BRITISH COLUMBIA

Ministry of Energy and Mines
Energy and Minerals Division

EXPLORATION AND MINING IN BRITISH COLUMBIA - 2001

Energy and Minerals Division

COVER PHOTO...

Looking north at DDH setup, Kemess North porphyry Au-Cu deposit (Mineral Resource Officer Brian McGrath in foreground).

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FOREWORD

The year 2001 was pivotal for both the exploration and mining industry in British Columbia, and for the Energy and Minerals Division of the provincial Ministry of Energy and Mines. All the key mineral exploration indicators in the province improved in 2001 for the second consecutive year since the all-time low levels of 1999, confirming a positive trend in the new millennium. However, substantial increases in the annual levels of exploration activity must occur to make the new discoveries that are needed to rebuild a sustainable mining industry in British Columbia. The metal mining industry faced commodity prices that plummeted to historically low levels during 2001. By year's end, the number of producing metal mines in the province decreased from nine to five. In contrast, the coal mining industry enjoyed a year of higher commodity prices, with higher production from most of the eight coal mines in the province, as well as accelerated exploration activity on several coal projects throughout the province. In late 2001, the Ministry of Energy and Mines announced plans both to streamline the exploration permitting process for industry, and to reduce geoscience programs as part of the provincial government's three-year program to reduce the size and cost of government.

Exploration activity in British Columbia during 2001 showed significant encouragement, with all key indicators showing improvement compared to 2000. Exploration expenditures increased by 15% to $31 million. Exploration drilling increased by 28% to 230,000 meters. The number of major projects increased by 18% to 58. These major projects also show a marked increase in both the kinds of target commodities and mineral deposit types from prior years. The amount of land tenured for exploration and mining in 2001 remained constant at 2.97 million hectares, with the amount of coal tenure increasing by 17%, compared to 1% decreases in both mineral and placer tenure. Mineral staking activity targeted new discoveries near Nelson on NTS maps 082G and 082F, near Stewart (103P), near Blue River (083D), and near Harrison Lake (092H). In spite of these positive trends, it remained challenging for junior companies to raise public venture capital for mining and exploration projects in British Columbia. This has been due in part to the perceived tenure uncertainty related to ongoing land use planning and First Nations issues in the province, in part to a lack of investor interest based on general suspicion lingering since the1998 Bre-X scandal, and in part to tightened securities regulations since amalgamation of the CDNX and TSE stock exchanges in 2001.

New discoveries in British Columbia during 2001 consisted mainly of successful follow-up work on or around previously known targets in productive districts. Sultan Minerals Inc. discovered widespread intrusion-related gold mineralization at the **Kena** project near Nelson, where there is potential for a large tonnage, low-grade open pit, and/or a high-grade, underground operation. Near their Kemess South open-pit copper-gold mine, Northgate Exploration Ltd. discovered a large, higher-grade but deep extension to the original **Kemess North** porphyry copper-gold prospect. At the past producing **Afton** copper-gold mine property near Kamloops, DRC Resources Corp. successfully traced the porphyry copper-gold-silver-palladium mineralization along strike and to depth. At Imperial Metals Corporation's **Mount Polley** porphyry copper-gold mine near Likely, the Springer North Extension Zone was discovered in 2001. Near Germansen Landing, Eastfield Resources Ltd. established greater continuity and size to the previously known zones of porphyry/iron oxide copper-gold-PGE mineralization at the **Lorraine** project. These successes underscore the strong interest in large precious metal-rich, intrusion-related deposits in British Columbia.

New discoveries from exploration of other deposit types highlight the diversity of mineral potential and the innovative approaches of explorationists in the province. At its **Cariboo Gold Quartz** project near Wells, International Wayside Gold Mines Ltd. found replacement-style gold mineralization along trend from the high grade Bonanza Ledge Zone. Although Leader Mining International Corp. originally targeted copper-nickel-platinum group element mineralization at its **Cogburn** project near Harrison Lake, the company instead recognized a large resource of magnesium-rich ultramafic rock. Commerce Resource Corp. explored the **Fir** and **Verity** tantalum and niobium-bearing carbonatite deposits, which are located near Blue River. On Vancouver Island near Courtenay, Priority Ventures Ltd. discovered both coal and coalbed methane at the **Dove Creek** project during their initial drilling program in 2001.

British Columbia's mines and quarries produced a wide variety of solid mineral commodities in 2001. The total value of production increased to $2.9 billion, up 2% from 2000. The most valuable commodities were metallurgical coal (34%), copper (22%), structural materials (16%), gold (11%), zinc (5%), silver (4%), molybdenum (2%), and industrial minerals, thermal coal and lead were less than 2% each. The prices for metallurgical and thermal coal rose substantially in 2001, creating increased revenues for and stability at the province's eight coalmines. As a result, exploration activity occurred at six new coal projects and several coal bed methane projects were initiated in 2001. Metal prices decreased and remained at near low historic levels during 2001, resulting in the temporary suspension of mining operations at Imperial Metals Inc.'s **Mount Polley Mine** near Likely, and Boliden-Westmin (Canada) Ltd.'s **Myra Falls Operation** near Campbell River. In 2001, Wheaton River Minerals Ltd. decommissioned the **Golden Bear Mine** near Telegraph Creek, and Teck-Cominco Ltd. permanently closed its flagship **Sullivan Mine** near Kimberley. Industrial minerals enjoyed a year of growth and increased diversification, with 22 major and many smaller operations producing aggregate, limestone and other products.

In 2001 British Columbia's newly elected majority government initiated a series of sweeping changes within the Energy and Minerals Division of the Ministry of Energy and Mines designed to increase private sector investment in mineral projects in the province. In 2002, the Victoria-based Geological Survey Branch is to begin delivering geoscience programs through industry-funded partnerships, and the prospectors assistance program will be discontinued. Over the next two years, the five regional offices of the Mines Branch are to be consolidated in one strategic location, and will move to a single-window, results-based permitting regime. With an improved investment climate, excellent mineral potential and sound geoscientific database, the positive trends seen in exploration and mining in British Columbia during 2001 are expected to accelerate in 2002. The province is long overdue for a major new mineral discovery, and all the key factors to slingshot such a discovery into an economic boom are now in place.

Part A of this publication contains a review of exploration and mining highlights in each of the five regions, contributed by the Regional Geologists in Smithers, Prince George, Cranbrook, Kamloops and Nanaimo. Part B of the publication contains geological papers contributed by geologists from both industry and government. Bill McMillan of Victoria critically reviewed the reports, and Janet Holland of the Geological Survey Branch carried out final compilation and preparation of the volume for publication.

