 u/g ddh, 1848 m
Quinsam Coal (Quinsan Coal Corporation)	092F 319	Nanaimo	92F/13E 92F/14W	Coal		25 pdh, 2522 m
Vananda Limestone (Lafarge Canada Inc.)	092F 394	Nanaimo	92F/10E	Limestone		geol; geophys; 92 pdh, 2600 m

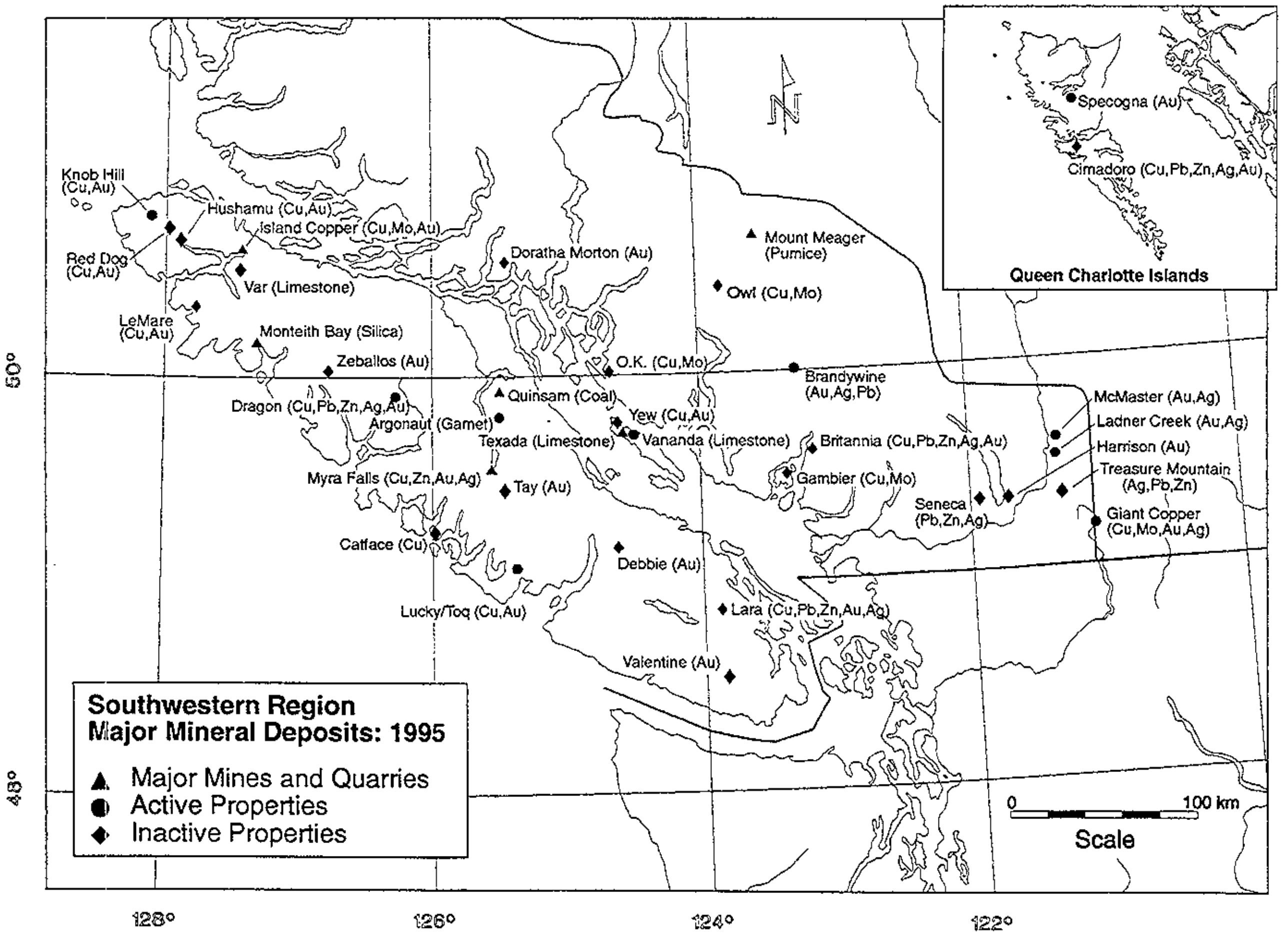

Figure 2. Selected mineral deposits and exploration properties, Southwestern Region - 1995.

few years, which has seen increased emphasis on relatively few advanced projects and lesser interest in early to middle stage programs. Of the major projects, two were at existing mines; three were at past-producing mines, or quarries, and two more were at well established advanced exploration sites. Only five could reasonably be classified as early or middle stage programs.

The major projects were aimed at a variety of commodities and deposit types and reflect the broad range of mineral development opportunities available in the region. There was a coal project. There were two industrial mineral projects, aimed at recovering garnet from tailings and reactivating a past-producing limestone quarry, and there were nine metallic mineral projects. The latter included four aimed at defining gold reserves in veins, three directed at locating porphyry copper deposits and two focused on the discovery of volcanogenic massive sulphide deposits.

Industrial minerals provide a very significant development opportunity in the region and there has been increasing interest in exploration for a variety of deposit types over the past few years.

The large producing limestone quarries on Texada Island and the smaller operation at Benson Lake, on Vancouver Island, are of obvious importance to the region and there has been substantial, low-key exploration for other deposits capable of producing large amounts of chemical, cement and/or agricultural grade limestone, or providing smaller amounts of "bright" calcite for use as a filler in the manufacture of high-quality paper.

There has also been considerable, but again low-key, interest in exploration for dimension-stone quarries capable of satisfying the currently very strong and increasing demand for decorative rock and tile in the Lower Mainland, the United States and elsewhere.

OPERATING MINES AND QUARRIES

The mines and major quarries in the Southwestern Region had a very good year and most expect to do as well, or better, in 1996. There is likely to be more zinc, coal and limestone produced than in 1995. However, the closure of the Island Copper mine will have a negative impact. The region will produce far less copper and gold and no molybdenum or rhenium.

MYRA FALLS OPERATION

Westmin Resources Limited operates a nominal 4000 tonnes per day underground mining operation at Myra Falls, at the south end of Buttle Lake, on Vancouver Island. It currently employs approximately 430 people.

In 1995, the operation had its first full year in production following a prolonged labour dispute that started in April, 1993. It ran at slightly below its rated daily capacity but produced 21 773 000 kilograms of copper, 26 779 000 kilograms of zinc, 818 895 grams of gold and 17 001 452 grams of silver from 1 197 399 tonnes of ore grading 2.03% Cu, 2.71% Zn, 0.13% Pb, 1.86 g/t Au gold and 22.49 g/t Ag.

Westmin mines a large volcanogenic massive sulphide deposit comprised of numerous descrete lenses. As of March, 1996, it had an aggregate mineable reserve of 11 150 400 tonnes grading 1.6% Cu, 6.1% Zn, 0.3% Pb, 1.5 g/t Au and 27.5 g/t Ag.

In 1995, the company took most of its production from the large, relatively low-grade, H-W lens, and it focused most of its development effort on establishing production from the recently discovered and delineated Gopher and Battle zones. It ramped a decline down into the Gopher zone, a particularly high-grade sulphide lens at the southeast end of the Battle zone, and started limited production through the access drift. Westmin continues to drive the main 24 level haulage drift towards the Gopher and Battle Zones. It should reach the Gopher lens sometime in 1996.

Ore from the Gopher zone is much richer in zinc (14.3%) than ore from the H-W lens (4.1%) and the product currently requires careful blending before it can be processed through the mill. When the haulage drift reaches the lens, the company will increase production from it and modify the mill circuit to accommodate the higher grade material. Westmin had hoped to double zinc production in 1996 while maintaining its current level of copper output. However, a rock fall in the Gopher area, in the fourth quarter of 1995, will have an adverse affect on production in the short term.

Westmin placed lesser emphasis on exploration in 1995 than it has in recent years, but it carried out two diamond drilling programs that produced very positive results. The company drilled three holes, for an aggregate length of 1323 metres, to provide additional information on the Trumpeter zone, which underlies the floor of Thelwood Creek valley to the southeast of the H-W shaft.

The zone comprises several copper-rich sulphide lenses that are devoid of any obvious underlying alteration zone and may, in part, be formed from transported sulphide. The mineralization is very similar to that found in "Block 43", in the H-W mine, which is roughly on strike to the northwest, although it is off-set and on the far side of major fault. Westmin has assigned the Trumpeter zone a proven and probable geological reserve of 227 900 tonnes grading 4.1% Cu, 4.4% Zn, 3.1 g/t Au and 68.9 g/t Ag.

The zone is open to the northwest but the extension will be difficult to explore from surface, as it lies at considerable depth beneath the mountain that separates Myra Creek from the Thelwood Creek valley. However, the company can use underground workings in the old Price mine to access the area. It plans to drive a cross cut from one of these workings and establish drill sites above the projection of the lens.

Westmin also completed three diamond-drill holes, for a total length of 1848 metres, from a cross cut in the Lynx mine on the northeast side of the major antiform that controls the distribution of the lenses within the deposit.

The holes intersected good quality ore in the newly defined Marshall zone to the north of a major structure, the North Down-drop fault and confirmed the presence of a significant zone of massive sulphide mineralization in highly prospective "mine series" stratigraphy. The third hole intersected two zones of massive sulphide. The upper zone ran 0.5% Cu, 13.2% Zn, 1.9 g/t Au and 51.2 g/t Ag over 6.4 metres. The lower zone returned 0.3% Cu, 3.4% Zn, 1.9 g/t Au and 64.8 g/t Ag over 8.1 metres.

The Marshall discovery opens up a large area of potentially productive stratigraphy to the northeast of the current workings. Westmin plans to drill the zone from surface and eventually extend a cross cut from another of the existing Lynx mine workings and establish stations for further drilling. The throw on the North Down-drop fault is such that any deposit discovered would probably be mineable through the H-W shaft.

ISLAND COPPER OPERATION

BHP Minerals (Canada) Limited closed the Island Copper mine, near Port Hardy on Vancouver Island, in 1995. The company finished mining in the pit in August and processed ore from the low-grade stockpiles throughout the fall. It shut down the mill at the end of December.

In its last year of operation, the mine produced 34 607 000 kilograms of copper, 1 449 000 kilograms of molybdenum, 591 400 grams of gold and 9 535 000 grams silver from 16 532 189 tonnes of ore. Over the course of its life, from 1971 to 1995, the mine produced approximately 1234.6 million kilograms of copper, 31.4 million kilograms of molybdenum, 33 591 kilograms of gold, 345 535 kilograms of silver and 27 000 kilograms of rhenium from approximately 361 million tonnes of ore.

BHP spent much of the year preparing for closure and completing its site reclamation plan. The company will landscape and seed the waste dumps and arrange for run-off water to be channeled into the pit. It plans to flood the pit with sea water next summer and complete the removal of the mill and other plant over the next couple of years. The company will monitor the site for several years to come.

QUINSAM COAL OPERATION

Brinco Coal Mining Corporation was restructured in 1995. The Quinsam coal operation is now managed by Quinsam Coal Corporation, a subsidiary of Hillsborough Resources Limited. It consists of an underground coal mine employing approximately 200 people, near Campbell River on Vancouver Island. In 1995, it produced approximately 590 000 tonnes of clean thermal coal which was used by cement plants in the Lower Mainland and by coal-fired electrical generating plants off-shore, in Chile and Japan.

The year started badly with a flood in part of the 2N development area. However, the company recovered its lost production and made considerable strides towards its long-standing goal of expanding to 1.2 million tonnes of clean coal production per year. Marubeni Corporation, of Japan, made a major investment in Hillsborough Resources that enabled the company to finance the underground development needed and purchase the plant required to handle the increased production. The BC Transportation Financing Authority also assisted the company by facilitating loan arrangements that enabled Quinsam to upgrade its access road and barge load-out facility near Campbell River. The wash plant expansion was close to completion at the end of the year.

Quinsam carried out two definition drilling programs at the mine. In total, it drilled and geophysically logged 25 percussion-drill holes with an aggregate length of 2522 metres. Drilling between the 2N and 3N production blocks provided detailed stratigraphic and structural information in an area where the coal had previously been considered to be too deep to mine by open pit methods. Detailed drilling on the 4S block provided similar information in a hitherto undeveloped part of the deposit.

Two adits were driven into the 4S block to obtain a bulk sample. The results were encouraging and the block will be ready for production in 1996. It will replace capacity lost when the smaller 2S operation closes down.

TEXADA ISLAND LIMESTONE QUARRIES

Holnam West Materials Limited and Ash Grove Cement Company, between them, employed approximately 150 people in 1995. The two companies shipped approximately 5.5 million tonnes of limestone, up from 5.0 million tonnes the previous year. The material was sold to cement and chemical lime plants and suppliers of agricultural lime throughout the Pacific Northwest. They also shipped oversized blocks as "rip-rap" to be used for construction and stabilization purposes.

Holnam West also acts as a trans-shipment point for coal from the Quinsam coal mine.

MINE DEVELOPMENT SUBMISSIONS

There were no new projects brought into the Mine Development Assessment Process, however, two already within the system received mine development certificates.

MONTEITH BAY GEYSERITE

Monteith Bay Resources Limited received a certificate to develop a seasonal "geyserite" silica quarry on the shore of Easy Inlet, at the north end of Vancouver Island. The company has completed its permitting but it is not yet in production. Eventually, the operation should produce between 70 000 and 100 000 tonnes of silica per year for the cement industry in the Lower Mainland.

MOUNT MEAGER PUMICE

Great Pacific Pumice Inc. received a certificate to develop a seasonal pumice quarry on the north slope of Mount Meager. It has completed the permitting process but it is not yet producing to full capacity. The company expects to produce between 35 000 and 50 000 tonnes per year, starting in 1996.

EXPLORATION ACTIVITY

VANCOUVER AND TEXADA ISLANDS

DRAGON

Westmin Resources Limited holds an option on the Dragon property, which straddles the Muchalat River, northwest of the community of Gold River. The property covers a large fault and intrusion-bounded block of Sicker Group, Myra Formation, stratigraphy that contains a felsic volcanic unit that is similar in lithology to that in the productive "mine series" unit at the H-W mine. The felsic volcanic rocks are locally strongly altered and mineralized and there are several significant occurrences of volcanogenic massive sulphide mineralization. These include the Falls and Dragon showings, immediately south of the Muchalat River, and the Norgate Creek area, approximately 2.5 kilometres farther south.

In 1995, Westmin Resources carried out a mapping and soil and rock sampling program in the Norgate Creek area. The program delineated a pronounced base and precious metal soil geochemical anomaly over a large area of intensely altered and strongly pyritic felsic volanic rock that may have accumulated on the flanks of a felsic dome.

The company drilled three diamond-drill holes, for an aggregate length of 722 metres, to test the depth extent of the alteration and to assess the significance of the geochemical anomaly. The holes cut several sections of strongly pyritic altered rocks that contain slightly elevated values of lead, zinc, copper, gold and silver.

LUCKY/TOQ

Consolidated Logan Mines Limited drill tested a strong electromagnetic anomaly in a poorly differentiated package of volcanic rocks southeast of Kennedy Lake. Five holes were drilled, for a total length of 826 metres. They intersected a linear pyrite-stringer stockwork in andesitic tuff.

Consolidated Logan noted weak, possibly porphyry-related, copper mineralization in boulders at two of the drill sites and interpreted the stringer stockwork as being part of a pyritic hydrothermal breccia associated with porphyry style mineralization. It increased its claim holding in the area and started to explore the property for its porphyry potential. It mapped and prospected the area and located at least two other zones of weak mineralization with similar characteristics.

KNOB HILL

First Choice Industries is exploring a high-level "epithermal" or possibly "transitional/porphyry" environment at Knob Hill, near Holberg, at the northwest end of the Island Copper "porphyry" belt.

The company established a grid over an area of poor exposure but significant past exploration interest and identified a broad polymetallic, gold, arsenic and copper-bearing soil geochemical anomaly that is more or less coincident with a linear magnetic high.

ARGONAUT

Aurizon Mines Limited is currently evaluating the feasibility of recovering garnet from the tailings pond at the past-producing Argonaut (Iron Hill) magnetite mine, near Campbell River. The company shipped an 80-tonne bulk sample to the Lower Mainland and carried out preliminary separation tests.

LAFARGE QUARRY

Lafarge Canada Inc. announced plans to spend US$95 million over the next few years up-grading and expanding its cement plant in Richmond. The improvements will enable it to increase its portland cement production to 1.0 million tonnes per year.

Lafarge currently purchases limestone from existing suppliers on Texada Island. However, it owns a now dormant limestone quarry, near Vananda, and is considering reopening it. It drilled 14 diamond-drill holes for an aggregate length of 1280 metres in 1993 and it conducted a more detailed exploration and delineation program in 1995. It drilled 92 air-track holes for a total length of approximately 2600 metres in and around the rim of the existing quarry. The company also carried out a detailed magnetometer survey to delineate a suite of cross cutting mafic dikes, and undertook petrographic and petrochemical studies to determine their bulk composition. The program should confirm the suitability of the limestone for cement manufacture and provide information on the composition, distribution, and over-all chemical significance of the dikes.

OTHER ACTIVITY

Other activity on Vancouver Island included exploration and grid work on the Berg and King properties, at the north end of the Island and other relatively inexpensive programs farther south.

Two of the smaller programs were particularly successful. Arne Birkeland located additional volcanogenic massive sulphide showings on the Jasper property, near Nitinat, and negotiated an option for it, and Simon Salmon successfully high-lighted the gold vein potential of the principal structure controlling the Ursus Creek valley, near Ucluelet. Both were, in part, sponsored by the provincial government's Prospector's Assistance Program.

SOUTHERN COAST

There was considerable exploration interest in the Southern Coastal part of the region in 1995. For the first time in several years there were three advanced projects as well as several earlier-stage programs in progress.

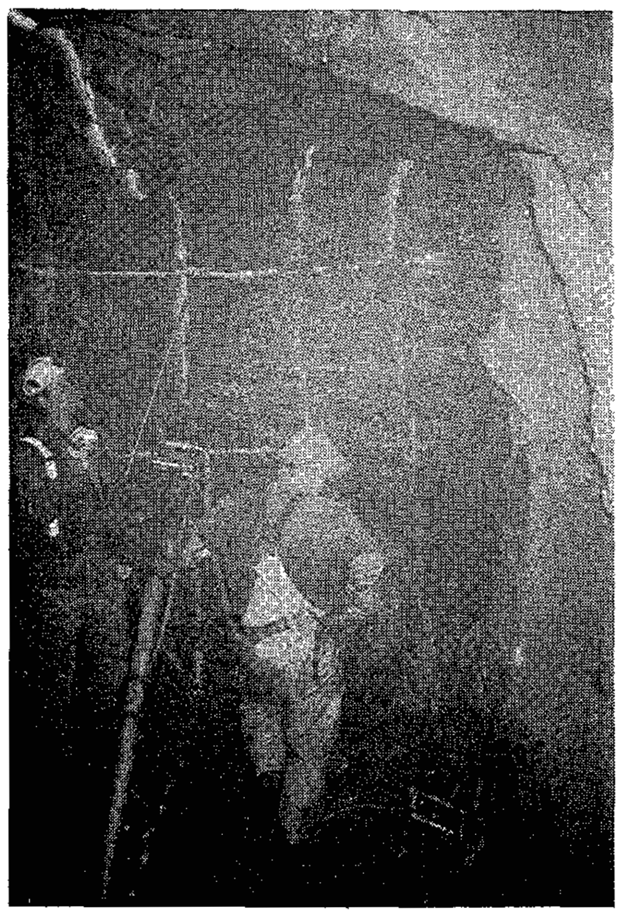

Photo 1. Exploration drift development at Ladner Creek mine, October 1995.

LADNER CREEK MINE

Athabasca Resources Limited optioned the past-producing Ladner Creek (Carolin) gold mine, near Hope, in 1994 and carried out a major exploration program in 1995. The company reopened the mine, drilled for additional reserves and conducted metallurgical tests aimed at improving on past gold recoveries, and recovering gold from the existing tailings (Photo 1).

The mine went into production, in 1981, as an underground operation with reserves of 1.5 million tonnes, grading 4.4 g/t Au, at a 2.4 g/t Au cut-off. It operated at a nominal mill capacity of 1360 tonnes per day and produced 1354 kilograms of gold from 799 119 tonnes of ore before shutting down in 1984. The mine was plagued by operational and metallurgical problems including excessive wall-rock dilution, poor recovery and a cyanide spill. It closed suddenly and the mill and much of the plant remain on site.

The Ladner Creek deposit is a mesothermal, "shear-hosted", gold deposit in Ladner Group metasedimentary rocks adjacent to the east strand of the Hozameen fault. It includes several en echelon ore shoots in the thickened hinge of an antiformal fold. The shoots dip steeply to the northeast and plunge at a relatively shallow angle to the north. Most of the 1980s production was from the largest of the three principal ore shoots identified at the time.

Athabasca's underground drilling program comprised 92 diamond-drill holes for an aggregate length of 7010 metres.

The program was designed to confirm remaining reserves, delineate additional ore within the three known shoots and locate additional reserves in a postulated fault off-set, down-plunge portion of the deposit. It fan-drilled the known shoots from the existing 800 and 900 level drifts with mixed, but generally encouraging, results that suggest that the company should be able to increase the mineable reserves significantly, at much the same grade as previously mined.

Athabasca also drove 280 metres of exploration drift on the 875 level, to provide stations for additional drilling for the off-set portion of the same target. In the course of drilling for the extension, it intersected several new zones that are subparallel to those expected. One hole cut a quartz-rich zone in mafic volcanic rock that returned an intersection running 11.32 g/t Au over 9.0 metres. The new zones are sufficiently close to existing underground workings that they should be readily accessible for mining.

The presence of good gold values in volcanic rock is unusual for the deposit. The ore bodies mined in the 1980s were largely comprised of irregular shaped zones of albite, quartz and carbonate alteration containing narrow stringer quartz veins in bleached, chloritic, greywacke and siltstone. The rocks generally contained abundant disseminated pyrrhotite and lesser amounts of pyrite and arsenopyrite. Some of the gold was free milling but most was tied up in pyrrhotite, which made it metallurgically difficult. Athabasca is considering a variety of processing options ranging from recovering gold on site, to direct shipment of auriferous-sulphide concentrate.

The company also surface drilled the McMaster and Lorraine zones which are similar "shear-hosted" mineral occurrences approximately 1.5 to 2.0 kilometres north of the Ladner Creek mine site, along the same structure. It drilled ten diamond-drill holes for an aggregate length of 827 metres to test the two zones. The results were encouraging. One of the McMaster zone holes cut a long intersection of altered and mineralized rock below a body of serpentinite.

GIANT COPPER

Bethlehem Resources Corporation acquired the Giant Copper (Canam) property, southeast of Hope, in 1988, and conducted a variety of exploration programs, including mapping, trenching and rotary and diamond drilling, that summer and the following year.

Since then the property has been dormant in part due to concerns regarding the ultimate land-use designation of the area. The property lies immediately adjacent to Ernest Manning Provincial Park and overlaps the Skagit Valley Recreation Area. The concerns were addressed in November, when the provincial government announced the creation of the Skagit Valley Provincial Park. It specifically excluded the company's claims and stated that the property will remain available for development.

The Giant Copper property covers a variety of polymetallic mineral showings (Invermay, AM) that have been explored intermittently since the 1930s. The showings appear to be associated with a northwesterly trending diorite to quartz diorite intrusion, the Invermay stock, that cuts a succession of deformed and metamorphosed immature volcaniclastic sedimentary rocks with interbedded andesite sills and/or flows, close to the trace of the Hozameen fault. The "main" showing, the AM zone, was extensively explored by underground development and drilling in the 1950s and 1960s (Photo 2).

The AM zone is in the volcaniclastic sedimentary package adjacent the diorite stock. It is approximately 350 metres long and 150 metres wide. It is pipe-like body, discordant with respect to stratigraphy, comprised of weakly to strongly altered "felsic" and "mafic" fragments in a matrix that is variously comprised of amphibole, biotite, chlorite, epidote, tourmaline, magnetite and, locally, coarse blebs of sulphide. There are relatively minor amounts of quartz and carbonate.

The breccia has undergone several phases of deformation and has had a long history of alteration and mineralization. The earliest fluids appear to have introduced abundant tourmaline and pyrite. Somewhat later fluids deposited chalcopyrite, local molybdenite, and pyrrhotite, and the latest fluids deposited arsenopyrite and sphalerite. There is gen-

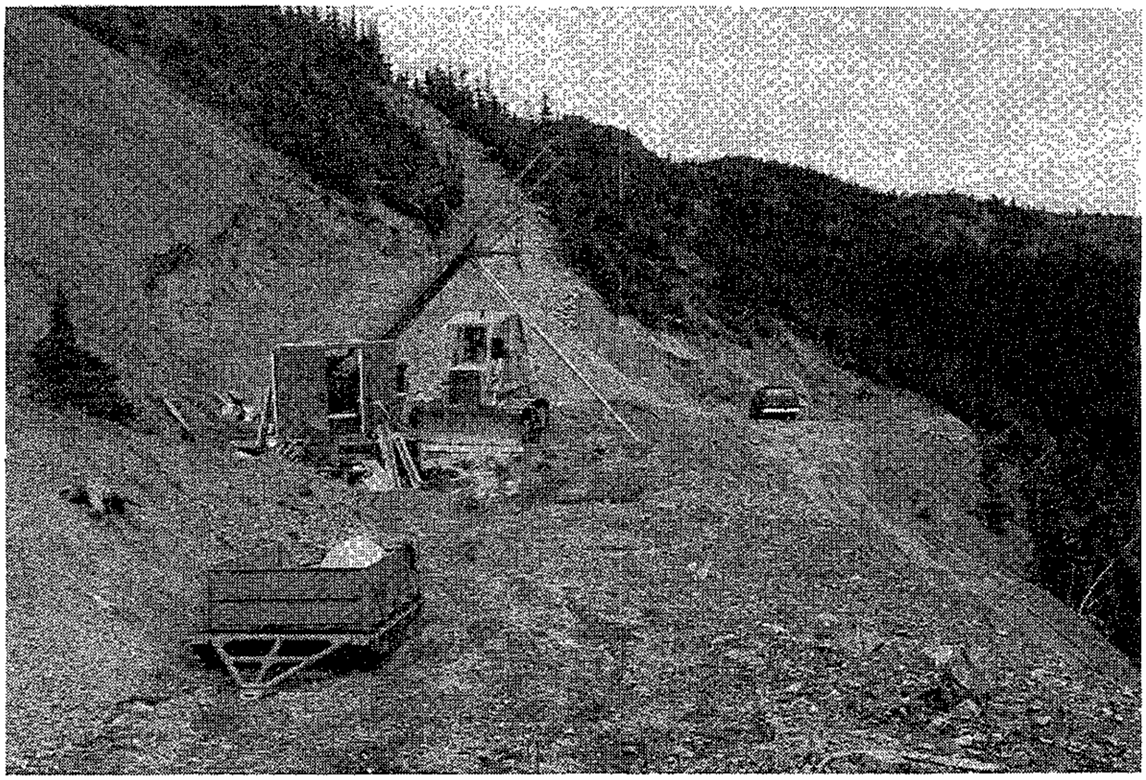

Photo 2. Surface drilling on the AM zone at Giant Copper, September 1995.

erally poor spatial correlation between copper and molybdenum content and that of gold, silver and arsenic. The breccia body is deformed along bounding structures that trend in a generally northwesterly direction and is cut and locally off-set by faults that trend in a northeasterly direction. Both appear to have influenced rock porosity and fluid flow and have had a marked impact on metal grade distribution.

Undergound drilling in the 1950s and 1960s identified and explored a higher-grade zone of mineralization containing a geological reserve of 3.35 million tonnes grading 1.17% Cu, 0.51 g/t Au and 20.6 g/t Ag in the northern "nose" of the breccia. The enrichment probably resulted from more thorough ground preparation. Although earlier operators were primarily concerned with the underground development potential of the deposit, Bethlehem Resources has concentrated on its open-pit potential. The AM zone currently has an open-pit reserve of 26.76 million tonnes grading 0.38 g/t Au, 12.34 g/t Ag and 0.65% Cu at a stripping ratio of 4.25 to 1.

Bethlehem Resources merged with Imperial Metals Corporation in 1995 and resumed exploration. The company collected 41 continuous surface chip samples and diamond-drilled eight angled holes, for an aggregate length of 1389 metres. The holes were drilled to check near-surface grades within the main body of the breccia and locate structurally controlled zones of higher-grade mineralization.

BRANDYWINE

La Rock Mining Corporation acquired ownership of the Brandywine property, near Whistler, in 1992. That year, the company drill tested a possible volcanogenic massive sulphide target at the Tedi pit, at the north end of the property, and later explored a large gold-in-soil geochemical anomaly in the vicinity of the past-producing Main Zone and Silver Tunnel deposits.

The company found the Dave's Pond gold deposit in 1993. The discovery hole intersected 7.54 g/t Au over 21.9 metres. La Rock commenced drilling the deposit and, by the end of 1994, it had recovered approximately 6700 metres of core. In 1995, it completed a further 26 holes for an aggregate length of 2286 metres.

The Dave's Pond deposit is a "shear-hosted" gold occurrence in Gambier Group volcanic strata in a roof pendant in the Coast Plutonic Complex. The deposit consists of weakly to intensely quartz-carbonate veined and altered mafic volcanic rock that contains trace amounts of galena, sphalerite, chalcopyrite and free gold. The principal controls on mineralization appear to be a northwesterly trending, near vertical, shear zone and a poorly defined structure with a shallow northeasterly dip.

La Rock also drilled three holes on coincident gold-in-soil geochemical and pulse EM geophysical anomalies near the McKenzie mill, approximately 1.5 kilometres to the southeast of the Dave's Pond deposit. The holes cut trace amounts of mineralization.

OTHER ACTIVITY

In other developments, International Curator Resources Limited ran a geophysical survey over part of the Seneca volcanogenic massive sulphide property, near Harrison

Lake. Navarre Resources Corporation obtained erratic but interesting gold values from a sulphide bearing, shear-hosted, quartz vein on the Rox claims, northeast of Powell River and Amcorp Industries Incorporated staked the old Salal Creek molybdenum property, northwest of Pemberton.

QUEEN CHARLOTTE ISLANDS

The Queen Charlotte Islands have seen very little exploration over the past few years, despite a considerable amount of remapping by the Geological Survey of Canada. However, this is likely to change as Misty Mountain Gold Limited, has acquired a major deposit and a large property position and other companies are showing greater interest in the area.

HARMONY

Misty Mountain Gold Limited merged with Romulus Resources Limited and acquired control of the Specogna (Cinola) deposit, together with over 400 square kilometres of mineral tenure over central Graham Island. The company flew an airborne geophysical survey over the entire area, conducted a regional exploration program, and embarked on a major surface drilling program on the main deposit, south of Port Clements.

The Specogna deposit is a large epithermal gold occurrence in Tertiary conglomerate along and adjacent to the Specogna fault, a splay of the larger Sandspit fault. City Resources Canada Limited explored the deposit in the mid-1980s and delineated a diluted open-pit "mineable reserve" of 31.3 million tonnes averaging 2.2 g/t Au at a 1.1 g/t Au cut-off and a stripping ratio of 1.7:1. The company completed a feasibility study but didn't take the property to production.

The deposit is comprised of a series of en echelon, gold-bearing, "crack-seal", epithermal quartz veins within a large volume of silicified, pyritic, conglomerate (Photo 3). Misty Mountain drilled 31 diamond-drill holes, for an aggregate length of 7110 metres, as the first phase of a program to reassess the grade of the deposit based on drill holes optimized on the orientation of the veins and stockworks.

The company hopes to locate sufficient higher grade material to develop an open pit or underground bulk mining operation. The veins and stockworks are mostly vertical and they strike in a northeasterly direction, at an angle to the Specogna fault. Misty Mountain is drilling angled holes in a southeasterly direction on a 20-metre grid. It completed five fences across the deposit in 1995 and expects to continue with the program in 1996.

The results show considerable but variable gold enrichment within the veins, compared to the grades encountered in the silicified conglomerate. Intercepts of 8 to 12 g/t Au over 5.0 metres or more are not uncommon. One particularly impressive hole intersected abundant visible gold and a "bonanza" grade of 41.09 g/t Au over 41.7 metres. Fluid inclusion studies suggest that most of the veins sampled to date were formed above the main boiling point "throttle zone" and there is considerable potential for grade improvement at depth. The company plans to drill some deeper holes to test for "bonanza" grade material.

The company followed up on a high-resolution airborne (magnetometer, EM, resistivity and radiometric survey) geophysical survey, flown in the spring, with a regional geological and stream sediment geochemical survey. The program was aimed at evaluating geophysical targets and structures for epithermal mineralization. The results were

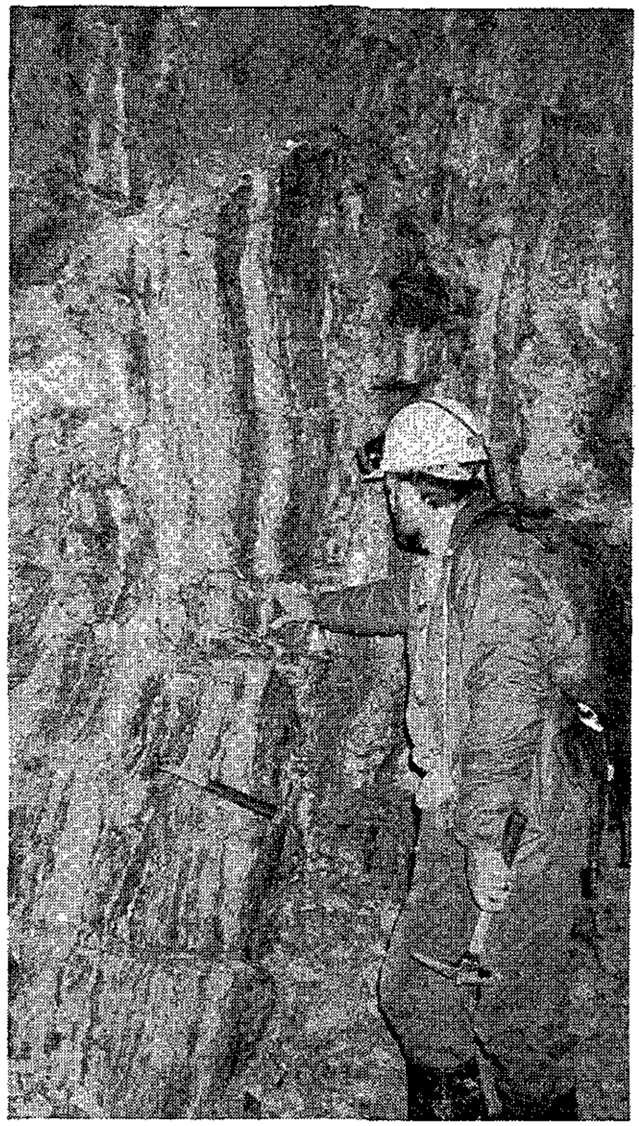

Photo 3. Composite quartz veins in the Specogna deposit, August 1995.

encouraging; four areas were selected for more detailed work.

Although there were few other projects in the Queen Charlotte Islands in 1995, Misty Mountain's success with the Harmony project has led to renewed interest and staking in the area.

LAND-USE ISSUES

Land-use issues are still a concern for many people exploring in the region. They were not all resolved but several government decisions and initiatives went a considerable way towards clarifying what land is, and is not, available for exploration.

VANCOUVER ISLAND

The Commission on Resources and Environment (CORE) completed its land-use process for Vancouver Island in 1994, and government announced its intention of creating 23, large, protected areas later the same year. However, the boundaries required definition and it wasn't until April, 1995, that it was able to confirm the areas to be protected.

The larger areas selected include, Nahwitti-Shushartie, Brooks-Nasparti, Walbran, Woss Lake, Tahsish-Kwois, Nimpkish Lake and Quatsino. The additions brought the over-all level of protection on Vancouver Island up to 12.64%.

In February, 1996, Government created a further 35, small, protected areas covering local features and sites of special interest. These brought the over-all level of protection on Vancouver Island up to 13%, which was government's objective.

The Protected Area Strategy (PAS) planning process for Vancouver Island is now complete and the emphasis has now moved back to land management and planning associated with management zones designated under the Forest Practice Code of British Columbia. The Mount Waddington and Nootka Sound Community Resource Boards were established to provide local input to assist in the implementation of the Vancouver Island land-use plan.

LOWER MAINLAND

Government made a series of PAS land-use decisions in 1995. It created several new, large and small protected areas that together bring the level of protection in the lower mainland up to 10.5%. Several of the areas were selected following considerable study and public debate. They include the Pinecone Lake - Burke Mountain, Tetrahedron, Stawamus Chief and Skagit. Others, such as Indian Arm, Sumas Mountain and Douglas Island were selected as part of government's Lower Mainland Nature Legacy Program. Between them, the new areas reduce the "gap" in protection in the region to approximately 100 000 hectares.

As well as announcing the creation of the new protected areas, government also announced the deletion of several redundant PAS study areas.

In 1994, a Public Advisory Committee, comprised of representatives from a broad range of interested groups, was established to assist in the selection of the remaining areas to be protected. The committee met throughout the fall of 1995 and into the new year. It expects to submit a negotiated, consensus recommendation to government later this spring.

In announcing its decision on the future of the Skagit Valley Recreation Area, government stated that part of the

Twenty-six Mile Creek watershed should be made available for exploration and possible future mine development. This part of the valley has been removed from the recreation area and excluded from protection in the newly created provincial park. The decision ensures that all of Bethlehem Resources Ltd.'s Giant Copper property is available for exploration and development.

GOVERNMENT ACTIVITY AND RESEARCH

In 1995, the provincial Geological Survey Branch completed a three-year study of the geology and exploration potential of Northern Vancouver Island. The study included: regional mapping by Graham Nixon *et al.*; mineral deposit studies, by Andre Panteleyev *et al.*; surficial geology and drift exploration studies, by Peter Bobrowsky *et al.*; and a variety of geochemical investigations by Steve Sibbick *et al.* The results are discussed in numerous articles in recent editions of British Columbia Geological Survey Branch, Geological Fieldwork. The reports provide a wealth of data on the geology and exploration potential of the Island Copper porphyry belt, north of Holberg Inlet and the Merry Widow Mountain and Mahatta River areas farther south.

The Geological Survey of Canada was also active on Vancouver Island. Kika Ross *et al.* sampled and dated zircons from intrusions associated with the Island Copper deposit and Lizelle Currie *et al.* carried out apatite fission-track studies on samples from a transect across Vancouver Island, near Port Alberni. The program was designed to unravel the Tertiary to Recent tectonic history of the Island.

The Geological Survey Branch was also active on the Lower Mainland; Gerry Ray *et al.* studied the wollastonite deposits near Sechelt; Peter Bobrowsky *et al.* developed an aggregate inventory for the province, that will have considerable application in the region, and started preliminary work on an aggregate potential mapping project; and Vic Levson *et al.* carried out a pilot surficial geology and earthquake hazard mapping program in the vicinity of Chilliwack.

The Geological Survey of Canada is also interested in rock failure and natural hazards. Sebastian Bell *et al.* investigated neotectonic stress orientation indicators in southwestern British Columbia.

ACKNOWLEDGMENTS

The author wishes to acknowledge the contribution of numerous public and private sector geologists and other professionals to this report.

ASSESSMENT REPORTS: A SOURCE OF VALUABLE CURRENT AND HISTORIC MINERAL EXPLORATION DATA

By A.F. Wilcox, P.Geo. and T.E. Kalnins, P.Eng.

SUMMARY OF ASSESSMENT WORK, 1995

Results of mineral exploration programs are submitted by the industry to the government in compliance with the Mineral Tenure Act Regulations and provide a valuable record of exploration data in British Columbia.

The number of assessment reports submitted and approved in 1995 totalled 540 with declared costs of $26,830,016, a 40% increase in expenditures over 1994 (Table 1; Figures 1, 2 and 3).

Drilling accounted for 60% of the expenditures, geochemical sampling 13%, geological mapping 11%, geophysical surveys 9%, physical work 6%, and prospecting 1% (Figure 4).

Assessment work, which is required for the maintenance of mineral claim tenure, comprises only a portion of the overall mineral exploration in the province.

Average exploration project costs by work type are shown in Table 2. These values are based on clearly apportioned cost statements including labour, consulting, food, accommodation, transport, camp equipment rentals and supplies, laboratory analyses, report preparation, and direct administration and management of the project.