Jacques Houle, P.Eng
Regional Geologist, Nanaimo

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PART B

PART A

REVIEW OF EXPLORATION AND MINING ACTITIVTY

NORTHWEST REGION

Paul Wojdak, P. Geo.
Regional Geologist, Smithers

SUMMARY

The year 2001 continued to be a difficult period for the mining industry. The value of gold, silver, copper and molybdenum metal produced from mines in the region decreased, due to a combination of lower prices and, at two mines, diminished output. Exploration activity continued at less than traditional levels. However, on a brighter note, both exploration spending and drilling increased slightly from 2000, giving cause for optimism that better times are ahead. Exploration spending in the Northwest was \$7.2 million, compared with \$6.5 million in 2000 (*see* Figure 1). Exploration drilling, an indicator of work on advanced properties, increased substantially from 31 735 metres in 2000 to 37 932 metres in 2001 (*see* Figure 2). Mine development drilling is excluded from the exploration data. Changes to the amount of land held under mineral tenure (*see* Figure 3) indicate grassroots activity is neutral, neither expanding nor declining. There were 5523 units acquired by staking, the second annual increase since the nadir in 1999, and nearly an identical 5521 units lapsed or were forfeit in the region. Skeena Mining District witnessed an increase of 1479 units held under mineral tenure while a decrease was experienced in Atlin (166 units), Liard (963 units) and Omineca (348 units) mining districts. New exploration in the Stewart-Iskut area and staking in the Ecstall massive sulphide belt account for activity in the Skeena district.

Among the mines in Northwest Region, output of gold from Eskay Creek diminished in 2001 but silver increased. Huckleberry and Endako increased their production of copper and molybdenum respectively, but Golden Bear's gold production fell off sharply as the heap leach operation was wound up. The region now has just three operating major mines. Mine data, including production and reserves, is shown in Table 1. Barrick Gold Corporation merged with Homestake Canada Inc., owner of the Eskay Creek mine. The new owner promptly indicated its intent, subject to government regulatory approval, to increase the mining rate at Eskay Creek to augment gold and silver production. Huckleberry and Endako mines continue to operate on very

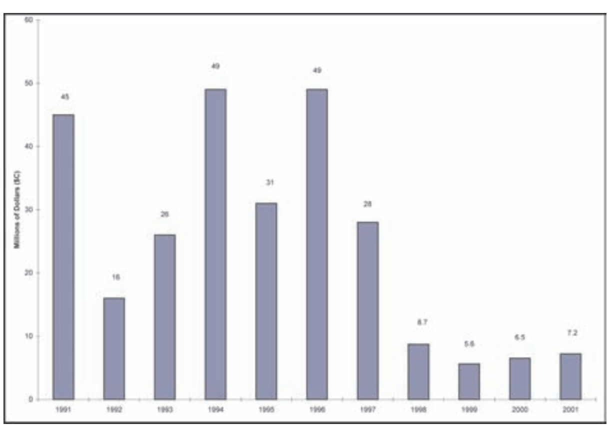

Figure 1. Mineral exploration expenditure in Northwest British Columbia.

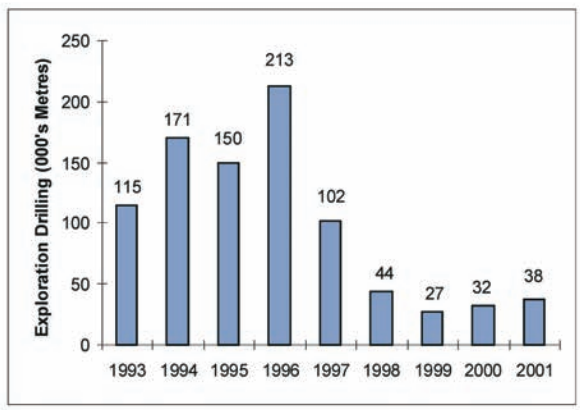

Figure 2. Exploration drilling in Northwest British Columbia.

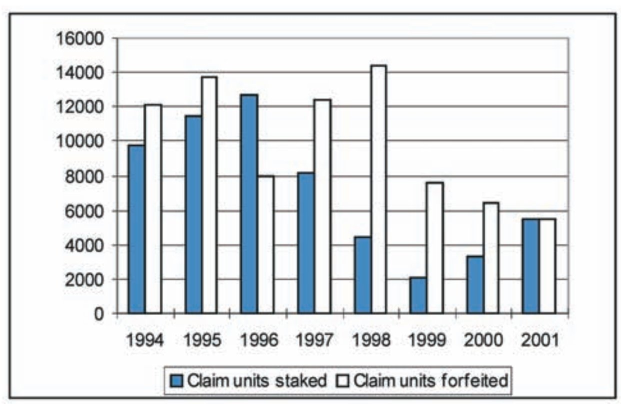

Figure 3. Claim activity summary, Northwest British Columbia.

TABLE 1
MINE PRODUCTION IN 2001 AND RESERVES, 2002

Mine	Operator	Employment	Production (2001)	Reserves (Jan 1, 2002)
Endako	Thompson Creek Mining, Ltd. & Nissho Iwai Moly Resources Inc.	200	5 565 499 kg Mo	Endako Pit, 55.4 million tonnes at 0.072% Mo Denak Pit, 1.5 million tonnes at 0.075% Mo Stockpile, 26.5 million tonnes at 0.047% Mo (on Oct 1, 2001)
Eskay Creek	Homestake Canada Inc.	256	9977 kg (320 784 oz) Au, 480 685 kg Ag	Shipping ore, 584 942 tonnes at 66.3 g/t Au, 3119 g/t Ag; Milling ore, 708 688 tonnes at 23.2 g/t Au, 910 g/t Ag
Golden Bear	Wheaton River Minerals Ltd.	35 (seasonal)	1039 kg (33 398 oz) Au	Heap leach reserves exhausted, mine closed
Huckleberry	Huckleberry Mines Ltd.	200	36 397 770 kg Cu, 888 380 kg Mo, 330 kg Au, 9052 kg Ag	Main Pit, 2 774 000 tonnes at 0.517% Cu, 0.014% Mo; East Pit, 51 610 000 tonnes at 0.478% Cu, 0.013% Mo
Fireside	Fireside Minerals Inc.	20 (seasonal)	10 000 tonnes of barite	Not available

Employment includes all employees and contractors as of December 2001. Reserves are from company news releases or by written correspondence with respective mine managers.

narrow margins of profitability due to depressed copper and molybdenum prices.