USING THE DATABASE

Assessment reports are the primary and most current source of detailed technical data available in the public domain. Reports on exploration may be viewed or paper and microfiche copies purchased after expiry of a confidentiality period (usually one year).

The Geological Survey Branch maintains a library of over 24 000 assessment reports dating from 1947. A computer index called ARIS (Assessment Report Indexing System) provides help to users wishing to locate specific information for planning new exploration programs, resource management - land use studies, or geoscience research.

This is a basic bibliographic index sorted by NTS map sheets. For each report the index provides geographic coordinates, claim names, operator, author, type of work reported and report year. Newly computerized, page-sized index maps show the approximate centre of exploration reported.

The Assessment Report Index is available on COMFICHE, PAPER printouts and DISKETTES. On diskettes the data fields are enhanced with additional information on geology, mineralization, mining camp and work done. Data

TABLE 1
SUMMARY OF ASSESSMENT WORK, 1995

No. of Assessment Reports	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)	Tunnelling (m)
156	3 976 087	13 414	165	882	12 589	21 876	1 549	3 765	32	3	371	--
170	5 730 013	34 755	834	697	23 605	31 939	7 898	5 475	1 575	1	453	386
89	3 463 773	36 232	3 498	1 258	18 956	14 338	1 360	7 100	1 821	7	328	--
35	2 436 245	22 055	1 062	106	8 237	10 292	--	660	800	2	220	–
36	1 732 970	3 040	5 163	4 785	4 445	6 233	--	5 950	25	--	--	--
54	9 490 928	37 221	40	520	23 340	39 483	517	1 275	170	20	304	--
540	26 830 016	146 717	10 762	8 248	91 172	124 161	11 324	24225	4 423	33	1 676	386
490	19 057 218	111 881	6 738	3 078	82 735	88 272	5 747	27 181	3503	83	1 507	2 221
478	17 082 345	137 365	4 521	1 954	72 626	91 270	6 681	23 101	4 903	41	1 359	
616	27 625 329	257 342	5 915	4 273	128 871	126 156	3 748	46 410	12 480	56	2 597	480

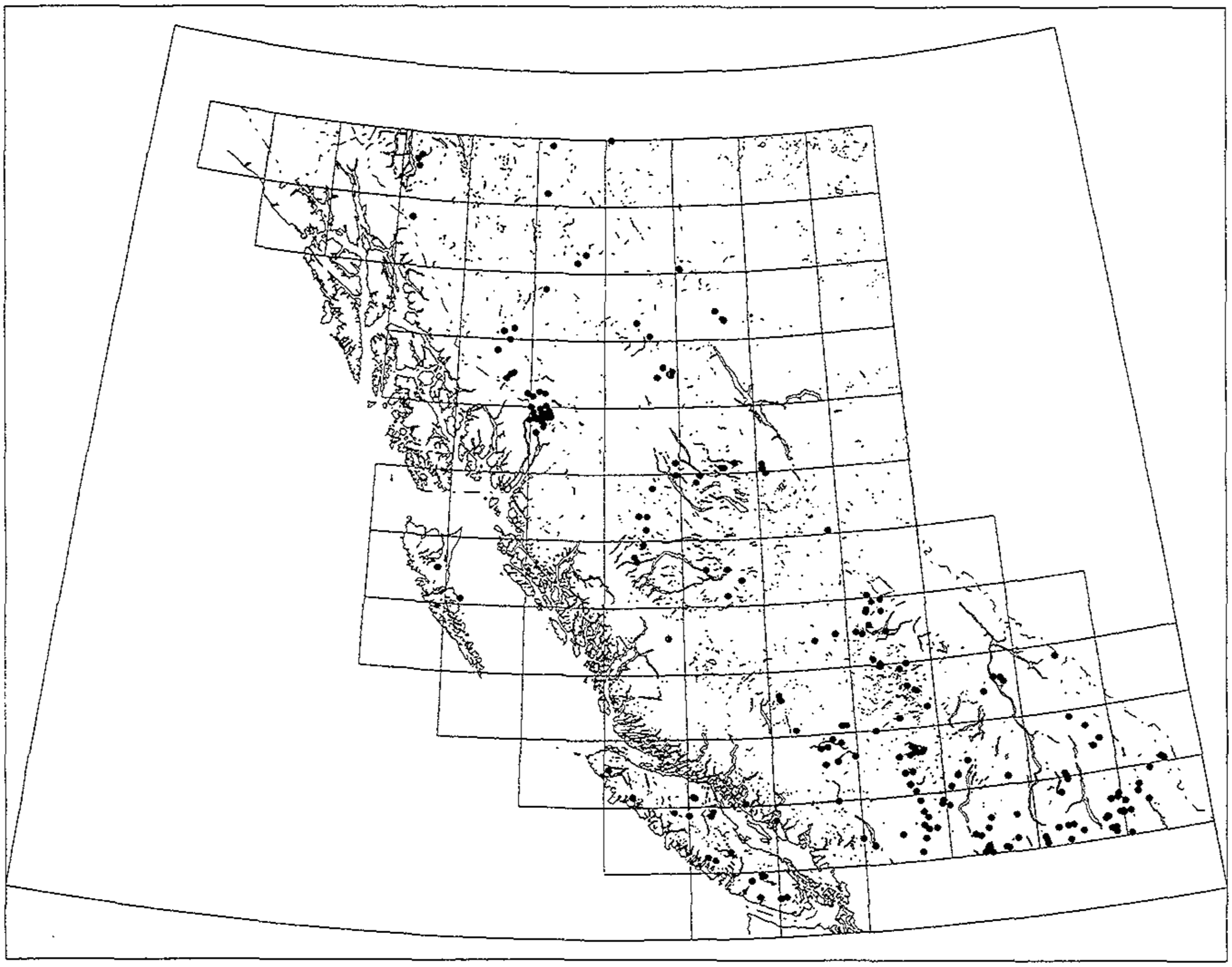

Figure 1. Assessment report distribution in British Columbia - 1995.

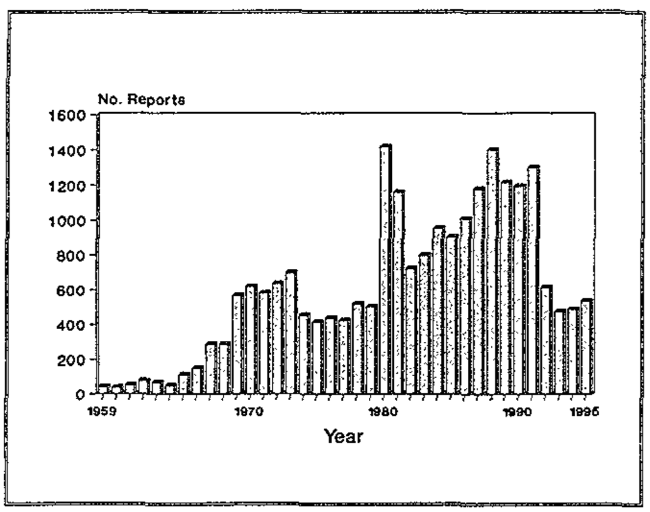

Figure 2. Assessment reports received.

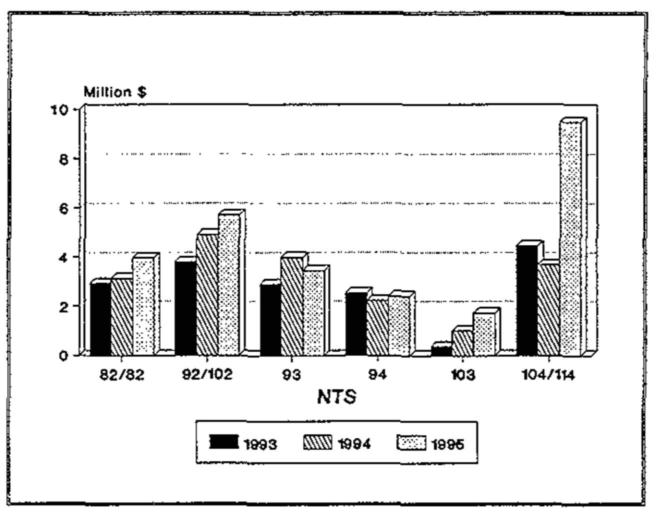

Figure 3. Assessment reports, value of exploration by NTS; 1993 - 1995.

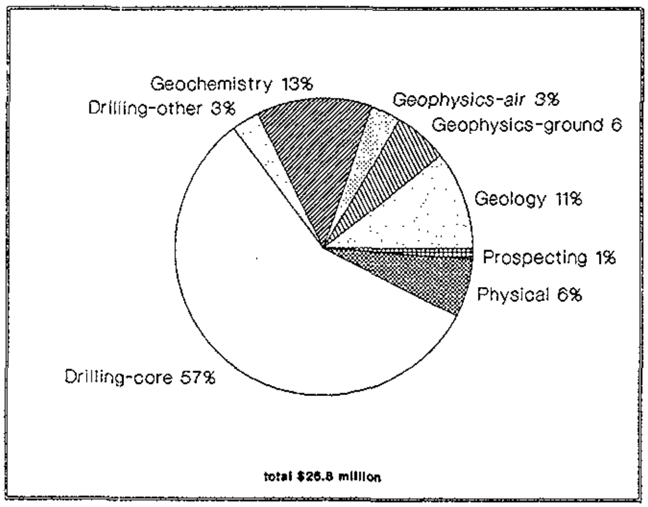

Figure 4. Value of exploration by work type; assessment reports, 1995.

on the diskettes are organized as a series of flat ASCII files to facilitate access by commercial software programs.

The paper index has been updated into five volumes. Volume I consists of the index maps and the 1994 - 1995 supplements. Volumes II - V contain the data covering southeastern, southwestern, central, and northern parts of the province (up to 1993).

These products may be purchased directly from:

British Columbia and Yukon Chamber of Mines
840 West Hastings Street
Vancouver, British Columbia
V6C 1C8

Telephone: (604) 681-5328
Fax: (604) 681-2363

Internet e-mail: chamber@bc-mining-house.com
WWW Homepage: http://www.bc-mining-house.com/chamber/

TABLE 2
AVERAGE EXPLORATION PROJECT COSTS, 1995
($ per unit of work)

TYPE OF WORK	1995	1994	1993
Geological mapping	19/ha	12/ha	20/ha
Mag./E.M. airborne	57/km	80/km	135/km
Magnetic, ground	382/km	269/km	272/km
Electromagnetic, ground	531/km	484/km	607/km
Induced polarization	1644/km	1594/km	1702/km
Self potential	435/km	430/km	798/km
Soils	34/sample	34/sample	31/sample
Stream sediments	90/sample	113/sample	50/sample
Rock chips	55/sample	49/sample	61/sample
Sampling assaying	26/sample	38/sample	63/sample
Core drilling	124/m	93/m	103/m
Drilling, non-core	65/m	53/m	62/m
Prospecting	11/ha	12/ha	13/ha
Line cutting, grid	513/km	429/km	565/km
Trenching	50/m	64/m	87/m

Average exploration project costs are based on reports with clearly apportioned cost statements including labour and consulting, room and board, transport, instrument and equipment rentals, camp supplies analyses, report preparation, and direct administration and management of the project.

These are not firm figures and should be used as a guide only.

A complete library of original assessment reports is located at the Branch's headquarters in Victoria. Partial libraries are located at the Regional Geologists' offices in Smithers, Prince George, Kamloops and Cranbrook. Complete libraries of microfiche assessment reports are available in all Regional Geologists' offices. Partial libraries are maintained in fourteen Gold Commissioners' offices throughout British Columbia. For further information contact:

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PART B

GEOLOGICAL DESCRIPTIONS OF PROPERTIES

Economic Geology / Stewart Complex / mineralization / Stewart District / Maple Bay / Anyox / Alice Arm / Kitsault

MINERAL DEPOSIT STUDIES IN THE STEWART DISTRICT (NTS 103O/P and 104A/B)

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J.K. Mortensen, The University of British Columbia
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INTRODUCTION

The Stewart Complex is a mineral-rich belt of Triassic and Jurassic volcanic rocks which forms the northwestern margin of the Bowser sedimentary basin in central British Columbia. The British Columbia Geological Survey has completed geological mapping and mineral deposit studies throughout the western part of the complex between Stewart and Telegraph Creek, and initiated the Cambria project in 1995 to extend these studies to the remainder of the belt which lies east and south of Stewart (Figures 1 and 2). This preliminary report combines data from historic and recent geological work with observations from 1995 property visits and new data from isotopic studies.

The project area lies along the eastern margin of the Coast Mountains at the head of the Portland Canal, a fiord 115 kilometres long which marks the southeastern boundary between the Alaska Panhandle and northwestern British Columbia. Located within the southern Boundary Ranges of the Coast Mountains, elevations range from sea level to 2717 metres on Mount Jancowski. Topography is rugged; the area is characterized by precipitous glaciated valley walls and rounded ridge crests. There is limited road access to the northern part of the study area and good boat access to the southwestern part of the area via the network of fiords. All other travel is by helicopter; there are permanent bases in Stewart and Nass Camp.

The study area covers 2000 square kilometres, centred on the Cambria Icefield (Figure 2). It includes the town of Stewart, British Columbia, the village of Hyder, Alaska, and the sites of the former mining communities of Anyox, Alice Arm, Kitsault and Maple Bay. The first two producing mines in the Stewart district (Outsider, Red Cliff) lie within the area which also encompasses the former producing mines at Anyox, Dolly Varden, Torbrit, Kitsault, Dunwell and Georgie River, and important new discoveries at Red Mountain and Willoughby Creek (Table 1). The project area contains 414 documented metallic mineral occurrences (5% of British Columbia's total mineral inventory). In addition there are many recent discoveries that have yet to be entered into our provincial database, including ten new occurrences reported by Teuton Resources Corporation and Minvita Enterprises Limited and dozens located by Lac Minerals Limited.

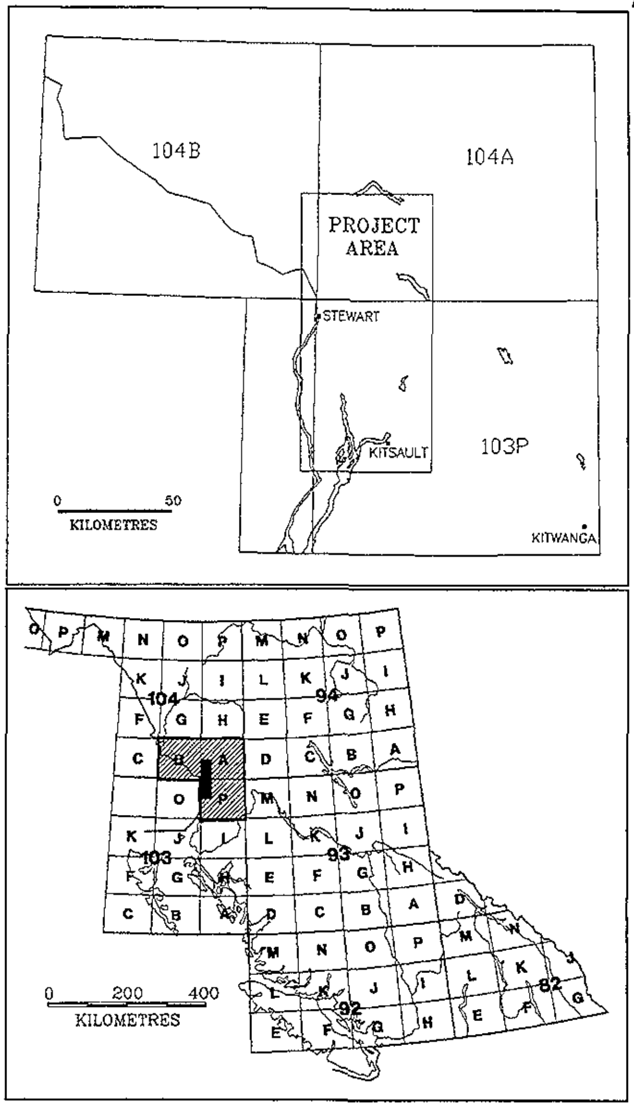

Figure 1. Cambria project index map.

The project area has new (1994) high-resolution black-and-white airphoto coverage (Figure 3). Standard-size photos (25 x 25 cm) are printed at 1:15 000 scale. The optimum satellite image for the area (zero cloud cover; minimum snow cover) is Landsat TM scene, Path 054, Row 021, August 5, 1993 (M. McPherson, RGI, personal communication).

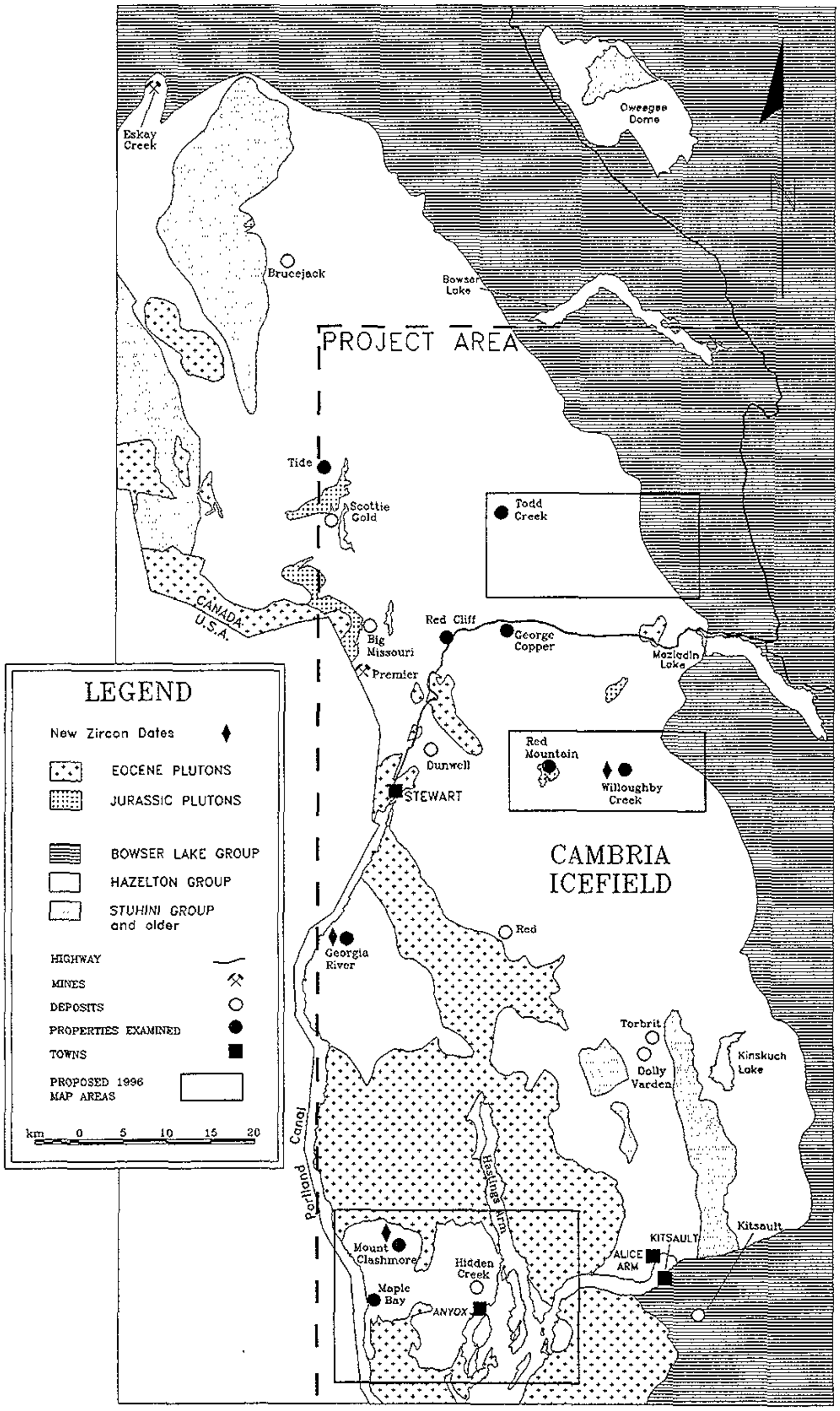

Figure 2. Cambria project location map showing properties examined and U-Pb zircon sample sites.

TABLE 1
PROPERTY MINFILE NUMBERS

PROPERTIES	MINFILE	PROPERTIES	MINFILE
Anaconda	103P 048	Main	103O 013
Anyox	103P 021	Maple Bay	103O 009/018
Back	103P 006		103P 040/043
Big Bulk	103P 016		103P 048/242
Blue Bell	103P 242	Marc	103P 086
Brad	103P 086	Marc Extension	103P 086
Bullion	103P 005	May Queen	103P 043
C-1	103P 249	Meg	103P 086
C-2	103P 249	MJ	104A 091
Cambria	103P 086	Montrose	104A 033
Camp	103O 013	Nelson Creek	104A 099
CC#1	103O 013	NI	103P 006
CC#2	103O 013	Nimble	103P 142
CCR	103P 006	North	103P 006
Clone	103P 249	Outsider	103O 018
Cobbett	103O 013	Pius	103P 006
Comstock	103P 040	Pond	103O 013
Del Norte Creek	103P 005	Premier	104B 054
Doc	104B 014/015	Princess	103P 048
Dolly Varden	103P 188	Red	103P 249
Dunwell	103P 052	Red Cliff	104A 037
Eagle	103P 043	Red Mountain	103P 086
East Bob	103O 013	Star	103O 018
East	103O 013	Southwest	103O 013
Eastmark	103O 013	Southwest Extension	103O 013
Edge	103P 006	Summit	103O 013
Friday	103O 009	Swamp Point	103O 017
Gem	103O 013	Thistle-Rose	103P 048
Gem A	103O 013	Tide Lake	104B 129
Gem Top	103O 013		104B 251-254
George Copper	104A 129	Todd Creek	104A 001
Georgia	103O 013	Torbrit	103P 191
Georgie River	103O 013	United	103P 043
Gertie	103P 048	Upper Icefall	103P 006
Glory Hole	104A 037	Wilby	103P 006
Granodiorite	103O 013	Willoughby	103P 006
Kitsault	103P 120	Willoughby Creek	103P 017
Kiwi	103P 006	Willoughby Creek	103P 006
Ledge	103P 006	Willow	103P 006
Lizzie	103P 048	Zinc	103O 013
Lower Icefall	103P 006	141	103P 086

Geological maps covering parts of this area include sheets by McConnell (1913), Schofield and Hanson (1922), Hanson (1929, 1935), Black (1952), Grove (1971b, 1986), Carter and Grove (1972), Carter (1981), Alldrick (1986a, 1986b, 1987, 1993), Greig *et al.* (1994), Evenchick *et al.* (1992) and Evenchick (1996). Geological map coverage within the project area was assessed. Three tracts that merit additional mapping have been selected for work over the following two field seasons: Anyox pendant, Willoughby Glacier and Todd Icefield (Figure 2).

CURRENT ACTIVITY IN THE AREA

The British Columbia Geological Survey carried out a six-week field program in July and August, 1995. Work focused on deposit examination, sampling and documentation and included visits to the following deposits and prospects: Maple Bay (Outsider mine), Red Cliff (Red Cliff, Montrose and Gloryhole prospects), Mount Clashmore, Tide Lake, Todd Creek, Red Mountain (Marc, 141, Brad, Marc Extension, Meg and Cambria zones), Georgie River (Southwest,

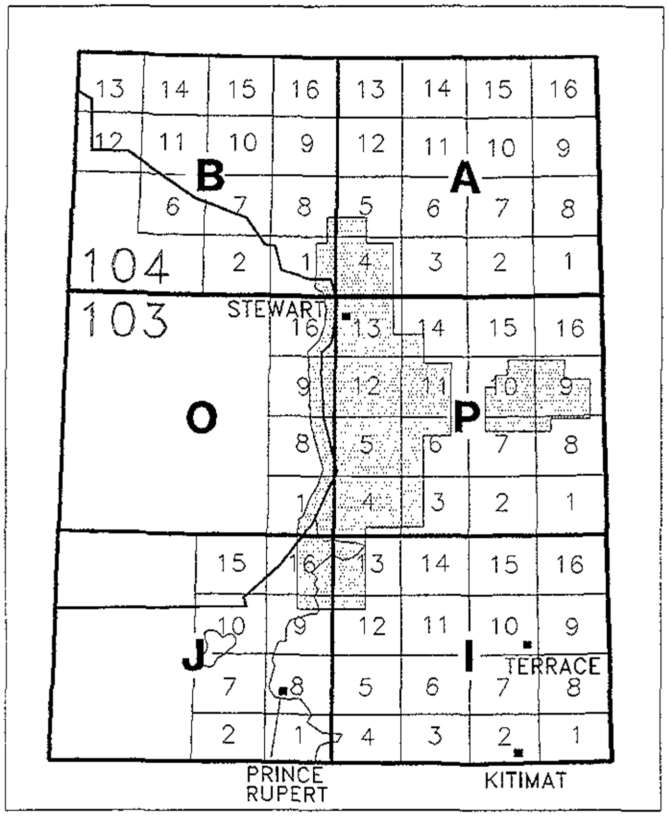

Figure 3. New airphoto coverage (1994 survey).

Bullion, Cobbett, Main, Summit, Georgia, CC #1, CC #2, Zinc, East Bob, Granodiorite, Gem, Gem A and Gem Top veins), George Copper and Willoughby Creek (North, Wilby, Willow, Edge, Kiwi & NI zones). Table 2 lists four new U-Pb zircon dates obtained from three sites in the project area (Figure 2). An accompanying report (Gabites *et al.*, 1996, this volume) presents new lead isotope data from five deposits in the study area.

Six exploration programs were in progress in the Stewart area during the summer of 1995. Hemlo Gold Mines Inc. completed an evaluation of its Tide property north of the Granduc millsite where a series of new gold-bearing arsenopyrite veins and one base metal vein have been located. Navarre Resources Corporation conducted an induced polarization survey over a set of high-grade silver-lead-zinc veins on the MJ property east of Long Lake, near the crest of Bear River ridge. Westmin Resources Limited completed another season of surface and underground exploration around the Premier mine. At Georgie River, Aquaterre Mineral Development Limited drilled fill-in holes within a block of previously defined inferred reserves on the Southwest vein of the Georgie River mine. Teuton Resources Corporation and Minvita Enterprises Limited carried out trenching and drilling on recently discovered showings, and continued prospecting work on their extensive claim block which surrounds much of the Cambria Icefield. Results this year include high gold assays from trench samples at the Red prospect, adjacent to earlier discoveries C-1 and C-2. Camnor Resources Limited continued the evaluation of gold-silver prospects on the Willoughby Creek property with surface drilling. Exciting gold-silver intersections prompted the company to proceed with an underground development program to establish additional drill stations.

TABLE 2
NEW URANIUM-LEAD (ZIRCON)
DATES FROM THE CAMBRIA ICEFIELD AREA

LOCATION	FIELD NAME	ROCK TYPE	AGE Ma	ERROR Ma
Georgie River	Granite dikes	Biot-Hbld granodiorite	50.7	+0.1/-0.1
Georgie River	Granodiorite dikes	Hbld-Kspar porphyry	187.2	+3.5/-0.9
Willoughby Creek	Willoughby stock	Hbld-Kspar porphyry	201.9	+1.4/-3.2
Mount Clashmore*	Diorite sills	Leucogabbro	364.0	+4.0/-4.0

*sample collected by R.W.J. Macdonald

REGIONAL GEOLOGIC SETTING

The Stewart district is underlain by an Upper Triassic (Stuhini Group) to Lower Jurassic (Hazelton Group) island-arc complex constructed upon a basement of Paleozoic volcano-sedimentary sequences (Stikine assemblage). The Mesozoic volcanic pile has both subaqueous and subaerial intervals and consists of calcalkaline basalts, andesites and dacites with interbedded sedimentary rocks. Lateral facies variations in volcanic rock textures indicate emergent paleotopographic highs and volcanic vent sites (Alldrick, 1989). Early Jurassic calcalkaline hornblende granodiorite plutons of the Texas Creek Plutonic Suite represent coeval, epizonal subsidiary magma chambers at depths of 2 to 5 kilometres below the stratovolcanoes. From these plutons, late-stage two-feldspar porphyritic dikes cut up through the volcanic sequence to feed surface flows. Following subsidence, this succession was capped by Middle Jurassic marine-basin turbidites (Bowser Lake Group).

Mid-Cretaceous tectonism was characterized by greenschist facies regional metamorphism, east-northeast contraction, and deformation. It produced upright north-northwest-trending en echelon folds and later east-verging, ductile reverse faults and related foliation. Mid-Tertiary calcalkaline biotite granodiorite of the Coast Plutonic Complex intruded the deformed Mesozoic arc rocks. The batholith, stocks and differentiated dikes of the Hyder Plutonic Suite were emplaced over a 30 Ma period from Early Eocene to Late Oligocene.

LANDSAT LINEAMENTS IN THE STEWART - NASS RIVER AREA

Study of a Landsat image (Landsat-2 MSS, Path 058, Row 021, July 17 1981, RGB image) centred on NTS mapsheet 103P shows a regularly spaced series of prominent northeast-trending topographic depressions (Figure 4). These linear troughs are filled by valley glaciers, fiords, rivers and creeks. The regional extent of these linear features and their regular spacing, 5 to 10 kilometres apart, cannot be recognized on large-scale maps or airphotos.

Geologic mapping has demonstrated dextral offset along two of these features. Greig *et al.* (1994) identified one of these lineaments as a fault during mapping of two adjacent 1:50 000 mapsheets. The northeast-trending (030°) Cambria fault is mapped with a dextral offset of 1.5 kilometres. It underlies the Sutton Glacier and is projected northeasterly for 42 kilometres under the Cambria Icefield, emerging in outcrop near the toe of the South Nelson Glacier. The pronounced linear trend of these two valley glaciers is attributed to the presence of this regional-scale fracture in the bedrock below the Cambria Icefield. Grove (1987b) indicated 3.0 kilometres of dextral offset along the 9 kilometre long Portland Canal (Dunwell) fault which is a segment of a Landsat lineament 50 kilometres long.

Although offsets have only been demonstrated for two of the 35 topographic lineaments indicated on the map, all of these northeast-trending structures may represent faults with relative dextral offsets. There is little deviation in the surface trace of these features despite extreme relief, which suggests that the underlying faults all have a vertical or near-vertical attitude.

There are few constraints on the age of these faults. They cut through mid-Eocene plutons of the Coast Plutonic Complex and must be younger than 50 Ma. Outside the project area, one of these northeast-trending lineaments is the locus for the eruption vents of the Aiyansh (Tseax) lava flows, dated at 220 years BP (Sutherland Brown, 1969). It will be instructive to determine whether the faults cut, or are cut by, regionally distributed biotite lamprophyre dikes which range in age from 35 to 25 Ma (Alldrick, 1993).

Recognition of these faults could influence exploration strategies:

- Major deposits may have been truncated by these structures, such as the Big Bulk disseminated copper-gold prospect on the southeast shore of Kinskuch Lake.
- Unrelated deposits may have been juxtaposed along these faults; an apparent close spatial association can encourage interpretations of a common genetic history. The Red Mountain and Willoughby Creek gold deposits, now 7.5 kilometres apart, have moved at least 1.5 kilometres closer together during right-lateral transport along the Cambria fault. In addition, documentation of this major fault underlying the Cambria Icefield has consequences for plans to access the Red Mountain gold deposits by a haulage-way collared at the Willoughby property. The presence of this major fault across the path of the proposed tunnel poses two challenges: a probable interval of bad ground conditions and the possibility of a deeply incised glacier floor that may extend down to the haulage-way level along this prominent zone of weakness.
- Depending on the age of formation of these lineaments, they may have controlled the localization of the younger porphyry molybdenum deposits in the Coast Plutonic Complex, including the world's largest molybdenum deposit at Quartz Hill, Alaska (27-30 Ma; Hudson *et al.*, 1979) and Nimble (36 Ma; Carter, 1981).

In summary, the series of prominent northeast-trending topographic depressions in the study area is due to erosion along systematically spaced regional-scale dextral faults. This hypothesis can be further tested in the field during ongoing mapping programs. Meanwhile, the concept can be applied in exploration programs as a guide for focusing prospecting efforts and as a conceptual tool for developing exploration strategies.

GEOLOGY AND MINERAL DEPOSITS OF THE MAPLE BAY AREA

Copper-gold deposits of the historic Maple Bay mining camp were examined for comparison with copper deposits of the Anyox mining district to the east, and with gold-copper veins in the Stewart Complex to the northeast. A three-day property visit consisted of examination of surface exposures at the Outsider mine and shoreline reconnaissance mapping. The information in this report is compiled from field notes and from documents listed in MINFILE bibliographies (Table 1).

Maple Bay is on the east side of the Portland Canal, 56 kilometres south of Stewart and 12 kilometres west of the Anyox minesite (Figure 2). It is easily accessible by helicopter or charter boat from Stewart, or by float plane from Prince Rupert. Topography in the Maple Bay area is generally steep, although there is an area of flat land adjacent to the northern shore of the bay. Mineral prospects are located at elevations ranging from sea level to 1220 metres. Old roads, trails, tramlines and railway grades are heavily overgrown.

Maple Bay has a long exploration history, one of the earliest mineral claims in the region was staked here in 1896. The exploration and mining history of the area is summarized in Table 3. In addition to geological studies carried out by companies, government geologists who have reported on this mining camp include Cloutier (1922, 1924), Dolmage (1922), Mandy (1933, 1936), Hanson (1935) and Grove (1971a). There has been no regional geological mapping of the Anyox pendant.

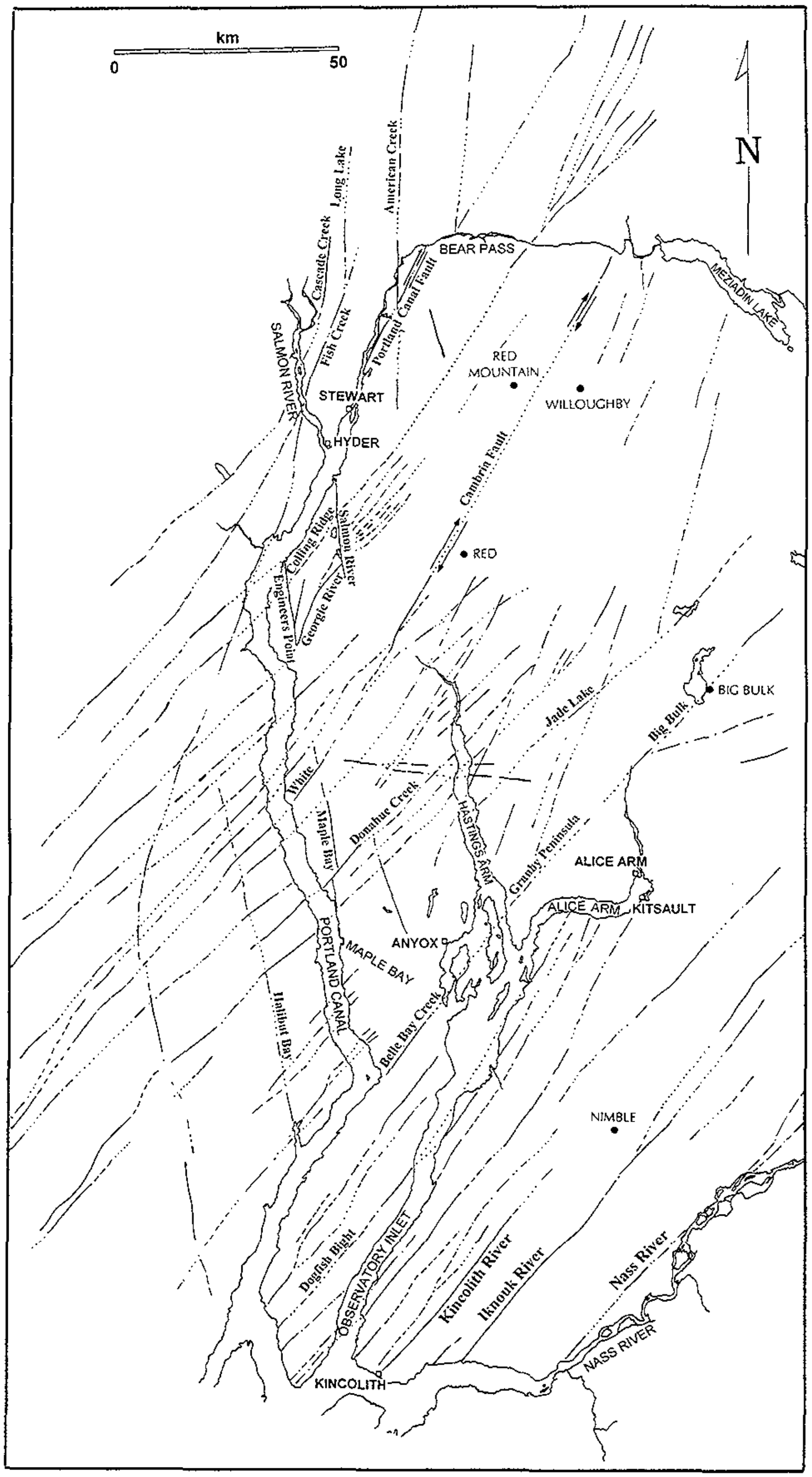

Figure 4. Landsat lineaments in the Cambria project area (from 1981 image).

TABLE 3
EXPLORATION AND PRODUCTION HISTORY AT THE MAPLE BAY MINING CAMP

YEAR	EVENTS
1896	Blue Bell claims staked at Maple Bay by Lieutenant Mosier of the US Navy.
1899	Claims not worked. Dropped and restaked by John Flewin of Port Simpson.
1899	Eagle claim staked by missionary Collinson, then combined with Blue Bell into the Bluebell claim group.
1900	John Flewin staked the Comstock group, south of the Bluebell group.
1902	Flewin located a vein assaying 2-15% Cu and $30 Au/ton (51.43 g/t).
1902	Collinson and Noble made several discoveries nearby.
1903	Portland Canal Co. optioned 3 claim groups (18 claims) and worked on these in 1903 and 1904.
1904	On the Copper King claims the Maple Bay (later Outsider) vein is traced for 700 m. Trenched and sampled every 30 m.
1905	Brown-Alaska options Copper King group, drives several prospect tunnels and raises between levels.
1905	Brown-Alaska later options Blue Bell claim group.
1906-07	Brown-Alaska produces 226 757 kg Cu (14 514 t @ 2.9% Cu). Outsider vein is traced across 7 claims.
1907	Copper King claim group is Crown-granted.
1907	On the Eagle claim group, a quartz vein 2.0-3.7 m wide is exposed and traced for 460 m.
1907	On Blue Bell claim, a tunnel is drifted on the vein for 15 m. A second cross-cut tunnel is driven 46 m below the first.
1907	Ownership of Outsider claim group transferred to Martin Waldson & Assoc. of Spokane after Brown-Alaska fails.
1913	Star claim Crown-granted.
1913	Granby Consolidated Mining and Smelting Company options all claim groups in the Maple Bay area.
1915	Princess and Comstock claim groups Crown-granted.
1916	Adit driven on Outsider vein for 215 m, 4536 t of silica flux material shipped to Anyox. Limited diamond drilling.
1916	Tunnel on Star claim driven 107 m. Railway constructed for 1220 m to connect to 215 m wharf structure.
1916	Thistle claim tested with an exploratory adit, then option dropped.
1916	Limestone quarry at Swamp Point in production at 3630 tonnes per month.
1917	Lower adit at Outsider extended 100 m.
1917	Swamp Point producing 4175 tonnes per month, access to Reserve Quarry inland is completed.
1918	912 Level tunnel driven 230 m on Outsider vein.
1918	Granby drops option and dismantles plant and facilities.
1918	Prospecting, trenching and tunneling on the Eagle, May Queen, Princess, Anaconda and Blue Bell veins.
1919	37 200 t limestone quarried at Swamp Point.
1922	Granby renews option on Outsider mine and produces until 1928. Veins followed underground for 600 m.
1923	Start of a 2-year, 760 m drilling program on the Eagle vein. Reserve estimate based on these results.
1926	Outsider produces 31 095 t ore yielding 469 981 kg Cu.
1922-26	From 1922-1926 mine produced 87 080 t ore yielding 1 542 240 kg Cu, 2022 g Au, 143 074 g Ag.
1955	Start of a 2-year diamond-drilling program on the Princess and Anaconda veins: 26 holes, 1950 m.
1956	Star adit extended to 75 m. Diamond drilling totalled 37 m in three holes.
1969	Princess vein drifting for 133 m on the 2400 level.
1970	A 490 m crosscut adit was driven through the Thistle, Anaconda and Princess veins.
1971	Road constructed from Maple Bay to the lower portal (920 Level) of the Outsider mine. 100 m of U/G development.
1972	The new 600 level adit is collared in a cliff above Roberson Creek and driven for 300 m to connect with the down-dip continuation of the Outsider vein. Not intersected.
1974	Outsider vein tested with 85 m of underground development on the 1295 level.

GEOLOGY

The eastern third of the Anyox pendant is composed of moderately deformed, weakly metamorphosed sequence of massive and pillowed basalt flows capped by a thick sequence of turbidites (Alldrick, 1986a, b). Mafic intrusions within the volcanic pile may be subvolcanic feeder dikes and sills to the extrusive flows and tuffs. Extrusive and intrusive rocks are characterized by the presence of fine hornblende crystals. Chert and limestone are important minor components of the sedimentary package.

Based on this season's work, the western two-thirds of the Anyox pendant is composed of a moderately metamorphosed and moderately to strongly deformed sequence of rapidly alternating thin-bedded mafic tuffs and interbedded clastic sediments. Marble units are minor but important components of the stratigraphic succession and the sequence is intruded in many places by conformable, sill-like bodies of medium to coarse-grained diorite.

The age and correlative stratigraphy of the rocks of the Anyox pendant are two enduring mysteries of Cordilleran geology. Grove (1986) correlated the rocks near the Anyox mine with Lower Jurassic Hazelton Group strata, based on visual similarities. The same strata have been interpreted as Upper Triassic Kunga Group equivalent rocks based on visual and chemical similaritites with the type rocks on the Queen Charlotte Islands (Sharp, 1980). Alldrick (1986a) and Alldrick *et al.* (1990) suggested a Late Triassic age based on lead isotope ratios from the stratabound syngenetic sulphide deposits at Anyox. Smith (1993) concluded that these rocks could be Early to Middle Jurassic correlatives of the Spider Peak Formation of the Methow Terrane, based on similar trace element chemistry and Sm-Nd systematics. Grove (1986) suggests the rocks in the western two-thirds of the pendant are strongly deformed and strongly metamophosed equivalents of the ore-hosting strata at the Anyox mine. However, the geology in the Maple Bay area is significantly different from that established in the Anyox mine area and the stratigraphy cannot be directly correlated between these parts of the pendant. Another possibility is that Maple Bay rocks are distal, more sedimentary equivalents to the more proximal Anyox volcanic pile, but a sample from one of the diorite sills cropping out near Mount Clashmore in the middle of the pendant produced a Late Devonian age (364 Ma; Table 2 and Figure 2). At this early stage in the study, the rocks in the western two-thirds of the pendant are regarded as a strongly metamorphosed Devonian or older volcano-sedimentary sequence, overlain in the eastern third of the pendant by the weakly metamorphosed Upper Triassic pillow lava, chert and turbidite succession which hosts the exhalative orebodies of the Anyox mining camp.

Rock types at Maple Bay include massive and bedded, fine and coarse basaltic ash tuffs, mafic volcanic siltstones and sandstones, dark grey turbidites, black carbonaceous mudstones with fine pyritic laminae and white to bluish grey limestone. No macrofossils or microfossils have been found in any of these rocks. Outcrops are sparse and no stratigraphic column has been compiled. All evidence indicates that the entire Maple Bay succession has been subaqueously deposited, but no pillowed flows were noted and none have been reported by earlier workers.

These rocks are intruded by massive, black aphanitic to fine-grained diorite dikes or sills, foliated hornblende granodiorite dikes, and by massive greenish grey microdiorite dikes and massive coarse-grained alaskite dikes.

Strata in the Maple Bay area strike 147° to 190° and dip 53° to 77° eastward. Foliation is preserved in some lithologies, but is absent in most intrusive rocks. Measured foliation attitudes range from 162° to 185° with dips ranging from 43° to 77°. Foliation is subparallel to bedding in most exposures. This similarity in attitude is significant because early studies in the Maple Bay area concluded that the veins were emplaced parallel to foliation. The Outsider vein examined in this study is parallel to bedding, and therefore vein formation may predate deformation.

There is no evidence to support an interpretation of broad, regional-scale zones of cataclastic deformation (Grove, 1986). Metamorphic grade is lower greenschist to lower amphibolite grade in most of the area examined. Uphill from Swamp Point, biotite hornfels has been overprinted on some well bedded basaltic tuffs adjacent to younger dike phases.

MINERAL DEPOSITS

The Maple Bay area produced copper together with quartz for smelter flux and minor recoverable gold and silver (Table 4). Reserves have been calculated for all these commodities. Production was only achieved from the deposits close to tidewater, although the best grades and reserves have been reported from deposits at higher elevations.

Fifteen individual veins have been located at Maple Bay. Twelve of these are grouped into three main vein systems: Outsider - Star, Eagle - May Queen and Princess - Anaconda. These consist of a strong main vein with a set of satellite veins running parallel to and locally across the strike of the main vein. Veins have sinuous, lenticular forms. They are typically hosted in silicified argillite and sometimes altered andesite near the contacts of diorite intrusions. The intrusive contact is marked by silicified argillite cut by spurs of the diorite dike.

The Maple Bay orebodies are quartz veins along brittle fracture zones. The veins generally consist of broken country rock that has been cemented by quartz and sulphides. In places bands of sparsely mineralized or barren silicified argillite occur as horses in the veins. All veins carry chalcopyrite except the Friday vein, which is pure quartz and a potential source of high-quality silica. Veins are typically composed of massive quartz with disseminations and local

TABLE 4
MAPLE BAY MINING CAMP PRODUCTION AND RESERVES

VEIN SYSTEM	VEINS	MINFILE	COMMODITY	YEARS	PRODUCTION (TONNES)	RESERVES (TONNES)	GRADE Copper %	Silver g/t	Gold g/t	Silica %
Friday	Friday	103O-009	Silica							
Outsider-Star	Outsider	103O-018	Cu, Si, Ag, Au	1906-1907	13 000		2.95	*no data*	*no data*	*no data*
				1924-1926	98 216		1.76	*no data*	*no data*	*no data*
				1927-1928	14 750		1.86	10.29	0.14	76.6
				1906-1928	125 966		1.90	*no data*	*no data*	*no data*
				1928		80 823	1.60	trace	trace	*no data*
	Star	103O-018	Cu, Si, Ag, Au	1917	4 845		2.80	*no data*	*no data*	*no data*
United-Comstock	United	103P-043	Cu, Si, Ag, Au							
	Comstock	103P-040	Cu, Si, Ag, Au							
Eagle - May Queen	Eagle + May Queen	103P-043	Cu, Si, Ag, Au	1924		1 112 000	1.54	trace	trace	*no data*
				1942		250 000	2.50	trace	trace	*no data*
				1942		108 400	3.21	trace	trace	*no data*
	Thistle-Rose	103P-048	Cu, Si, Ag, Au							
Princess-Anaconda	Anaconda	103P-048	Cu, Si, Ag, Au	1942		32 400	2.14	trace	trace	*no data*
	Princess May	103P-048	Cu, Si, Ag, Au							
	Princess Alice	103P-048	Cu, Si, Ag, Au							
	Princess Alexandria	103P-048	Cu, Si, Ag, Au							
	Gertie	103P-048	Cu, Si, Ag, Au							
	Lizzie	103P-048	Cu, Si, Ag, Au							
Blue Bell	East Blue Bell	103P-242	Cu, Si, Ag, Au							
	West Blue Bell	103P-242	Cu, Si, Ag, Au							

massive pods, shoots and bands of chalcopyrite and pyrrhotite. Pyrite is minor and only trace amounts of sphalerite and galena have been reported. Some sulphide-rich veins are banded and there are local areas of brecciation within the veins.

The veins and vein systems will be reviewed in order from northwest to southeast (Figure 5).

The **Friday** vein is 4 to 5 metres wide and is exposed over a strike length of 50 metres. It strikes 170° with a near-vertical dip. The quartz is relatively pure and the occurrence is only 500 metres from the shore. Consequently, this vein represents the best quality silica source in the Maple Bay area. Quartz is coarse grained and mainly milky white. Minor reddish brown staining occurs along fractures and some rusty weathering zones are present locally. Well formed prismatic quartz crystals line voids. Only trace amounts of sulphide minerals are present, but some siltstone inclusions occur along the western edge of the vein.

The **Outsider - Star** vein system lies at a much lower elevation than the other two systems. From 1906 to 1908 the Outsider vein was mined for copper. Ore was direct-shipped to the Brown-Alaska Company Limited smelter at Hadley, Alaska (Table 4). The Star and Outsider veins were mined for smelter flux in 1916 and from 1924 to 1926, respectively. Overall, 138 854 tonnes were mined at a grade of 1.84% Cu and 72% silica. For most of this production, the primary

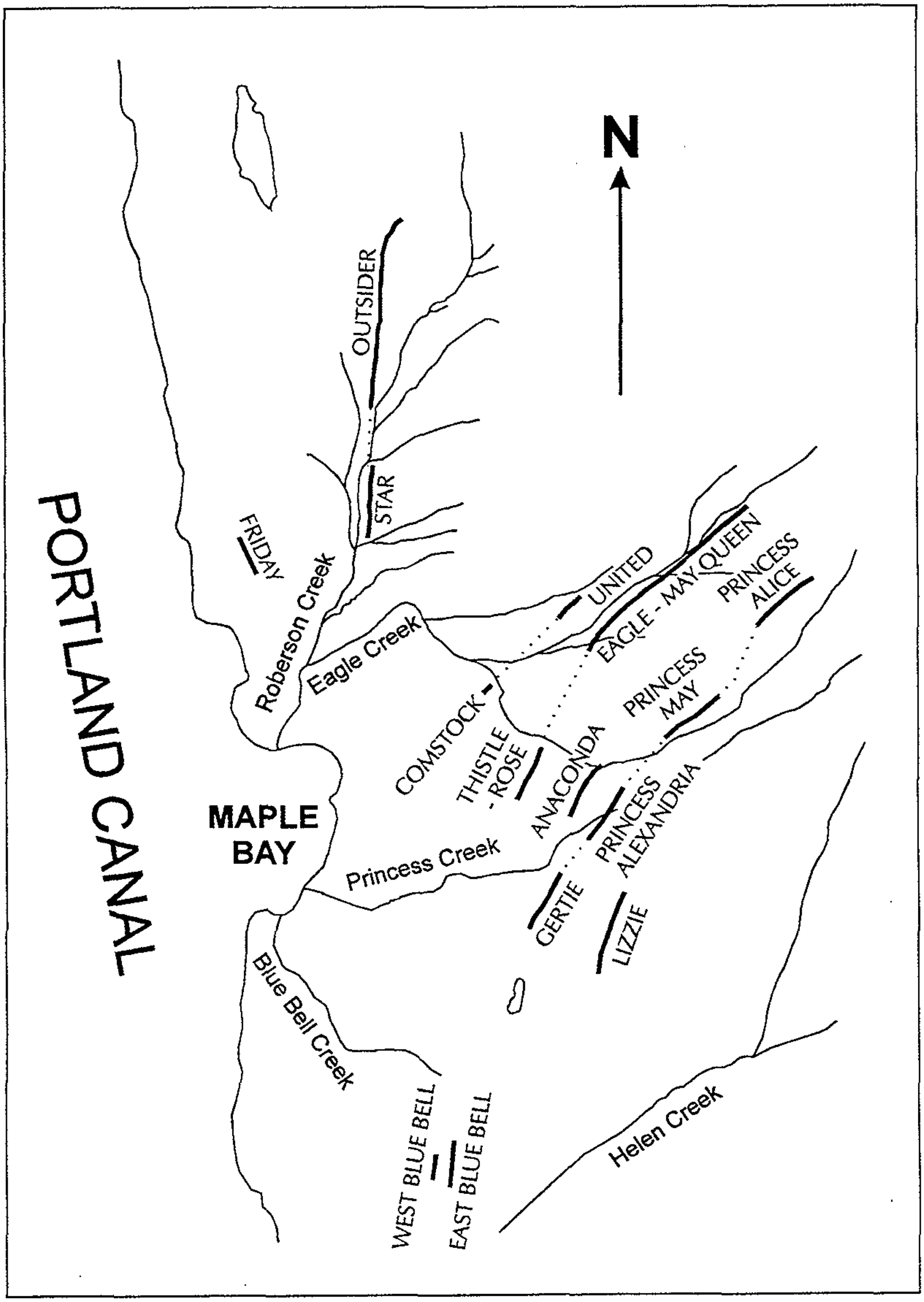

Figure 5. Major veins of the Maple Bay mining camp. Y symbols indicate adits.

requirement was silica flux for the Anyox smelter, so copper grades were not optimized.

The Outsider vein was developed from eight adits and the Star adit accessed the Star vein at a lower elevation. The Star vein may be a more southern, lower-elevation continuation of the Outsider vein, or it may be a parallel structure. These alternatives were recognized 90 years ago and have not yet been resolved.

The **Outsider** vein strikes 030° and dips 50° east and has been traced on surface for 920 metres, ranging from 0.6 to 6.5 metres in width. The vein has been developed and stoped for the southernmost 610 metres over a vertical interval of 150 metres. Copper grades ranged between 2 and 4%.

The lowest access from surface is the 900-foot level, but a winze allowed drifting on the 800-foot level. The combination of local topography and the attitude of the Outsider vein make it a difficult target to drill from surface in order to test its extension below the old workings. Consequently in 1972 an adit was driven on the 600-foot level to develop ore between that level and the old workings above. Three hundred metres of drifting was completed towards the vein, but failed to intersect it.

The footwall of the Outsider vein is a band of silicified argillite a few metres thick; this unit is in contact with the vein for most of its known length and depth. On the west side of (below) the silicified argillite is an argillite unit averaging 15 metres thick. The hangingwall of the vein is a metamorphosed mafic tuff or "hornblende schist". A diabase dike follows the northern part of the vein and crosses from side to side along its length. These intrusive relationships indicate that the dike is post-ore.

The Outsider vein consists mainly of massive to granular, milky white quartz with minor scattered country rock inclusions. Ore shoots above the 900-foot level comprise banded fine-grained grey to white quartz with minor to accessory amounts of granular, fine-grained chalcopyrite and pyrrhotite. Pyrite is minor, galena and sphalerite are rare. Gold and silver grades are consistently low. Ore shoots averaged 2.5 to 3.7 metres wide and were localized in wide vein sections marked by inflections or kinks in the main vein trend. Only minor sulphide mineralization was found where veins narrowed.

The **Star** vein extends for 680 metres along strike with widths ranging from 0.5 to 1.8 metres. The Star adit development work started in 1916, with the portal collared at 115 metres elevation on the east bank of Roberson Creek. In 1917, 4845 tonnes of quartz ore from the Star adit, grading 2.8% Cu, was shipped to the smelter at Anyox for silica-rich flux. Tracks and machinery were removed in September, 1917. Additional drifting in 1956 extended the tunnel to 250 metres in length.

The **United** vein is about 6 metres wide. It crops out for a distance of 75 metres and strikes 050°, dipping 40° to 60° degrees northwest. The **Comstock** vein is located 730 metres northeast of Maple Bay where it is exposed on a resistant knob on the west bank of Comstock Creek, at the southern end of the Maple Bay Crown-granted claim (L. 2881). The vein is over 10 metres wide here and composed of granular milky white quartz with up to 10% disseminated chalcopyrite and minor disseminated pyrite. Bands or seams of chlorite are also distributed through the vein. This quartz body is significant because it may represent the southwestward continuation of the United vein, indicating a possible combined strike length of 750 metres. In 1931, five holes were reportedly drilled on the adjacent Comstock claim, intersecting narrow sulphide bands, but there is no documented showing on this claim - the drill site may have been the nearby outcrop of the Comstock vein.

The **Eagle - May Queen** vein system is the highest grade, widest and most continuous of the three vein systems in the Maple Bay area. Although it may be the best deposit in terms of size and continuity, it is also the least accessible. The vein strikes northeast, dips 80° southeast, and has been traced on surface for over 1000 metres between elevations of 730 metres and 1220 metres. Trenching over this length shows that the mineralization is intermittent but locally strong; the average grade of samples from the six best trench exposures along a 500 metre interval was 4.07% Cu over an average width of 2.16 metres.

At its southernmost end, on the Eagle claim, the Eagle - May Queen system consists of three narrow veins. These merge northwards into a single vein with outcrop exposures ranging between 2.1 to 3.7 metres wide. At 700 metres elevation, a short crosscut tunnel intersects the vein where it is 7.6 metres wide; assays across this section ranged from 1 to 3.5% Cu. Four short diamond-drill holes were completed in 1923. These intersections, combined with trench assays, were used to calculate the Eagle - May Queen reserve figures in Table 4.

The **Princess - Anaconda** vein system is the weakest of the three. However, it is more accessible than the larger Eagle - May Queen system. Hostrock to the veins is described as chlorite-biotite schist and hornblendite. Veins consist of milky white, sugary quartz with pods, streaks and specks of fine-grained sulphides, as well as scattered chlorite seams. The veins are commonly crudely banded and usually vuggy. The sulphide minerals include chalcopyrite, pyrrhotite and minor pyrite, which form spongey masses in the quartz vein. As at the Outsider vein, sulphide and copper concentrations appear to be related to bulges or dilatant zones in the veins.

The **Thistle - Rose** vein crops out at 640 metres elevation, strikes 350° and dips steeply to the west. It is exposed over a length of 150 metres, ranging from 5 to 7.5 metres wide. The average assay from three trench samples across the vein is 3.4% Cu. The main quartz vein carries minor pyrrhotite and chalcopyrite, with a 0.5-metre sulphide-rich band on the hangingwall margin. The 1875-level adit was collared 30 metres below the vein outcrop in 1916, and driven for 53 metres where it intersected a metre-wide barren quartz vein. Although the attitudes of the two veins are quite different, the Thistle - Rose vein is on trend with the southwestward projection of the Eagle - May Queen vein, and may represent a continuation of this major structure.

The **Anaconda** vein has a strike length of 300 metres; maximum width is 2.6 metres. Sixteen drill holes tested this vein; eight intersections averaged 5.53% Cu over 0.55 metre. Surface trenches along the drilled section averaged 1.79% Cu over 1.9 metres.

The **Princess** vein strikes northeast and dips southeast. It is exposed as four vein segments: the Princess Alice, Princess May, Princess Alexandria and Gertie veins, with a total extent of 2.1 kilometres. These vein sections are characterized by irregular pinching and swelling along their length, forming pods up to 7.6 metres wide composed almost entirely of vuggy white quartz with erratic knots and lenses of coarse-grained pyrite, pyrrhotite and chalcopyrite. The Princess Alice vein crops out at 1220 metres elevation and extends for 300 metres. The Princess May has also been traced for 300 metres by trenching. The Princess Alexandria segment only reaches widths of 2.4 metres. There are no descriptions of the **Gertie** vein and it was not examined this season.

The Princess vein has been evaluated by extensive surface trenching, diamond drilling and underground drifting on two levels. In late 1969 it was explored by a 135-metre drift at the 2400-foot level. In 1970, the 1875-level adit under the Thistle vein was extended another 460 metres, intersecting both the Anaconda and Princess veins. The 1875 crosscut proved that the Princess vein is nearly vertical, and persists over a vertical interval of 180 metres, from the 2400-level to the 1800-level. Where intersected in the adit it is 2.5 metres wide and averages 2.49% Cu. Resampling in 1971 returned 3.10% Cu over 2.5 metres. A drift along the vein for 9 metres at this location showed the vein narrowing to 0.6 metre, which assayed 3.44% Cu. From 1955 to 1957, eleven drill holes were completed on the Princess vein. Intersections were narrow above the 2400-level, but below this level three drill holes gave an average grade of 2.27% Cu over 1.55 metres. The average grade of all surface trenches in the drilled area was 2.06% Cu over 2.3 metres width.

The **Lizzie** vein was drill-tested in 1956; no results have been reported.

The **East Blue Bell** and **West Blue Bell** veins crop out 100 metres apart on a cliff-top 1375 metres southeast of Maple Bay, at 460 metres elevation. The quartz veins range from 0.3 to 1.5 metres wide and are mineralized with chalcopyrite and some pyrite. The east vein has a strike length of 230 metres; the west vein is exposed in outcrop for 100 metres. Both veins strike 010° and dip 45° east. They have been tested by two adits. The longest tunnel, collared 46 metres below the outcrop of the veins and driven for 110 metres, failed to intersect them.

CONCLUSIONS

The age of these major veins and their hostrocks is unknown. In addition, the overall structural pattern of the large system of fractures which host these veins has not been resolved. There are few features in common between these veins and the stratabound exhalative massive sulphide lenses of the Anyox mine area to the east, however, there are some similarities with the copper-gold veins of the Red Cliff mine to the north (Figure 2). Detailed studies in the Maple Bay mining camp will be a component of the ongoing Cambria project.

GEOLOGY OF THE GEORGIE RIVER MINE

Gold-silver veins of the Georgie River mine were examined for comparison with Jurassic and Tertiary precious metal veins throughout the Stewart district (Alldrick, 1993). A three-day property examination consisted of reconnaissance mapping, documentation and sampling of 14 veins and drill core study. Property-scale geology maps have been completed by Kruchkowski (1981, 1990), Kruchkowski and Konkin (1989) and Bray and Rainsford (1990). Useful geological descriptions are available in assessment reports and Minister of Mines Annual Reports. The following summary is compiled from field notes and from cited reports.

The minesite is 13 kilometres south of Stewart, on the east side of the Portland Canal (Figure 2). A 13-kilometre pack-horse trail was constructed up the Georgie River from its mouth to the minesite in 1928 and an earlier foot trail heads due west from the minesite to tidewater. However, present access to the property is by helicopter.

GEOLOGY

The mine lies within a roof pendant of the eastern Coast Range batholith, measuring 16 kilometres east-west by 24 kilometres north-south. Volcanic and sedimentary strata within this pendant are probably equivalent to the Stuhini and Hazelton Group rocks of the main block of the Stikine Terrane farther to the east. The property is underlain by a repetitive sequence of mafic flows, fragmental rocks, crystal and ash tuffs and minor turbidite sequences. Volcanic rocks are generally dark grey-green, fine grained and massive. Strata include coarse pyroxene-porphyritic massive mafic flows or crystal tuffs that are tentatively correlated with similar rocks of the Upper Triassic Stuhini Group. Reported pillow units could not be identified during this property examination. The regional strike averages 135°, with dips of 50° to 75° southwest, an attitude close to that of the regional foliation in this area, which strikes between 120° and 150°, with dips of 50° to 70° to the southwest. Top directions have not been determined.

The volcano-sedimentary package has been intruded by two main phases of granodioritic dikes. Hornblende-porphyritic granodiorite dikes, 5 to 10 metres wide, can be distinguished from the more abundant, wider biotite granodiorite dikes. The older hornblende granodiorite series is medium to coarse grained and locally porphyritic with potassium feldspar megacrysts up to 3 centimetres and hornblende phenocrysts up to 1.5 centimetres long. Individual dikes may show chilled margins and flow banding near the margins. This rock is commonly weakly foliated and hornblende crystals may be partially altered to chlorite. Fresh samples have an overall medium to light grey colour. Dikes follow either bedding or foliation planes, hence these rocks may be sills emplaced along bedding or post-deformation dikes emplaced along foliation planes. In either case their strike is consistently northwest, with steep southwest dips. They appear to have been affected by the mid-Cretaceous regional deformation and metamorphism. They have been interpreted to be Early Jurassic in age due to textural and mineralogical similarities with dated potassium feldspar megacrystic, hornblende-porphyritic dikes elsewhere in this region ("Premier porphyry", Alldrick, 1993). One of them, sampled in outcrop just south of the Pond vein, yielded an age of 187.2 Ma (Table 2, Figures 2 and 6).

The younger, wider, unfoliated, lighter coloured, biotite granodiorite dikes strike east-northeast (averaging 075°), dip moderately southward (averaging 55°) and range up to 100 metres in width. The rock is fresh, unfoliated, light grey biotite-hornblende granodiorite, with an equigranular texture and rare xenoliths. One of these dikes, sampled from drill core in diamond-drill hole GR-95-15, yielded a mid-Eocene age of 50.7 Ma (Table 2, Figures 2 and 6), identical to ages from similar dikes of the regionally distributed Portland Canal dike swarm (Alldrick, 1993; Green *et al.*, 1995).

Metamorphic grade on the property is lower greenschist. Country rocks display chlorite-carbonate alteration and are moderately silicified near the contacts with intrusives. Trace amounts of finely disseminated pyrite are noted throughout all rock types on the property.

East-northeast, northwest and north-trending faults on the property have localized quartz-sulphide veins. The fault zones are represented by strongly foliated chlorite schist. Wallrocks vary from relatively unaltered medium green-brown massive basalt, to altered, mottled, grey-green-maroon andesitic crystal tuff or altered andesite tuff. Wallrocks are usually silicified and exhibit strong epidote and calcite alteration associated with minor quartz veining. The feldspar phenocrysts commonly found in the altered andesitic crystal tuff are also silicified. Minor carbonaceous siltstone

TABLE 5
EXPLORATION AND PRODUCTION HISTORY AT GEORGIE RIVER MINE

YEAR	EVENTS
1912	Surface sampling and 5.18 m test shaft completed.
1913	16.76 m of tunneling on Bullion vein.
1915	Bullion vein tunnel advanced to 74.68 m; 10.67 m raise completed.
1916	Bullion vein tunnel advanced to 110.34 m mark; 10.67 m winze sunk to test an ore shoot.
1917	Bullion vein tunnel advanced to 118.87 m mark; raise pushed through to surface. Bonanza ore runs 80.53 g/t Au.
1918	Bullion vein tunnel advanced to the 124.97 m mark; crosscut driven west for 10.67 m; winze deepened to 12.80 m.
1922	Packhorse trail along Georgia River completed.
1925	Georgia River Gold Mines Ltd. incorporated.
1928	Wagon trail along Georgia River completed.
1929	Permanent camp completed; No.3 level advanced 158.50 m toward Southwest vein.
1932	Crosscut from Bullion vein intersects Southwest vein; drifted for 94.48 m.
1933	9 holes totalling 929.64 m intersected "no values of importance".
1936	Mill with 10 tpd capacity completed.
1937	454 t of stockpiled material processed at grades of 22.56 g/t Au, 28.11 g/t Ag and 0.73% Pb.
1979	6 BQ holes totalling 342.91 m test Southwest vein near intersections with Main and Georgia veins.
1980	15 BQ holes totalling 904.46 m test Southwest and Georgia veins. 137 trenches completed. No.2 level sampled.
1981	14 BQ holes totalling 1105.17 m test Southwest, Main and Georgia veins. Inferred reserves calculated from results.
1988	15 BQ holes totalling 2628.77 m test Southwest, Main and Georgia veins. Inferred reserves recalculated.
1989	8 BQ holes totalling 1528.40 m test Southwest and Georgia veins. Inferred reserves calculated for two ore shoots within Southwest vein.
1990	15 BQTW holes totalling 1556.66 m test 8 geophysical targets, 3 minor veins and the ore shoots within the Southwest vein.
1995	19 NQ holes on 15 m centres totalling 1840 m defined drill-indicated reserves in the two ore shoots within the Southwest vein.

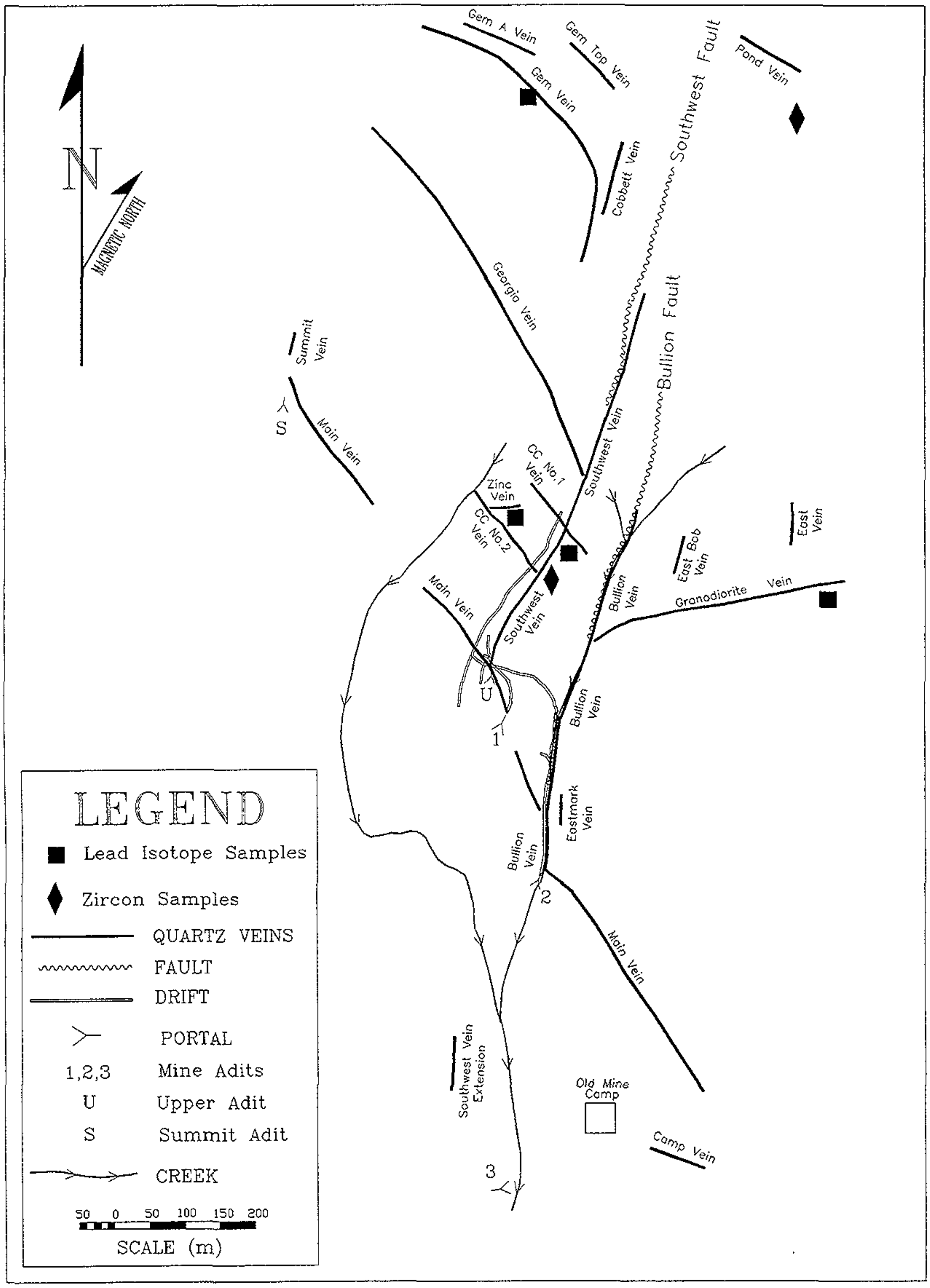

Figure 6. Major veins and isotope sample sites on the Georgie River mine property (modified from Kruchkowski, 1981).

units generally display biotite hornfels alteration adjacent to these fault-controlled quartz-sulphide veins.

MINERAL DEPOSITS

The Georgie River area was staked in 1910. In addition to 454 tonnes of production in 1937, there has been intermittent exploration from 1910 to 1979, and a series of exploration programs since 1979. The exploration history is summarized in Table 5. Production and reserves are listed in Table 6. Despite this long history, there has been no petrographic work or other research on these deposits.

Nineteen veins crop out on the property between 945 metres elevation and the crest of the ridge at 1340 metres. The veins can be separated into three sets based on vein orientation, sulphide and gangue mineralogy, gold-silver grades and lead isotopic compositions (Gabites *et al.*, 1996, this volume). There are two east-northeast-trending veins, nine northwest-trending veins and eight north-trending veins (Figure 6). The sulphide-rich Zinc and Granodiorite veins, strike east-northeast (075°) with steep dips to the north (080°). Northwest-trending semiductile shears host wide quartz veins with sparse pyrite, pyrrhotite, sphalerite and galena. The northwest-striking (320°) veins are the Main, Georgia, Gem, Gem A, Gem Top, CC#1, CC#2, Pond and Camp. Later, narrower, north-trending faults host narrow quartz veins with pyrite, pyrrhotite, galena, sphalerite, chalcopyrite, arsenopyrite and electrum. North-striking (010°) veins are the Southwest, Southwest Extension, Bullion, Summit, Eastmark, East Bob, East and Cobbett. The three vein trends carry varying amounts of gold, with the richest mineralization occurring at the intersection of the northwest and north-trending veins.

Only two veins, Southwest and Bullion, have been explored by drilling and underground development, and only the Southwest vein has been extensively drilled. The Georgie River mine has been developed by five adits. Mine workings extend between 974 metres and 1115 metres elevation. A total of 102 drill holes, totalling 10 836 metres, have been completed on the property to the end of 1995.

In order of decreasing abundance, vein mineralogy comprises quartz with accessory pyrite, pyrrhotite, sphalerite and minor galena. Quartz veins locally contain seams of massive pyrite, pyrrhotite, sphalerite and galena with minor chalcopyrite, trace arsenopyrite and tetrahedrite, and rare electrum. The east-northeast trending veins are massive sphalerite and pyrite with subordinate quartz-carbonate seams and stringers. Northwest-striking quartz veins typically carry less than 5% disseminations, blebs and stringers of pyrite and pyrrhotite with trace to minor sphalerite and galena. North-striking veins average 10% disseminations, blebs and stringers of pyrite, pyrrhotite, sphalerite and galena with minor chalcopyrite and arsenopyrite.

NORTHEAST-TRENDING VEINS

The Zinc and Granodiorite veins are similar in mineralogy and orientation, although they are separate structures. Both veins are sphalerite-rich lenses which may have adjacent quartz-calcite bands. Both veins carry only minor galena, but locally the sulphide seams are comprised of 50% sphalerite and 50% pyrite. The **Zinc** vein is 0.12 to 1.1 metres wide and has been traced for 25 metres. The **Granodiorite** vein is over 250 metres long and ranges from 0.25 to 0.4 metre in width. Despite the long strike length and abundant sulphides, the Granodiorite vein shows erratic gold values except where it is exposed in Bullion Creek, at its intersection with the Bullion vein. Here samples assayed 9.25 to 22.41 g/t Au. Lead isotope compositions from the

TABLE 6
GEORGIE RIVER MINE PRODUCTION AND RESERVES

VEINS	MINFILE	YEAR	PRODUCTION TONNES	RESERVE CATEGORY	RESERVES TONNES	GRADE Gold g/t	Silver g/t	Lead %
Southwest	103O-013	1937	454			22.54	28.09	0.73
Southwest	103O-013	1981		Drill Inferred	21 486	15.64	18.36	
Southwest	103O-013	1988		Drill Inferred	68 974	19.51	20.41	
SW Zone 1	103O-013	1989		Drill Inferred	76 356	17.73	18.67	
SW Zone 2	103O-013	1989		Drill Inferred	31 227	48.76	20.41	
Southwest	103O-013	1989		All	276 377	27.63	20.91	
Southwest	103O-013	1995		Drill Indicated	12 825	48.69		
Bullion	103O-013	1988		Drill Inferred	5 620	4.18	10.29	

Granodiorite and Zinc veins indicate that the sulphides are Jurassic age (Gabites *et al.*, 1996, this volume).

NORTHWEST-TRENDING VEINS

The **Main** vein is a large silicified shear zone striking 315° and dipping 55° to 65° southwest. It is composed of layers of silicified material separated by bands of chlorite schist, with silicification gradually fading into the wallrock. These vein textures support the interpretation that northwest-trending veins are siliceous replacements along pre-existing semiductile shear zones. This zone has been traced along a strike length of 650 metres with horizontal offsets of 6 metres across the Southwest vein and 20 metres across the Bullion vein. Sulphides are sparse and consist of pyrite, pyrrhotite and minor arsenopyrite. Only low gold assays (up to 0.1 g/t) have been returned from this vein.

The **Georgia** vein strikes parallel to the Main vein about 300 metres to the northeast. It averages 1 metre in width and is discontinuously exposed for 450 metres. It locally contains volcanic fragments. Sulphides consist of pyrite, pyrrhotite and local concentrations of sphalerite and minor galena. Sampling returned assays up to 0.17 g/t Au. This vein is offset 27 metres to the right along the Southwest vein.

The Gem, Gem Top and Gem A veins strike parallel to the Georgia vein. **Gem** vein ranges from 1 to 3 metres wide and is exposed over a length of 150 metres. Sulphides are sparse, with local concentrations of pyrite, pyrrhotite, minor sphalerite and rare galena. The two nearby veins, the **Gem Top** and **Gem A** , range up to 2 metres wide and are also sparsely mineralized.

The **Camp** vein has not been reexamined in recent years, and was not located on a reconnaissance traverse, although it is reported to be exposed in trenches adjacent to the road, near the old mine camp (Figure 6). The trenches may have sloughed in.

The CC #1 and CC #2 veins are parallel to and a short distance from the Georgia vein. **CC #1** vein consists of quartz veins and stringers and is sparsely mineralized. **CC #2** vein comprises stringers and lenses of massive pyrite, sphalerite and galena in quartz gangue. Both veins are approximately 100 metres long and up to 1.5 metres wide. Low gold values have been reported from both veins.

The **Pond** vein is a wide shear zone comprised of bands of siliceous material separated by intervals of sericitized schist. The zone strikes 320° and has been traced for 100 metres. It is cut off by a fault to the northwest and feathers out into small quartz stringers to the southeast. Low gold values were reported from a trench. Like the Main vein, this vein zone also suggests a silicification or replacement style of mineralizing process along a pre-existing shear zone.

NORTH-TRENDING VEINS

The **Southwest** vein is follows a fault zone and strikes 005° to 010°. The vein is vertical based on surveyed drill intersections, however, old mine plans suggest a steep westerly dip (75° west; Mandy, 1936). It has been traced in discontinuous outcrops for 600 metres; a possible southern extension, just west of the old mine camp, may indicate a length of at least 1200 metres (Figure 6). This vein has been intersected over a vertical range of 260 metres. All past production has come from this vein, and it has been the focus of most recent exploration drilling. The 1995 drilling program focused on establishing reserves in the higher grade shoots within it (Table 6).

In addition to intensive drilling, the Southwest vein has been explored by two adits. The No. 1 level has drifted 47.8 metres along the vein; the No. 2 level has drifted along the vein for 155.5 metres. A crosscut from the No. 3 level failed to intersect the Southwest vein, but probably stopped short of the point of intersection.

The vein consists of short, discontinuous and overlapping mineralized quartz lenses within green chlorite schist. The schist zone varies from 1 to 4 metres wide and shows evidence of repeated fault movement. Near the intersections with the Georgia, CC #1 and CC #2 veins, the Southwest vein contains a zone 80 metres long and 0.94 metre wide averaging 33.25 g/t Au and 38.39 g/t Ag. In detail, this enriched zone consists of as many as three overlapping ore shoots. Individual lenses vary in length from 8 to 30 metres and extend up to 20 metres vertically. Sulphide mineralogy consists of galena, sphalerite, pyrrhotite, pyrite, trace to minor arsenopyrite and trace chalcopyrite. Rare electrum is typically associated with galena.

The **Bullion** vein is also emplaced along a fault zone. It is well exposed in Bullion Creek and has been traced along strike for 600 metres. It ranges from 0.1 to 0.35 metre wide and has been drifted on by both the No. 2 and No. 3 levels. The fault zone contains up to 50% green, altered volcanic fragments ranging up to 5 centimetres across. Gold occurs in discontinuous quartz lenses within this fault zone, however, the best grades have been obtained from a narrow vein of massive pyrrhotite-pyrite which is exposed along the east side of the main quartz vein along the waterfall at the head of the Bullion Creek canyon. Post-vein faulting has resulted in rafts of coarse barren quartz fragments in a matrix of green chloritic gouge.

The **Summit** vein consists of a series of narrow parallel quartz lenses, from 0.07 to 0.33 metre wide, within a shear zone 11 metres wide. High gold assays have been reported from these narrow veins.

The **Cobbett** vein is a zone of parallel quartz and calcite veinlets, 3 metres wide, parallel to the Southwest vein and similar in character to the Pond and Summit vein zones. Sparse disseminated sulphides are distributed across the band of strongly foliated volcanic rock. Stringers of pyrite, galena and sphalerite contain only silver values. This zone of veins and veinlets is exposed over a strike of 90 metres.