The most active area of exploration was the Stewart - Iskut district. The largest project in the region was the drill program conducted on the Eskay Creek mine property by Homestake Canada Inc. (now Barrick Gold Corp.). Three areas of encouraging results will lead to more drilling and possibly an increase in ore reserves. In the same district, Newmont Exploration of Canada Ltd., Teck Cominco Limited, CSS Explorations Inc. and St. Andrew Goldfields Ltd. also carried out various drilling, grassroots exploration and district compilation projects in search of a precious metal-enriched, massive sulphide deposit similar to Eskay Creek. Pacific Booker Minerals Inc. carried out the second largest project in the region on its Morrison porphyry copper deposit in the Babine district. All major exploration projects are listed in Table 2 and their locations are shown in Figure 4.

METAL MINES

The Eskay Creek underground gold-silver mine continued to improve operations, enlarge facilities and develop new mining areas. It also increased the mining rate for the sixth successive year since it opened in 1995. Capital cost of improvements was about $14 million (G. Biles, pers. comm.). The deposit consists of clastic sulphosalt-sulphide

TABLE 2
MAJOR EXPLORATION PROJECTS, 2001

Property	Operator	MINFILE	NTS	Commodity	Deposit Type	Work Done
Copper Star	Doublestar Resources Ltd.	093L 326	93L/3W	Cu, Mo	Porphyry	Access trail, 2.3 km; 9 ddh, 1580 m
Eskay Creek	Homestake Canada Inc.	104B 008	104B/9W	Au, Ag, Zn, Cu	Epithermal VMS	36 sfc ddh, 16 104 m; 21 u/g ddh, 2912 m; Development 24 sfc ddh, 4513 m; 290 u/g ddh, 11 203 m
Firestorm	Cantec Ventures Inc.		93L/1E	Precious Opal	Gemstone	Access trail, 0.7 km; Excavator trench, 200 m; Bulk sample, 20 cu m
Homestake Ridge	Teck Cominco Ltd.	103P 077,091, 165, 210, 214	103P/12E	Au, Ag, Zn, Cu	Epithermal VMS	Geol; Rock geochem
Huckleberry	Huckleberry Mines Ltd.	093E 037	93E/11E	Cu, Mo	Porphyry	IP and Mag, 14 km; Drill access, 0.5 km; 19 ddh, 2120 m.
Morrison	Pacific Booker Minerals Inc.	093M 007	93M/1W	Cu, Au	Porphyry	Drill access, 0.5 km; 39 ddh, 10 560 m
Mountain Boy	Mountain Boy Minerals Ltd.	104A 011	104A/4W	Ag, Zn, Cu	Vein	19 ddh, 630 m
PBR	Homestake Canada Inc.		104B/15E	Au, Ag	Epithermal VMS	1 ddh, 1418 m
Praxis	CSS Explorations Inc.	103O 016	103O/9E, 103P/12W	Au, Ag	Epithermal VMS	Geol; Geochem; EM (horizontal loop) and Mag 7 km
RDN	Newmont Exploration of Canada Ltd.	104G 144	104B/15E, 104G/2E	Au, Ag	Epithermal VMS	Max Min EM, 0.5 km; 13 ddh, 2255 m

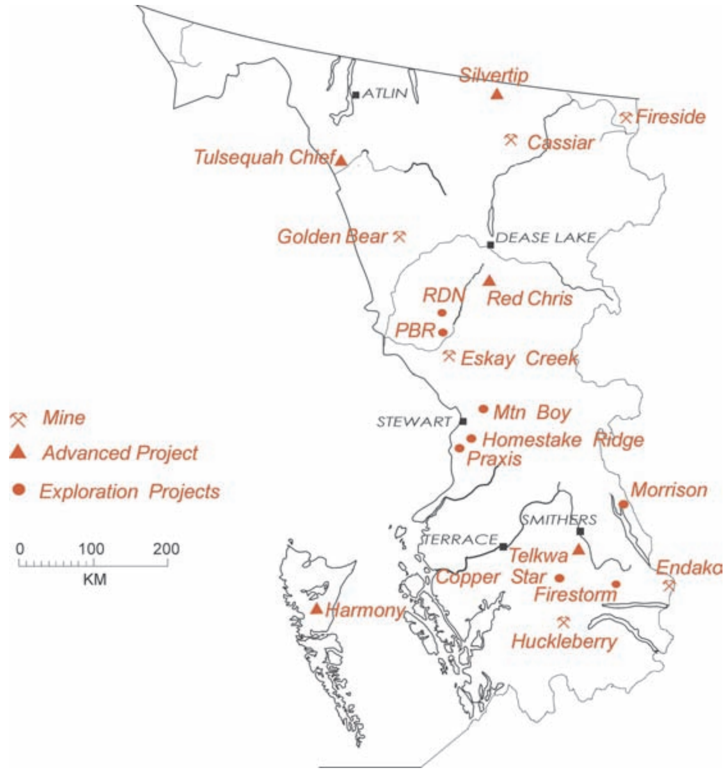

Figure 4. Location map, mines and exploration projects in northwest British Columbia, 2001.

beds (high in deleterious elements) in mudstone that is sandwiched between underlying rhyolite, which contains lower grade stringer ore, and overlying basalt. All these rocks are of middle Jurassic age. Ownership of the mine changed on December 14, 2001 when shareholders of Homestake Mining Company voted to merge with Barrick Gold Corporation, formally completing an arrangement announced on June 25, 2001.

Eskay Creek produced 109 949 tonnes of direct shipping ore in 2001 with a grade of 71.5 g/t gold and 3449 g/t silver. The mill treated 98 080 tonnes grading 32.3 g/t gold and 1301 g/t silver. Mill recoveries were 93.1% for gold and 96.3% for silver. Total gold recovery, including losses from smelter ore, was 89.8%. About fifty percent of the extraordinarily rich 21B stratiform deposit has been mined and an increasing amount of ore now comes from smaller and lower grade stopes. This led to reduced gold production in 2001 but pushed silver production to record levels (*see* Table 1). Gold equivalent production cost increased from $US 19 to $US 49 per ounce as a result of the slight reduction in gold output and lower silver prices which resulted in lower dollar credits against production cost. The company intends to increase production of direct shipping ore to 300 tonnes per day (tpd) for the first six months of 2002, and then to 370 tpd. Planned mill throughput in 2002 is 300 tpd but an increase to 360 tpd is being considered for future years. Synchronized depletion of the two ore types is an important consideration in maximizing mine life and extraction of the resource. Some lower grade mill ore may not be economically viable without the concurrent cash flow generated from direct shipping ore.