There is a series of veins parallel to and east of the Bullion vein. The **East** vein consists of three discontinuous veins, less than 20 metres long and 0.09 to 0.6 metre wide. The **East Bob** vein is a quartz vein 10 metres long and 0.1 to 0.2 metre wide. The **Eastmark** vein was not examined during this visit; it is described as a zone of quartz stringers up to 2 metres wide, extending for 50 metres along strike. All three of these veins have returned elevated gold and silver values.

In addition to U-Pb dating of dike rocks, four samples of vein sulphides from the property were submitted for galena lead and sulphide lead isotope analyses (Gabites *et al.*, 1996, this volume). These new lead isotope data suggest that the two base-metal-rich northeast-trending veins are Jurassic age mineralization, but the gold-bearing northwest-trending and north-trending veins are Tertiary. Other examples of superimposed mineralization of different ages have been documented in the region at the Brucejack Lake and Granduc deposits (Alldrick *et al.*, 1990)

The detailed sequence of Tertiary faulting and vein formation, determined by Kruchkowski (1990) following three seasons of exploration work, is summarized here:

1. Early northwest-trending faults were overprinted by quartz veining and wallrock silicification. This early phase of vein development resulted in vein systems up to 12 metres wide, such as the Main vein, but most of the veins formed during this stage are 1 to 2 metres wide. Quartz is generally white and massive. Sulphides occur as blebs, disseminations and small discontinuous stringers.
2. The second stage of faulting generated northerly trending structures and resulted in development of chlorite schist and gouge. Lateral movement up to 20 metres can be demonstrated by the offset of the Main vein along the Bullion fault. Narrow quartz veins and stringers carrying pyrite, pyrrhotite, sphalerite and galena as blebs and dissemination were emplaced along these faults.
3. Subsequent fracturing of these veins and stringers was accompanied by the main episode of quartz-gold-silver-polymetallic mineralization. This produced sections along the Southwest vein containing both unbrecciated sulphide-bearing quartz with low gold and base metals and brecciated sulphide-bearing quartz with high gold and base metal values. The main quartz-gold-silver-polymetallic phase produced quartz veins with seams of massive pyrite, pyrrhotite, sphalerite and galena with minor chalcopyrite and arsenopyrite. Pyrite and pyrrhotite may comprise up to 50% of the vein in massive sections; galena and sphalerite in equal amounts form the other 50%. Mariposite or fuchsite is common within the chlorite schists. In contrast to the northwest-trending veins, this rock has a brecciated appearance with fractures filled with the sulphide assemblage. High-grade gold intersections carry from 5 to 30% sulphides, averaging 10%. Gold and silver minerals are not common, but pale yellow electrum has been seen in both drill core and outcrop as clusters of fine flakes. The Au:Ag ratio is extremely variable among individual assays, ranging between 10:1 to 1:10, but the overall ratio is close to 1:1.
4. Penecontemporaneous with the formation of the north-trending veins, Tertiary biotite granodiorite dikes intruded the area. These dikes cut the north-trending veins and have calcsilicate alteration haloes characterized by quartz-calcite-epidote-pyrite-pyrrhotite-sphalerite stringers and veins which carry low gold and silver values. These veins occur within the calcsilicate alteration envelope.
5. The final stage of development is post-mineralization fault movement along the north-trending vein system, and deposition of quartz-calcite veinlets. Although this late-stage faulting has caused some disruption of the mineral zones, little lateral movement is evident. However, some vertical displacement may have occurred. Calcite is the last gangue mineral to be deposited and is commonly found filling fractures in the wallrock.

One of the best areas to document the relationships between all three vein sets is along Bullion Creek. In the canyon between the waterfall and the No. 2 level portal, the offset and drag-folding of the Main vein by the Bullion fault, the relationship between the Bullion vein and the Bullion fault, and a late, thin, white quartz veinlet superimposed on the Bullion vein, are all well displayed. Farther north along Bullion Creek, above the waterfall, an exposure clearly shows the sulphide-rich, Jurassic, Granodiorite vein drag-folded and cut off by the Bullion fault and the Bullion vein.

DISCUSSION

There is an abundance of Tertiary veins distributed throughout the Stewart Complex. Alldrick *et al.*, (1987) concluded that all these veins were silver-rich coarse-grained quartz-galena-sphalerite veins with low pyrite and negligible gold content. However, recent exploration work has shown that there are at least three Tertiary veins in the region that carry significant gold: the Doc deposit on the west bank of the South Unuk River, a gold-bearing massive arsenopyrite vein that crops out south of Red Mountain (A. Bray, personal communication, 1991), and the northwest and north-trending veins at the Georgie River property. The following explanation may account for these few gold-rich exceptions to the more general pattern of silver-rich Tertiary veins. Most Tertiary veins are hosted by, or close to, thick turbidite sequences with characteristically high background levels of lead, zinc and silver that may be leached by throughgoing hydrothermal fluids (Alldrick, 1993, pp.91 and 98). However, the Georgie River, Doc and arsenopyrite veins are all hosted by thick volcanic packages with only thin turbidite members. The fluids depositing these veins may have leached metals from more iron-zinc-gold-rich basalt-andesite sequences, rather than from silver-lead-zinc-rich turbidites.

CONCLUSIONS

Recognition of the Tertiary age of gold-bearing veins, and the close genetic and spatial association between the Tertiary biotite granodiorite dikes and the gold-bearing veins, should change the scope and orientation of exploration strategies in the area. Exploration programs to date have concentrated on the north-trending Southwest and Bullion veins and the north-trending envelope around them. These veins have developed along pre-existing shear structures, but the mineralizing fluids were probably derived from the same mid-Eocene magma chamber that produced the regionally extensive east-northeast-trending biotite granodiorite dike. Future reconnaissance exploration programs should focus on tracing Tertiary dikes and prospecting a 500-metre swath on either side of these prominent intrusions.

GEOLOGY AND MINERAL DEPOSITS OF THE WILLOUGHBY CREEK AREA

The Willoughby Creek deposits were examined on surface and in drill core during a one-day property visit. This summary is compiled from field notes and a technical report by Visagie (1996).

The Willoughby Creek gold-silver property is 26 kilometres east of Stewart and 7.5 kilometres east of the Marc Zone deposit at Red Mountain (Figure 2). Placer gold was reported from this area before the turn of the century. These placer deposits are historically significant; the prospecting

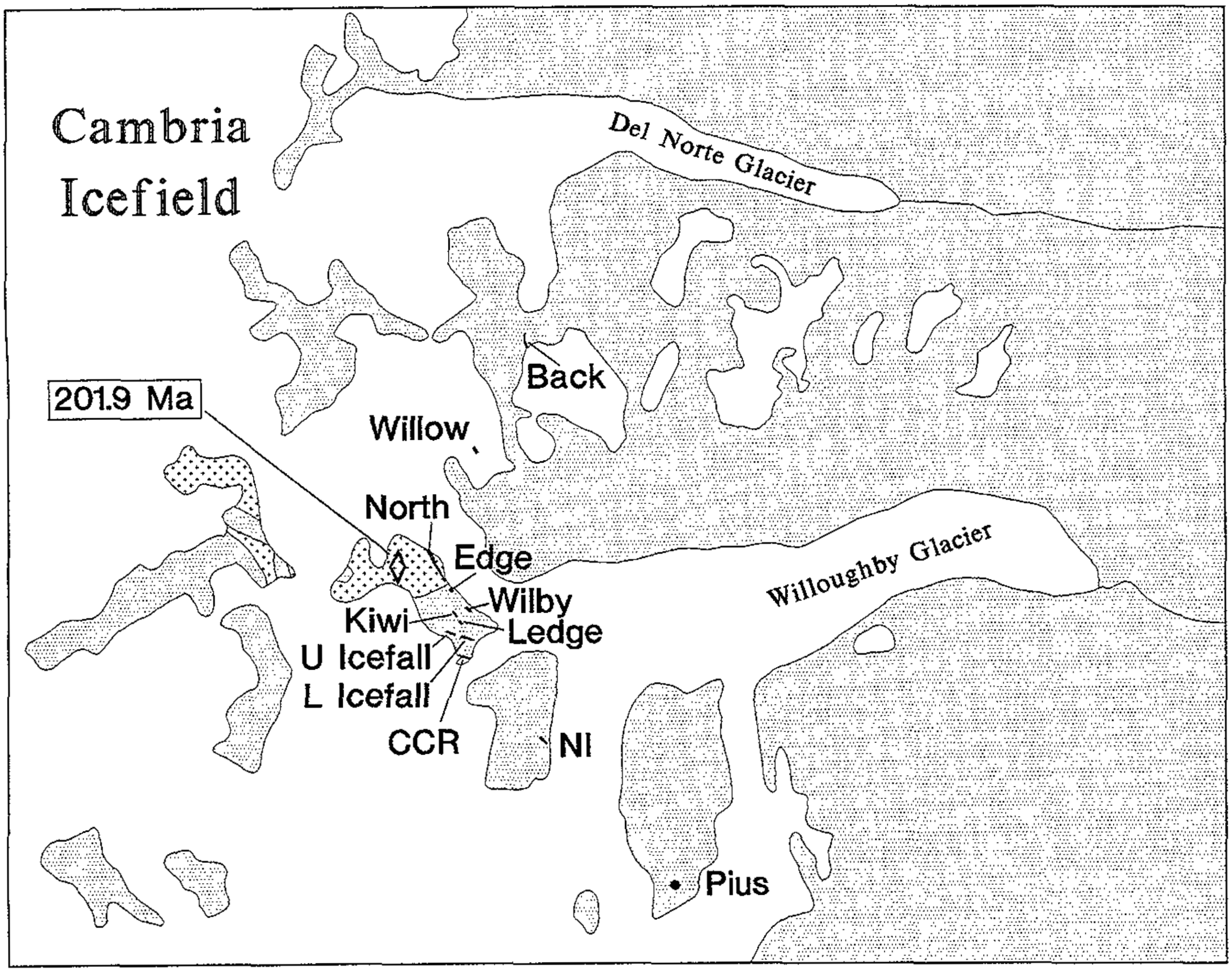

Figure 7. Mineral prospects and U-Pb zircon sample site at the Willoughby Creek property (modified from company plans).

expedition of 1898 that led to the establishment of the town of Stewart set out to relocate these gold-bearing creeks. Minor placer production was achieved from Nelson, Del Norte and Willoughby creeks in the early part of this century. Outcropping mineralization was discovered on the main nunatak at the headwall of Willoughby Glacier in 1941 by geologists of the Premier Gold Mining Company. Twelve showings have been located to date (Figure 7). The claims are currently being evaluated by joint venture partners Camnor Resources Limited (50%), Royal Oak Mines Inc. (25%) and Gold Giant Minerals Inc. (25%).

GEOLOGY

Stratigraphy across the property has been mapped as Upper Triassic Stuhini Group, Lower Jurassic Hazelton Group and Middle Jurassic Bowser Lake Group (Greig *et al.*, 1994). The regional strike is northerly with moderate easterly dips. In the vicinity of the mineral prospects, bedrock is weakly metamorphosed and locally strongly altered andesitic tuffs, turbidites and fossiliferous limestones of the Hazelton Group. Fossil-rich limestone beds indicate a relatively shallow marine depositional environment. These strata are cut by Goldslide intrusions, an early phase of the Early Jurassic Texas Creek Plutonic Suite. Intrusions are small stocks, sills and dikes of equigranular to hornblende-plagioclase-porphyritic quartz monzodiorite, granodiorite or diorite. The Willoughby stock is a Goldslide intrusion which hosts the North Zone mineralization on the Willoughby property. A sample of this intrusive was collected for dating from the peak of the nunatak directly above the North Zone and yielded an age of 201.9 Ma (Table 2 and Figure 7), comparable to the main Goldslide stock at the Red Mountain property (Rhys *et al.*, 1995). Other younger dikes exposed on the property are interpreted as products of four later intrusive episodes.

MINERAL DEPOSITS

Gold-silver mineralization occurs in sericite-pyrite-chlorite-carbonate-altered Lower Jurassic Hazelton Group volcanic rocks and coeval Early Jurassic Goldslide intrusions of the Texas Creek Plutonic Suite. The twelve showings on the property crop out as semimassive pods, lenses and stockworks containing pyrite, together with minor pyrrhotite, sphalerite, galena, arsenopyrite, chalcopyrite and stibnite. Rare native gold, electrum, and tellurides have been identified. Gold:silver ratios average 1:3. Ten of these zones have irregular forms and textures resembling skarn-like metasomatic replacement bodies within Hazelton volcanic rocks; the other two zones are shear-controlled vein systems in Goldslide intrusive rocks. A total of 58 drill holes (6476 m) have been completed on four of the showings (North, Wilby, Willow and Upper Icefall). The **North** and **Wilby** zones are the most promising prospects discovered to date. The **Back, Willow, Edge, Kiwi, Ledge, Upper Icefall, Lower Icefall, Pius, CCR** and **NI** zones offer additional potential and will be evaluated in upcoming programs. Prospecting is continuing.

The **North Zone** crops out on a steep cliff-face where it is exposed over a 60 by 300 metre panel. The mineralized system is subdivided into three vein categories: pyritic stockworks, pyrite-sphalerite-galena stockworks and quartz stockworks. The zone of veins defines a northwest trend within strong sericite-carbonate-altered Goldslide intrusive rock. Drilling to date has tested a 100-metre strike length to depths of 75 metres. The zone remains open at depth and along strike to the southeast. In late 1995, development work began on a 100-metre exploration adit that will provide drill stations to test the on-strike and depth extensions.

The northwest-striking, west-dipping **Wilby Zone** is a series of semimassive to massive pyrite-pyrrhotite replacement lenses in coarse lapilli tuff. The largest of these gold-silver-bearing lenses has been traced by drilling for 65 metres down dip. Widths range from 3 to 8 metres. The zone remains open at depth and along strike in both directions.

DISCUSSION AND CONCLUSIONS

There are few obvious controls to the mineralization. The proximity to an Early Jurassic Goldslide intrusion is considered a key element, similar to the relationship between the main Goldslide stock and the Marc zone at Red Mountain. The dominant northwest trend to most of the prospects has not been explained, however, the Marc, AV and JW deposits at Red Mountain are also planar, blade-like zones. Although rock textures in outcrop have only been identified as fragmental andesite tuff, drill core reveals that there are discrete diatreme breccia bodies close to mineralization at all zones drilled to date. In some drill holes the mineralization is superimposed on these breccias, in others the breccias and mineralized zone may be several metres apart. Drill core also shows a similar proximal relationship between mineral zones and Goldslide dikes that have not been mapped on surface. It has not been possible to demonstrate a geometric relationship between the dikes, diatreme breccias and the alteration or sulphide zones from the drill intersections obtained to date. The abundance of dikes and diatreme breccia pipes does indicate that the mineralized area is at or near a cupola of the Willoughby stock. The numerous mineral prospects concentrated in this small area suggest that this local geologic setting has also focused mineralizing fluids (*e.g.*, Rye, 1993).

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LEAD ISOTOPE DATA FROM MINERAL PROSPECTS IN THE CAMBRIA ICEFIELD AREA, STEWART MINING DISTRICT (NTS 103O/P AND 104A/B)

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INTRODUCTION

Galena Pb-Pb and sulphide Pb-Pb isotopic compositions were determined for samples from four mineral prospects and one past-producing mine in the district. Deposit locations are shown on Figure 1. Brief deposit descriptions are provided in this report and in Alldrick *et al.* (1996, this volume). Capsule geological descriptions and comprehensive reference lists for these deposits are available from MINFILE (Table 1).

ANALYTICAL

Lead-lead analyses and data reduction were completed by J.E. Gabites at the Geochronology Laboratory, Department of Earth and Ocean Sciences, The University of British Columbia. Small, clean cubes of galena were hand picked, washed and dissolved in dilute hydrochloric acid. Trace lead (chalcopyrite and galena) samples were prepared by hand picking 10 to 50 milligrams of clean sulphide, which was leached in dilute hydrochloric acid to remove surface contamination before dissolution in nitric acid. The samples were passed through ion exchange columns in hydrobromic acid, and the lead collected in hydrochloric acid. Approximately 10 to 25 nanograms of the lead in chloride form was loaded on a rhenium filament and isotopic compositions were determined using a modified VG54R thermal ionization mass spectrometer. The measured ratios were corrected for instrumental mass fractionation of 0.12% per mass unit based on repeated measurements of the NBS SRM 981 (Standard Isotopic Reference Material). Errors reported in Table 1 were obtained by propagating all mass fractionation and analytical errors through the calculation. Three of the samples were run in duplicate as an internal check on analytical reproducibility. The total procedural blank on the trace lead chemistry was 130 picograms.

DISCUSSION AND INTERPRETATION

Analytical data are listed in Table 1 and plotted on Figure 2. Previous analyses from the area are plotted on Figure 2 for comparison. Lead isotope ratios from deposits in the Stewart district plot in two clusters which define deposits of different ages and genetic type (Alldrick, 1993, pp. 54-57). The less radiogenic data group represents mineral deposits which are cogenetic with Lower Jurassic Hazelton Group volcanic rocks and coeval subvolcanic plutons of the Early Jurassic Texas Creek Plutonic Suite. The more radiogenic data are from vein and porphyry deposits of Early Tertiary (Middle Eocene) age that are related to granitic intrusions of the Coast Plutonic Complex. Eight of the samples analyzed in this study plot within the two defined clusters (Figure 2), the sample from the George Copper prospect plots outside the clusters and the significance of this result is discussed below.

The two Tertiary samples are from the north-trending Southwest vein and the northwest-trending Gem vein on the Georgie River property. Both samples were collected from crosscutting mesothermal-style quartz-sulphide veins that postdate hostrocks comprised of Upper Triassic volcanic and sedimentary strata and Early Jurassic hornblende granodiorite dikes (Alldrick *et al.*, 1996, this volume). Among the seven samples with Jurassic lead isotope signatures, two samples were collected from the Granodiorite vein and Zinc vein, also on the Georgie River property. These latter veins are east-northeast-striking epithermal-style sphalerite-pyrite-quartz-calcite veins. The contrasting lead isotope data from this property are consistent with crosscutting vein relationships and support the conclusion that there are Jurassic base-metal-rich but precious-metal-poor epithermal-style veins and Tertiary gold-bearing mesothermal-style veins on the Georgie River claims.

Lead isotope data from the newly discovered NI showing on the Willoughby Creek property plot within the Jurassic cluster and close to, but are less evolved than, previous analyses of samples from other mineral showings on the property (Figure 2). The previous analyses are interpreted here as particularly radiogenic "Jurassic" leads which plot between the two main data clusters. Alternatively, they may represent a third mineralizing event in the district, of Late Jurassic to Early Cretaceous age.

The Todd Creek prospect is a north-trending subvertical fracture zone, 900 metres long. The southern section of this fracture hosts an undulating, rhythmically banded quartz vein 1 to 3 metres wide. The central section, up to 5 metres wide, is massive hematite-cemented fault breccia with high copper-gold values, and has been the primary exploration

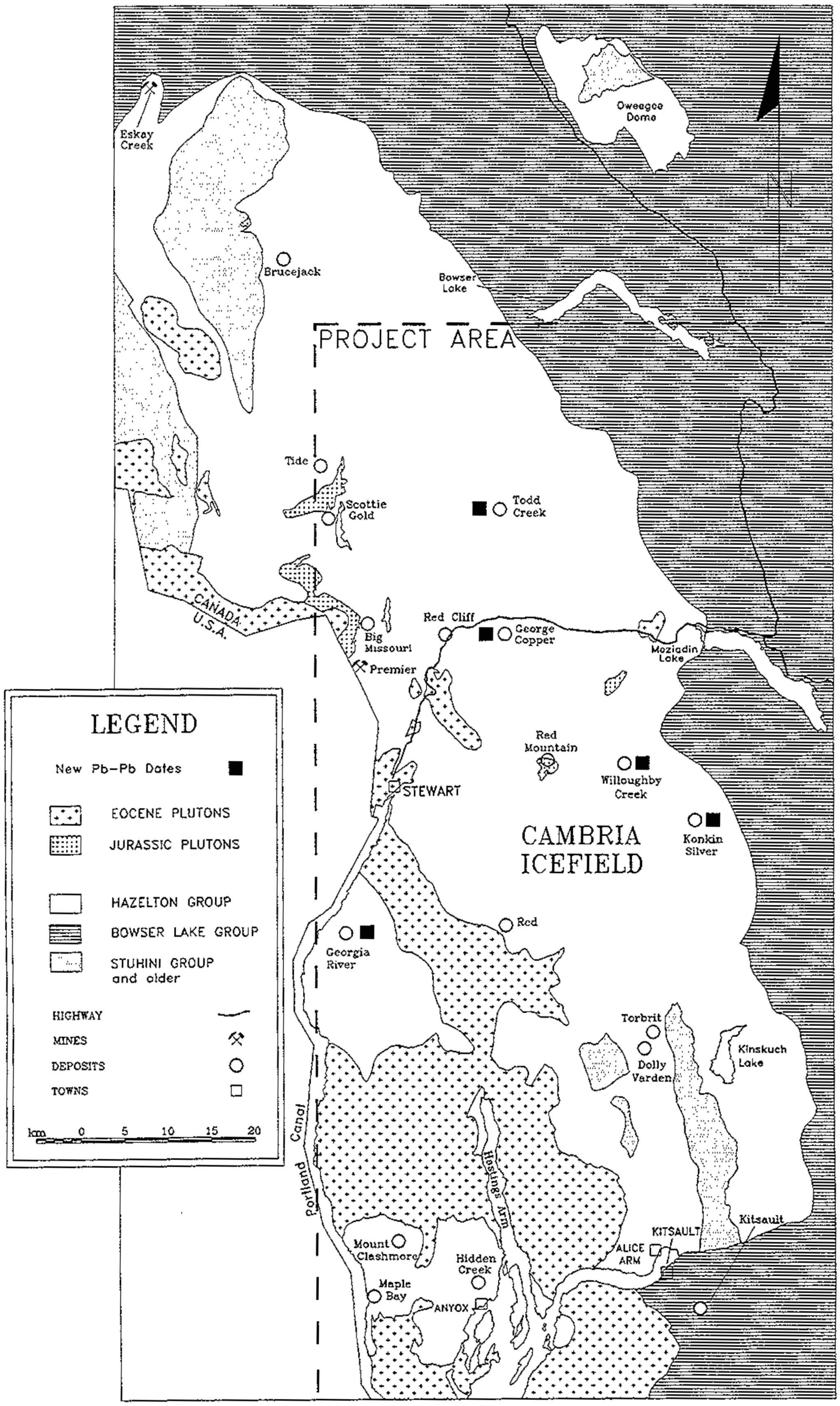

Figure 1. Project location map showing sample sites.

TABLE 1
LEAD ISOTOPE DATA FROM THE CAMBRIA ICEFIELD AREA

DEPOSIT	Figure Symbol	MINFILE Number	Min	$^{206}Pb/^{204}Pb$	Error %	$^{207}Pb/^{204}Pb$	Error %	$^{208}Pb/^{204}Pb$	Error %	$^{207}Pb/^{206}Pb$	Error %	$^{208}Pb/^{206}Pb$
SW Vein, Georgie R.	1	103O 013	sph*	19.0711	0.007	15.6312	0.003	38.5973	0.008	0.8196	0.001	2.0239
Gem Vein, Georgie R.	2a	103O 013	gln	19.1189	0.005	15.6463	0.003	38.6725	0.006	0.8184	0.003	2.0228
Gem Vein, Georgie R.	2b	103O 013	gln	19.1085	0.003	15.6375	0.003	38.6392	0.004	0.8184	0.001	2.0223
Zinc Vein, Georgie R.	3	103O 013	sph*	18.8636	0.097	15.5808	0.096	38.4029	0.098	0.8260	0.016	2.0358
Granodiorite Vein, G.R.	4	103O 013	gln	18.9206	0.003	15.6302	0.003	38.5247	0.004	0.8261	0.001	2.0362
NI#1, Willoughby	5	103P 006	gln	18.9429	0.004	15.6293	0.003	38.4882	0.004	0.8251	0.002	2.0318
NI#2, Willoughby	6	103P 006	gln	18.9269	0.005	15.6132	0.003	38.4369	0.005	0.8249	0.004	2.0308
Todd Creek	7	104A 001	cpy*	18.9192	0.012	15.6553	0.009	38.6199	0.013	0.8275	0.007	2.0413
George Copper	8	104A 129	sph*	19.0071	0.007	15.6609	0.006	38.6083	0.007	0.8240	0.003	2.0313
Konkin Silver	9	103P 250	gln	18.8577	0.004	15.6135	0.003	38.4659	0.004	0.8280	0.001	2.0398

Minerals are gln = galena, sph = sphalerite, cpy = chalcopyrite. * indicates trace lead chemistry technique used.
Lead isotope ratios have been corrected for fractionation by 0.12%/mass unit, as defined by repeated runs of NBS 981 lead standard.

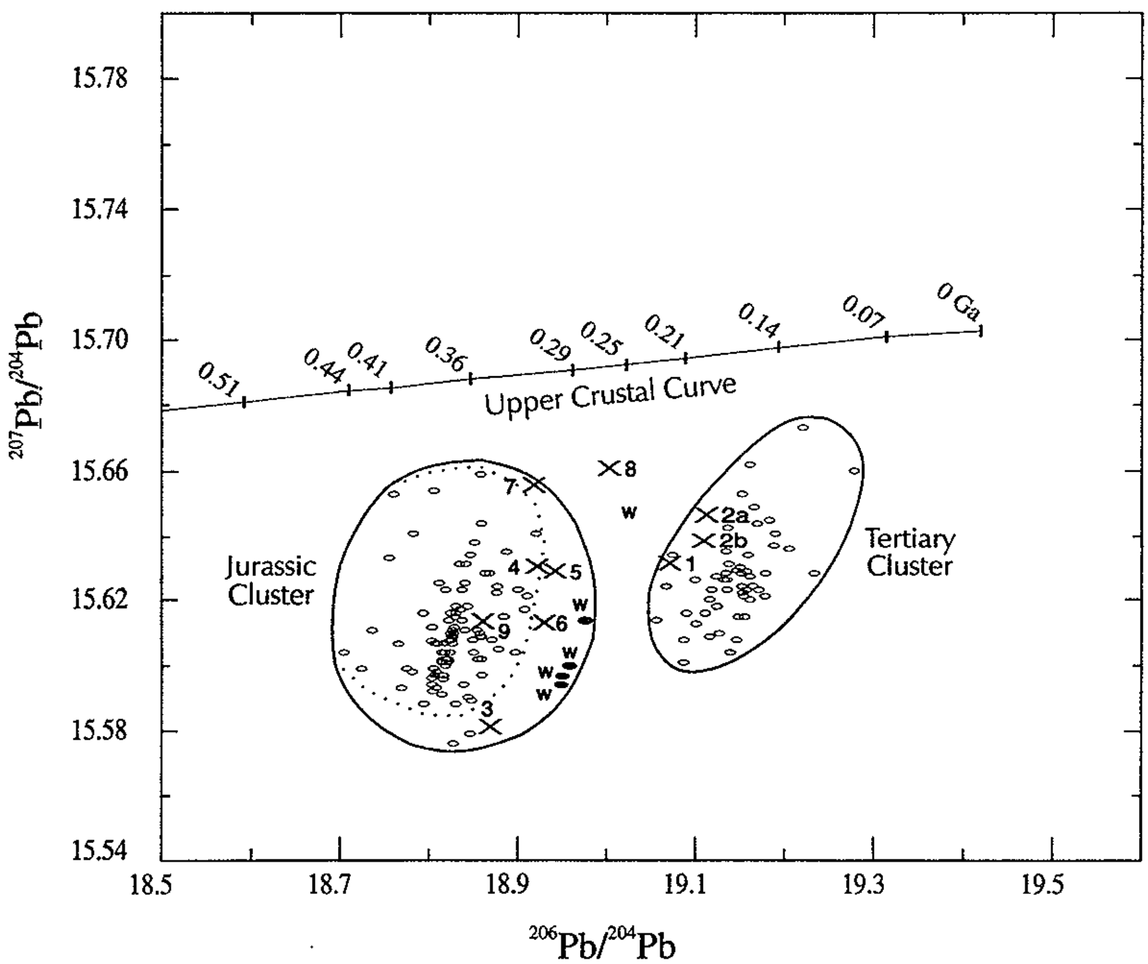

Figure 2. $^{207}Pb/^{204}Pb$ *vs* $^{206}Pb/^{204}Pb$ plot of lead isotope data from this study and from all previous analyses from the area (Godwin *et al.*, 1988). W symbol denotes previous lead isotope analyses from Willoughby Creek property. Dotted line shows previous perimeter of "Jurassic cluster" (Alldrick, 1993). The upper crustal growth curve (Zartman and Doe, 1981) has been plotted for reference.

target on the property. The northern end this structure is a zone 15 metres wide, marked by two parallel bands of semi-ductile shearing with minor disseminated pyrite and narrow, undulating quartz veinlets. The hematite-cemented breccia contains clasts of quartz and disseminations, seams and pods of medium to coarse-grained pyrite. This prospect has several features in common with the recently discovered Red prospect (103P 249) located 20 kilometres south of the Red Mountain deposit (103P 086; Figure 1). Lead isotope analyses from a single sample of a sulphide seam within the hematite-cemented breccia of the Todd Creek prospect suggest this showing is Jurassic in age. However, additional careful sampling and lead isotope analysis would be prudent, especially for such a complex, unusual deposit.

The George Copper prospect is a truncated lens of semi-massive sulphide. The showing crops out along the trend of a regionally mappable iron formation (magnetite-rich chert). The iron formation lies stratigraphically above a massive andesitic crystal tuff and below a dacitic pyroclastic unit. In the immediate area of the prospect there is also a thin lens of black calcareous turbidite overlying the iron formation. The deposit is well exposed on a north-facing cliff as a 2 by 10 metre wedge of disrupted and intensely buckled or colloform banded red-brown hematite and pyrite with minor to accessory chalcopyrite, minor sphalerite and magnetite, chlorite, epidote and silica within an epidote-rich alteration envelope. Adjacent country rocks host disseminations, veins and veinlets of sulphides. Eastward, the mineralization grades into sulphide knots, disseminations and veinlets within the magnetite-chert unit which can be followed for 65 metres along strike. Westward, the sulphide lens terminates where the sulphides and hostrock strata are cut by a fine-grained feldspar-porphyritic biotite-hornblende granodiorite dike which is regarded as an Eocene intrusion correlative with the Portland Canal dikes of the region (Green *et al.*, 1995). This dike strikes southeast and dips moderately southwest; the sulphides are exposed on the footwall side. In view of these field relationships, the George Copper prospect has been interpreted as both an epigenetic Tertiary skarn deposit, formed where the dike intersects the local lens of limy turbidite, and as a syngenetic Jurassic stratabound exhalative deposit formed at a local depression and vent site along the trend of the regionally distributed iron formation (*e.g.*, Davidson, 1992) and subsequently

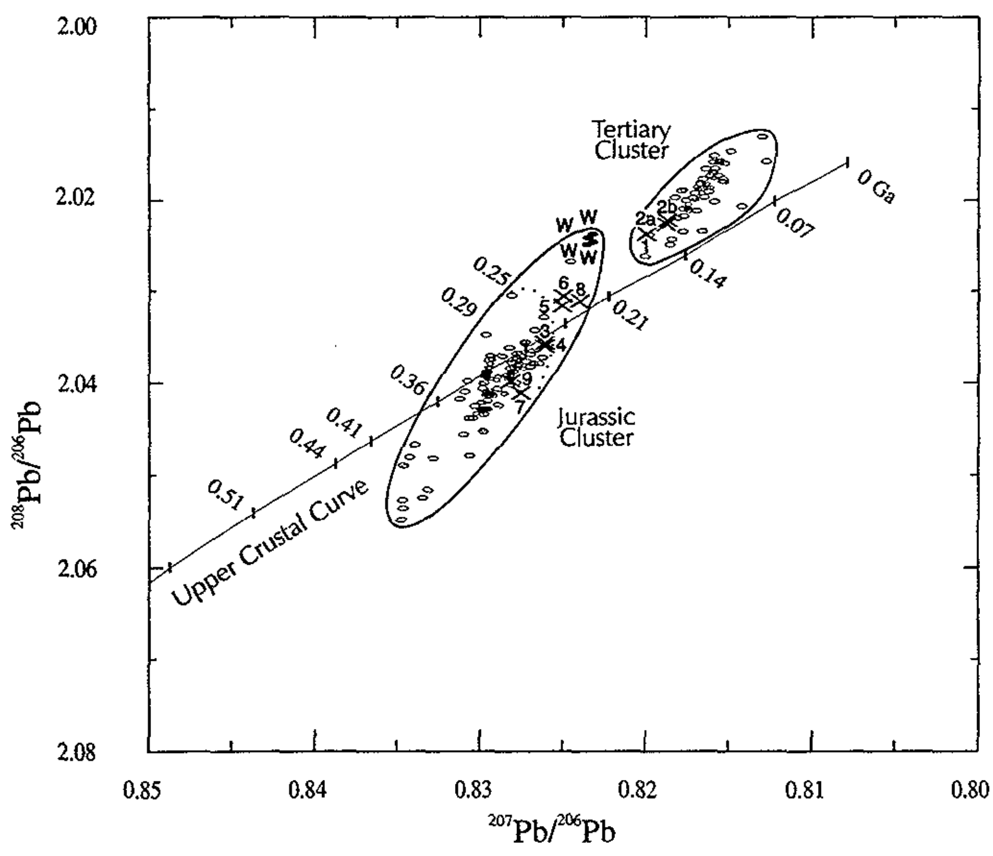

Figure 3. $^{208}Pb/^{206}Pb$ vs $^{207}Pb/^{206}Pb$ plot of lead isotope data from this study and from all previous analyses from the area (Godwin *et al.*, 1988). W symbol denotes previous lead isotope analyses from Willoughby Creek property. Dotted line shows previous perimeter of "Jurassic cluster" (Alldrick, 1993). The upper crustal growth curve (Zartman and Doe, 1981) has been plotted for reference.

buckled and deformed by the later dike intrusion. In Figure 2, the isotope ratios for the sphalerite sample plot significantly outside the main cluster of Jurassic leads. This is probably caused by ^{204}Pb measurement error; this isotope ratio plot is particularly sensitive to errors in the measurement of the low abundance ^{204}Pb isotope. The effect of ^{204}Pb error can be removed by using the $^{208}Pb/^{206}Pb$ versus $^{207}Pb/^{206}Pb$ plot (Figure 3). In this plot the George Copper sphalerite sample plots within the Jurassic cluster, indicating that this is a Jurassic deposit.

The recently discovered Konkin Silver prospect consists of coarse crystalline galena with minor sphalerite and rare ruby silver and native silver in calcite-quartz-barite gangue. Mineralization occurs as an irregular replacement zone within intermediate and felsic volcanic hostrocks. Lead isotope analyses from a single sample indicate that this showing is also a Jurassic age prospect.

CONCLUSIONS

The deposits sampled are representative of the two main metallogenic pulses already documented in this district. Results also demonstrate that there are two generations of sulphide-bearing veins on the Georgie River property. Once age relationships among the Georgie River veins are resolved by isotopic studies, these veins can be distinguished by characteristic differences in orientation, sulphide and gangue mineralogy and gold-silver content. Lead isotope data have clarified age relationships among the many veins on the property, and can be used to help focus exploration efforts on the most prospective targets.

Preliminary results suggest there may be two generations of veins on the Willoughby Creek property. Some Willoughby veins may represent a different age of mineralization than any previously recognized in this district. Further study of the several prospects on the Willoughby claims is warranted.

The Todd Creek, George Copper and Konkin Silver prospects are Jurassic age mineral prospects.

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/ Babine Intrusions / Copper / Babs

BABS - UNUSUAL COPPER MINERALIZATION IN A SOUTHERN EXTENSION OF THE BABINE PORPHYRY CAMP

By Paul Wojdak

Location:	Lat: 54°51'N Long: 126°00'W 75 km east of Smithers, 15 km east of Granisle on the east side of Babine Lake within Omineca Mining District (refer to Figure 1)
MINFILE:	093L 325
Claims:	Babs 1-21
Access:	From Topley Landing via Northwood Pulp and Timber Company ferry across Babine Lake, and then 9 km on the Nose Bay and Pat's Forest Service roads.
Owner:	Ralph Keefe, Joseph Hidber, Melvin McQuatt
Operator:	Pacific Sentinel Gold Corp. & Northern Dynasty Minerals Ltd.
Commodities:	Cu, Au

HISTORY

The Babs property lies 7 kilometres southeast of the Granisle copper mine, a past producer within the Babine porphyry camp. In 1991, prospectors discovered a float train consisting of angular cobbles to 1.5-metre boulders of biotite feldspar porphyry containing chalcopyrite and magnetite. The biotite feldspar porphyry (BFP) is similar to Babine intrusions which host mineralization at the Granisle, Bell and Morrison deposits. Some 100 boulders are concentrated in an area measuring 300 by 150 metres, elongated southeasterly. There is no record of previous work although Hanson (1993) reports that a mineral claim was located, and subsequently abandoned, over altered volcanic rocks in a borrow pit 400 metres northeast of the boulder train (Figure 1).

During 1992 Equity Silver Mines Limited carried out drift prospecting, soil geochemistry, overburden trenching and magnetometer, VLF-EM and induced polarization geophysical surveys followed by diamond drilling. Seven holes were completed totalling 322 metres (Hanson, 1993). Noranda Exploration Company Limited held the Babs claims under option from July 1993 to July 1994, conducting geological and soil geochemical surveys, 40 kilometres of magnetic and 23 kilometres of induced polarization surveys, as well as drilling four core holes totalling 397.4 metres [AR 23536 = Kemp and Robertson (1994): 23261 = Kemp (1994a): 23589 = Kemp (1994b)]. Neither exploration program located the source of the BFP porphyry copper float, but an unusual style of copper mineralization was found.

RECENT EXPLORATION

Prospecting in a new clear-cut in 1995 extended the boulder train about 250 metres southeast. Northern Dynasty Minerals Ltd. optioned the property in mid-year, formed a joint venture with Pacific Sentinel Gold Corporation and began a 46-kilometre induced polarization survey and 12-hole diamond-drilling program in December, 1995.

GEOLOGICAL SETTING OF THE BABINE PORPHYRY BELT

The Babs prospect is within the Babine porphyry belt described first by Carter (1981). Porphyry copper deposits are associated with Eocene intrusive and extrusive rocks that comprise the remnants of volcanic edifices constructed on rocks of Stikine Terrane (Dirom *et al.*, 1995). This continental magmatic arc measures 40 kilometres in width by 100 kilometres in length and is known as the Babine igneous suite (Carter *et al.*, 1995). Porphyry copper-gold deposits include Bell, Granisle (both past producers), Morrison, Nak and Hearne Hill (refer to Figure 2). The Babine intrusions were emplaced into a series of northwesterly trending grabens formed by Tertiary extension and transtensional faulting (Dirom *et al.*, 1995) that affected a sequence of Triassic to Cretaceous volcanic and sedimentary rocks. However, the Babs property is underlain primarily by granite to quartz monzonite of the Late Triassic to Early Jurassic Topley intrusions, and is separated from the previously recognized limits of Eocene basin and range faults and Babine intrusions by the Takla fault (Carter, 1973; Wheeler and McFeely, 1991; MacIntyre *et al.*, 1996).

The Babine intrusions are characterized by small stocks and dikes of grey, crowded biotite feldspar porphyry of granodiorite to quartz diorite composition. These bodies are the principal hosts to porphyry mineralization within the camp. Other lithologies of the Babine igneous suite include even-grained granodiorite to quartz diorite, quartz biotite feldspar porphyry and rhyolite to rhyodacite plugs and domes (Di-

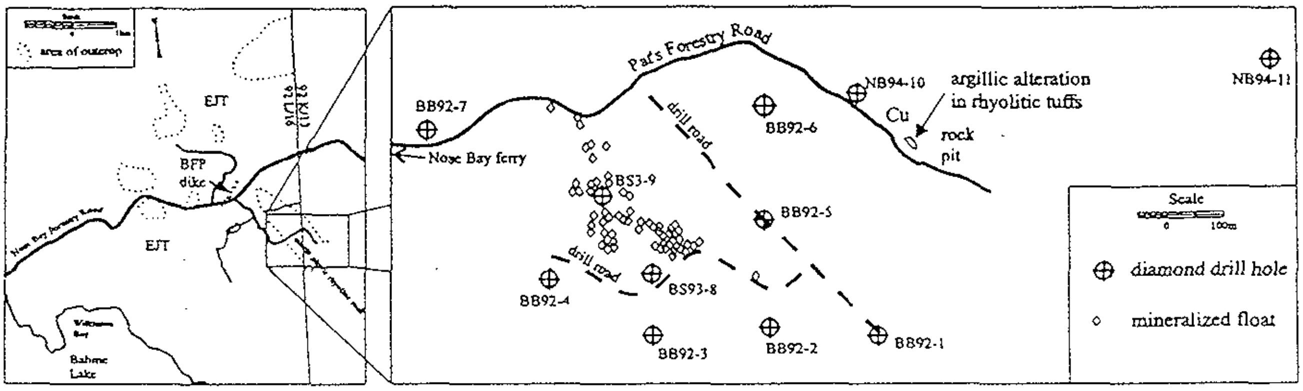

Figure 1. Geology and drill-hole locations on the Babs property.