Construction of a tailings pipeline to Tom MacKay Lake that began in 2000 was completed and use of the pipeline started in the fall of 2001. Considerable commissioning difficulties were encountered with the $5 million, state-of-the-art twin pipeline with its sophisticated leak detection system. Inaccurate bathymetry data for Tom MacKay Lake resulted in the outfall structure being ineffective at delivering a de-aerated tailings slurry to the lake bottom. This eventually led to blockage of the outfall line in the lake. The problems were corrected and the line resumed operation in mid-November with tailings dispersed underwater into the 42 metre deep lake. Waste rock continues to be trucked to Albino Lake for subaqueous disposal. On the mine site, the camp was expanded to provide rooms for 204 people. All level ground at the mine site is now closely utilized (Photo 1).

Underground, 5 ramp, a descending spiral to access ore in the NEX zone, was driven northerly to the 525 metre elevation. A drift into the hangingwall at the 490 metre elevation will facilitate more effective exploration drilling than is possible from surface to find and delineate the small, structurally dismembered lenses of rich NEX zone ore. Surface drill holes are long and difficult to complete (Photo 2). Due to high levels of carbon dioxide gas in mine workings below about the 650 metre elevation in the NEX zone, the workings are continuously ventilated for miner safety. The footwall 21C zone was accessed by a southwesterly extension of 2 ramp. Trial mining of the 21C zone gave margin-

Photo 1. Eskay Creek mine surface facilities including (from left to right) living quarters, warehouse, office/mine dry, mill (largest building) and two direct-shipping ore sheds (foreground).

Photo 2. Exploration holes in the NEX zone are routinely drilled to 1500 metres. A truck departs the minesite carrying ore containing about $250 000 in gold and silver, destined for the DOWA or Noranda smelters.

ally economic results because of costs related to difficult ground conditions. Alternative mining methods are being considered to determine if economics of this zone can be improved.

Exploration expenditure at Eskay Creek made it the largest project in the region. The total of all drilling at Eskay Creek amounted to 34 732 metres, of which 19 016 metres is classed as exploration and included in Figure 2. The balance, 15 716 metres, is classed as mine development drilling. Surface and underground exploration holes were directed to a variety of bedded and footwall stringer zone targets. Channel-filling NEX lenses present small exploration targets, most are just 15-25 metres wide and 5-10 metres thick on a 5-10° north plunge line (J. Rogers, pers. comm.). The final hole of the 2001 surface program, 100 metres north of known mineralization, returned an intersection of 50 g/t Au equivalent over 17 metres. It may prove to be another NEX ore lens. In addition to the NEX zone, deep holes were drilled into the West Limb of the Eskay anticline, also in search of bedded ore in the contact mudstone.

Office review of previous drill results defined the primary footwall target of the 2001 program as the area where the footwall dacite is cut by the important Pumphouse fault (I. Dunlop, pers. comm.). The enigmatic Pumphouse fault, which may have hundreds of metres of right lateral displacement, is interpreted to mark the east side of the graben that contains the 21 zone deposits and also to have localized discharges of hydrothermal fluids (E. Masarsky, pers. comm.). Where the Pumphouse fault crosses an amygdaloidal horizon at the top of the footwall dacite, drill holes encountered semi-massive pyrite with significant gold grades. The area will be explored further in 2002. The felsite bluffs, subvolcanic feeders of the footwall rhyolite and long known to contain sporadic gold and base metals, were drill tested for near-surface mill ore to replace the nearly depleted footwall 109 zone. Results were disappointing. Lastly, development drilling in the 21C zone inadvertently discovered a new mineralized area, named the Water Tower zone. It appears to be controlled by a splay of the Andesite Creek fault (I. Dunlop, pers. comm.), that delineates the western boundary of the 21 zone trough. Drill intercepts are up to 15 g/t Au over 7.5 metres with negligible amounts of silver or deleterious elements. This metal signature is typical of footwall mineralization. Although little of the ore mined in 2001 was replaced by new reserves, the three areas described - the deep NEX, footwall dacite and Water Tower zone - give promise for exploration success in 2002.

Endako is a porphyry molybdenum deposit within an early Cretaceous granite batholith. At the Endako open pit mine, molybdenum production (Table 1) increased as the in-pit crusher, which was installed late in 2000, operated efficiently to deliver ore to the mill. The mill treated 9 468 492 tonnes of ore containing 0.0753% Mo. Mill recovery averaged 78.0%. Exceptionally low costs, achieved with the in-pit crusher and by deferred stripping, were needed to maintain the operation because the historically low molybdenum price continued throughout the year. Power cost deferrals negotiated by the B.C. Job Protection Commission were in effect during 2001 but expire in January 2002.

A decision to resume mining waste rock from the south wall of the Endako pit is anticipated in 2002. A 10 000 tonne rock fall on the south wall of the pit resulted from a wedge failure caused by the intersection of the South Basalt fault with a molybdenite-gouge vein swarm that dips gently northward, into the pit. In the previous year, a 30 000 tonne fall happened near the same place along the South Basalt fault. The new rock fall was removed as part of planned mining of the South Ramp because the in-pit crusher obviated need for the ramp. Improved drainage at the crest of the south wall is expected to guard against future failures. Five exploration holes cored in December tested both an historic drill intercept and unexplained molybdenum soil and water anomalies. Two holes 1000 metres southeast of the Endako pit encountered pyritic quartz monzonite similar to the south margin of the Endako pit. Five to seven hundred metres northwest of the Endako Pit, where molybdenum was intersected in a percussion hole, two of three holes encountered encouraging geological conditions and molybdenum mineralization. The best intercept was 0.079% Mo over 3 metres. Both areas may receive further drilling.

Huckleberry is a porphyry copper deposit that is related to a late Cretaceous Bulkely intrusion. Mineralization developed mainly in hornfelsed volcanic rocks adjacent to the intrusion. The Huckleberry open pit mine increased copper production by some 9% during 2001 through a combination of higher head grades and improved mill throughput. The mill treated 7 415 900 tonnes of ore at an average grade of 0.522% Cu. The milling rate averaged 20 400 dry tonnes per day. Operating costs were $C 0.586 per pound and capital costs were $C 0.121 per pound. Waste removal in the Main pit amounted to 3.8 million tonnes. Mining of the Main pit is advanced and is scheduled for completion early in 2002. Pre-stripping of overburden and waste rock for the second phase of the East pit began in the summer. A total of 3.2 million tonnes of non-acid generating granodiorite, that contains minor copper and molybdenum, was quarried immediately west of the Main pit and used to raise the elevation of the tailings dam. Northerly faults along the granodiorite contact, that are sub-parallel to the west wall of the Main pit, caused a minor pit-wall stability problem.