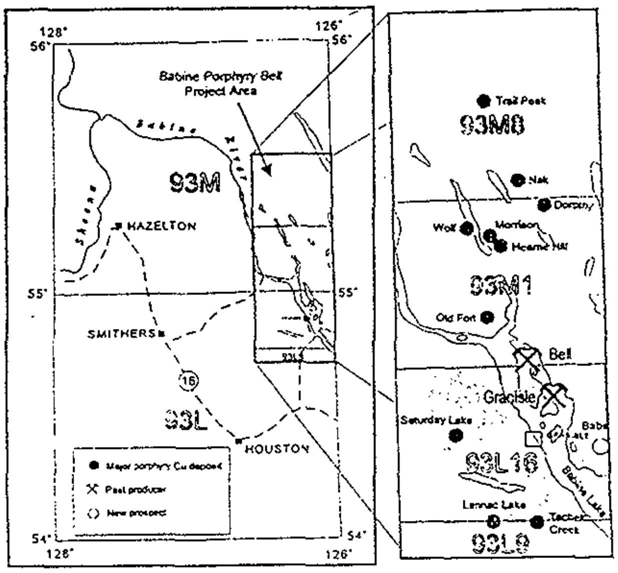

Figure 2. Location of the Babine porphyry belt (from MacIntyre *et al.*, 1993).

rom *et al.*, 1995). Near the Bell and Granisle deposits, Babine intrusions are associated with columnar jointed andesite and lahar, extrusive equivalents of the intrusions. This is evidence for a subvolcanic level of formation of porphyry deposits in the Babine area.

GEOLOGY

The Babs property is characterized by low relief and an extensive blanket of glacial till resulting in sparse outcrop in the vicinity of the mineralized boulder train. Geological mapping by Kemp (Kemp and Robertson, 1994) indicates several outcrops of felsic tuff over an area measuring 1 kilometre square, centred on the southeast end of the mineralized boulders. The best exposure of felsic tuff is within a rock pit used for road construction on the Pat's forest service road located 500 metres east of the boulder train. There, the felsic tuff is strongly altered and fractured and stained with limonite and a trace of malachite. Topley granitic rocks surround the area of felsic tuff but the closest outcrops are more than a kilometre east and northwest. From the magnetic gradient, Hanson (1993) interprets the Topley - felsic tuff contact to trend northerly about 300 metres east of the rock pit. About 1 kilometre northwest of the boulder train, MacIntyre *et al.*(1996) report a northeast-trending BFP dikelet cutting Topley monzonite.

Angular, glacially transported boulders of BFP contain chalcopyrite and magnetite in veinlets and as disseminations. The boulder train is in a forest clear-cut and extends southeast from the Pat's forestry road. Samples assay from trace up to 1.2% Cu and 1.3 g/t Au (Northern Dynasty Minerals- Pacific Sentinel Gold press release, Dec. 7, 1995). Alteration consists of clots of hydrothermal biotite and potassium feldspar envelopes to quartz veins (Hanson, 1993). Boulders of quartz-phyric felsic tuff are intermixed with the mineralized boulders. Ice-flow directions have been investigated by Kemp and Robertson (1994) at a local scale, and on a regional scale by Stumpf *et al.* (1996). Ice movement was from 320° to 340°, similar to the BFP boulder train which trends about 330° (Hanson, 1993). Eskers trend both southeast and southwest. The former direction is parallel to ice flow and the latter is parallel to slope as meltwater drained toward Babine Lake. The direction of ice flow is not unexpected and some explorationists have suggested that BFP boulders at Babs were derived from the Granisle deposit which consists of similar mineralization and lies precisely in the up-ice direction just 7 kilometres away. Anomalous copper values occur in soil within a roughly circular area 800 metres in diameter and centred on the boulder train.

DRILLING RESULTS

Drillholes BB92-1 to BB92-4 tested an east-west-trending coincident magnetic and induced polarization anomaly located 100 metres south of the southeast end of the boulder train. The drilling intersected the felsic tuff sequence, dikes or sills of feldspar porphyry, and crosscutting, weak to moderately magnetic, andesite dikes (Hanson, 1993). No core from these holes was assayed. Drillholes BB92-5 to BB92-7 and NB93-8 to NB94-10 were collared within and east of the mineralized boulder field. Although some were drilled only a few metres into bedrock, these holes also intersected the felsic volcanic sequence consisting of pink to pale grey, massive quartz feldspar porphyry to flow-banded rhyolitic lapilli tuff. Hole NB94-11 was drilled into magnetite-bearing Topley granodiorite 1 kilometre east of the boulders

Three holes; BB92-6, NB93-8 and NB94-10 intersected low-grade copper mineralization in the felsic volcanic sequence. Core assays are up to 0.64% Cu and the longest interval is 0.19% Cu over 77.3 metres in NB94-10 (Kemp, 1994b). The core was examined by the author and several samples taken for thin section study. Copper mineralization is unusual and difficult to recognize; indeed it was missed in BB92-6 until the 1994 assay results were received. Careful examination shows fine chalcopyrite on and within phenocrysts. These phenocrysts were identified as quartz in surface samples and in drill core (Kemp 1994a, 1994b, MacIntyre *et al.*, 1996), but thin section examination reveals chalcopyrite is associated only with potassium feldspar although plagioclase and quartz are also present (Photos 1 to 4). Potassium-feldspar crystals exhibit simple Baveno twinning and are unaltered. Generally, chalcopyrite forms irregular masses within these crystals but in some instances chalcopyrite is aligned parallel to the {001} cleavage. Pyrite is much less abundant than chalcopyrite and forms disseminated euhedral crystals, not associated with potassium-feldspar. In contrast to fresh potassium-feldspar, plagioclase phenocrysts are extensively to completely altered to fine sericite, so that polysynthetic twinning is faintly preserved to obliterated. Quartz phenocrysts are less abundant and smaller than feldspar, occurring as 1 to 3-millimetre euhedral crystals, commonly broken. In flow-banded crystal tuff, quartz also occurs as abundant spherulites. Lapilli tuffs contain a variety of flow-banded and aphanitic rhyolitic clasts in a pervasively argillized matrix. In NB93-8 one 2- centimetre, medium-grained granitic clast that contains disseminated chalcopyrite was noted.

DISCUSSION

Kemp (1994a) interpreted the felsic volcanic sequence to dip subvertically, but his interpretation based on core angles of contacts, bedding and flow banding is ambiguous. There is no distinctive marker to correlate stratigraphy between drillholes. This author believes the felsic volcanic sequence dips gently to moderately northward, based on core angles in drill core from holes angled to the north, south and vertically, but the data are not conclusive. Massive quartz

Photo 1. BB93-8. Potassium-feldspar phenocryst under crossed polars; euhedral, Baveno-twinned with minor chalcopyrite replacement. Field width about 1.5 mm.

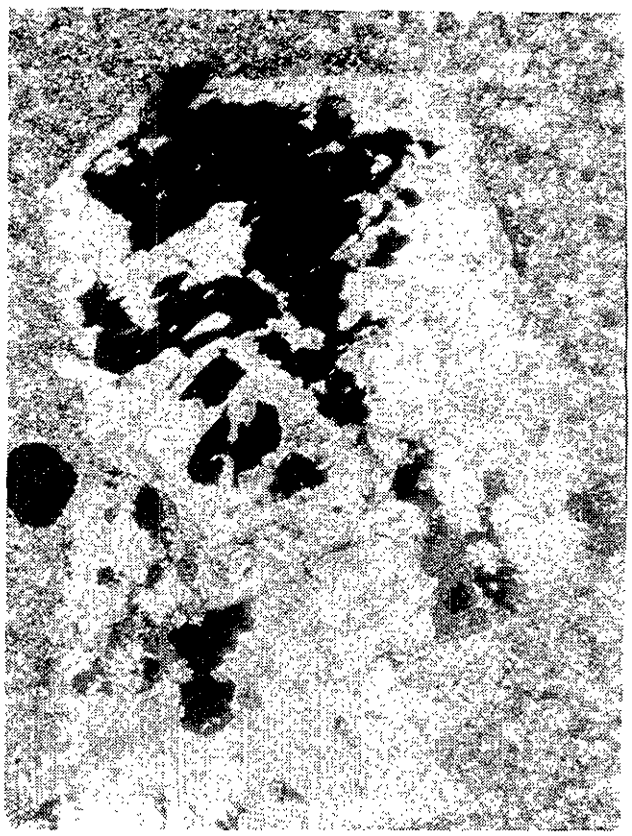

Photo 2. BB94-10, Potassium-feldspar phenocryst with crystallographically controlled replacement by chalcopyrite, under plane light. Field width about 1.5 mm.

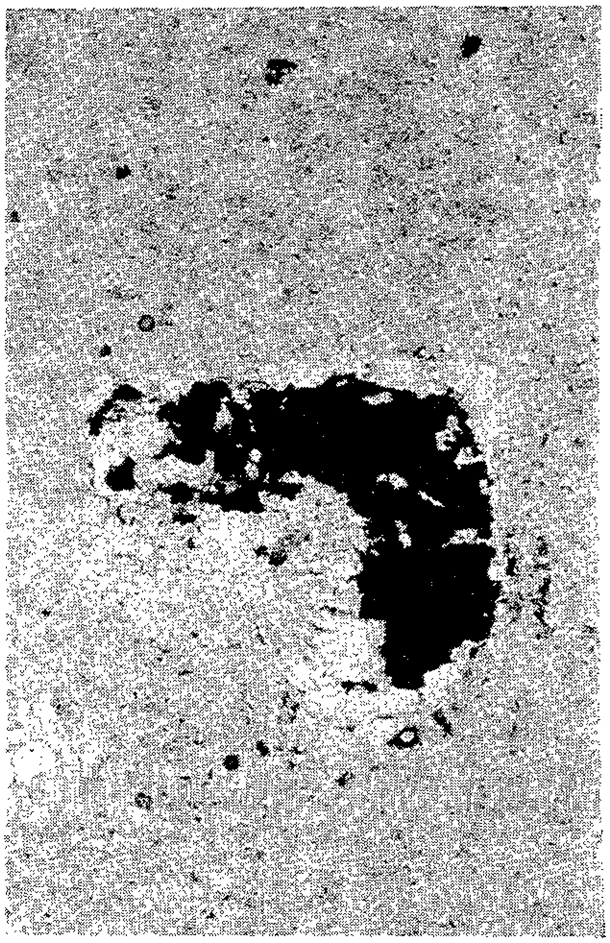

Photo 3. BB94-10, Potassium-feldspar phenocryst under plane light, almost completely replaced by chalcopyrite. Field width about 1.5 mm.

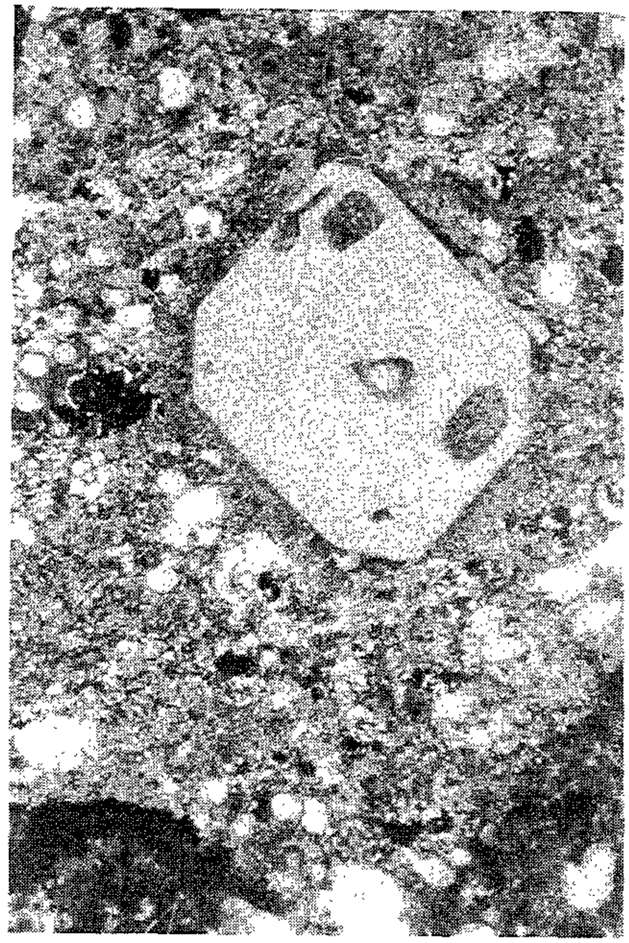

Photo 4. BB93-8, Euhedral quartz phenocryst in a matrx of quartz spherulites, under plane light. Field width about 1.5 mm.i

feldspar porphyry may be intrusive as chilled margin contacts were observed locally on narrow dikes. Massive and flow-banded rhyolite of the felsic volcanic sequence at Babs is similar in texture and composition to rhyodacite to rhyolite plugs and domes exposed on the Newman Penninsula. The Babs felsic volcanic sequence is correlated with the Babine igneous suite (MacIntyre *et al.*, 1996), and felsic eruptive rocks represent a new facies.

Regionally, Babine rhyolite plugs predate the distinctive mineralized biotite feldspar porphyry stocks. Intrusive rhyodacite at the Bell mine hosts 30% of the orebody (Dirom *et al.*, 1995). An intense stockwork formed by crackle brecciation in the rhyodacite, grades to fine-grained sulphide disseminations in the Bell orebody. Chalcopyrite in potassium-feldspar that occurs at Babs is unlike copper mineralization hosted in rhyodacite at Bell, but there is strong circumstantial evidence that mineralization at Babs is porphyry related:

- Boulders of rhyolite to rhyodacite and mineralized biotite feldspar porphyry are intermixed. Both lithologies can be correlated with the Babine igneous suite.
- Rhyolite to rhyodacite underlies the boulder train and contains sub-ore grade copper mineralization. It is most improbable that glacial till with mineralized boulders could be deposited on top of mineralized bedrock in which boulders and bedrock are correlative but mineralization is unrelated.

The significance of the unusual style of copper mineralization in the felsic volcanic rocks at Babs is not understood. Perhaps rhyolite magmatism entrained components of an ore fluid which reacted with and altered the solidifying magma, and deposited chalcopyrite on stable potassium-feldspar. Additional drilling and study will be informative. The felsic volcanic sequence at Babs is at least 100 metres thick and, as deduced by MacIntyre *et al.* (1996), is most likely contained in a down-dropped fault block within the Topley intrusions. Logically this might be a southeastern continuation of the Morrison graben, bounded by the Morrison and Newman faults that provided a favourable setting for porphyry copper mineralization at Granisle, Bell and other deposits.

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Economic Geology/Okanagan-Boundary District/Industrial Minerals/

SEVERAL NEW INDUSTRIAL MINERAL AND ORNAMENTAL STONE OCCURRENCES IN THE OKANAGAN - BOUNDARY DISTRICT (82E, 82L)

By B.N. Church, P.Geo

KEYWORDS: Tertiary outliers, quarry, dimension stone, zeolites, agates, diatomite.

INTRODUCTION

The Interior Plateau area of British Columbia is blanketed by deeply dissected early Tertiary lavas, associated pyroclastic rocks and intercalated sedimentary units. These rocks occur within a northwesterly trending belt about 150 kilometres wide, extending 800 kilometres from the Republic mining district in Washington State to the Babine Lake area of central British Columbia. The thickness of these rocks ranges from less than 100 metres to more than 1200 metres. The base of the succession, where best developed, is composed of fluvial sandstone and conglomerate (Gaylord *et al.*, 1994). The upper boundary of these rocks is generally coincident with a gently rolling 'upland surface' locally unconformably covered by a veneer of Miocene and younger 'plateau' basalt.

During the summer of 1995 the author visited selected mineral occurrences associated with the Tertiary assemblages in the Okanagan-Boundary district. These include: the Angel Hot Spring tufa deposit near Kelowna (Church, 1996, this volume); the Clearcut rhodonite occurrence in the Greenwood area (Simandl and Church, 1996); the Terrace Mountain perlite deposit in the Vernon area (Simandl *et al.*, 1996); the Shingle Creek porphyry and Beaverdell porphyry (Margranite quarry); Ewer Creek diatomite; Lightning Peak lherzolite; Mount Swite agate locality in the Kelowna area; epithermal vein occurrences such as Picture Rock near Midway and the City of Paris Au-Ag quartz vein system on the Lexington property at the north end of the Republic graben (Seraphim *et al.*, 1995) and zeolite occurrences associated with the sedimentary rocks in the lower part of the Tertiary sequence (Hora and Church, 1986). Figure 1 shows the location of the principal occurrences and the main geological domains (Church, 1995).

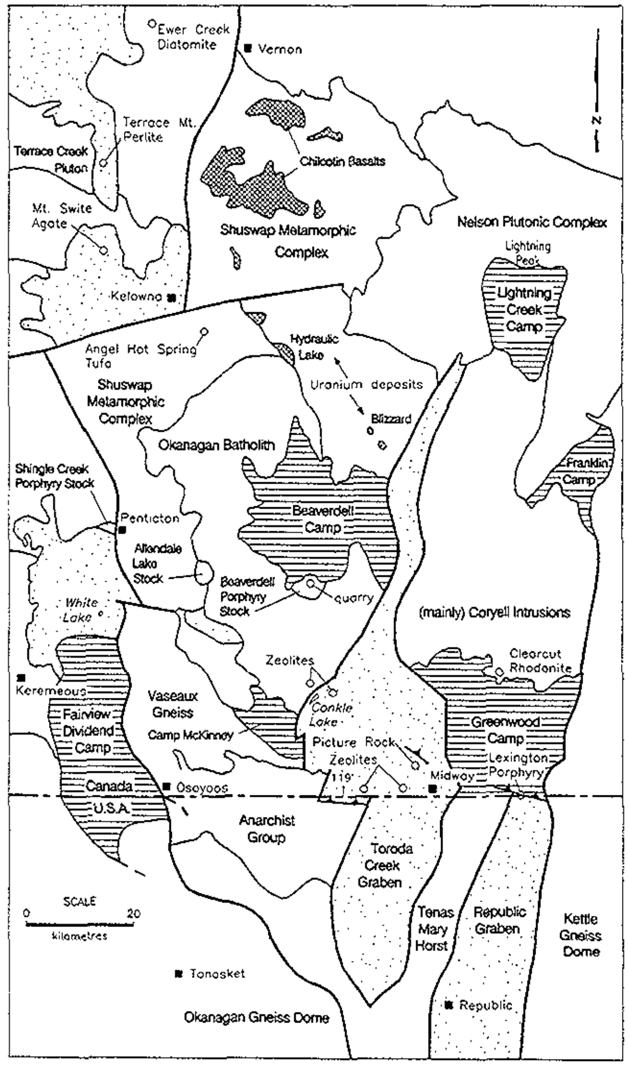

Figure 1. Map of the Okanagan Highlands (Okanagan-Boundary district) showing geological tracts and Tertiary mineral occurrences (Tertiary outliers are stippled); apparent discontinuities along the Canada/USA boundary are due to thrust faulting.

ZEOLITE OCCURRENCES (ROCK CREEK AREA)

Zeolites are most abundant in the lower part of the Penticton Group, apparently as the result of 'load' metamorphism, although the composition of the hostrocks is a controlling factor. For example, there is a close association of natrolite and secondary analcite with calcite in amygdule fillings in the sodic rhomb-porphyry lavas of the Yellow Lake member. It may be that these minerals, excluding quartz, formed at the time of first cooling of these undersaturated lavas. However, the association of clinoptilolite with tuffaceous sedimentary rocks high in the section suggests the possibility of an authigenic origin of some zeolites. Elsewhere, the occurrence of laumontite and heulandite in fissures throughout wide sections of the Penticton Group is evidence of an episode of low-grade regional metamorphism (Hora and Church, 1986).

During the 1995 field season, a broad program was undertaken to sample the Kettle River Formation for zeolites. This unit, consisting of arkosic sandstone, granite boulder conglomerate and rhyolite tuffaceous beds at the base of the Penticton Group, was deemed to offer opportunity for new zeolite discoveries, employing the 'load' metamorphism model. Approximately 60 samples were collected from the Kettle River Formation in the Toroda Creek graben near Rock Creek and Midway. X-ray diffraction and thin section analyses of these samples showed a preponderance of feldspar and quartz with variable amounts of clay. Four samples contained accessory zeolites - all in the Rock Creek area. These consisted of stilbite in one sample from granite-boulder conglomerate, northwest of Conkle Lake, three samples (Figure 1) with harmotome from rhyolite tuff northeast of Conkle Lake and two similar samples near the U.S. border.

Naturally occurring zeolites are generally easily accessible, relatively inexpensive and have many uses such as in cation exchangers, adsorbents, molecular sieves and desiccants for industrial, agricultural and environment protection technologies (Kallo and Sherry, 1988). The discovery of small amounts of stilbite and harmotome by this study simply indicates a local favourable environment for the formation zeolites. Further work is required to establish an economic target.

BEAVERDELL PORPHYRY (MINFILE 082ESE169)

The Beaverdell porphyry is a subcircular granitic stock (5 km diam.) centred 14 kilometres south of Beaverdell. It is exposed mostly northeast of the Kettle River in the drainage basin of Dominion Creek, in the area west of Boyer Creek and south of the mouth of Tuzo Creek. The stock (dated 49.4±0.7 Ma, this study) and satellitic dikes intrude granodiorite phases of the Okanagan batholith (Jur.-Cret.) on Tuzo and Boyer creeks and basal Tertiary rhyolite and conglomerate that contain clasts of the Okanagan batholith, in the headwater area of Dominion Creek. The stock is cut by numerous basaltic dikes (Miocene-Pliocene) and a few Coryell-related pulaskite and rhomb-porphyry dikes (Eocene) as seen along Highway 33.

The Margranite quarry is located near the south margin of the stock (Lat. 49°20.4', Long. 119°03.25') on Highway 33 (Figure 1). It has been the focus of intermittent quarry development (the Beaverdell granite quarry) by Continental Granite and Marble Ltd. since the early 1960s. In 1990 the ground was restaked and became part of the Cascade Coral property owned by 1885 Holdings Ltd. The property is presently owned and operated by Margranite Industries Ltd. The quarry trends northeast from the highway following a 40 metre-band of massive, lightly jointed granite porphyry for a distance of approximately 130 metres (Photo 1). This band of quarry rock is flanked on the northwest by alternating bands of strongly and weakly fractured porphyry of the same composition (Figure 2). A study of the fracture pattern shows three main joint sets - subhorizontal sheeting (differential expansion/contraction due to cooling and/or off-loading), a principal joint set averaging 035°/60°NW and a secondary set at 090°/55°N (Figure 3). The typical rock at the quarry face contains rectangular phenocrysts of pink potassium-feldspar (to 6 cm) set in a granular groundmass of 55% orthoclase, 15% quartz, 20% plagioclase, and 10_ combined biotite, hornblende and magnetite (Kidlark, 1990). The age of this rock is 49.4±0.7 Ma, based on K-Ar

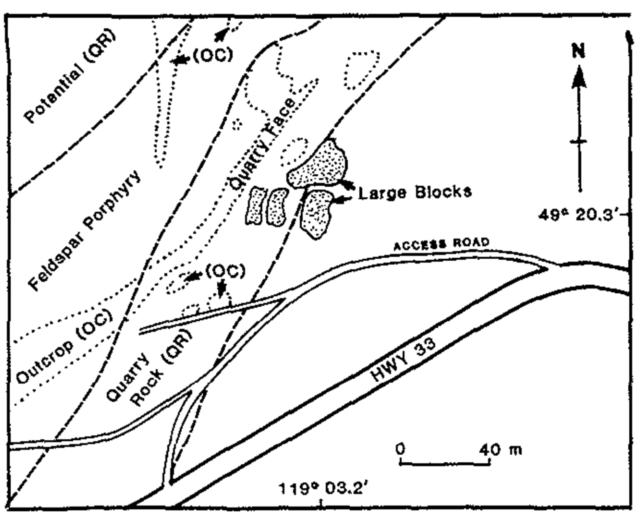

Figure 2. Geological setting of the Margranite (Beaverdell) quarry (after Kidlark, 1990).

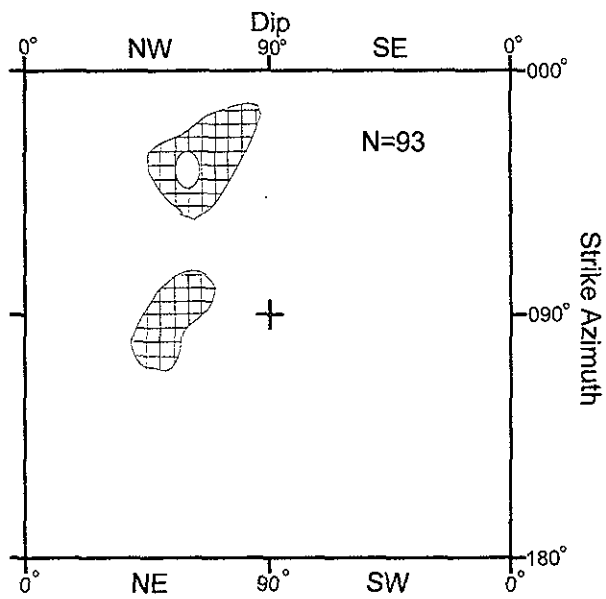

Figure 3. Fracture frequency plot for the Beaverdell porphyry.

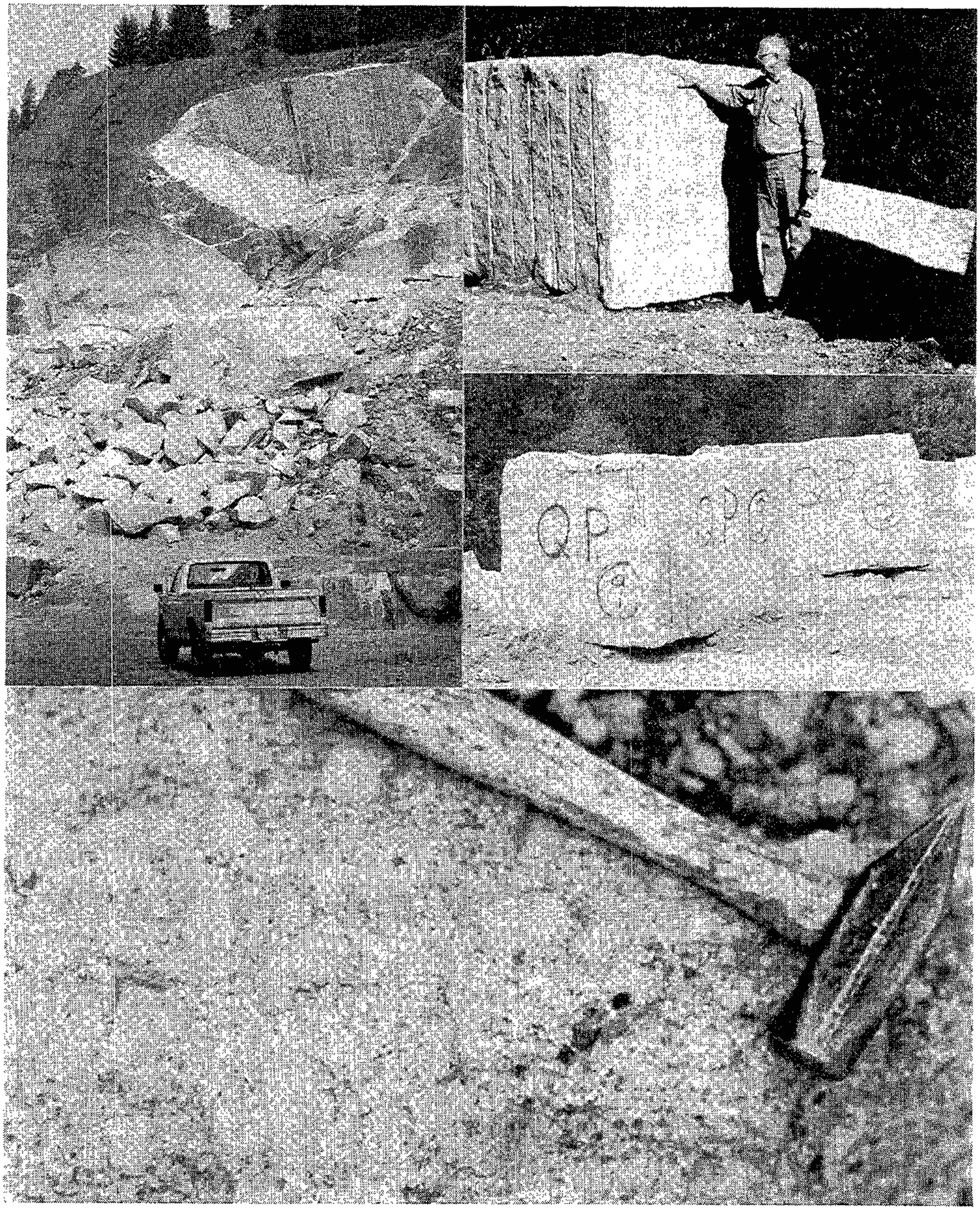

Photo 1. Scenes from the Margranite quarry (Beaverdell porphyry), 15 kilometres south of Beaverdell; upper left, view of quarry looking northwest;upper right, view of quarry blocks weighing 10-14 tonnes; lower, typical porphyritic texture of quarry rock.

analysis of biotite (UBC). The chemical composition of the porphyry is 72.35% SiO_2, 0.29% TiO_2, 14.89% Al_2O_3, 1.40% Fe_2O_3, 0.03% MnO, 0.46% MgO, 1.39% CaO, 4.44% Na_2O, and 4.74% K_2O (major oxides recast to 100% and total iron given as Fe_2O_3). This closely resembles the composition of the Shingle Creek porphyry near Penticton which is 72.18% SiO_2, 0.39% TiO_2, 15.16% Al_2O_3, 1.69% Fe_2O_3, 0.05% MnO, 0.57% MgO, 2.53% CaO, 2.63% Na_2O, and 4.80% K_2O. Physical testing of the quarry rock by the B.C. Ministry of Transport and Highways in 1986 yielded the following results (Kidlark, 1990):

Specific gravity	2.61
Density	162.63 lb/ft^3, (2605 kg/m^3)
Absorption	0.50 wt%
Strength (comp.)	8110-9543 psi (55.92-65.80 MPa)
Strength (trans.)	1151-1460 psi(7.94 -10.07 MPa)

Since 1993 the quarry has produced blocks for tiles and polished slabs and crushed and sized fragments for terrazzo and precast concrete slab products. Total production is estimated to be several hundred tonnes.

SHINGLE CREEK PORPHYRY (MINFILE 082ESE166)

The Shingle Creek porphyry is located immediately west of Penticton on the Penticton Indian Reserve (Bostock, 1966). The porphyry forms an irregularly shaped lenticular stock (2 x 7 km) concave to the south, with several large offshoot dikes at the western boundary. It is characterized by large, twinned potassium feldspar (1-10 cm), smaller plagioclase phenocrysts (to 1.5 cm), quartz bipyramid euhedra/subhedra (to 1 cm) and minor mafic minerals (magnetite/biotite) in a medium to fine-grained groundmass of similar composition. The stock intrudes diorite and granodiorite phases of the Okanagan batholith and part of its own volcanic pile that consists of rhyolite tuff and breccia containing large broken sanidine phenocrysts. The age of the porphyry, based on K-Ar analysis of fine-grained biotite inclusions within sanidine phenocrysts, is 52.4±1.8Ma (Church, 1982a). The bipyramidal quartz crystals ('Herkimer diamonds') and large, commonly twinned, sanidine and orthoclase phenocrysts that weather free of the hostrock, are of interest to mineralogists and rockhounds.

TERRACE MOUNTAIN PERLITE (MINFILE 082LSW160)

Perlite was found by the author on Terrace Mountain 30 kilometres southwest of Vernon (Figure 1). It occurs in a porphyrytic obsidian unit exposed in cuts on the road leading to the forest look-out tower on Terrace Mountain (Lat. 50°06', Long. 119°38'). The perlitic rocks are mottled light grey and brown and consist of 15% plagioclase phenocrysts (2 to 7 mm) and accessory biotite in a glassy matrix with characteristic concentric 'perlitic' cracks (Simandl *et al.*, 1996). The expansion of the rock when heated is negatively affected by low water content and porphyritic characteristics according to preliminary tests by the Ministry of Highways laboratory in Victoria.

The Terrace Mountain area is underlain by relatively fresh volcanic rocks, equivalent in part to the Penticton Group, in a northerly elongated, westerly dipping, half graben structure. This structure developed on a basement complex consisting of strongly folded and faulted Paleozoic and Mesozoic oceanic cherts, turbidites, greenstones and younger granitic rocks (Church, 1980a, 1982b). The volcanic succession on Terrace Mountain is about 900 metres thick and consists, from top to bottom, of fine-grained dacite, forming a tilted cap approximately 30 metres thick on the summit, underlain by approximately 120 metres of porphyritic obsidian (perlite host), underlain in turn by a series of feldspar porphyry trachyandesite lava flows some 180 metres thick, and a series of andesitic lava flows and breccias approximately 550 metres thick, at the base. The summit dacite is tentatively correlated with similar rocks near Naswhito Creek, 20 kilometres to the north; the porphyrytic obsidian may be equivalent to the Bouleau Lake ash-flow deposit that occurs below the Naswhito Creek unit north of Bouleau Lake and in the drainage basin of Ewers Creek (Read, 1996). The feldspar porphyry trachyandesites and andesitic units exposed on the lower slopes of Terrace Mountain are correlated with the Kitley Lake and Attenborough Creek members (Church, 1982b).

The age of the Terrace Mountain perlite, determined from K-Ar analysis of the biotite phenocrysts, is 52.3±1.8 Ma (Church, 1980a). This is similar to the age of the Marron Formation, Penticton Group (Church, 1982b).

MOUNT SWITE AGATE (082ENW106)

The Mount Swite agate locality (Lat. 49°57.8', Long. 119°37.5') is just east of the summit of Mount Swite, 12 kilometres northwest of Kelowna (Church, 1980a, b). It is accessed from the Bear Creek (Lambly Creek) road via the Hidden Creek logging road that passes 2 kilometres east of the summit (Figure 4). The agates consist of quartz and chalcedony filling amygdules and fissures in the Attenborough Creek member (Photo 2). The amygdules are commonly elongated almond-shaped structures (0.5 to 5 cm), filled with fine-grained blue-grey quartz, chalcedony and white plume opal aligned parallel to flow direction of the lava. Thunder eggs are larger agates (6 cm.) with radiating quartz crystals lining vugs and/or chalcedony in variegated horizontal or concentric bands on cavity floors or walls. Agates

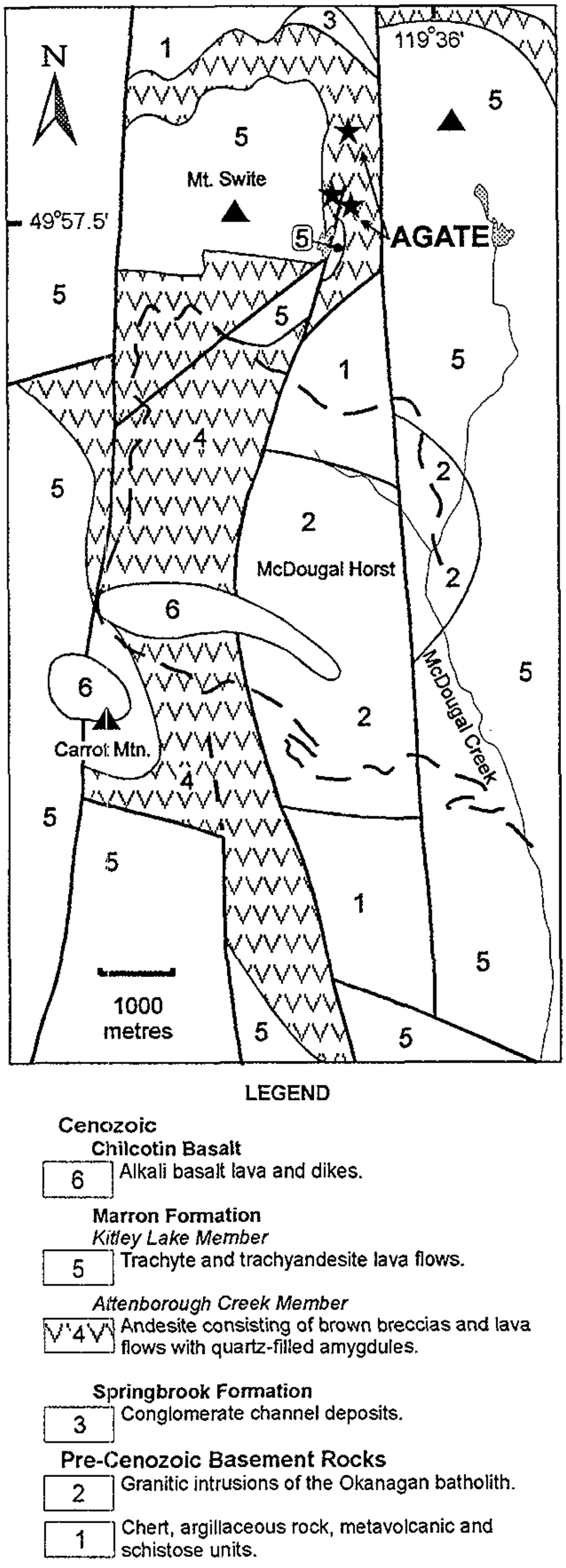

Figure 4. Geological setting of the Mount Swite agate localities.

are believed to form within gas cavities of volcanic hostrocks when microcrystalline chalcedony fibres nucleate on vug walls and grow inward. Oscillatory zoning and iris banding is the result of variations in silica concentrations in solutions at the tips of the growing chalcedonic fibres forming smooth and regular or botryoidal surfaces parallel to the banding (Heaney and Davis, 1995). The most probable source of the silica-rich solutions is the host Attenborough Creek andesite. Analyses of the andesite from different locations shows uniform composition and excess silica based on norm calculations. For example, the andesite from Mount Swite contains 57.04% SiO_2, 1.08% TiO_2, 16.79% Al_2O_3, 5.03% Fe_2O_3, 2.38% FeO, 0.10% MnO, 4.05% MgO, 6.70% CaO, 3.36% Na_2O and 3.47% K_2O (major oxides recast to 100) that yields 6.57% free silica/quartz (CIPW norm). By comparison Attenborough Creek andesite from Terrace Mountain shows 57.29% SiO_2, 1.18% TiO_2, 16.02% Al_2O_3, 4.55% Fe_2O_3, 2.32% FeO, 0.11% MnO, 4.00% MgO, 7.46% CaO, 2.96% Na_2O, 4.11% K_2O that yields 6.43% normative quartz. It is concluded that part of the excess silica, accompanied by fluids and gases, moved from the andesite lava to gas cavities and fracture openings during the original lava cooling process.

PICTURE ROCK (MINFILE 082ESE242)

The Picture Rock veins are associated with a belt of serpentinite that traverses the Lexington - Lone Star area on the Canada-U.S. border, and thence through the Midway mine area north of the town of Midway, then arching southwesterly back into Washington State (Little, 1983). The serpentinite is believed to be part of a disrupted Paleozoic ophiolite that includes a number of peridotite, talc and listwanite bodies (Fyles, 1990). Because of the ductile nature of these rocks, the belt has become a tectonically active zone and the locus of much shearing, thrusting, igneous intrusion and vein mineralization. The common Mg-Fe carbonate (listwanite) alteration and serpentinization are believed to be related to major thrusting of the ophiolitic rocks during the Jurassic. In the Late Cretaceous and Early Tertiary these thrusts were re-activated by a tectonic squeeze directed subparallel to the developing north-south elongate graben structures. Accompanying igneous activity is believed to be related to numerous vein deposits.

The Picture Rock quarry is 4.5 kilometres northwest of Midway between Bauer and Ingram Creeks directly under a major hydroelectric power line (Lat. 49°02.3′, Long. 118°47.8′). Access is by a dirt road to the power line from the former railway crossing on Highway 3, west of Midway. The quarry is 500 metres south of the Midway mine from which about 19 tonnes of Ag-Au ore with lead and zinc credits were shipped in the late 1960s and early 1970s. The area was explored for large tonnage precious metal potential by Dentonia Resources and Kettle River resources in 1983,

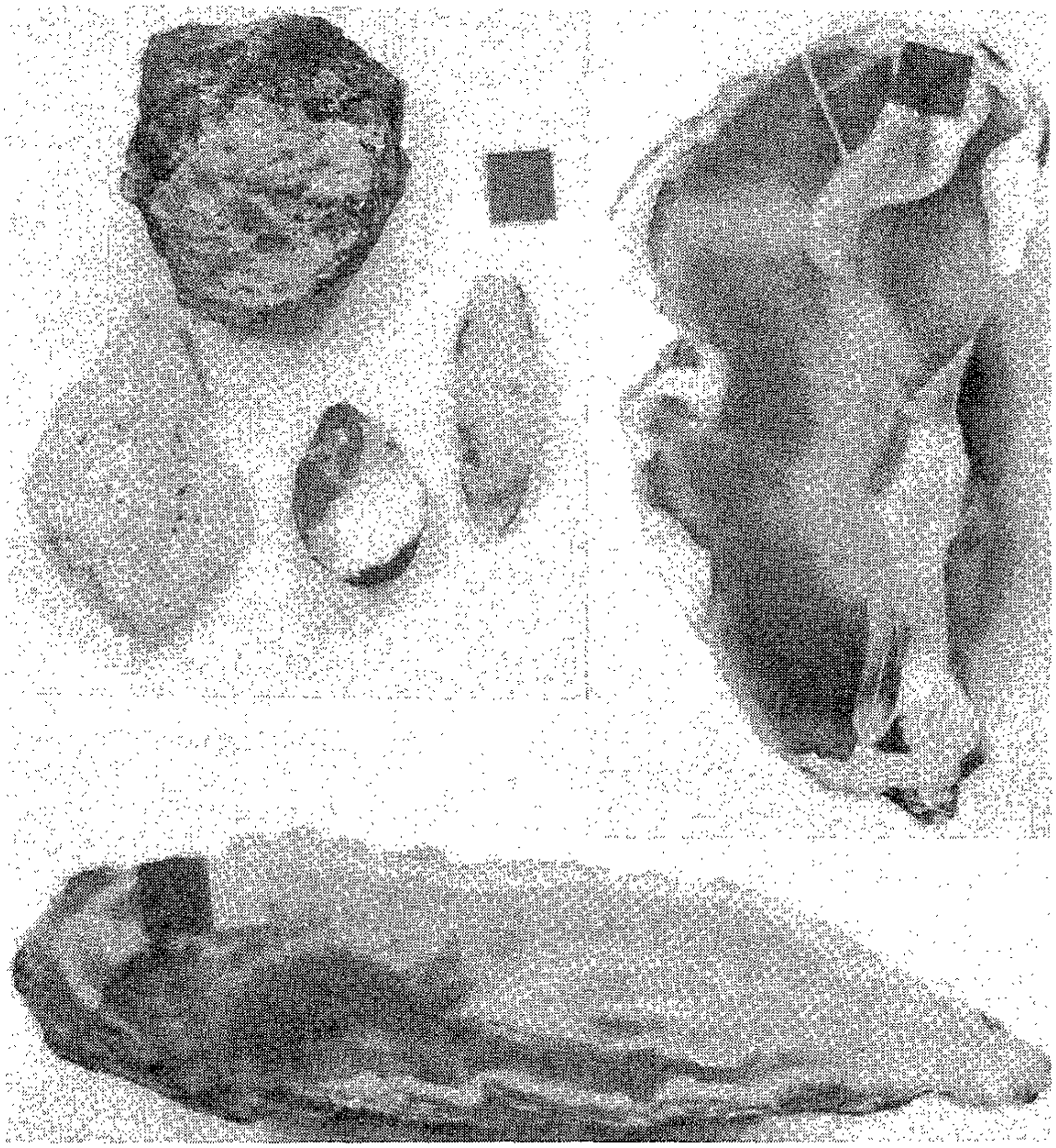

Photo 2. Agates from Mount Swite (black markers are 1 cm); upper left, a collection of almond-shaped chalcedonic and opal amygdule fillings; upper right, typical thunder egg containing white plume opal and blue-grey fine-grained quartz; lower, agate showing combination of concentric banding and radiating chalcedonic quartz.

Kerr Addison Mines Ltd. in 1984, BP Resources Canada Ltd. from 1987 to 1989 and Minnova Inc. in 1989 and 1990 (Lee, 1990). Through this period to the present, ornamental quartz has been obtained from the Picture Rock locality for lapidary purposes.

At the Picture Rock quarry epithermal quartz veins cut altered serpentinite (listwanite) and feldspar porphyry dikes. The quarry actually comprises a group of small detached and interconnected pits developed over a radius of several tens of metres on the crest of a low ridge. The veins are generally narrow (up to 50 cm wide) and mostly gently dipping to the east and northeast. Typically they are delicately banded in white, grey, light blue and blue-green layers that are developed parallel to the vein walls or around listwanitic breccia clasts (Photo 3). Except for the largest veins, seen in the floor of the main pit, which has a hangingwall composed mostly of dickite several centimetres thick, the walls are little altered by the veining. The veins have Au, Ag, As, Sb epithermal signatures with anomalous but subeconomic precious metal values (Lee, 1990).

The Picture Rock quartz has proven attractive for the manufacture of clock faces and ornaments by local artisans.

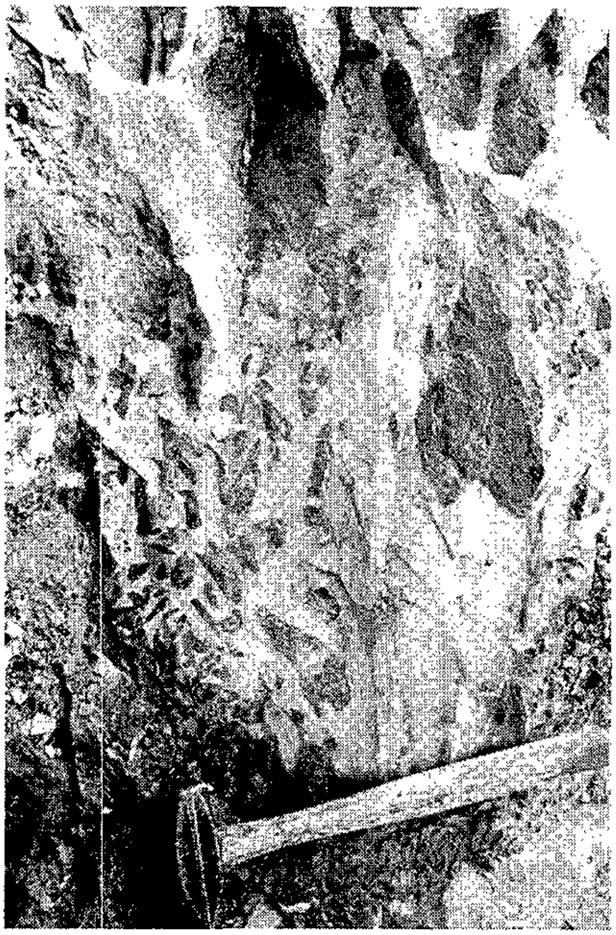

Photo 3. Breccia in epithermal quartz vein, Picture Rock quarry, Midway area.

The bluish green colour of some of the chalcedony was thought to be due to the presence of nickel, as chrysoprase, derived from the ultramafic and listwanitic hostrocks. However, analysis of a sample of the bluish vein material yielded only 15 ppm Ni. Other elements, possibly contributing to the colour, include 71 ppm Co, 94 ppm Mn, 0.46% Fe, 538 ppm Sr, 96 ppm Cr, 100 ppm Na and 641ppm W.

EWER CREEK DIATOMITE (MINFILE 082LSW159)

Diatomaceous earth associated with the Blizzard uranium deposit has been reported by Read (1996). The diatoms are hosted by carbonaceous shales, intercalated with the Chilcotin basalt lava flows filling paleostream channels. Similar diatomaceous earth was recently discovered in logging road cuts in the headwater area of Ewer Creek (Lat. 52°25′, Long. 119°37′), several kilometres northwest of the Klinker opal deposit in the Vernon area. These rocks are absorbant, light in colour and weight, and contain a mixture of tuffaceous debris and diatom filaments. The age of these rocks appears to be Miocene, based on preliminary evaluations of well preserved fossil leaves and pollen grains (L. Donaldson, Okanagan College, personal communication, 1996).

LIGHTNING PEAK LHERZOLITE (MINFILE 082ENE018)

Lherzolite xenoliths (inclusions) are found in Chilcotin basaltic rocks at several localities in the Okanagan Highlands (Hamilton and Edwards, 1996). These rocks are sought by gemologists and rockhounds for peridote and a source material for crafting cabochons. The most notable occurrences are associated with volcanic vents near Ideal Lake (Lat. 50°01′, Long. 119°06′), Hydraulic Lake (Lat. 49°46′, Long. 119°11′) and Lightning Peak (49°52.7′, Long. 118°31.7′). The host basalts at Lightning Peak and Hydraulic Lake occurrences have been dated dated at 2.5±0.1 Ma by the K-Ar analysis . The xenoliths are subrounded and range in size from less than 1 centimetre to more than 15 centimetres. They are composed mainly of a granular (or porphyrytic) mixture of green olivine (70-85%), dark brown orthopyroxene (5-10%) accompanied by accessory, bright green clinopyroxene (chrome diopside), black spinel/magnetite and (rarely) amphibole (Brearly and Scarfe, 1984). Average grain size of these rocks ranges from <1 millimetre (magnetite) to 4 millimetres (olivine and clinopyroxene). Porphyrytic varieties contain orthopyroxene (poikilitic) and/or olivine (clear peridote) up to 1 centimetre, as seen at the Lightning Peak locality.

ACKNOWLEDGMENTS

The study is part of an ongoing project to investigate the industrial mineral potential of the Okanagan-Boundary area. This is to express much appreciation to colleagues George Simandl and Dan Hora for assistance during the fieldwork stage of this study and to Kirk Hancock for computations and drafting. Thanks are also owing Trygve Hoy and Dorthe Jakobsen for their reviews of the manuscript, to Ray Lett and Dick Player for sample preparation and lapidary work and Jim McLeod of Cominco Ltd. for laboratory support.

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Economic Geology / Kelowna /

ANGEL HOT SPRING DEPOSIT, KELOWNA AREA (82E/14W)

By B.N. Church, P.Geo

KEYWORDS: Angel Hot Spring, tufa deposit, Kelowna ~~area, Angel Hot Spring.~~

INTRODUCTION

Angel Hot Spring is located 15 kilometres southeast of Kelowna (latitude 49°47.7′ north, longitude 119°20.4′ west) on a small tributary of Klo Creek. Access is about 3 kilometres by trail from the Little White Mountain forest access road (Figure 1).

Until recently the hot spring was known only to local residents and a few hikers. This report briefly describes this new occurrence based on a visit to the area in August 1995.

Hot springs occur in many areas throughout the province and range widely in characteristics such as flow volume, temperature, source, and the composition of associated deposits (McDonald, 1991). For example the 'Bubble Hotspring Deposit' near Black Dome Mountain in the Chilcotin area is a yellow silica sinter associated with Eocene volcanic rocks (Church, 1987). In contrast the Liard Hot Spring west of Fort Nelson, near the Alaska Highway, is yielding water (21° to 54°C) flowing at rates up to 4200 litres/minute from several vents, one of which features a calcareous tufa mound (Pavlick, 1974). The source of the water appears to be fractures cutting Devonian carbonate and clastic beds, possibly related to a middle Devonian reef complex that is a major geothermal reservoir underlying much of northeastern British Columbia (Church and McAdam, 1983).

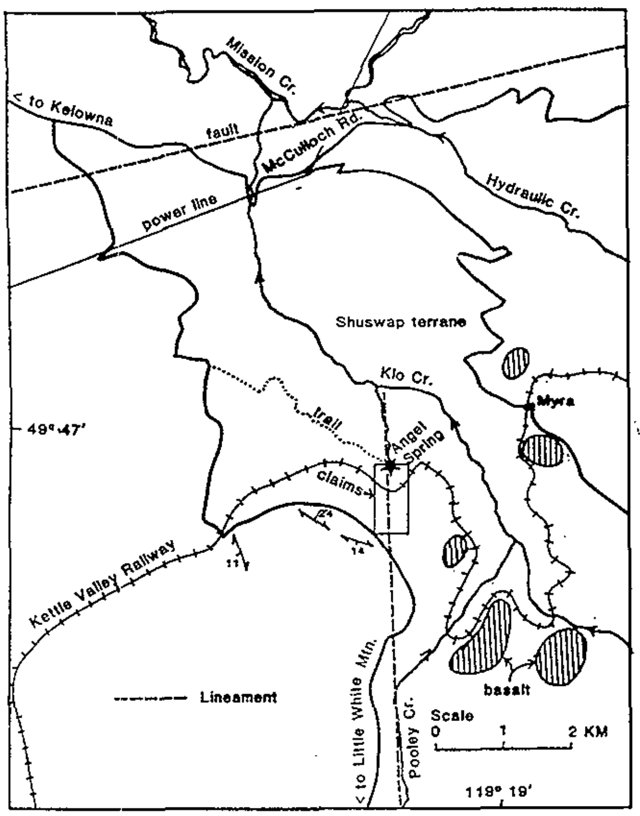

Figure 1. Geological setting of Angel Hot Spring.

GEOLOGICAL SETTING

Angel Hot Spring is above the McCullough road in the canyon section of the Klo Creek drainage basin, approximately 300 metres below the Kettle Valley railway cut, on the lower northern slope of Little White Mountain. The area is underlain by gently dipping Shuswap gneiss and schist and small outliers of Chilcotin basalt accompanied by criss-crossing feeder dikes. The basalts range in age from Miocene to recent. These rocks and associated fissures are believed to be a geothermal source (Dostal *et al.*, 1996). The area is within a region of high geothermal potential that includes much of the central and southern parts of the Okanagan Valley and is characterized by geothermal gradients ranging up to 70°C/km (Fairbank and Faulkner, 1992).

The site of Angel Hot Spring is on a northerly trending lineament that can be traced from a notch just west of the summit of Little White Mountain and thence along the upper course of Pooley Creek to the confluence of Angel Creek and Klo Creek. The lineament appears to be a subsidiary splay of the Okanagan fault system that is displaced in the Kelowna area by a major easterly trending cross-fault on Mission Creek (Figure 1). An intricate network of small fractures associated with the faulting may be tributary to the hydrothermal plumbing system feeding Angel Hot Spring. Typically the principal joints and cleavages (av. 038°/84°SE) feather acutely from the Pooley Creek lineament cutting sharply across the gently dipping Shuswap gneisses and schists (av. 058°/25°NW to 125°/20°NE).

THE SPRING AND DEPOSIT

Angel Hot Spring consists of a weak flow of warm water (several litres per minute, 21° to 29°C) from a main vent and several ancillary seeps at slightly higher elevation (the seeps yield the highest temperatures). The water is generally clouded and actively precipitating calcium carbonate. At the main vent the water issues from a tufa accumulation without significant sulphur odour although there is some smell of decaying vegetation associated with algal growth.

The algae comprise slimy yellow filaments that cling to the walls of the spring and banks for several tens of metres downstream. As the water flows from the spring it precipitates calcium carbonate, continuously building microterraces and an impervious floor to the stream.

Analysis of the spring water gives a pH of 6.92 and a major element composition of calcium 187 ppm, sodium 148 ppm, silicon 55.5 ppm, magnesium 25.9 ppm, potassium 7.4 ppm, strontium 1.84 ppm, manganese 0.62 ppm, iron 0.23 ppm, and lithium 0.16 ppm. The dissolved anions consist of bicarbonate 633 ppm, chloride 5.3 ppm and sulphate 281ppm (M. Sato, personal communication, February 29, 1996).

Over time the stream has built a large mound of tufa 300 metres long, 150 metres wide, and up to 8 metres thick along the bottom of the valley of Angel Creek. The deposit consists of grey to brownish, crudely bedded, cellular carbonate tufa forming successive lenses, each ranging from several centimetres to more than a metre thick, intercalated with gravel, logs, standing tree trunks, branches and twigs. The numerous cavities in the tufa are mostly the casts of twigs, sticks and other decaying or decayed and dissipated organic debris (Photo 1).

Analyses of tufa obtained from 5 samples, collected along the length of the mound, are listed in Table 1. This shows a range in CaO from 51.92 to 53.88%, MgO from 0.26 to 0.44%, Fe_2O_3 from 0.09 to 1.03%, Al_2O_3 from 0.06 to 0.43 %, and SiO_2 from 0.37 to 1.73%. There is a slight increase in SiO_2 and Fe_2O_3 distally from the spring and an overall decrease in Al_2O_3. In general the composition is similar to the Clinton tufa deposit (Kerr, 1980). X-ray diffraction analyses of the 5 samples (courtesy of Jim McLeod of the Cominco Laboratory, Vancouver, B.C.) indicate that the predominant mineral in the tufa is calcite.

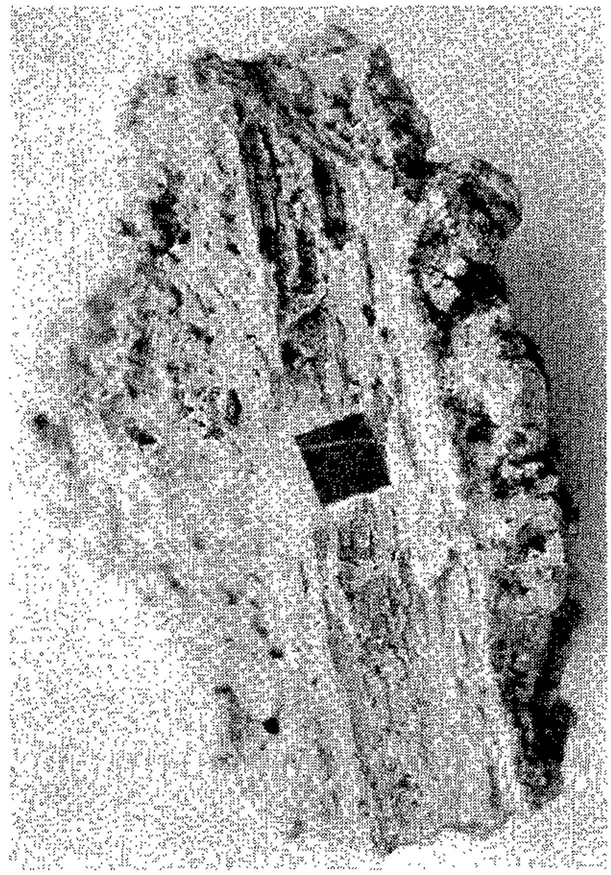

Photo 1. Organic debris in Angel Hot Spring tufa, (black marker is 1 cm).

TABLE 1
ANALYSES OF CARBONATE TUFA

	Angel Hot Spring Deposit					Clinton
Nos.	51171	51172	51173	51174	51429	Tufa
	%	%	%	%	%	%
SiO_2	0.37	0.28	0.77	0.99	1.73	0.65
TiO_2	0.01	0.01	0.01	0.01	0.01	
Al_2O_3	0.43	0.22	0.26	0.23	0.06	0.24
Fe_2O_3	0.19	0.09	0.18	0.2	1.03	0.16
MnO	0.04	0.01	0.01	0.01	0.14	
MgO	0.37	0.27	0.26	0.26	0.44	0.55
CaO	53.58	53.56	53.88	53.66	51.92	54.60
Na_2O	0.07	0.11	0.06	0.06	0.11	
K_2O	0.02	0.03	0.02	0.02	0.09	
SrO	0.10	0.09	0.10	0.10	0.09	
CO_2	42.90	41.80	42.90	42.60	41.80	

THE RESOURCE

The hard, dense variety of tufa is called travertine. This is a decorative stone that became widely used for buildings in ancient times and for modern construction. The so-called "Mexican onyx" or "onyx marble" is a beautifully banded travertine found in extinct spring deposits. Other uses of tufa are as a source of calcium to improve soil for gardening and the agricultural industry, and as a souce of lime for the manufacture of concrete products.

Angel Hot Spring was staked by World Canada Co. Ltd. as the Angel 1 and 2 claims in August, 1996, to investigate the possiblity of developing a thermal spa for tourists. Subsequently the company initiated a program to expore the site using VLF EM methods and a magnetic survey to delineate a thermal conduit preparatory to drilling.

The Angel Hot Spring tufa deposit is similar to the Clinton Tufa deposit located 4 kilometres southwest of Clinton, B.C. (*see* MINFILE No. 092P 079) which is estimated to contain more than 300 000 tonnes of calcium carbonate. This was developed in 1948 and 1953 for local agricultural needs (two small quarries) and previously (1944) was burnt in an adjacent kiln to produce lime (no details available).

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MINERAL DEPOSIT MODEL ABSTRACTS

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BRITISH COLUMBIA MINERAL DEPOSIT PROFILES

British Columbia Geological Survey

The British Columbia Geological Survey (BCGS) started a mineral potential assessment project in 1992 utilizing deposit models for defining and characterizing mineral deposits which exist, or could exist, in the province. The deposit models are used to classify known deposits and occurrences, to estimate undiscovered mineral resources, and to group deposits to allow compilation of representative grade and tonnage data. Initially, the Survey relied on mineral deposit models published by the United States Geological Survey (USGS) in Bulletin 1693 and Open File report 91-11A. As the project proceeded, the BCGS updated many of these models and created others. More than 140 deposit models are relevant to British Columbia. This selection of models represents a compromise between very specific classifications with limited variation within a group and very general models which encompass a number of deposit types. The BCGS classification system includes more than 50 deposit types not addressed by the USGS, many of them for industrial minerals. There are also models for a few deposit types that are applied in the Canadian Cordillera, which are not widely accepted elsewhere.

The model descriptions, called mineral deposit profiles, are being developed by BCGS staff in cooperation with experts from the Geological Survey of Canada, industry and universities. They describe deposit types which are found, or could be found, in British Columbia. Wherever possible, they incorporate both provincial and global deposit characteristics. The profiles include information on commodities, tectonic setting, depositional environment, geological setting, age of mineralization, associated rock types, deposit form, texture and structure, mineralogy, ore controls, genetic models, exploration guides, associated deposit types, general references and economic factors. For some of the profiles, the BCGS has generated probability curves based on grade and tonnage data from the province's mineral deposits and mines.

Industry experts have classified over 9900 of British Columbia's mineral occurrences by BCGS deposit type. The most common deposits in the province are vein, porphyry and skarn deposits. This reflects the abundance of island arc volcanic terranes, but also the levels of erosion of many of these terranes mainly and the mineral industry exploration emphasis over the last century. The single most abundant deposit type is polymetallic silver-lead-zinc veins which comprise 25% of the known occurrences in the province. No other deposit type exceeds 5%; porphyry copper, alkalic porphyry, copper skarn, gold-bearing quartz veins and basaltic copper are the next most common.

The province presents numerous opportunities to pursue traditional base, precious metal, and industrial mineral targets. As a complete set of profiles is developed for the province, the potential to find less well known types of orebodies will be better defined. For example, British Columbia is prospective for basaltic copper (volcanic redbed copper), closed basin zeolite, bentonite, sparry magnesite, Broken Hill-type lead-zinc, gold skarn and opal deposits. Furthermore there are several deposit types, which occur in equivalent geological settings, that are not clearly represented by any known deposits in the province, including sediment-hosted copper, iron oxide Cu-Au breccias, carbonate-hosted disseminated Au-Ag (Carlin-type), emeralds and diamonds.

MAKING MODELS MATTER

M.A. Etheridge and R.W. Henley

The exploration business is, like all other businesses, subject to increasing accountability and the requirement for performance measurement and quality assurance. Increasingly, we are being asked by non-technical people to explain in plain language what we do, why we do it that way and how we can measure our effectiveness. Managers and investors require assurance that the exploration programs in which they have a direct interest are being carried out at least as effectively and efficiently as those of their competitors.

What do these issues have to do with the scientific process of exploration and, in particular, with the question of exploration models? Even the most "pragmatic" of explorers use geological models to justify their decisions as to exploration methodology and prospectivity, and to argue that their approach is more efficient/effective (*i.e.*, lower risk) than others.

This paper examines the ways in which we develop and use exploration models. It is particularly concerned with the following questions:

1. Are the models that we use sufficiently specific and useable to be able to support the decision-making process in a practical way?
2. Can they provide real input into the evaluation of exploration risk and the analysis of the cost versus value of information?
3. Do the models enable geoscientific information to be linked in a practical way to an exploration methodology?

In our experience, many of the deposit or exploration models that are widely used by explorers and researchers fail to meet one or more of these criteria. The principal deficiency in such models is that they do not incorporate a sufficiently detailed and precise understanding of **the critical geological processes** that were responsible for forming and localising the deposit. As a result, the models lack the essential predictive capability to become genuinely effective exploration tools. We will briefly examine some of the more widely used models for porphyry, epithermal, VHMS and sediment-hosted deposit styles to demonstrate these points.

The geological process factor that is most commonly overlooked or grossly generalized in hydrothermal deposit/exploration models is **the hydrodynamics of the ore-forming system**. We will analyse this factor in some detail to illustrate the value of being more disciplined in the development and application of models.

We will demonstrate that the hydrodynamics of most ore-forming systems are largely controlled by fault/shear systems that were active at the time of mineralization. We will also show that certain structures or parts of structures are likely to be more effective in localising fluid flow. These relationships between deposits and key segments of active structures require that models are specific in both **spatial** and **temporal** terms with respect to the potential localising structure(s). However, few deposit models include such information, and few exploration programs appear to include acquisition of such information as a priority. For example, the critical process in forming a porphyry Cu deposit may well be the dilatant deformation that gives rise to the stock work vein system rather than the petrogenesis of the intrusive host rock or even the associated alteration. Yet how may porphyry models incorporate any explicit structural information?

How then do we "make models matter"? We recommend that deposit/exploration models be developed, applied and continuously revised according to the following principles:

1. The models should be based on a thorough understanding of the dominant geological processes involved in the formation of the deposit type being sought. The emphasis should be on process rather then just product. It is particularly important for hydrothermal deposits that the hydrodynamic and therefore structural controls are carefully specified.
2. The exploration team should develop/refine and 'own' the model(s) relevant to its needs and to the particular geological setting of the exploration area. Generic models taken 'off-the-shelf' are rarely suitable.
3. The models should be linked to the whole process of exploration, including the acquisition and assessment of information, a clear decision-making strategy, the development and implementation of risk-management procedures, and the formulation and budgeting of the exploration program. However, technical decision making should be kept separate from commercial decision making.
4. Models must be translated into map form that is relatable to the geology of the exploration area. Integrated geological, geophysical and geochemical databases can then be compared to the model maps to produce probability maps, enabling exploration dollars to be focused on the areas with the lowest technical risk.
5. Realistic geological process models for most deposit types are complex. They usually incorporate several physical and chemical processes with complex interdependencies. They should therefore incorporate at least

some of the 'fuzzy' logic associated with chaotic processes.

In other words, we need to develop, apply and continuously revise our exploration models within the business framework, and not just see them as intellectual or 'academic' exercise that is somehow divorced from the 'real business' of exploration. We should be able to measure the effectiveness and efficiency of exploration programs against the models, and make sensible business decisions on the basis.

THE CHARACTERISTICS OF GOLD SKARNS

G.E. Ray
B.C. Geological Survey

Gold skarns are defined as skarn deposits in which gold is the primary or dominant economic metal present. The following features should be noted about these deposits:

1. They occur worldwide along destructive plate margins and tend to have a spatial and temporal association with Cu porphyry provinces.
2. They are associated with subduction and arc-related plutonic rocks of largely gabbro-diorite-granodiorite composition. These intrusives tend to be undifferentiated, being relatively depleted in LIL-elements such as Rb, Ce, Nb, and La, and enriched in Cr, Sc, Sr and V.
3. They are mostly developed in calcic skarn with exoskarn envelopes dominated by Ca-silicate assemblages (clinopyroxene and garnet). Magnesian Au skarns (with Mg-silicates such as olivine and serpentine) are very rare; one example however, is the Butte Highlands deposit (Montana).
4. The gold in Au skarns is commonly micron-sized; thus, the ore is visually indistinguishable from waste. It may be associated with Bi-tellurides and arsenopyrite, and in some deposits there is an enrichment in Co.
5. Depending on the mineralogy and garnet-pyroxene chemistry of the prograde exoskarn and ore, Au skarns can be separated into reduced and oxidized types.
6. Reduced Au skarns are marked by low garnet/pyroxene and pyrite/pyrrhotite ratios and the presence of hedenbergitic pyroxene and Fe-rich biotite. The intrusives have low Fe_2O_3/FeO ratios and the ore bodies are developed distal to the pluton, in the outer parts of the pyroxene-rich exoskarn envelopes. Examples include Nickel Plate (B.C.), Fortitude (Nevada) and Buckhorn Mountain (Washington State).
7. Oxidized Au skarns are characterized by high garnet/pyroxene and pyrite/pyrrhotite ratios, and by the presence of diopsidic pyroxene, pyrite, magnetite and hematite. Ore bodies tend to form more proximal to the intrusions than those in the reduced Au skarns. Examples include Nambija (Ecuador) and McCoy (Nevada).
8. Compared to the ore in Cu, Fe, Mo, W, Pb-Zn and Sn skarns, ore in most reduced and oxidized Au skarns has distinctly low metal ratios (Cu/Au <2000; Cu/Ag <1000; Zn/Au <100, Ag/Au <1).
9. There is no correlation between Cu and Au in many Au skarns (unlike in Fe and some Cu skarns where a good correlation exists between these metals). Thus, the gold potential of a skarn can be easily overlooked if copper sulphide-rich outcrops are preferentially sampled and other sulphide-bearing or sulphide-lean assemblages ignored.
10. In some Au skarns (*e.g.* the Nickel Plate and Fortitude deposits) there is a metal and mineralogical zoning throughout the exoskarn envelope. This zoning consists of proximal garnet-dominant skarn with high Cu/Au ratios and distal pyroxene-dominant skarn with low Cu/Au ratios and the gold ore bodies.

Although most Au skarns have some or most of the above characteristics, individual deposits can have unique features, and it is likely that new types or varieties of Au skarns will be discovered. In exploration, any skarn of any class should be routinely and systematically assayed for gold. Essentially, any calcareous or carbonate rock package intruded by an arc pluton has a potential for hosting Au skarn deposits, although such favorable packages are generally small and relatively rare in typical island arc or back-arc environments. However, primary target areas would include (a) reef aprons, which often flanked the original island volcanoes (b) carbonate facies formed along the margins of the back-arc basins, and (c) thrust slices of allochthonous platformal carbonates which were subsequently intruded by arc magmatism.

END MEMBERS OF THE DEPOSIT SPECTRUM ON THE CARLIN TREND: EXAMPLES FROM RECENT DISCOVERIES

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Newmont Exploration Limited

The Carlin trend is a 60 kilometer-long line of sedimentary-rock-hosted gold deposits located in the Great Basin physiographic province of the western United States. Production of gold from the Carlin trend totals 750 tonnes (24 million troy ounces), and reserves and resources stand at approximately 3100 tonnes (100 million troy ounces). In recent years, resource additions have come largely from the discovery of high-grade (+6 grams per tonne), carbonate-rock-hosted, refractory deposits at depths in excess of 400 metres. These deposits, and their oxidized equivalents, span a spectrum of models between stratigraphically-controlled and structurally-controlled end members. Two recent refractory gold discoveries, the Hardie Footwall and Deep Star deposits, exemplify the end members of the deposit spectrum on the Carlin trend.

The Hardie Footwall deposit lies immediately north of the Carlin mine and represents a downdip, refractory extension of the original Carlin oxide-gold deposit. It was discovered in 1993 as a result of detailed stratigraphic and structural studies of exposures in the Carlin East pit and relogging of a limited number of deep drill holes north of the Carlin mine. At a cut-off of 6 grams/tonne, the deposit contains a drill-indicated, geologic resource of 1 315 000 tonnes at an average grade of 16 grams per tonne gold. In plan, the deposit is 500 metres long and 100 to 250 metres wide. In section, ore zones are from 6 to 25 metres thick and confined to dolomitic, silty limestone and lesser calc-arenite in the upper 100 metres of the Silurian-Devonian Roberts Mountains Formation. Alteration is stratiform in nature and consists of widespread decalcification, or removal of calcite, within the upper 100 metres of the Roberts Mountains Formation and lower 20 metres of micrite of the Devonian Popovich formation. The gradational contact between these two units is marked by carbon flooding at the top of the alteration zone. Silicification is restricted to replacement of rare calc-arenite and debris-flow limestone beds and high-angle fault zones within the deposit. Decarbonatization, or the complete removal of all carbonate mineral species, is typically developed below the gold zones near major bounding structures. Highest gold grades are associated with decalcified and dolomitic rock, less-commonly with silicified structures and rarely with decarbonatized zones. High-angle, normal faults form sharp boundaries to the deposit and locally control high-gold grades within the larger stratiform mineral system. Veining and brecciation are absent from the deposit, and high-grade zones are visually indistinguishable from surrounding waste rock. Sulfide, largely in the form of arsenical pyrite, and organic carbon contents average 1% and 0.5 to 1%, respectively. Narrow dikes of andesitic to latitic composition occupy several structural orientations and, like the faults, either bound or locally upgrade gold zones. Intrusive rocks, however, constitute less than 0.5% of the Carlin and Hardie Footwall deposits.

At the other end of the deposit spectrum are a series of very high-grade breccia bodies located in proximity to the Goldstrike intrusion on the northern end of the Carlin trend. Individual deposits include Deep Star, Deep Post and Purple Vein (Barrick Gold Corporation's Meikle mine). Deep Star, which is undergoing underground development via twin decline access from the Genesis open pit, has a drill-indicated, geologic resource of 797 000 tonnes at a grade of 32 grams per tonne gold. The deposit is located between steeply-dipping strands of the Genesis fault zone at depths of 350 to 500 metres and, in plan, measures only 75 by 100 metres. It consists of quartz-dolomite-kaolinite-sulfide breccia developed in marble, calcsilicate rocks and exoskarn between lobes of propylitized diorite of the Goldstrike intrusion. Ore zones are characterized by quartz-dolomite-clay alteration and sulfide contents up to 18 wt %. Sulfide species are limited to gold-bearing arsenical pyrite, marcasite and minor amounts of arsenopyrite. Carbon, in the form of graphite, is present in minor amounts. Breccia masses are largely matrix-supported and monolithic in character and are interpreted to be products of dissolution and replacement of marble, calcsilicate rocks and skarn. Penetrative shear fabric and milling of fragments highlight a structural overprinting in much of the deposit. The hangingwall of the deposit, although barren of gold, displays elevated pyrite, dolomite and siderite contents in calcsilicate rocks and quartz hornfels.

Exploration discoveries on the Carlin trend continue to record variations in the original "Carlin-type" model for sediment-hosted deposits in northern Nevada. The contrasting features of newly-discovered refractory deposits are, in large part, a function of geometry and lithology of carbonate stratigraphy, diverse structural settings and the relative abundance and type of intrusive rocks.

CARLIN-TYPE GOLD DEPOSITS: CANADIAN POTENTIAL?

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The Carlin-type deposits of Central Nevada occur mainly in finely laminated silty dolomite or carbonate-bearing siltstone and represent a cumulative gold resource estimated at 2300 tonnes. Geological and genetic models for Carlin-type deposits continue to evolve, in part because many deposits of this type in the Great Basin are intensely oxidized so that many of the primary features of hypogene ores are obscured. This oxidation also has rendered the Nevada deposits amenable to bulk tonnage mining and heap-leach processing, an economic artifact that has led to the mistaken impression that all deposits in this class are of large tonnage and low grade. New deep discoveries of hypogene ore, however, are of moderate tonnage, high grade and amenable to underground mining. Geological models that emphasize the hypogene aspects of these deposits (Table 1) will be most relevant to Canadian exploration.

The early genetic interpretation of Carlin-type deposits in the Great Basin was one of epithermal origin and of Miocene age related to basin-and-range extension: this interpretation has been largely refuted on geological grounds. There are however two prominent current views on the origin of these deposits, one intrusion-related and the other a deep-crustal fluid-fault model: the first allows for both Mesozoic and Tertiary deposits, the second demands a sole Oligocene age.

The following points of geological comparison can be made between favourable geological settings in Nevada and those with Canadian potential for Carlin-type deposits:

1) Most deposits of this type in Nevada occur in an area between the Golconda and Roberts Mt. Thrusts but mainly in footwall strata: The Paleozoic stratigraphy of the Roberts Mountains Allochthon is correlative with that of the Kootenay arc and Selwyn Basin in Canada and that of the Golconda allochthon is correlative with Slide Mountain rocks.

2) Remnants of terranes (*i.e.*, Northern Sierra, Grindstone, Olds Ferry) preserving evidence of Late Devonian-Early Mississipian continental arc magmatism, analogous to Yukon-Tanana terrane, occur outboard of the Carlin gold belt.

3) The Carlin deposits straddle, or mainly occur to the east of the .706 "initial Sr line". This line, which approximately marks the western limit of subsurface continental crust in North America, extends into Canada and follows the western margin of the Omineca Belt.

4) Apart from Au, there are important metallogenic similarities between the Nevada gold belt and equivalent Canadian segments of the Mesozoic continental margin:
   a) the gold belt is coextensive with the "Nevada Ba belt" Sedex deposits which have comparable analogs in Selwyn Basin;
   b) the gold belt overlaps with, but occurs mainly east of a significant Mesozoic W+/-Mo skarn belt; comparable to Kootenay, Cantung, MacTung *etc.*;
   c) there is a weak correlation between the Carlin and Cortez gold belts and the occurrence of vein- and manto-type Cretaceous/ Early Tertiary Ag-Pb-Zn mineralization comparable to that in East Kootenay, Cassiar, Keno Hill.

TABLE 1: CHARACTERISTICS OF CARLIN-TYPE SEDIMENT-HOSTED MICRON GOLD DEPOSITS

TYPE EXAMPLE: Carlin, Nevada

OTHER EXAMPLES: Global- Mercur Utah, Golden Reward, S.D., Guizhou, China Canadian: Golden Bear, B.C. (?); Brewery Creek, YT (in part ?)

DIAGNOSTIC FEATURES:

- stratabound low-sulphide replacement of carbonate rocks
-micron sized Au with As, Sb, Hg but negligible to low base metals
-structurally and stratigraphically controlled zones of silicification and brecciation
- commonly near hornfels, skarn or calcsilicate rocks but outward of contact aureoles

SIZE AND GRADE:

-up to 500 tonnes Au; commonly 1 to 10 million tonnes ore grading 1 to 20 g/t Au

OREBODIES:

- irregular discordant breccia bodies and concordant stratabound disseminated zones confined to particular stratigraphic members; controlled by normal faults

GEOLOGICAL SETTING:

- in carbonate and impure carbonate-argillite facies of continental platforms and shelves that have been overprinted by regional thrusting, extension faulting, felsic plutonism and zones of contact metamorphism

HOST ROCKS:

- mostly in impure sedimentary carbonate rocks but also rarely in granitoid rocks, clastic sedimentary rocks and greenstones

ORE AND GANGUE MINERALS:

- pyrite with overgrown arsenian pyrite rims containing gold inclusions; orpiment, realgar, cinnabar and stibnite common accessories at deposit scale

METAL SIGNATURE

- Ag:Au highly variable but typically less than 1
- locally high concentrations of As, Sb, Hg

HYDROTHERMAL ALTERATION:

- decalcification and silicification (jasperoid) of carbonate rocks most commonly associated with ore but may be enveloped by zones of argillic and sericitic alteration
- Nevada deposits deeply oxidized to produce supergene zones favourable for bulk mining and heap-leach processing.

SEDIMENT-HOSTED STRATIFORM COPPER DEPOSITS: AN OVERVIEW

R.V. Kirkham
Geological Survey of Canada

Sediment-hosted stratiform copper (SSC) or "diagenetic sedimentary" copper deposits are a large, diverse class of deposits that include some of the richest and largest copper deposits in the world. They are also important sources of silver and from the central Africa Copperbelt of Zambia and Zaire are the world's most important source of cobalt.