As part of a pit optimization study, three mine definition holes were drilled on the east margin of the East pit, to follow-up on an ore grade intercept that fell outside the designed pit. Definition drilling also tested two previous ore grade intercepts near the Main pit. To the northwest, three holes were drilled in the 225 zone and, to the northeast, four holes were put into the 227 zone. Although copper mineralization was intersected, the indicated tonnage was insufficient to justify modifying the mine plan for the Main pit (C. Craig, pers. comm.). Three exploration holes tested the 256 zone, an area of supergene mineralization southeast of the East pit. Assays from a prior drill hole reported 0.8% Cu over 16 metres, but the new holes returned lower grades over shorter intervals. An IP survey was also conducted along the trend of the ore-controlling 105 fault east of the East pit, but no significant anomaly was detected. As well, mapping of limited outcrop disclosed minimal alteration, so no drilling was done. Six core holes west of the tailings impoundment area explored a till-covered area for the source of copper-mineralized granodiorite cobbles. The program was unsuccessful, and mineralized material may have been transported from the Main zone by west-flowing glacial ice.

The Golden Bear gold deposit is a structurally controlled siliceous replacement within dolomitized and carbonaceous limestone, and is characterized by an absence of veining or visible sulphide minerals. Wheaton River Minerals Ltd. concluded heap-leach mine operations in 2001 and began to decommission and reclaim the site. In 2001 gold was produced at a cost of about $US 200 per ounce, but over the five year life span of the heap leach operations Golden Bear produced 8250 kgm (265 000 ounces) of gold at an average cost of $US 170 per ounce. The operation returned $43 million in cash flow, which made Golden Bear the most successful heap leach mine in Canada.

INDUSTRIAL MINERALS AND GEMSTONES

Fireside Minerals Limited mined 15 000 tonnes of barite ore from the East and West Bear pits on the Fireside property (94M 003), which is 125 km east of Watson Lake. Crushing and sorting by jigs resulted in recovery of 10 000 tonnes of barite. The product was trucked to Watson Lake for grinding and bagging, and then stockpiled for sale into the western Canadian oil and gas drilling market. Although the Fireside property was idle in 2000, 2001 production was comparable on a seasonal basis to that in 1998 and 1999.

Nephrite jade was mined from three properties in the Turnagain River area east of Dease Lake. The Jade West Group shipped 100 tonnes from the Polar deposit (104I 083) near Serpentine Lake and 130 tonnes from Kutcho Creek (104I 078). Mining in the Polar quarry uncovered an abrupt thickening of the 0.5 metre thick jade seam and a large block of exceptional quality was recovered. Reputed to be the best ever produced in British Columbia the 18 tonne piece, named Polar Pride, is valued at $US 1 million (K. Makepeace, pers. comm.) but has not been sold, awaiting a special single-piece project. Jedway Enterprises shipped about 60 tonnes of jade from the Blue J claims near Kutcho Creek, and a small amount from the Cassiar waste dump.

The remains of the Cassiar chrysotile asbestos mill, scene of a disastrous fire late in 2000, were cleaned up. An insurance claim was settled, but Cassiar Mines & Metals has not been able to undertake reconstruction and hence the future of the mine remains uncertain.

Cantec Ventures Inc. acquired an interest in the Firestorm precious opal prospect from Dennis Schaefer of Burns Lake. Common and precious opal are developed in boulders of highly vesiculated Tertiary basalt near Maxan Creek, 20 km west of Burns Lake. One stone recovered by Mr. Schaefer has an appraised value of $Cdn 11 000 ($Cdn 4000 estimated actual value). Cantec excavated a series of trenches to determine the relationship between the opal-bearing boulders and underlying bedrock, and to collect a bulk sample. In the trenches, opalized boulders are seen to be disaggregated bedrock (talus or regolith) that directly overlies similar bedrock, and are covered by a thin veneer of glacial till. Opal was recovered from 20 cubic metres of excavated material by washing, screening and hand sorting. Evaluation of the precious opal is ongoing. A canyon exposure near the trenches shows that the basalt comprises a series of vesicular flows and flow breccias, underlain by a rhyolite ignimbrite that is evidently the source of the silica that is leached and redeposited in the basalt (*see* Exploration and Mining in British Columbia - 2001, Part B).

At Whitesail Opal (93E 120), 10 km south of Huckleberry mine, Bruce Holden and Randy Lord continued to prospect for precious opal. Agate and opal mainly replace the matrix of Tertiary basalt breccia. Forest road development has approached to within 2 kilometres of the claims and will alleviate the high cost of helicopter transportation formerly needed to access the property to extract and transport the raw opal. Finished pieces are marketed in British Columbia and the western United States.

The Xeno claims (formerly Kechika Yttrium, 94L 017) cover 11 kilometres of a 20 kilometre-long belt of Paleozoic alkalic igneous rocks (intrusive and extrusive) and carbonatite that is located near the Turnagain River about 140 kilometres east of Dease Lake. Pacific Ridge Exploration Ltd. sampled three areas, mainly for rare earth elements. The RAR 5 is a carbonatite-diatreme complex that is 450 metres long and averages 25 metres in width. Chip samples across the zone contain an average of 3747 g/t total rare earth oxides, notably cerium, lanthanum and neodymium. The diatreme contains altered olivine, garnet and chromium-spinel (W. Roberts, pers. comm.) and a 10 kgm sample is being processed for possible diamond content. Results are anticipated. The RAR 3 zone, a sheared carbonatite that is 2 kilometres long and 12 metres wide, returned 2116 g/t rare earth oxides. RAR 7, the largest zone of syenite and carbonatite, measures 1000 metres by 300 metres. Abundance of rare earth elements, in particular yttrium, dysprosium and europium, vary, but grab samples taken by the company averaged 514 g/t rare earth oxides.

PLACER MINING

By Daryl Hanson, P.Eng.