Analysis of many deposits and districts indicates that most SSC deposits formed during diagenesis in sediments deposited in low-latitude arid and semi-arid areas. A variety of processes were involved in different districts but metals were characteristically deposited at redox boundaries where oxic, evaporite-derived brines containing metals extracted from redbed aquifers encountered reducing conditions. The reducing environments were fundamentally of two types: 1) those with stratigraphically-controlled fixed reductants (Kupferschiefer and some redbed-type deposits), and 2) those with mobile reductants, such as H_2S-bearing waters and hydrocarbons (Dzhezkazgan-type). Outward and upward away from the oxidized zone is the complete or partial sequence of minerals: hematite, native copper, chalcocite, bornite, chalcopyrite, galena, sphalerite and pyrite. Recent studies also support the concept that similar ore-forming processes continue into higher temperature metamorphic environments and were aided by regional tectonic processes.

Models can be constructed for several districts based on an appreciation of the above features and basinal fluid-flow characteristics. For the Kupferschiefer, many major deposits in the central African Copperbelt, White Pine in Michigan and several other deposits and occurrences, metalliferous brines in underlying redbeds, possibly mobilized as a result of basinal compaction, were forced upward and outward into overlying anoxic sediments in which the metals were precipitated. In many redbed or continental environments the oxic cupriferous brines migrated through arenaceous aquifers where metals were deposited in roll-front-type redox reaction zones between oxidized and originally reduced sediments with wood trash and early diagenetic pyrite. In the Dzhezkazgan area in Kazakhstan and possibly the Revett Formation of the Belt Supergroup in western Montana and Idaho, oxic metalliferous brines in arenaceous aquifers in redbed sequences migrated up dip until they encountered mobile reductants, derived from underlying anoxic formations, that were trapped in closed regional anticlines or actively migrating up fault systems. Metal precipitation occurred at stratigraphically crosscutting regional redox boundaries. In the Graviisk area of Russia possibly both fixed and mobile reductants controlled metal precipitation. In other areas, such as the Lisbon Valley, Utah, evidence indicates that heated cupriferous brines derived from redbed aquifers, migrated up fault zones until they encountered reducing environments where the metals were precipitated. Possibly in the central African Copperbelt ore fluid flow was controlled by large-scale, gravity-driven systems created by orogenic activity and uplift in the Zambezi and/or Damaran belt to the south and west. Evaluation of many areas thus indicates several important variations on a theme for the formation of SSC deposits where oxic brines derived from evaporites migrated though and extracted metals from, redbed aquifers at different times and precipitated them at redox boundaries of diverse nature.

SSC occurrences are known in meso- and neo-Proterozoic sequences in the Rocky and Mackenzie mountains in the eastern Canadian Cordillera (*e.g.* Grinnell Formation and Redstone River area). Possible SCC and volcanic redbed copper (VRC) occurrences, the analogues of SSC deposits in volcanic sequences, are widely distributed in Triassic and Lower Jurassic sequences in the western Cordillera. Although in many localities they are offset by numerous faults, these occurrences offer significant exploration potential in British Columbia and Yukon Territory.

SEDEX Pb-Zn DEPOSITS: CREATING A FRAMEWORK FOR UNDERSTANDING AND USING HYDROTHERMAL ALTERATION AS AN EXPLORATION GUIDE

Robert Turner
Geological Survey of Canada

Careful scrutiny over the last 20 years of hydrothermal alteration associated with volcanogenic massive sulphide (VMS) deposits has led to exploration models based on the geochemical and mineralogic zoning around VMS deposits. Such models have not been forthcoming for sedimentary exhalative (SEDEX) deposits in spite of striking similarities between the deposit types. The reason for this is at least two fold: an undeserved reputation that SEDEX deposits lack associated alteration, or if present the alteration is subtle and not extensive, and a variety of alteration types that prevent formulation of a single model for alteration zoning. The purpose of this talk is to rationalize the diversity of alteration types and identify the geologic settings in which SEDEX alteration is most likely to be a useful exploration guide. To do this we consider the role that host sediment composition and tectonic setting have on controlling the nature of SEDEX alteration and modern analogue hydrothermal systems.

Strata hosting stratiform deposits can be divided into three imprint types: siliceous, calcareous and feldspathic. Siliceous rocks include siliceous shale, chert and quartz-chart-rich sandstone and siltstone that are dominated by a quartz-clay mineralogy (*e.g.* Earn Group, Selwyn Basin; Gunsteel Fm, Kechika Trough). Calcareous strata such as dolomitic or calcareous siltstone and limestone and are a carbonate-quartz-clay assemblage (*e.g.* Road River Fm, Selwyn Basin; Mt. Isa Group and Barney Creek Fm., Australia). Feldspathic strata include feldspathic sandstone and siltstone and are composed of feldspar-quartz-clay assemblage (e.g. Aldridge Fm., B.C.; Broken Hill Group; Australia; Vangorda Fm., Yukon; Salton Sea, California; Middle Valley, NE Pacific).

Hydrothermal alteration associated with stratiform deposits differs according to host rock type. Deposits in siliceous rocks tend to have poorly developed alteration zones; where present silicification is dominant, ferroan carbonate alteration can be important (*e.g.* Tom-Jason, Yukon; Cirque and Driftpile, B.C.). Calcareous sediment-hosted deposits tend to have more extensive alteration that includes silicification, dolomite or ferroan carbonate alteration (*e.g.* Sheep Creek, Montana; Mt. Isa and Century, Australia; Jason End, Yukon). Feldspathic sediment-hosted deposits display the best developed alteration zones and most diverse alteration assemblages. These include potassic (muscovite, k-spar), tourmalinite, chloritic and albitic assemblages (*e.g.* Sullivan, B.C.; Broken Hill and Cannington, Australia; Zincgruven, Sweden; Anvil, Yukon). These alteration assemblages are similar to alteration associated with feldspathic sediment-hosted Besshi deposits (*e.g.* Ducktown, USA) and modem sedimented rift-hosted deposits (*e.g.* Middle Valley).

It is worth considering how variation in sediment composition could be understood in light of the tectonic setting of the basin. Stratiform deposits are associated with continental rift basins. Continental rift basins evolve from an early syn-rift phase (mechanical subsidence) involving faulting, lithospheric thinning, high heat flow and magmatism, to a rift-sag phase (thermal subsidence) continental platform environment. Syn-rift basins are characterized by feldspathic sediments: locally sourced basement-derived arkoses during early rift stages (*e.g.* Salton Sea, California) or feldspathic turbidites derived from continental-scale drainages during later continental margin formation. However, rift-sag basins are characterized by more mature (*i.e.*, quartzose) recycled siliciclastic sediment as well as platformal carbonate and their off shelf calcareous shale equivalents.

Stratiform deposits are associated with both the syn-rift phase and extensional reactivation during rift sag phase. Syn-rift stratiform deposits occur in feldspathic clastic rocks associated with high heat flow and magmatism (*e.g.* Sullivan, Broken Hill, Cannington, Aggenays-Gamsberg). Such deposits commonly display diverse and extensive alteration types because of their feldspathic host but also possibly due to higher temperature hydrothermal fluids. Using somewhat different criteria, syn-rift deposits are described as Broken Hill type by Parr and Plimer (1995). Syn-rift deposits are transitional to Besshi type deposits which share similar stratal composition and alteration mineralogy. Rift-sag stratiform deposits typically occur in siliceous or calcareous strata and are associated with lower heat flow extensional basins (*e.g.* Mt. Isa, Hilton, Century, McArthur River, Tom-Jason, Cirque, Rammelsberg, Meggen). Extent and nature of alteration is dependent on whether it is a siliceous or calcareous host.

GENESIS OF CARBONACEOUS SHALE-HOSTED Ni-Mo-PGE DEPOSITS

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Nickel-Mo-PGE sulphide deposits are hosted typically by carbonaceous shale and chert within sedimentary basins. The age of these deposits is highly variable and ranges from Cambrian to Cretaceous. The two most important examples occur in Middle Devonian and earliest Cambrian basinal facies of the Yukon, Canada, and southern China, respectively. The deposits are typically thin (cm) but extend over distances greater than 1000 km. The thickness, stratigraphy, sedimentology, mineralogy and bulk and isotope compositions are also remarkably uniform laterally. The Yukon deposits are underlain by a 3m-thick unit that consists of carbonate concretions up to one metre in diameter. The Chinese deposits are underlain by a black phosphorite up to 34 cm thick. The sulphides display sedimentary textures that appear to have been disrupted by dewatering of organic-rich sediments during compaction. The sulphide assemblage is variable between deposits of different ages but remarkably uniform between deposits of the same age. The sulphides consist of combinations of pyrite, marcasite, vaesite, gersdorffite, millerite, sphalerite, wurtzite, molybdenite, chalcopyrite, and tennantite. Microframboidal to euhedral pyrite grains occur disseminated throughout the organic-rich host rock or are clustered along bedding planes. Most of the other sulphides are finely intergrown with pyrite or form secondary veinlets.

Maximum metal values are as follows: Yukon - Ni (7.0%), Cu (660 ppm), Zn (2.3%), Mo (0.33%), V (2400 ppm), Cr (280 ppm), Ga (27 ppm), Tl (390 ppm), Ag (8 ppm), Pt (511 ppb), Pd (202 ppb), Ru (12 ppb) and Ir (10.9 ppb); China - Ni (2.3%), Cu (0.38%), Zn (0.36%), Mo (4.4%), V (3900 ppm), Cr (2500 ppm), Ga (23 ppm), Tl (290 ppm), Ag (35 ppm), Pt (391 ppb), Pd (87 ppb), Ru (8.4 ppb) and Ir (2.9 ppb). Ru/Ir ratios are chondritic. ^{34}S values for sulphides in both Yukon and China sections show a sharp decrease at the Ni-PGE horizon. ^{13}C values for carbonates in China also decrease sharply at this time, consistent with a major biomass drop. The thickness uniformity and lateral extent of the mineralization, the absence of a hydrothermal vent complex and associated alteration, and the difficulty of transporting relatively immobile elements such as Ir and Ru by hydrothermal fluids argues against an origin by seafloor hydrothermal or other endogenic processes (*e.g.*, anoxic ocean turnover). However, these attributes, combined with chondritic Ru/Ir ratios and the association of this mineralization with mass extinction boundaries, are consistent with the formation of this unusual mineral assemblage by the raining of Ni-PGE-rich quenched droplets to the seafloor of an anoxic ocean following the volatilization of a major chondritic meteorite and the lofting of this material into the stratosphere after impact with the earth's surface. The association of Ni-PGE mineralization with high organic matter contents (7.3 and 17.1% maximum in the Yukon and China, respectively) and related carbonate concretions probably reflects higher rates of organic matter sedimentation following the mass extinction event. The unusual occurrence of Ni-sulphides as sedimentary minerals most likely reflects the limiting effect of H_2S on the buildup of dissolved iron in the ambient reduced water column and the seeding of this column with metals (Ni, Mo, Fe, Zn, Pb, Ag, Ga, Tl, *etc.*) of meteoritic and crustal origin following meteoritic impact. Only then could Ni_2^+ compete with Fe_2^+ for reduced sulphur under seafloor sedimentary conditions and form sedimentary Ni-sulphides. Although the carrier phases for PGEs have not been identified, they probably occur with other meteoritic components (*e.g.*, Cr, Fe, V) in microtektites that have been highly altered.

IRISH STYLE CARBONATE HOSTED LEAD - ZINC DEPOSITS

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How do we classify these deposits? Are they unique to Ireland or can we find them in other localities such as British Columbia or the Yukon? Are they syngenetic, epigenetic or diagenetic? Are they similar to MVT, sedex or in a class of their own? These are some of the questions that we need to answer so that we can define the deposits. We need to understand them so that wi can be more effective in our exploration for them.

People have spent years looking at these deposits, but the recent discoveries, Galmoy and Lisheen have helped to provide some excitement and encouraged the geological community to revisit the models for these deposits. This will review some of the recent published data which provides some insights into the deposits. Certain characteristics that will be useful for exploration will be emphasized. In particular (1) Tectonic setting; (2) Geology; (3) Structural setting; (4) Morphology; (5) Metal ratios; (6) Isotopes; and (7) Fluid inclusions will be discussed.

The characteristics considered important are:

1) Active tectonics during sedimentation and some of the mineralization,
2) Deposits are hosted by Carboniferous carbonates, basal section of the Waulsortian mud mound complex and Navan beds,
3) Strong structural control seen in the deposits,
4) Mineralization is stratabound with some local sections which cross cut,
5) Mineralization textures are generally replacive and brecciated but locally banding is evident,
6) Iron andmMagnesium carbonates seen in and around the mineralization,
7) Zinc,lead, iron,copper and silver are known in the deposits and have some zoning laterally and vertically,
8) Isotopes point to two fluids being involved in the process, one hydrothermal and the other Carboniferous sea water,
9) Fluid inclusions indicate that the temperature ranges from 100°C to 300°C.

Some of these characteristics are similar to MVT deposits and some are similar to sedex deposits. It is these differences and similarities that have caused a lot of discussion over the genesis of these deposits.

My own bias is that the deposits formed primarily below the sea floor and are therefore diagenetic to epigenetic in origin. There is some evidence for an early portion of the mineralization to have formed on the sea floor, but the bulk of the mineralization is later. The alteration occurring with the mineralization has also been documented above the mineralized horizons.

In comparing characteristics of sedex and MVT deposits to Irish deposits we can see that they have some common characteristics to both deposit types. The Irish deposits probably represent a deposit type that is in between the two end members. In evaluating the deposits in detail we can see that there are numerous differences within the Irish style deposits.

The Cordillera does have the environment to host these types of deposits, although they may not look exactly like the Irish deposits.

PRAIRIE-TYPE SEDIMENTARY Au-Ag-Cu

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The discovery of microdisseminated Au-Ag-Cu and related mineralization in basement and sedimentary rocks of the Western Canada Sedimentary Basin (WCSB) at Fort MacKay, northeastern Alberta, has led to the recognition of a new and potentially important occurrence of low temperature sedimentary mineralization. Prairie-type mineralization consists of native and intergrown or alloyed Au-Ag-Cu and related metals and associated alteration including fe-oxide, -chloride, -carbonate, native S, and pyrite. Mineralization and alteration are inferred to be related to metal transport in oxygenated brines originating in halite evaporites of the Prairie Formation, Elk Point Group. Downward, density driven flow of these brines into red bed-evaporite sequences and fractured Precambrian basement, followed by up-dip migration and eventual discharge at the eastern margin of the basin provides the mechanism for mobilization and transport of metals. Microbially mediated redox reactions involving coupled oxidation of organic material and hydrocarbons and reduction of sulphate has produced widespread occurrences of native sulphur and may have localized deposition of Au and other metals by controlling redox conditions.

Fort MacKay is located in the Athabasca River valley near the eastern margin of the WCSB and is perhaps best known for the nearby Athabasca tar sands mining operations. Basement rocks in northeastern Alberta range from Archean to Paleoproterozoic in age and are predominantly highly metamorphosed granitoid gneisses. They are unconformably overlain by a Paleozoic passive margin sequence comprising Middle Devonian Elk Point Group regolith, red bed-evaporites, dolostone, and shale, and Late Devonian Beaverhill Lake Group massive to argillaceous limestone with minor evaporites. The passive margin sequence is unconformably overlain by Early Cretaceous siliciclastics of the Mannville Group, part of a Middle Jurassic to Tertiary foreland basin succession, which host to the tar sands deposits. Reconstructed burial depths and estimated paleogeothermal gradients indicate that temperatures attained during maximum Laramide age burial did not exceed 90°C in this part of northeastern Alberta. Structure is relatively simple, although the combined effects of uplift on the Peace River-Athabasca Arch in the late Paleozoic, collapse due to salt dissolution in the Prairie Formation, and karsting related to exposure at the sub-Cretaceous unconformity, have produced a network of small scale horst and graben structures and a number of northerly trending normal faults with west-side-down displacement. The Athabasca river valley is the discharge point for three distinct aquifer systems: the Cretaceous-Quaternary (TDS g/l) aquifer which is recharged by meteoric waters in highland areas, an upper Devonian (TDS 2 g/l) aquifer, and a lower, sub-salt Devonian (TDS 200 g/l) aquifer.

Prairie-type mineralization has been observed from basement to Cretaceous age rocks at Fort MacKay, although the most abundant Au and related mineralization occurs in argillaceous limestones of the Late Devonian Waterways Formation. Here Au occurs in association with Ag, Cu, Zn, Pb, Cd, Fe, Cr, Ni, Sb, Bi, Cl, Ca, Al, and Si. Gold is next most abundant in basement rocks where it is associated with Ag, Cu, Pb, Sb, Sn, W, and Cl. Other workers have shown that transport of copper and Au-PGE mineralization is possible in saline brines at oxidation potentials set by equilibra-

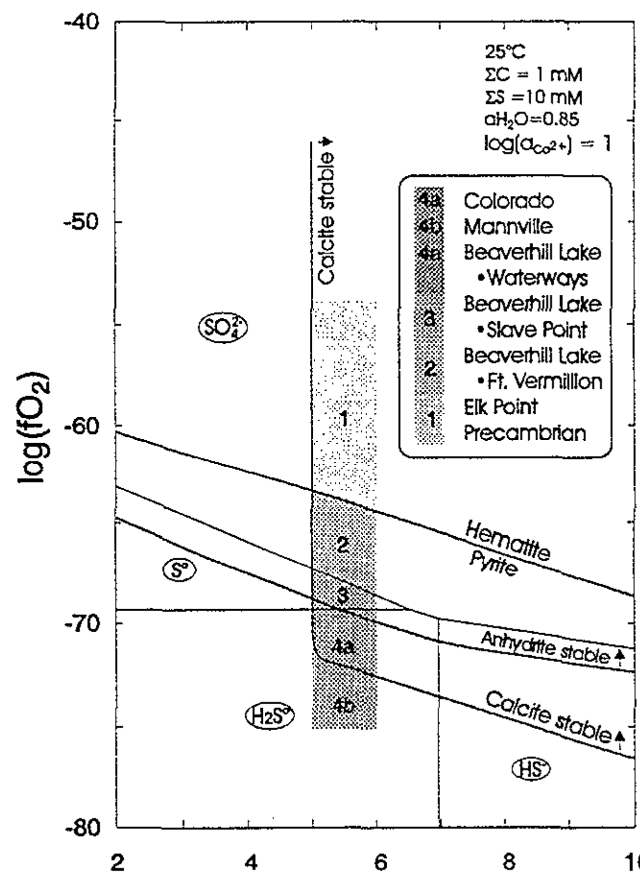

Figure 1. pH vs logarithm of oxygen fugacity for northeastern Alberta. Shading indicates the relation between pH-redox and stratigraphy.

tion of the brine with hematite-anhydrite. The presence of native copper in silty carbonates of the Waterways Formation in the Fort MacKay region is indicative of oxidation potentials exceeding the minimum oxidation potential set by equilibrium with hematite-anhydrite, further enhancing the capability of these brines to scavenge and transport Cu and Au-PGE metals.

Alteration is complex and reflects variable redox states. Native sulphur has been observed at a number of stratigraphic levels where it marks the boundary between relatively oxidized and reduced environments. The origin of native sulphur is under investigation, but similar occurrences elsewhere have been linked to reactions between microbially produced $H_2S_{(g)}$ and sulphate-bearing formation waters in the presence of liquid hydrocarbons or immature organic material. Native sulphur occurs regionally at the base of the Beaverhill Lake Group at the interface between reduced, pyrite-bitumen bearing limestones of the Waterways Formation and oxidized, hematite-anhydrite red bed-evaporites of the Elk Point Group. Native sulphur also is visible in fractures cutting organic-rich laminites which occur near the base of the Winnipegosis Formation, Elk Point Group, and has been observed microscopically in basement rocks. Figure 1 shows the redox distribution of iron and sulphur species in the system Fe-C-O-H-S and the relationship between redox and stratigraphic position. Further studies of the relations between mineralization, alteration type (redox state), hydrocarbons, and organic matter are underway.

THE DUBLIN GULCH INTRUSIVE-HOSTED GOLD DEPOSIT

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The Dublin Gulch Project is an advanced exploration project on an intrusive-hosted gold deposit located near Mayo, Yukon Territory, Canada. The project is 100% owned by First Dynasty Mines Ltd., a Yukon incorporated, Denver based, resource development company. The company is currently completing a pre-feasibility and Initial Environmental Evaluation (IEE) on the property.

The project area is underlain by Late Proterozoic to Early Cambrian Hyland Group clastic rocks of the Selwyn Basin. These rocks have been deformed by Early Cretaceous thrusting and later regional scale gentle folding. Subsequent to this deformation, the clastic rocks were intruded by Cretaceous Tombstone Suite intrusions.

Alteration and mineralization on the property are related to the Dublin Gulch Stock, a granodiorite intrusive dated at 92.8±0.5 ma. Country rocks have been hornfelsed, and skarns occur locally. A pervasive fabric related to the Cretaceous thrusting event is still visible, but is no longer a plane of weakness. Mineralization associated with the Dublin Gulch Stock includes:

- Sheeted, low-sulphide quartz veins within the intrusion, containing gold and bismuth ('Fort Knox' style of mineralization) along the north side of the intrusion.
- Pyroxene-scheelite skarn zones, notably the Mar Tungsten Deposit on the southeast side of the stock, which contains an estimated resource of 5.4 million tonnes grading 0.82% WO_3.
- Structurally controlled, auriferous quartz-arsenopyrite veins within both the intrusion and surrounding sediments, especially proximal to the northern contact.
- Cassiterite in a tourmalized breccia zone on 'Tin Dome', situated north of Dublin Gulch.
- High Silver quartz-sulphide veins (*e.g.*, Peso Silver and Rex) found distal to, but on trend with, the stock.

The potential of the Dublin Gulch Stock to host an intrusive-hosted, bulk mineable, deposit was first tested in 1991. Four mineralized zones were identified: the Eagle, Olive, Shamrock, and Steiner zones. In 1993, an inferred plus potential resource of 98.6 million tonnes grading 1.19 g/T Au (0.035 opt) was calculated solely based on the Eagle zone. All 1995 work was focused on this zone.

In the Eagle Zone, alteration and mineralization changed character as the magma cooled. A transition from magmatic fluids in equilibrium with the host stock; to hydrothermal fluids, no longer in equilibrium, resulted in increased alteration. A corresponding shift from feldspar-dominant to sericite-dominant alteration, an increase in sulphide mineralization, and a decrease in gold deposition, is observed.

Earliest mineralization ranges from fracture fill and wallrock impregnations consisting of kspar ±quartz ±albite to veins containing quartz ±kspar with very weak alteration or narrow feldspar ±sericite selvages. These stages are characterized by gold-bismuth deposition, low sulphide mineralization, and the absence of wallrock fabric.

Earlier veins grade into veins possessing distinct sericite selvages, lower Au+Bi precipitation, and more abundant but still low sulphide content (arsenopyrite, pyrite-pyrrhotite). Narrow zones of deformation occur along selvages.

Late veins have wide zones of sericite alteration, very little gold, and contain up to 1% sulphide in the wallrock. Brittle deformation and narrow cataclasite zones are commonly associated. Clay in the deposit is probably due to weathering, especially along structures, and not due to hydrothermal fluids.

Gold occurs as native gold liberated in gangue or associated with bismuth minerals. Grains are relatively large, with an average size of 120-150 microns. Lesser amounts of gold appear encapsulated in arsenopyrite. Individual veins grade in the range of 10-30 g/T (0.29-0.87 opt) Au, however sample intervals of 1.5m (5 feet), encompassing both the vein and granodiorite host material, typically grade between 0.8 to 2.0 g/T (0.023-0.058 opt) in the ore zone. Silver values are generally lower than gold values.

First Dynasty Mines Ltd. spent $US 3.2 million on the Dublin Gulch Project in 1995. Work included 14 000m (46 000 ft) of reverse circulation and diamond drilling. The goal was to delineate 30-40 million tonnes of mineable reserve centered within the larger Eagle Zone 'inferred and potential resource' at a similar or higher grade. In conjunction, engineering, economic, environmental, and social aspects of the project were studied. Pre-feasibility and IEE reports are expected to be completed in January 1996. Plans include a 20 000-25 000 tonnes per day open pit mine with an approximate 1:1 ore to waste stripping ratio, coupled with a cyanide heap-leach extraction process.

In fulfilling its mission statement to undertake ethical and socially responsible resource development, First Dynasty Mines has followed the highest environmental guidelines and proactively shared the planning and concerns of the Dublin Gulch Project with the local people and communities.

So far, everything looks favorable for the continued advancement of the Dublin Gulch Project. If economics and permitting allow, First Dynasty Mines foresees the commencement of mine production in 1997.

INTRUSION-RELATED GOLD AND BASE METAL MINERALIZATION ASSOCIATED WITH THE EARLY CRETACEOUS TOMBSTONE PLUTONIC SUITE, YUKON AND EAST-CENTRAL ALASKA

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The Tombstone Plutonic Suite (TPS) is a lithologically and metallogenetically diverse suite of mid-Cretaceous (95-90 Ma) plutons that intrude miogeoclinal strata of the northern Cordillera in central Yukon and westernmost Northwest Territories. These intrusions form an east-west trending belt more than 550 km long and up to 100 km wide that stretches from the Mackenzie Mountains southeast of Macmillan Pass to the Tintina Fault in the Dawson area of western Yukon. A western continuation of the belt has been dextrally offset approximately 450 km along the Tintina Fault, and extends a further 200 km southwest from the central Circle quadrangle in east-central Alaska at least as far as the Fairbanks mining district. Three Au deposits that are directly hosted by, or are spatially closely associated with TPS intrusions are in advanced feasibility to pre-development stages (Fort Knox: ~4M oz. contained Au; Dublin Gulch, ~2M oz. contained Au, and Brewery Creek (~800K oz. contained Au). The TPS is presently being actively explored for additional economic Au and base metal deposits.

Intrusions of the TPS range from isolated dikes and sills to multiphase batholiths up to 250 km^2 in area. The TPS in Yukon displays an extended compositional range, from rare clinopyroxenite, gabbro and tinguite through more typical diorite, syenite, quartz syenite, monzonite, granodiorite and granite. TPS intrusions in Alaska appear to be more restricted in composition, consisting mainly of tonalite, granodiorite and granite. The plutons are commonly weakly porphyritic, and observed field relations and preliminary geobarometric studies indicate emplacement depths from near-surface to 5 km. Wall rocks to the TPS intrusions range in metamorphic grade from essentially unmetamorphosed to upper greenschist facies, and a pronounced contact aureole up to several hundred metres wide is developed around most intrusions. The timing of intrusion was immediately post-tectonic with respect to craton-directed thrust faults that affected the northern Cordilleran miogeocline in this area.

Mineralization spatially associated with TPS intrusions ranges from intrusion-hosted "Fort Knox-style" porphyry Au-(Bi-W-Mo) deposits (*e.g.*, Ft. Knox, Dublin Gulch, Emerald Lake, Pukelman), to intrusion and wallrock-hosted Au-bearing quartz-arsenopyrite veins and breccias (*e.g.*, Ryan Lode, Dublin Gulch), to proximal W-(Au) skarns (*e.g.*, Mar/Ray Gulch, Scheelite Dome, Rhosgobel, Tungsten Hill), to distal(?) Au and/or Sb-rich replacement/manto deposits (*e.g.*, Scrafford, Wayne). Relatively late, lower-temperature, Ag and base metal-rich veins locally both overprint the intrusion-centred systems (*e.g.*, Dublin Gulch) and occur distal to the intrusion (*e.g.*, Keno Hill, Peso, Rex, Wayne). Intrusion and country rock-hosted, possibly Carlin-like, disseminated/stockwork Au-As-Sb mineralization is also developed in several areas (*e.g.*, Brewery Creek, Neve/Brick, True North).

The TPS offers a unique opportunity to investigate the factors controlling a wide range of styles of intrusion-related mineralization. A transition from late miarolitic cavities containing Au, native Bi, bismuthinite, and a variety of Au-tellurides to sheeted, "pegmatitic", Au-bearing quartz-(K-feldspar) veins similar to those at Fort Knox is observed at the Emerald Lake occurrence, clearly demonstrating that at least some of the Au-bearing fluids responsible for mineralization associated with the TPS are of magmatic origin. Other factors, such as the specific differentiation history of the magmas, depth of emplacement, composition and metamorphic grade of country rocks, and nature and extent of structural preparation, all vary widely along the length of the Tombstone belt; and on-going research is directed at evaluating the relative importance of these factors in controlling the genesis and nature of intrusion-related mineralization.

PORPHYRY COPPER AND RELATED GOLD MINERALIZATION IN THE SULPHURETS DISTRICT OF NORTHWESTERN BRITISH COLUMBIA - IMPLICATIONS FOR INTRUSION-RELATED GOLD EXPLORATION

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The Sulphurets district, 60 km northwest of Stewart and 20 km southeast of the Eskay Creek mine, contains at least four significant Cu-Au deposits: the Kerr Cu-Au (148 million tons [MT], .76% Cu, .01 opt Au), West zone Au-Ag (.71MT, .43 opt Au, 20 opt Ag), Snowfield Au (8 MT, .08 opt Au), and Mitchell Cu-Au (geologic resource of ±200 MT, .2% Cu, .025 opt Au). This report concerns the northern portion of the district on the flanks of Mitchell Valley, the area of the Mitchell and Snowfield deposits. Host rocks, apparently correlative with the Early Jurassic Hazelton Group, include submarine hydroclastic basaltic lava flows, dioritic intrusive rocks, and volcaniclastics. Calcalkaline granitoid (commonly quartz-syenite) stocks occur at the base of the alteration system, are altered and mineralized by stage 1 (*see* below), and are believed to have driven the hydrothermal activity. Fluorite (post stage 1) is common proximal to the syenites. Ar-Ar and U-Pb dating of hydrothermal tourmaline and quartz-syenite, respectively, indicate an Early Jurassic (about 192 Ma) mineralization age. A Middle Cretaceous (110 Ma) thermal event is also recognized and is probably coincident with post-mineralization low-grade greenschist metamorphism and thrusting.

Excellent exposures and high relief have facilitated the recognition of four superimposed hydrothermal/mineralization events representing a gold-enriched porphyry-epithermal transition. From earliest to latest these are:

(1) porphyry-style Cu-Au stage consisting of pervasive potassic alteration (K-feldspar-magnetite-biotite-specularite) of deep-level, intrusive quartz-syenite and surrounding volcanic rocks; Cu-Au-bearing quartz stockworks (*e.g.*, Mitchell deposit) developed at high levels within country-rock volcanic and intrusive rocks; electrum occurs within chalcopyrite, and there is a strong positive correlation between Cu and Au;

(2) relatively high-level quartz-sericite-chlorite-pyrite alteration hosting quartz-molybdenite veins and tourmaline, both of which were introduced at this time;

(3) unmineralized, blanket-like, advanced-argillic alteration (pyrophyllite-kaolinite-woodhouseite-pyrite-barite) at high levels; and underlying massive pyrite veins enriched in Bi-Te-Sn;

(4) gold-rich, quartz-barite veins containing galena-sphalerite-tetrahedrite-pyrargyrite-gold-acanthite (Pb-Zn-Au-Ag-Sb-Cu-Cd-Hg±Te) best developed at high and peripheral positions (West zone style); and a high-grade, basalt-hosted disseminated Au zone (Snowfield deposit) with a similar mineral assemblage. This disseminated gold mineralization occurs proximal to a high-level, stage-1 stockwork zone and beneath and laterally adjacent to an advanced-argillic cap. Gold precipitation at Snowfield apparently resulted from sulfidation of previously altered (stages 1 and 2) basaltic andesite which was highly permeable due to a coarse hydroclastic texture. Within the stage-4 veins, abundant barite and absence of adularia are evidence that fluid mixing as opposed to boiling led to precipitation of gold and metal sulfides. Although stage-3 massive pyrite veins may contain high but erratic gold grades, textural relations indicate that gold (with galena-sphalerite-tetrahedrite) was introduced by the stage-4 fluid.

Two gold environments are present at Sulphurets:

(1) earliest, central (within or above granitoid), porphyry-Cu stage, with gold apparently carried as a chloride complex at relatively high temperature in a dominantly magmatic fluid of high salinity;

(2) latest, typically high-level and distal (to granitoid and stage-1 system), base-metal related, gold mineralization akin to adularia-sericite type epithermal systems, with gold apparently carried as a sulfide complex at lower temperatures in a relatively alkaline and reduced fluid with a larger component of meteoric water. Stable isotope data provide evidence for these two fluid types and temperatures.

Exploration in porphyry-style systems must be geared to recognize and target these two settings, as both may be economically viable. In addition, a third, rarer setting, not present at Sulphurets is the acid-sulfate-related enargite-gold (high sulfidation) style of mineralization; such deposits typically occur in a high-level and central position relative to underlying causative porphyry intrusions and potassic Cu-rich mineralization. It is possible that such a system existed in the advanced-argillic zone at Sulphurets but was eroded. However, the temporal transition from the acidic stage-3 system to the more alkaline and gold-rich stage 4 system at Sulphurets is an emerging characteristic of at least some high sulfidation gold deposits. Although the early, high-temperature Cu-Au environment is similar in most districts, the late, generally peripheral, lower-temperature gold system may assume a variety of deposit styles, chiefly dependent upon host-rock type, precipitation mechanisms, and hydrothermal flow regimes. The distinctive transition from Cu precipitation to Mo-B-F precipitation is consistent with the protracted exsolution of magmatic aqueous fluids from the crystallizing silicic melt, as demonstrated in experimental studies of other workers.

THE SNIP AND JOHNNY MOUNTAIN GOLD MINES: EARLY JURASSIC INTRUSIVE-RELATED VEIN DEPOSITS, ISKUT RIVER AREA, NORTHWESTERN BRITISH COLUMBIA

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The Snip and Johnny Mountain gold mines occur five kilometres apart on Johnny Mountain in northwestern British Columbia. The area is underlain by in a folded sequence of LateTriassic turbiditic and volcaniclastic rocks, which host the Snip mine. The Triassic rocks are unconformably overlain by flat lying Early Jurassic volcanic rocks at the Johnny Mountain mine.

Ore at the Snip mine occurs in two southwest-dipping shear veins, the Twin zone and its splay, the 150 vein, which together contain 30 tonnes Au. The deposit comprises interlayered (i) laminated calcite and chlorite-biotite-pyrite replacement shear veins and (ii) dilatant quartz and pyrite-pyrrhotite veins. Veins were emplaced progressively during normally-directed simple shear that accompanied a period of semi-brittle deformation.

The Johnny Mountain mine (Stonehouse deposit, 3 tonnes Au production) located south of Snip, consists of a set of steep north-dipping dilatant quartz-pyrite veins with K-feldspar alteration envelopes. The veins are superimposed on flat lying Early Jurassic volcaniclastic rocks that are intruded by a series of Early Jurassic feldspar porphyry dikes. Structural relations suggest that the Stonehouse veins represent a higher level, more brittle response to the same deformational event that formed the stratigraphically deeper Snip orebodies.

The Early Jurassic Red Bluff K-feldspar megacrystic quartz diorite stock intrudes Triassic rocks 300-800 metres northeast of the Twin zone. The intrusion is affected by (i) early intense quartz-magnetite-sericite-K-feldspar-biotite (potassic) alteration associated with abundant quartz-magnetite-hematite veins and Au-Cu-Mo mineralization, overprinted by (ii) sericite-pyrite-quartz (phyllic) alteration characterised by pyrite veining. Geologic relations, including similarities in alteration and structural style, geochronology, and camp-scale mineralogic and alteration zoning, indicate that intrusion, deformation, initiation of the porphyry hydrothermal system, and formation of the structurally hosted Au and base metal deposits are closely related spatially, temporally and probably genetically.

MESOTHERMAL GOLD-QUARTZ VEIN DEPOSITS IN BRITISH COLUMBIA OCEANIC TERRANES

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Mesothermal gold quartz vein deposits in British Columbia (*e.g.* Bralorne-Pioneer and Cassiar) and gold placer deposits derived from such veins (*e.g.* Atlin, Cariboo, Dease Lake and Manson Creek) are, or were hosted within or marginal to collisional suture zones where large volumes of CO_2-rich fluids have been channeled. These zones represent major crustal breaks between diverse assemblages of island arcs, subduction complexes and continental margin clastic wedges. They are delineated by the presence of obducted remnants of ancient oceanic lithosphere, *i.e.* dismembered ophiolitic rocks.

Deposits are intimately associated with carbonate altered ultramafic rocks "listwanite" derived from oceanic lower crustal plutonic or upper mantle metamorphic protoliths. The presence of such ultramafic rocks at surface, in essence characterize the trans-crustal nature of these major fault zones. Listwanite is therefore significant in that it delineates such suture zones and, more importantly marks areas where the sutures have channeled potential mineralizing fluids.

Gold mineralization is characterized by silicification, pyritization and potassic metasomatism localized along fracture zones within broader carbonate alteration halos. Economic concentrations, due to the likelihood of vein continuity and definable reserves are most likely hosted by the more competent lithologies of the obducted oceanic lithosphere, which form relatively large tectonic blocks. The differentiated mafic plutonic oceanic crustal segment of the East Lisa Complex (*"Bralorne Intrusion"* or *"Bralorne Diorite"*) hosting the Bralorne gold veins and the upper crustal volcanic rocks of the Sylvester allochthon hosting the Erickson gold veins are British Columbia examples. The Grass Valley district in the Motherlode Belt was the richest and most famous gold mining district in California, with practically all the gold recovered from lodes. As at Bralorne, the veins are hosted in a mafic plutonic-volcanic section of obducted crust, the Smartville Complex.

These veins appear to form during periods of metamorphism and partial melting due to tectonic crustal thickening in response to arc-continent collision. They are typically associated with late syn-collisional intermediate to felsic magmatism. Mineralizing hydrothermal fluids are interpreted to be derived, at least in part, from tectonically thickened, hydrated oceanic lithosphere that undergoes metamorphic dehydration and partial melting during and after faulting.

Ar^{39}/Ar^{40} ages of hydrothermal vein mica from the Cache Creek and Bridge River Terrane define temporally restricted mineralizing events which closely follow a collisional episode. In contrast, published K/Ar data for deposits associated with the Slide Mountain Terrane suggest that mineralization was temporally much less restrictive and formed during a period of uplift and extension in Early Cretaceous. The available age data suggest that either:

- There are two distinct tectonic regimes of mesothermal gold-quartz vein formation in the Cordillera, one involving a collisional event and the other produced during extension and uplift, or that
- All these vein deposits are late-syncollisional and the K-Ar systematics of mesothermal vein deposits occurring in association with oceanic lithosphere above the American continental margin have been reset by later thermal events.

Mesothermal gold quartz vein deposits are found along suture zones where affected by intense and pervasive carbonate alteration that is closely associated with late syn-collisional, structurally controlled intermediate to felsic magmatism They are potentially economic where hosted by relatively large, competent tectonic blocks of obducted oceanic crust.

RED MOUNTAIN, NORTHWESTERN BRITISH COLUMBIA: AURIFEROUS PYRITE STOCKWORKS IN A ZONED, PORPHYRY-LIKE SYSTEM

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Gold-silver mineralization at Red Mountain (1992 resource of 2.5 million tonnes grading 12.8 g/t Au and 38.1 g/t Ag) occurs within several discrete zones within a folded sequence of Middle to Late Triassic sedimentary rocks, Early Jurassic volcaniclastic and pyroclastic rocks, and Early Jurassic intrusions. Three phases of Early Jurassic sills and stocks collectively comprise the Goldslide intrusions: (i) irregular bodies of medium-grained hornblende monzodiorite (Hillside porphyry), (ii) hornblende-biotite + quartz porphyritic monzodiorite to quartz monzodiorite (Goldslide porphyry; U-Pb zircon ages of 197.1 ± 1.9 Ma), and (iii) biotite porphyritic hornblende monzodiorite sills (biotite porphyry). Contact breccias and igneous breccia dikes are common features of the Goldslide intrusions. Chemical similarities and equivalent ages of volcanic rocks and intrusions, and the presence of intrusive clasts in volcanic rocks suggest that the intrusions are feeders to overlying volcanic units.

Hydrothermal alteration affects all pre-Tertiary rocks on Red Mountain, including all phases of the Goldslide intrusions. Several shallow-dipping alteration zones are developed sequentially above a propylitic quartz stockwork/molybdenum zone. These include: (i) sericite-quartz-pyrite alteration (pyrite-dominant alteration), (ii) chlorite-K-feldspar-sericite-titanite alteration with disseminated and vein pyrrhotite (pyrrhotite-dominant alteration) and (iii) brown to black tourmaline veins and K-feldspar-pyrite-titanite-actinolite alteration. Anomalous gold (0.3 g/t) mineralization is developed at the transition from the pyrite to the pyrrhotite dominant alteration over a 1 km2 area. Within this anomalous zone, high grade (3-20 g/t Au) gold-silver mineralization occurs in 5 to 29 m thick, semi-tabular pyrite ± pyrrhotite stockworks with intense sericitic alteration and surrounding disseminated sphalerite + pyrrhotite.