Placer gold mining in the Atlin and Dease Lake areas continued at a reduced level for the second year. Many operators remain idled by the low gold price, high cost of fuel and scarcity of shallow paydirt. The number of mining projects was down slightly from the previous year at 26, and there were less than half the number of exploration projects (18) as in 2000. There were two large reclamation projects in 2001.

On Ruby Creek in the Atlin district, Ruby Gold Ltd. partnered with Pelly Construction Ltd. to implement a more aggressive mine plan. Pelly's equipment, no longer required at Golden Bear, was used to strip 160 000 cubic metres of overburden and basalt lava that cover rich paygravel in the paleochannel of Ruby Creek (Photo 3). Up to 12 workers were employed. The excavation intersected a drain tunnel, driven in 1926 in granite bedrock just below the gravel contact. The tunnel extends for 300 metres underneath the 100 000 year-old basalt and is still effective in directing groundwater away from the pit, so pumping is not required. An underground drift of the same vintage was also uncovered, but otherwise the area was not mined. The gravel is well indurated, in part by manganese oxides, and required considerable effort to disaggregate, before it could be sluiced. About 40 000 cubic metres were processed. The coarse nuggets of Ruby Creek command a substantial premium above the listed gold price. A similar stripping program is planned upstream from the Ruby Creek - Pelly joint venture by Sisters Resources Ltd. and West Coast Paving Co. Ltd. This year, Sisters Resources and West Coast sluiced 10 000 cubic metres on Wright Creek with limited success.

Photo 3. Rich paygravel in the old channel of Ruby Creek excavated beneath columnar-jointed basalt; two old underground drifts can be seen.

The most notable development in the Dease Lake area is increased activity on Thibert Creek, spurred by the creek's history of significant platinum yield. Taiga Ventures sluiced 25 000 cubic metres of gravel on lower Thibert Creek. Wesley Gwilliam and Trio Gold Ltd. tested further upstream on Thibert Creek and along its tributaries, Vowell and Cache creeks. Elsewhere in the Dease Lake area, Michael Swenson and Ed Asp continued systematic mining on Dease Creek and Goldpan Creek respectively.

MINERAL EXPLORATION

(Refer to Table 2 and Figure 4)

SMITHERS-HOUSTON-BABINE AREA

Pacific Booker Minerals Inc. continued to delineate the Morrison porphyry copper deposit (93M 007). The deposit is centred on an Eocene biotite-feldspar porphyritic granodiorite stock that was emplaced into mid-Jurassic sedimentary rocks of the Bowser Lake Group along the graben-bounding Morrison fault. The standards of work caried out in the 1960s are not adequate for a new feasibility study; 1960s assay samples were based on AQ core, core recovery was poor in some intervals and gold analyses were based on sample composites. In 2001, thirty-nine holes were completed, all were inclined at -45°, they were drilled on a 60 metre grid, and the program employed thin-wall NQ core (Photo 4). This "deposit appraisal" drilling is included in exploration statistics shown in Figure 2. The deposit is characterized by long intervals of uniform copper and gold grades and there are no post-ore dikes. When the new drill program is complete, which is scheduled for March 2002,

Photo 4. Pacific Booker Minerals Inc. geologist, Konstantin Lesnikov, and Tom Schroeter examine Morrison drill core.

the company will contract Kilborn Engineering to calculate an ore reserve. Pacific Booker also contracted preparation of a detailed topographic map.

Doublestar Resources Ltd. cored nine holes on the Copper Star property (93L 326, also known as Chisholm Lake and WG) under an earn-in agreement with Misty Mountain Gold Ltd. In 2000, Misty Mountain identified five IP anomalies. The largest, which is more than one kilometre in length, included a logging road exposure of porphyry copper mineralization at the contact of a (late Cretaceous) Bulkley intrusion. A hole underneath the showing intersected 0.26% Cu over 123 metres in the granodiorite stock but other holes revealed that the geology is more complex than was evident from sparse outcrop. Lithologic units are tentatively identified as Skeena Group sandstone, Endako Group mafic volcanic rocks, and highly pyritic felsic volcanic rocks that might correlate with the Cretaceous Skeena Group or with the Tertiary Ootsa Lake Group. These younger rocks are interpreted to be preserved in a fault basin down-dropped into Hazelton Group andesite. Doublestar terminated its agreement after the drill program and Misty Mountain transferred its interest to Continental Minerals Corporation, an affiliated company.

Several small programs were conducted in the Smithers-Houston-Babine area. Huckleberry Mines Ltd. completed two reconnaissance lines of IP on the Ted zone (93E 086) north of Huckleberry Mountain near Sweeney Lake. No significant anomaly was detected, consequently no drilling was done. Teck Cominco examined mid-Jurassic Hazelton Group rhyolite, that was mapped by Diakow and Koyanagi (GSB Open File 1988-2) near Whitesail Lake. The target was a geologic environment similar to that of the Eskay Creek deposit. Telkwa Gold Corp. performed a transient EM survey over a 16 km grid on their Del Santo VMS prospect (93L 025) southeast of Smithers, but was unable to fund a planned drill program. Jim Hutter, aided by a Prospector Assistance grant, explored Golden Eagle (93L 015), a small past-producer of high-grade silver ore. Excavator trenching uncovered a new ore shoot and VLF-EM detected several parallel conductors that may represent a continuation along strike of the vein structures.

KITIMAT AREA

The British Columbia Geological Survey recently released results of a stream silt geochemistry survey of the Ecstall volcano-sedimentary pendant in the Coast Range. Prior to, and after the May data release, claims were staked on massive sulphide targets. CSS Exploration Inc. acquired the luxta claims (200 units) and Doublestar Resouces Ltd. staked 80 units to surround the Bell lead-zinc showing optioned from prospectors Shawn Turford and Ralph Keefe. Turford and Keefe benefited from Prospector Assistance Grants and continued to prospect the southern continuation of the Ecstall belt. They staked the Dani claims on a base metal occurrence near Cheens Creek on Hawkesbury Island. Doublestar Resources Ltd. subsequently returned the Bell property to the owners.

STEWART-ISKUT DISTRICT

Newmont Exploration of Canada completed 13 holes in two campaigns of drilling on the RDN property (104G 144), 40 km north of Eskay Creek mine, but subsequently returned the property to Rimfire Minerals Corp. Drilling (Photo 5) tested EM conductors in search of precious metal enriched VMS mineralization similar to Eskay Creek. In the Wedge zone, silicified rhyolite was discovered that contained minor sphalerite, chalcopyrite and galena, and traces of tetrahedrite, pyrobitumen and orpiment. The best intercept was 3.7 g/t Au over 1.5 metres. The mineralized rhyo-

Photo 5. Geologists Al Montgomery, David Caulfield and Henry Awmack discuss drill results on the RDN.

lite is overlain by argillite on the overturned limb of an anticline near the Forrest-Kerr fault (A. Montgomery, M. Stammers, pers. comm.). In 1991, prior to recognition that the Wedge zone was an exhalative target, a drill hole by Noranada cut a 2 metre-wide quartz vein that assayed 101 g/t Au.