Stratigraphic, spatial and geochronologic relations and alteration zoning indicate that mineralization formed in a subvolcanic environment at the top of the Goldslide intrusions and at the base of the Early Jurassic volcanic pile. The Goldslide porphyry is interpreted to be the mineralizing intrusion. The alteration zoning, molybdenum-copper mineralized quartz stockworks, extensive K-silicate and tourmaline alteration, and the relationship with a hypabyssal porphyritic intrusion show similarities to many porphyry systems.

INTRUSION-RELATED Au-(Ag-Cu) PYRRHOTITE VEINS

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Intrusion-related gold-bearing pyrrhotite veins occur as a series of parallel, tabular to cymoid veins of massive iron sulphide and/or bull quartz. These moderate tonnage, high-grade veins are emplaced in en echelon fracture sets around the periphery of subvolcanic plutons. Examples of this newly-recognized deposit-type include some of the historic gold camps of British Columbia. These deposits are attractive exploration targets because of their high profit potential (high grades), ease of mining (strong, regular, structural control), relative ease of exploration (predictable restricted geologic setting; characteristic geophysical response) and high exploration potential (deposits occur in clusters or sets of veins and also have close genetic associations with other important mineral deposit types).

Veins may be composed of (i) massive fine-grained pyrrhotite and/or pyrite, or (ii) massive bull quartz with minor calcite and minor to accessory disseminations, knots and crystal aggregates of sulphides. These two dominant vein types may occur independently or together. The two mineralization styles may grade into each other along a vein, may form parallel to each other in a compound vein, or they may occur in adjacent but separate veins within an en echelon set.

The subvolcanic setting for these deposits is transitional between the setting for porphyry copper systems and the setting for epithermal systems. Mineralization is synvolcanic and syn-intrusive and formed along the thermally "brittle-ductile transition envelope" that surrounds subvolcanic intrusions. Late magma movement generated localized shearing which opened en echelon vein sets. Circulating hydrothermal fluid precipitated gold-rich iron sulphides and gangue.

All examples of this deposit type are emplaced in volcanic arc environments in oceanic or continental margin settings. These deposits have close associations with other ore deposits that are typical of arc environments. Consequently intrusion-related Au-(Ag-Cu) pyrrhotite veins should provide new exploration targets within established arc-related porphyry and epithermal camps. Conversely, discovery of these high-grade gold veins in frontier areas should spur exploration for additional deposits of this type, and for all the associated mineral deposit types of the volcanic arc environment.

THE ESKAY CREEK MINE: A PRECIOUS METAL-RICH, CLASTIC SULPHIDE-SULPHOSALT DEPOSIT

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The Eskay Creek Mine is a high-grade precious and base metal-rich sulphide and sulphosalt deposit located 80 km northwest of Stewart, British Columbia. A number of mineralized zones identified on the property can be distinguished by varying mineralogy, textures and grade. Economic concentrations of precious and base metals are contained in the 21 zone, which contains a number of distinct sub-zones. The bulk of the ore is hosted in the stratiform 21B zone. Production from the 21B zone commenced in January 1995 with a proven and probable mining reserve of 1.08 million tonnes grading 65.5 grams/tonne Au and 2,931 grams/tonne Ag.

Stratiform mineralization is hosted in marine mudstone at the contact between underlying rhyolite and overlying basalt packages. This succession forms the upper part of the Early to Middle Jurassic Hazelton Group. At the same stratigraphic horizon as the 21B zone are the 21A zone, characterized by As-Sb-Hg sulphides, and the barite-rich 21C zone. Stratigraphically above the 21B zone, mudstones host a localized body of base-metal-rich, relatively precious metal-poor, massive sulphide (the "hanging wall" zone). Stockwork vein mineralization is hosted in the rhyolite footwall in the Pumphouse, Pathfinder and 109 zones. The Pumphouse and Pathfinder zones are characterized by pyrite, sphalerite, galena and chalcopyrite rich veins and veinlets hosted in strongly sericitized and chloritized rhyolite. The 109 zone comprises gold-rich quartz veins with sphalerite, galena, pyrite, and chalcopyrite associated with abundant carbonaceous material hosted mainly in siliceous rhyolite.

The 21B zone consists of stratiform clastic sulphide-sulphosalt beds. The ore minerals are dominantly sphalerite, tetrahedrite and Pb-sulphosalts with lesser freibergite, galena, pyrite, electrum, amalgam and minor arsenopyrite. Sphalerite in the 21B zone is typically Fe-poor. Stibnite occurs locally in late veins and as a replacement of clastic sulphides. Rare cinnabar is associated with the most abundant accumulations of stibnite. Barite occurs as isolated clasts and in the matrix of bedded sulphides and sulphosalts, or as rare clastic or massive accumulations, mainly in the northern portion of the deposit and in the 21C zone.

The clastic ore beds in the 21B zone show rapid lateral facies variations. Individual beds range from mm to 1 m thick. The thickest beds occur at the core of the deposit and comprise sulphide cobbles and pebbles in a matrix of fine-grained sulphides. These beds have an elongate trend which approximately defines the long axis of the deposit and which probably were deposited in a channel-like depression. Lithic clasts within the beds are mainly chloritized rhyolite and black mudstone. Angular, laminated mudstone rip-up clasts have locally been entrained within the clastic sulphide-sulphosalt beds. Both laterally and vertically, the ore beds become progressively thinner, finer grained and interbedded with increasing proportions of intervening black mudstone. Vertically successive clastic beds, either graded or ungraded, vary from well to poorly sorted. Bedded ore grades outwards from the core of the deposit into areas of very fine grained, disseminated sulphide mineralization.

The 21B zone exhibits many characteristics analagous to Kuroko-type volcanogenic massive sulphide deposits, but is associated with an epithermal element suite and high precious metal content. These features may be explained if the deposit formed in a relatively shallow water environment and significant boiling of the hydrothermal fluids occurred. The variability in textural characteristics of the clastic ore may reflect a variety of mechanisms related to explosive hydrothermal and/or sedimentary processes.

SHALLOW SUBMARINE HOT SPRING DEPOSITS

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Recent studies of modern, shallow submarine hot springs have established a direct link with volcanogenic gold deposits and identified a number of new deposit types as targets for exploration in Canada. More than 50 sites of shallow submarine hydrothermal activity have been documented world-wide in volcano-tectonic settings ranging from (1) island arc volcanoes and related rifts (Izu-Bonin arc), (2) back-arc spreading centers (Lau Basin, Okinawa Trough, Havre Trough), (3) rifted continental margins (California Borderland), (4) fore-arc rifts and related alkaline volcanic centers (Tabar-Feni Chain, Lihir Island), (5) shallow segments of the mid-ocean ridges (Iceland Plateau, Axial Volcano), and (6) intraplate hot spot volcanoes (Azores). Among these examples, a number of geologic environments have been recognized as important sites for productive shallow submarine mineralization, including (1) the summit areas of large volcanic edifices or seamounts (1500-1000 m depth), (2) the collapsed calderas of submarine volcanoes and young volcanic cones (1000-500 m depth), (3) the flanks of active volcanic islands (500-50 m depth), and (4) near-shore environments adjacent to subaerial geothermal systems (2 m depth). At least seven different styles of mineralization are recognized, including (1) gold-rich polymetallic massive sulfides (Palinuro Seamount), (2) gold-barite deposits (Kita-Bayonnaise Caldera), (3) epithermal vein and disseminated-stockwork mineralization (Tabar-Feni arc), (4) pyritiferous muds and pyrite replacement deposits in volcaniclastic sediments (Vulcano, Italy), (5) submarine solfataras and acid-sulfate springs (Lau Basin, Desmons Cauldron), (6) carbonate hot springs (Piip Volcano), and (7) low-temperature Fe & Mn oxide deposits (Santorini).

Shallow submarine hot springs are particularly common on the submerged volcanoes of Pacific island arcs (Aleutians, Kuriles, Japanese Islands, Izu-Bonin arc, Marianas Islands, Papua New Guinea, Solomons, New Hebrides, Fiji, Tonga-Kermadec, Taupo Volcanic Zone off New Zealand). Volcanic islands throughout this region host extensive hot spring and fumarolic activity and locally have produced large porphyry copper and epithermal gold deposits (*e.g.*, 40 million oz. megadeposit at Lihir). A number of known submarine hot springs occur in close proximity to active gold-depositing systems (*e.g.*, in the harbour at Lihir). Widespread hot spring activity near sea level at these sites suggests extensive submarine venting may also occur on the submerged flanks of many of the volcanic islands. Mineral deposits forming at these hot springs resemble deep-sea metalliferous deposits but also have distinctive epithermal characteristics similar to gold deposits on the adjacent volcanic islands. Examples are known from submerged caldera environments in the Kuriles, S. Kyushu, PNG, and off White Island NZ. Massive barite-sphalerite-galena deposits are currently forming in the shallow calderas of submerged volcanoes of the Izu Bonin arc, and these containup to 2300 ppm As, 670 ppm Sb, 350 ppm Ag, and 2.7 ppm Au (Iizasa *et al.*, 1992). At Fushime, on the shores of Kagoshima Bay (S. Kyushu), hydrothermal precipitates are presently forming below sea level as mineral scales in geothermal wells, and these consist of massive sphalerite and galena with up to 12 000 ppm Sb, 2200 ppm Ag, and 1.4 ppm Au (Akaku, 1988), closely resembling the mineral assemblage at Eskay Creek. Similar deposits are well-known at Palinuro Seamount in the Aeolian Arc (Tyrrhenian Sea), where barite-polymetallic sulfides are forming at 600 m water depth and contain up to 4800 ppm As, 2000 ppm Sb, 6600 ppm Hg, 420 ppm Ag, and 7.1 ppm Au (Puchelt, 1986). These examples represent a continuum from subaerial, volcanogenic epithermal gold deposits to submarine polymetallic massive sulfides and occur in a variety of shallow-water volcanic settings that previously were considered non-prospective for VMS. Although examples from island arc settings are among the best documented, shallow submarine volcanism and epithermal-style gold-base metal mineralization are not limited to emerging volcanic arcs. The diverse volcanic and tectonic environments which host shallow submarine hot springs indicate that a wide range of geologic settings may be important for this type of mineralization (*e.g.*, mid-ocean ridges, hot spot volcanoes, rifted continental margins, rifted fore-arcs, near-trench volcanoes associated with ridge subduction).

In the geologic record, shallow submarine hot spring deposits are represented by stratiform Au-Ag barite deposits, pyritic Cu-Au stockworks, and auriferous polymetallic sulfides. Examples include the Au-Ag barite deposits of Wetar Island, Indonesia (Lerokis, Kali-Kuning) and similar deposits in the Sunda-Banda arc (Flores, Sumbawa Islands) and in the Philippines (Binebase and Sarangani Islands). Examples of gold-rich pyritic stockwork deposits with barite-rich caps occur in Miocene volcanic belts of Japan (Yoshino mine) and also in Fiji (Undu deposit). Gold-rich barite deposits and epithermal gold-base metal deposits are known in the Pontides mineral belt (Koprubasi, Turkey), in the Yunnan Prov. of China (Laochang), and possibly in Eastern Australia (Mt. Chalmers). Examples from the Skellefte district, Sweden, include the Asen stratiform barite-pyrite deposit, located 20 km from Boliden, and similar emergent volcanic settings may be represented in the Bergslagen district. In Canada, Archean examples in shallow-water volcanics include the Selbaie deposit (NW, Quebec) and mineralization at Onaman Lake (NW Ontario). Deposits with Kuroko-type affinities and distinctive epithermal characteristics also occur in eastern Canada (Tulks Volcanic Belt, Nfld., Mindamar, NS). Important examples from the Cordillera, in addition to Eskay Creek, may include the gold-rich pyritic stockworks at Johnson River and the high-grade Ag deposits at Samatosum and Rea Gold. Many of these deposits may be hybrids (*e.g.*, high-level epithermal-style mineralization superimposed on pre-existing polymetallic massive sulfides) but further illustrate the wide range of potential exploration targets.

MAGMATIC CONTRIBUTIONS TO SEA FLOOR DEPOSITS: EXPLORATION IMPLICATIONS OF A HIGH SULPHIDATION VMS ENVIRONMENT

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Over the last ten years, two types of fundamentally different precious metal epithermal deposits have been recognized. Although several names have been used for these types, the terms now in favour are high and low sulphidation. The two deposit types differ in their ore and alteration mineralogy, their geometry and ore controls, and the composition and origin of the ore forming fluids. There is strong evidence for a major magmatic contribution to the fluids that form high sulphidation deposits while low sulphidation fluids are dominated by meteoric water with some evidence for local and transient magmatic input. High sulphidation deposits form in magmatic-hydrothermal systems, an environment characterized the upper part of many strato volcanoes.

Based on the mineralogical classification used for epithermal deposits, the majority of volcanogenic massive sulphide (VMS) deposits could be classified as low sulphidation. These VMS deposits formed from an ore fluid that was dominated by modified seawater, and as with low sulphidation epithermal deposits, evidence for magmatic contributions to these systems is limited. There are also, however, VMS deposits and seafloor occurrences whose mineralogy suggests that a high sulphidation classification is appropriate. These high sulphidation VMS deposits probably formed from magmatic hydrothermal systems that were active in submarine settings.

High sulphidation VMS deposits contain abundant pyrite and several of the following: enargite, chalcocite (hypogene), covellite, bornite, tennantite, and tetrahedrite. Alteration associated with high sulphidation VMS deposits is characterized by the presence of quartz and alunite with important barite, sulphur, kaolinite, pyrophyllite and diaspore. These mineralogical characteristics are similar to epithermal high sulphidation deposits, however the seafloor setting for the VMS type influences the geometry of the deposits, the outer and upper alteration mineralogy (reflecting the involvement of seawater), and the stratigraphic control on deposits.

Examples of high sulphidation VMS deposits occur on the modern seafloor. The mineralogy of the gold-rich polymetallic massive sulphides on the Palinuro seamount suggests a high sulphidation affiliation. Of more significance are the gold-rich barite-silica-sulphide precipitates and associated alunite-rich advanced argillic alteration that have been discovered at the Hine Hina hydrothermal field in the Lau Basin. This alteration is forming at a water depth of 1850-2000 m, well below the depth at which normal seawater will boil, and thus the alteration mineralogy probably reflects the direct input of magmatic volatiles. There are several Cenozoic to Mesozoic deposits with high sulphidation mineralogy that formed in a probable submarine environment. Examples occur in the Green Tuff belt of Japan, on Wetar Island in Indonesia, in the Pontid belt of northeastern Turkey, and in Haiti and adjoining parts of the Dominican Republic. These deposits are typically characterized by copper±gold-rich, enargite-pyrite stringer mineralization associated with silicification and advanced argillic alteration. Some deposits are capped by barite-rich zones which probably formed at or close to the seafloor. In the case of the Lerokis and Kali Kuning deposits on Wetar Island, sulphide in the baritic zones has been oxidized (either on the seafloor or post-uplift) resulting in gold-bearing iron oxide-barite sand which constitutes the ore. Older high sulphidation VMS deposits may also exist, although deformation and metamorphism hinder the interpretation of their mineralogy and geometry. Possible examples include the latest Proterozoic-Early Cambrian Carolina Slate Belt gold deposits, the mid-Proterozoic Boliden deposit in the Skellefte VMS district of northern Sweden, and the Archean Bousquet deposits of Quebec.

The recognition of high sulphidation VMS mineralization has implications for exploration:

1. Deposits will be gold-rich, and if oxidized, the gold may be easily recovered.
2. Unlike high sulphidation epithermal deposits, the VMS equivalent will show a strong stratigraphic control. Recognition of volcanic breaks and chemical sediments will be important.
3. High sulphidation VMS deposits may occur in camps dominated by traditional VMS deposits, particularly those that formed in arc settings, and conversely, VMS deposits may occur in areas where high sulphidation systems exist and have been assumed to be subaerial.

In the Cordillera, a possible example is the Treaty Glacier prospect in the Iskut area. Geological and geochronological data suggest that advanced argillic alteration in this area formed in a magmatic hydrothermal system at more or less the same time as the unusual Eskay Creek VMS deposit. There are also indications that the Treaty Glacier system was submarine, part of the alteration being superimposed on roughly coeval pillow basalts. The Treaty Glacier prospect suggests that there is potential for high sulphidation VMS mineralization in the Cordillera.

SUBVOLCANIC Au-Ag-Cu: TRANSITIONS FROM PORPHYRY TO EPITHERMAL ENVIRONMENTS

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Transitions from high level magmatic to hydrothermal conditions account for a variety of mineralization styles. Henley (1990) noted: 'magmatic vapour from crystallizing plutons is critical to (mineralization in) the epithermal environment much as described for porphyry copper-molybdenum-gold deposits' and ' in volcanic terrains the distinction of epithermal from porphyry-type environments of mineralization becomes largely one of convenience for exploration than one of reality'. The recognition that epithermal mineralization occurs in shallow parts of porphryry systems has been known for many years. The high-sulphidation epithermal deposits are generally considered to be intrusion-related. Low-sulphidation deposits are less convincingly so and, if intrusions are present, the deposits tend to occur well away from them.

Lateral and vertical zoning of deposit types and metals centred on intrusive bodies, and their overlying stratovolcanoes, is amply documented. These relationships, and other related styles of mineralization, are particularly well documented in Southwestern Pacific and Andean magmatic arcs. The superimposition, blending and blurring of porphyry and epithermal characteristics can take place in volcano-plutonic arcs when "telescoping" of hydrothermal systems occurs. This is commonly evident as an overprinting of earlier mineralization by lower temperature, more oxidized, advanced argillic alteration assemblages. The telescoping that take place during the late life of the mineralizing hydrothermal systems is commonly due to rapid erosion of volcanic edifices by tropical weathering or glacial erosion, swift degradation of hydrothermally damaged volcanic structures, or cataclysmic decompressional events such as gravitational sector collapse.

Transitional mineralization can be regarded to be a closely related variant of high-sulphidation systems. The mineralizations are genetically related in as much as the hydrothermal fluids involved are derived from the same, or similar intrusions. However, there are enough significant differences to warrant a separate identity for a 'transitional' deposit type. The high-sulphidation deposits have characteristic copper sulphide (covellite) and Cu-As-Sb minerals (tennantite-tetrahedrite, enargite-luzonite) and advanced argillic (acid sulphate) alteration derived from highly oxidized and highly acidic fluids. The transitional deposits can have similar alteration and mineralization as well but it is generally subordinate and restricted to late, localized acidic fluid flow. The dominant mineralization is by quartz-sericite-pyrite derived from less oxidized, neutral-pH to weakly acidic, relatively high temperature and pressure and highly saline solutions that are more akin to porphyry than epithermal deposits.

The main characteristics of transitional deposits are summarized as follows:

- Mineralization is intrusion-related; (subeconomic) porphyry copper-molybdenum deposits can occur nearby
- The intrusions are emplaced as high-level, subvolcanic stocks; coeval volcanic rocks may, or may not, be present. Quartz-feldspar porphyry domes and flow dome complexes can be mineralized in their interior parts but, overall, they most commonly host typical epithermal and vein deposits
- Cu-Au-Ag and/or Au-Ag ore is associated with polymetallic mineralization, typically with abundant As and Sb
- Pyrite is the dominant sulphide mineral. Chalcopyrite, tetrahedrite/tennantite are common, enargite is rare or absent
- Structural and lithologic permeabilities are the main ore controls
- Sulphide minerals are present in stockworks, veins, breccias and local massive replacement to disseminated zones. The ore stockworks and vein sets are composed of sulphide-bearing fractures; they contain only minor quartz
- Quartz-sericite-pyrite is the dominant alteration, mainly as a pervasive replacement of the ore hostrocks. Advanced argillic alteration forms a locally developed overprint with pervasive kaolinite and veins with quartz-alunite-(jarosite) assemblages. Higher-temperature zones contain andalusite, pyrophyllite, zunyite, diaspore and rare corundum; tourmaline is abundant in some deposits. Propylitic alteration is widespread in the hostrocks surrounding the ore zones
- Vertical zoning is evident and lateral zoning of ore metals may be developed in deposits. From shallow to greater depth there is a progression from Au, Ag with increasing Cu, Zn and Pb, locally Mo, Bi and W and, rarely, Sn
- Mineralization is related to 'robust' high temperature and relatively high pressure fluids emanating from porphyritic intrusions. The ore solutions are highly saline, moderately oxidized and less-acidic than those in high-sulphidation epithermal deposits

Deposits that will be discussed to exemplify this deposit type are the Kori Kollo mine, Bolivia, and Equity Silver mine, British Columbia.

Linkages between porphyry and epithermal deposits (and probably even Carlin-type jasperoid Au-Ag ores) are now recognized, but are poorly documented. In order to fully define an intrusion-related transitional deposit type, detailed geological deposit studies and careful investigations of alteration, ore and hostrock geochemistry, fluid inclusions and isotopes need to be conducted.

WRANGELLIA - A NEW Ni-Cu-PGE METALLOGENIC TERRANE

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Triassic mafic-ultramafic intrusive complexes along the eastern margin of "Wrangellia", adjacent the Denali fault from east-central Alaska to northern British Columbia, constitutes a newly recognized Ni-Cu-PGE metallogenic terrane that can be traced along strike for at least 600 km. These sill-like intrusive centres acted as subvolcanic magma chambers that fed the thick overlying, oceanic plateau basalts of the Nikolai Group. Confinement of these olivine-rich ultramafic sills, Ni-Cu-PGE mineralization, more olivine normative and primitive coeval basalts exclusively to the eastern portion of Wrangellia is believed to be a product of melts forming in closer proximity to the hotter axial "jet" of the mantle plume that initiated melting, relative to the cooler more distal portions. Although the parental magmas that gave rise to these intrusive and extrusive rocks are clearly of a tholeiitic origin, the intrusive complexes have striking similarities to Archean and Proterozic komatiitic ultramafic bodies that host world class nickel sulphide deposits.

Detailed compositional investigations of silicates and oxides, from both the intrusive and extrusive Triassic magmatic environments, has provided valuable information allowing one to constrain the nature of the parental magmas, the influence of crustal contamination, the degree of communication with magmatic sulphides, and noteworthy spinel elemental associations only observed elsewhere in other major nickel deposits or promising prospects.

U-Pb dating of zircon from a consanguineous hypabyssal, gabbroic sill that intrudes the upper portion of a mineralized mafic-ultramafic complex, end feeds the proximal Nikolai basalts, provides a minimum age for these complexes and associated mineralization, and a precise age for the onset of Triassic volcanism in Wrangellia (232.3 + 1.0 Ma).

Geochemical and isotopic studies indicate that crustal contamination of the parental magmas that gave rise to the intrusive lithologies and ores has taken place. However, these studies in conjunction with magma mixing models, also suggest that there is an optimum amount of crustal contamination beyond which the quality of the mineralization decreases with respect to its Ni, Cu, Se, and PGE+Au grades. Selective emplacement of these subvolcanic intrusions at or near the interface of a major stratigraphic transition, where the chemical nature and the lithological competency of the strata changes, facilitates not only regional exploration, but also quantification of crustal contamination - magma mixing models to explain grade variations at certain localities.

Examination of base and noble metal concentrations, in apparently unmineralized mafic and ultramafic lithologies with comparable sulphur contents and degree of fractionation, throughout the eastern Wrangellia allows distinction between mineralized and unmineralized intrusions. Cryptic chemical differences in the chalcophile element concentrations, normative olivine content and primativeness of the Triassic basalts have also been recognized between western and eastern Wrangellia. These differences have profound exploration, petrogenetic and metallogenic implications.

Prior to this study only the regional geology of the study area was available, knowledge pertaining to the tectonostratigraphic and tectonomagmatic setting was vague at best, and little if any appreciation existed for the significance of the mafic-ultramafic complexes. Because of the potential economic significance of this newly recognized Ni-Cu-PGE metallogenic terrane, and the general absence of vital information pertaining to the intrusions, sulphide deposits and mineralized occurrences, and the surrounding local geology; the author has attempted to provide a detailed documentation pertaining to this much needed information. In addition, an attempt has been made to provide a better understanding of the tectonostratigraphic and magmatic setting of Wrangellia and Ni-Cu-PGE metallogenic processes during the Triassic.

SEDIMENT-HOSTED SPARRY MAGNESITE DEPOSITS

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Magnesium is a light metal, commonly produced from magnesite, that play increasingly important role in aerospace and automotive industries. Calcined magnesite has a broad range of industrial, chemical, environmental and agricultural applications. Dead-burned and fused magnesia are used mainly in high-performance refractories. Worldwide, most economic magnesite deposits are associated either with ultramafic or sedimentary rocks. Sediment-hosted magnesite deposits are either fine-grained with well preserved sedimentary textures or sparry. The origin of sparry magnesite deposits is controversial.

In British Columbia, the large sparry magnesite deposits (Figure 1) are hosted by sedimentary rocks of Precambrian to Cambrian age. They are stratabound, occur in belts, and are associated with paleobathymetric highs of probable tectonic origin. The Mount Brussilof deposit is the only magnesite mine in Canada. The magnesite occurs within the Cambrian Cathedral Formation that is comprised of shallow-marine platform carbonates at the edge of the Cathedral escarpment and capped by an unconformity. The Brisco - Driftwood Creek deposits occur along the Windermere high, a paleobathymetric feature (Figure 2). They are hosted by carbonates of the Precambrian (Helikian) Mount Nelson Formation and associated with redbeds containing carbonate pseudomorphs after halite as well as stromatolite horizons, that indicate a shallow marine or lacustrine depositional environment. Magnesite deposits in the Cranbrook area are special because they occur in quartzites of the Cambrian Cranbrook Formation and may not be directly associated with a major paleotopographic high and are possibly reworked.

All, but Botts Lake deposit which is located in the Brisco area, consist mainly of magnesite characterized by sparry, pinolitic and zebra textures that can be interpreted as diagenetic or metasomatic replacement. Typical impurities are quartz or chert and dolomite; typical minor impurities commonly occurring as fracture fillings, in vugs or along bedding lanes are pyrite, calcite, clay and iron oxides, chlorite, calcite, mica, palygorskite and aragonite. Dolomite is either of planar or sparry variety. Where a clear age relationship is observed, sparry dolomite post-dates sparry magnesite.

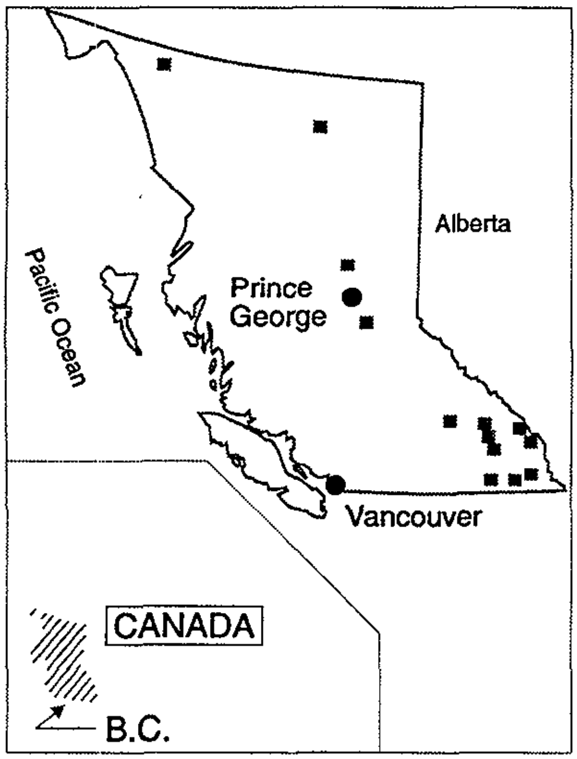

Figure 1

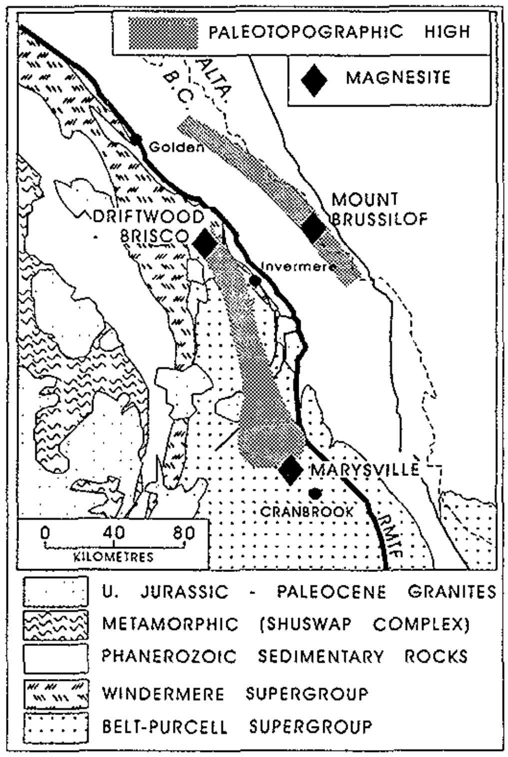

Figure 2

There are two preferred theories regarding the origin of sparry magnesite deposits:

1. Replacement of dolomitized, permeable carbonates by magnesite due to interaction with a metasomatic fluid, assuming an appropriate aCa^{2+}/aMg^{2+} ratio, salinity, temperature, high fluid/rock ratio *etc.*
2. Diagenetic recrystallzsation of a magnesia-rich protolith of chemical, possibly evaporitic origin that may consist of fine-grained magnesite, hydromagnesite, huntite or other low temperature magnesia-bearing minerals.

The main difference between these hypotheses is the source of magnesia. It is external in case of metasomatic replacement and *insitu* in the case of diagenetic recrystalization of magnesia-rich protolith.

Temperatures of homogenization of inclusions constrain the temperature of magnesite formation or recrystalization to 110 to 240°C depending on the deposit and are in agreement with late-diagenetic or low temperature metasomatic origin or overprint. Both hypotheses are consistent with field and petrographic observations. Currently the diagenetic recrystalization theory is preferred, largely because of the stratigraphic association of carbonate-hosted sparry magnesite with paleotopographic highs, unconformities, hot Cambrian paleoclimate that prevailed in the area encompassed by British Columbia, shallow marine depositional features of the magnesite protoliths and the older age of magnesite than that of cross-cutting sparry dolomite that is commonly associated with MVT, Pb-Zn deposits.

A number of recent cryptocrystalline sedimentary magnesite deposits of exploitable size and grade are known, such as Salda Lake in Turkey and the Kunwarara deposit in Quensland, Australia. These cryptocrystaline deposits, as well as, huntite-magnesite-hydromagnesite deposits of Kozani Basin, Northern Greece, and the magnesite- or hydromagnesite bearing evaporitic occurrences from Sebkha el Melah in Tunesia may be recent analogs to a pre-diagenetic protolith of British Columbia sparry magnesite deposits.

The model involving diagenetic recrystalisation of a primary magnesia-rich protolith restricts potential exploration areas in comparaison to the metasomatic replacement model. It imposes stratigraphic, paleoclimatic, paleotopographic and shallow depositional environment controls on the most favourable areas targetted for exploration. Nevertheless it is possible that some deposits, such as those of Cranbrook area, may represent reworked (secondary) deposits outside, but nearby, the expected prime exploration areas.

ERNEST HENRY-TYPE Cu-Au-MAGNETITE DEPOSITS IN THE PROTEROZOIC

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The Ernest Henry Cu-Au deposit was discovered by Western Mining Corporation Ltd. and Hunter Resources Ltd. in 1991 within early Proterozoic rocks of the eastern Mount Isa Inlier (Cloncurry Belt), about 130 km ENE of Mount Isa (35 km NE of Cloncurry), Queensland, Australia. The deposit contains a measured and indicated resources of 167 Mt at 1.1% Cu and 0.54 g/t Au.

Ernest Henry is the largest of a number of Cu-Au deposits in the eastern part of the Mount Isa Inlier. The Osborne (~15Mt at 3.0% CU + 1.3g/t Au), Selwyn (~5Mt at 1.0% Cu + 5.0g/t Au), Eloise (~3Mt at 5.8% Cu + 1.5g/t Au) and Mt. Elliot (~2Mt at 3.0% Cu and 1.3g/t Au) deposits are currently being mined. Most of the deposits and numerous smaller occurrences) are associated with 'ironstones' and coincide with moderate to large amplitude magnetic anomalies.

Ernest Henry and other deposits of the Cloncurry Belt have a number of similarities (and some obvious differences) to a variety of iron-rich Cu-Au deposits in middle Proterozoic and possibly the Kiruna-type deposits of Scandinavia).

Geological Setting of Ernest Henry-Type Deposits

The Cloncurry Belt comprises Early to Middle Proterozoic meta-sedimentary and meta-igneous rocks intruded by at least two quite distinct suites of granitoids. The metamorphic rocks range in depositional age from about 1800 Ma to as young as 1630 Ma and were derived from two or three principal tectonostratigraphic sequences that occur throughout northern Australia. Metamorphic grade ranges from mid-greenschist to upper amphibolite facies, and all of the supracrustal rocks have been subject to a complex compressional to transpressional deformational history during the Isan Orogeny between about 1600 and 1500 Ma.

The older granitoid suite was intruded during a widespread extensional event dated at about 1740Ma, and has consequently been overprinted by the Isan orogeny. The younger and more voluminous granitoids of the Williams Batholith intruded near the close of the Isan Orogeny at about 1500 Ma, and are spatially and temporally associated with a regional hydrothermal alteration event of spectacular scale and intensity.

Deposit Characteristics

All of the significant Cu-Au deposits in the Cloncurry Belt share the following characteristics:

1. They postdate the principal regional metamorphism and associated foliation(s) of the Isan orogeny.
2. They are spatially and temporally associated with the Williams Batholith granitoids.
3. They are structurally controlled by fault/shear zones, commonly with a complex brittle-ductile character: breccias and kink-folds are common in ore zones.
4. They occur in a wide variety of host rocks, including felsic to mafic meta-volcanics, granitoids, (meta)-diabase, and meta-sedimentary rocks ranging from carbonaceous slates to calc-silicates.
5. They are associated with iron-rich, high temperature alteration assemblages, most commonly magnetite-bearing (ironstones), although massive pyrrhotite-pyrite-chalcopyrite mineralization occurs at Osborne and Eloise.
6. Cu:Au ratios range from about 4:1 (Eloise and other sulphide-rich, magnetite-poor deposits) to less than 1:5 (parts of the Selwyn deposit). Mineralized systems range from very low grades of both CU and AU to quite high grade ores (*e.g.* Selwyn and Eloise).

The key factors in developing exploration models for this type of deposits are the **granitoid association** and the **structural association.**

The Granitoid Association

A genetic link between the Cu-Au deposits of the Cloncurry district and the granitoids of the Williams Batholith is now well established and broadly accepted. Middle Proterozoic Cu-Au mineralization, including the Olympic Dam deposit, in the Gawler craton of southern Australia is associated with a distinctive suite of similar post orogenic granitoids (Hiltaba Suite).

The characteristics of the Williams-type granitoids of the Cloncurry district are as follows:

1. They are I-type and dominantly granodiorite or more felsic in composition (mostly 60% SiO_2; as such, they differ significantly from the generally more mafic suites generally associated with porphyry Cu-Au mineralization in modern and ancient arc settings.
2. They commonly show evidence in their chemistry of significant crystal fractionation.
3. Widespread metasomatic alteration of the granitoids and their county rocks; both high K/Na and low K/Na alteration styles are common.

The Structural Association

A strong structural control is evident in most deposits of this type. The most common structural association is with dilational breccias on ductile to brittle shear/fault zones. In the Cloncurry district, Cu-Au deposits occur in dilational sites on reverse, oblique-reverse and strike-slip faults of a range of orientations.

Ernest Henry appears to have formed on a reverse shear/fault zone where it shallowed in dip as it passed through a more competent meta-volcanic unit within calc-silicates. Ore grade mineralization corresponds closely to throughgoing dilational brecciation of the meta-volcanics.

Deformation accompanying mineralization, although locally significant, is regionally minor and related largely to limited reactivation of a structures formed earlier in the deformation history.

Exploration Criteria

The principal regional to local exploration criteria which follow from our current understanding of Ernest Henry-type mineralization are as follows:

1. Proximity, preferably in the roof zones, to a distinctive suite of middle Proterozoic post-orogenic, fractionated granitoids.
2. Dilational sites on active shear/fault zones in the aureoles of the prospective granitoids.
3. More competent rock units, but otherwise little host-rock control.
4. Iron-rich alteration, most of the known mineralization is associated with magnetite-bearing alteration, and magnetics is therefore a widely used prospecting tool. However, Cu/Au-poor magnetite ironstones are widespread and some deposits contain little or no magnetite.

OLYMPIC DAM-TYPE IRON OXIDE (Cu-U-Au-LREE) DEPOSITS

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Olympic Dam-type iron oxide (Cu-U-Au-LREE) constitute a distinct class of ore deposits characterized by iron-rich, low-titanium rocks formed in extensional tectonic environments. These deposits formed primarily in shallow crustal environments (-6 km) and are expressions of deeper-seated, volatile-rich igneous-hydrothermal systems, tapped by deep crustal structures. Salient characteristics of this class are:

(1) *Age.* The majority of known deposits, particularly the larger examples, are found within Early to mid-Proterozoic host rocks (1.1 - 1.8 Ga). However, examples are recognized into the Tertiary.

(2) *Tectonic setting.* The deposits are located in areas that were cratonic or continental margin environments; in many cases there is a definite spatial and temporal association with extensional tectonics. Most of the districts occur along major structural zones, and many of the deposits are elongated parallel to regional or local structural trends. The host rocks may be igneous or sedimentary; many of the deposits occur within silicic to intermediate igneous rocks of anorogenic type. However, mineralization in many deposits is not easily related to igneous activity at the structural level of mineralization.

(3) *Mineralogy.* The ores are generally dominated by iron oxides, either magnetite or hematite. Magnetite is found at deeper levels than hematite. CO_3, Ba, P, or F minerals are common and often abundant. The deposits contain anomalous to potentially economic concentrations of LREEs, either in apatite, or in distinct LREE mineral phases.

(4) *Alteration.* The host rocks are generally intensely altered. The exact alteration mineralogy depends on host lithology and depth of formation, but there is general trend from sodic alteration at deep levels, to potassic alteration at intermediate to shallow levels, to sericitic alteration and silicification at very shallow levels. In addition, the host rocks are locally intensely Fe-metasomatized.

In spite of these similarities, many variations occur between and within individual districts, particularly in deposit morphology. Individual deposits occur as strongly discordant veins and breccias to massive concordant bodies. Both the morphology and extent of alteration and mineralization appear to be largely controlled by permeability along faults, shear zones and intrusive contacts, or by permeable horizons such as poorly welded tuffs. Local variations in mineralogy and geochemistry may be largely attributable to wall-rock composition, and to P, T, and fO_2 controls related to depth of formation.

Examples of Olympic Dam-type deposits are found in the Wernecke Mountains of eastern Yukon Territory and in the western portion of the Northwest Territories. The Wernecke Mountains contain approximately 90 discrete breccia bodies which are concentrated along the Richardson Fault Array, a major fault zone that controlled block faulting from the mid-Proterozoic to the Tertiary. The breccias cut the Proterozoic Wernecke Supergroup, a 4.5 km thick section of marine sediments. All the breccia bodies contain minor to significant amounts of iron oxide. Sulfide mineralization appears to be a late-stage event in all the breccia bodies. In the deeper breccias, chalcopyrite replaces magnetite and is intergrown with, or replaces pyrite and hematite. In stratigraphically higher breccias, chalcopyrite is veinlet-controlled and disseminated, as either replacements of magnetite or as interstitial grains within carbonate or specular hematite. Uranium minerals and gold commonly occur on the periphery of breccia bodies. LREEs in the Wernecke breccias are concentrated in apatite and monazite. Isotopic studies suggest that the hydrothermal fluids responsible for alteration and mineralization in these breccia bodies had near magmatic compositions.

Though the Olympic Dam-type deposits constitute major sources of iron (Kiruna, Chilean Fe), only two deposits are currently exploited for other metals (Olympic Dam - Cu, Au, U; Bayan Obo - LREE). The variability of Cu-U-Au-LREE contents within this deposit class, combined with potentially difficult metallurgy, makes these deposits a high risk exploration target. However, these factors are partially offset by the large size potential of these deposits.