Midway between Eskay Creek and RDN, Homestake Canada Inc. (now Barrick Gold Corp.) drilled a single 1.4 km deep hole on the PBR property in an attempt to locate the Eskay Creek horizon at the base of a thick pillow basalt sequence. The hole passed through two mudstone units but did not reach the Contact Mudstone. It was abandoned when drilling exceeded its target depth. Pillow basalt extends north from the mine, apparently in a fault basin defined by the Harymel and Forrest-Kerr faults.

Teck Cominco Limited entered the search for an Eskay Creek type deposit with a mapping and sampling program on 580 claim units some 25 km southeast of Stewart. The company investigated Homestake Ridge where Salmon River Formation andesite, rhyolite and mudstone, close to the Hazelton/Bowser Lake Group transition, are intruded by a subvolcanic pluton, one of the Goldslide intrusions. The ridge is littered with trenches and short adits, dating from the 1930's, that tested innumerable gold, arsenic and mercury enriched polymetallic vein occurrences. A stratigraphically lower felsic volcanic unit in the Illiance River area was also explored (G. Evans, pers. comm.). The lower felsic horizon is also associated with a subvolcanic intrusion and a series of mineral occurrences, including Leftover (103P 047), which was interpreted as an Eskay Creek-type target in GSB Open File 1999-2.

The Praxis property, which consists of about 325 claim units, is located 25 km south of Stewart. It was explored by CSS Exploration Inc. for an epithermal massive sulphide deposit, like Eskay Creek. Geological mapping and ground EM followed up on exceptionally strong airborne EM anomalies defined by a survey in year 2000. Eskay-age rhyolite flow-domes, first recognized by a Geological Survey of Canada field crew, are underlain by pillow basalt and overlain by Salmon River pyritic mudstone. The stratigraphic units are similar to those at Eskay Creek but are in a different sequence. Silt samples from drainages that originate in the target area are anomalous in base and precious metals. Prospecting discovered a new pyrrhotite-sphalerite vein occurrence that has significant gold values (G. Hendrickson, pers. comm.).

St. Andrew Goldfields formed a strategic alliance with Dolly Varden Resources Inc. and Heritage American Resource Corporation, to explore for an Eskay Creek type precious metal deposit (G. Laing, pers. comm.). Together with new staking, the companies hold more than 800 claim units in the Stewart-Iskut area. This includes a 50% interest in the Lulu zone (104B 376) on the SIB property, and claims formerly held by Tagish Resources Limited that were acquired from the Court Bailiff. Staking near the Illiance River was in competition with Teck Cominco. An interesting prospect in the Illiance-upper Kitsault area is the Big Bulk (103P 016) where previous work found widespread copper-gold mineralization in a sub-volcanic intrusive body. St. Andrew acquired copies of all assessment reports for the area around Eskay Creek and reports by the Mineral Deposit Research Unit, The University of British Columbia, for computer modeling to derive exploration targets. Expenditures in the area were substantial (R. Billingsley, pers. comm.) and the company appears poised to initiate a major exploration program.

Rimfire Minerals Corp. acquired the Tide property (104B 129) 40 km north of Stewart and just 1 km from the millsite of the former Granduc mine. An important feature of the property is a 2 by 3.5 kilometre gold soil anomaly that is inadequately explained, despite the presence of numerous narrow base and precious metal veins. The gold anomaly overlies the pervasively sericite-pyrite altered northern contact zone of the Summit Lake stock which intrudes coeval Hazelton Group volcanic rocks. The area was previously explored by Newmont Mining and Hemlo Gold Mines Ltd. Although small scale mineralized structures trend east-west, work by Rimfire determined that a 1.6 km north-south feature, named the Arrow fault, might be the locus of high grade mineralization.

Five kilolmetres north of Stewart, Lloyd Rodway drilled eleven holes on his Lloyd claims (also known as Mobile, 103P 069) to test auriferous quartz-base metal sulphide veins. Mountain Boy Minerals Ltd. completed 17 short core holes from two sites 50 metres apart to test the High Grade silver-lead-zinc-barite vein (104A 011) near American Creek, 22 km north of Stewart. The holes failed to intersect argentite and stromeyerite mineralization that was noted in underground workings dating from the 1930's. Two additional holes drilled from a third site tested copper-gold quartz veins. The company elected not to proceed with purchase of the 50% of the Mountain Boy property it does not already own.

CASSIAR-STIKINE-ATLIN AREA

Rimfire Minerals Corporation optioned the Bill property (94E 092) from prospectors Lorne Warren and John Mirko. Located near the head of the Stikine River, 140 km southeast of Dease Lake and 50 km northwest of the Toodoggone district, the Bill has been inactive since 1984. Swarms of auriferous arsenopyrite-pyrite-quartz veins, enveloped by carbonate-sericite alteration, were discovered by Cominco in 1981 during follow-up of silt geochemical anomalies. Subsequent drilling by a Cominco-Dupont joint venture yielded a best intercept of 35 g/t Au over 2 metres. Veins and attendant alteration are developed in chlorite schist over a one by two kilometer area in the core of a structural dome. They fill steep tension fractures that generally cross foliation at high angles, but also occur as foliation-parallel veins and disseminations. The Bill property, and a nearby early Jurassic quartz monzonite, lie within a 10 kilometre wide magnetic depression, which suggests that structural doming of the host rock, gold veins and carbonate-sericite alteration are all intrusion-related (M. Baknes, pers. comm.). The company re-mapped the property and compiled data to evaluate potential for both high grade and bulk tonnage targets. The latter is exemplified by an intercept, recompiled from 1984 drill core, of 1.17 g/t Au over 149 metres.

Silvertip Mining Corporation, a subsidiary of Imperial Metals Corp., performed 10 line kilometres of AMT electromagnetic survey in the area north of the portal on the Silvertip silver-lead-zinc prospect (104O 038). They looked for evidence of mantoes in the McDame limestone or underlying calcareous sandstone of the Sandpile Formation. This is a deeper stratigraphic horizon than targeted by previous exploration, which focused on the Earn-McDame unconformity. However, no anomalies that warrant drilling were found.

Five prospecting programs were partially funded by the Prospector Assistance Program. J. Peter Ross and Egil Livgard each pursued tantalum Regional Geochemical Survey anomalies that are associated with highly evolved granites of the Surprise Lake and Glundebery batholiths respectively, in search of a greisen or pegmatite deposit. These granites comprise part of a 200 km long, east west belt of late Cretaceous plutons that intrude rocks of the Cache Creek terrane. John Hope examined ultramafic-associated PGE and gold targets including the Blue River complex, 30 km north of Cassiar, and a nickel-silica hotspring deposit related to the Nahlin fault. Near the head of the Cottonwood River 145 km southwest of Watson Lake, Robert Russell looked for VMS mineralization in quartz sericite schist of the Paleozoic Ram Creek assemblage. These strata correlate with rocks of the Yukon-Tanana terrane. Erik Ostensoe and Tom Lisle explored a porphyry copper-gold and related epithermal system near Hatchau Lake (104J 015, 021) in the Sheslay district, 40 km northwest of Telegraph Creek.

Regional geochemical survey (RGS) results from the Dease Lake map area (NTS 104J) prompted a private syndicate to stake the Zah claims on a multi-sample tantalum-rare earth element anomaly near the head of Beatty Creek. On the claims, an intense gossan is developed in Quaternary rhyolite and trachyte of the Level Mountain volcanic complex. A mercury occurrence is noted in Minfile. The same group staked two base metal anomalies in the northeast sector of the map-area, looking for a massive sulphide deposit in Paleozoic to Triassic rocks.

ENERGY PROJECTS

Exploration for coalbed methane is proceeding in coal-bearing areas of the Province that are close to markets and gas pipelines. The Telkwa coalfield contains a potential CBM resource of 130 billion cubic feet and, considering its immediate proximity to the PNG pipeline, is well located for development. Auction of CBM rights is expected within one to two years. Sherritt International Corporation became owner of coal licenses at Telkwa by way of its takeover of Luscar Coal Ltd. in February 2001, but no development of the thermal coal deposit took place. No exploration of coal or coalbed methane potential elsewhere in the region, principally the Klappan and Groundhog coalfields, is planned at this time.

Coast Mountain Hydro Corp. investigated an 80-100 megawatt, run-of-river hydroelectric development in the Iskut River canyon, 15 kilometres northwest of Eskay Creek. The site is at the confluence with Forrest-Kerr Creek where Recent eruptions of basalt lava from a cone near Volcano Creek confined and, from time to time, blocked the Iskut River. The project contemplates diverting flow from the river into a 3.3 kilometre tunnel leading to an underground powerhouse. Only 15 megawatts would be generated during low winter flow. Five holes (184 metres total) were drilled, mainly into basalt at the proposed intake site. If built, a transmission line connecting to the Provincial grid will run alongside the Eskay Creek access road and Highway 37. The transmission line could stimulate mine development in the region.

ACKNOWLEDGEMENTS

We sincerely thank prospectors, geologists and engineers, and mine staff for their hospitality while visiting their exploration projects and mines. This review would not be possible without their sharing information. Mine managers improved sections on their respective operations by their comments on an early version of this report. The final version benefited from skillful editing by Bill McMillan.

NORTHEAST-CENTRAL REGION

Bob Lane, P. Geo.
Regional Geologist, Prince George

SUMMARY

Mineral exploration activity in the Northeast-Central region increased marginally in 2001. Exploration expenditures were up by approximately \$0.8 million to an estimated \$7.2 million and the amount of diamond drilling jumped by roughly 13 000 metres to 49 900 metres. The number of major exploration projects increased from 12 to 14. Large drill programs at several porphyry copper-gold prospects generated very encouraging assay results and led to the expansion of mineral resources at the Kemess North deposit and reserves at the Springer zone at the Mount Polley mine. Activity in the Peace River coalfields was up considerably over last year. There was one development project, Willow Creek, and five exploration projects where significant rotary and core drilling took place.

The year 2001 was a turbulent one for mining companies. Depressed metal prices resulted in closure of the Mount Polley copper-gold mine. However, the Kemess gold-copper mine continued to improve its operating efficiency by increasing both throughput and metal recoveries. There was a revival in the coal mining sector province-wide because of the recovery in world coal markets. The Bullmoose metallurgical coal mine benefited from the improved prices and was on pace for record production.

METAL MINES

KEMESS

Northgate Exploration Ltd. owns and operates the large **Kemess** open-pit gold-copper mine located 300 km northwest of Mackenzie. The 50 000 tonne per day operation is in its third full year of production. Total 2001 production is approximately 277 000 ounces gold and 66.3 million pounds copper, both well above levels recorded for the same period in 2000. The average milling rate rose sharply to over 42 000 tonnes per day. Improvements in mill metallurgy, mill availability and throughput have resulted in increased metal recoveries and production. Mining takes place from a single open-pit developed on the Kemess South ore body, a porphyry deposit with proven reserves of 146 million tonnes grading 0.653 g/t Au and 0.235% Cu (as of December 31, 2000). During 2001, Northgate continued its program of operational improvements at the Kemess mine. Capital expenditures of \$4.4 million were made to complete repairs to both of the large ball mills and to install a back-up power transformer.

In 2001, Northgate conducted a 16-hole, 8220-metre drilling campaign on the Kemess North porphyry gold-copper prospect (Photograph 1). The Kemess North deposit, located 6 km north of the Kemess South orebody, is marked by a large gossan that occurs over a 3.5 km east-west strike length. Drilling by previous workers focused on the near-surface potential of the deposit, but deeper drilling by Northgate identified higher grade mineralization over broad intervals. Some of the more impressive drill assay results are: 177.8 metres averaging 1.249 g/t Au and 0.51% Cu in hole KN-01-10, and 248.0 metres averaging 0.91 g/t Au and 0.40% Cu in hole KN-01-11. The drill results led to an expansion of the inferred mineral resource for the zone to 442 million tonnes grading 0.40 g/t Au and 0.23% Cu (using a cut-off grade of 0.6 g/t Au-equivalent). A higher-grade core, estimated to contain 170 million tonnes grading 0.50 g/t Au and 0.29% Cu (using a cut-off grade of 0.80 g/t gold-equivalent), exists within the larger resource.

The Kemess North deposit is characterized by a core zone of intense silicification with well-developed pyrite-chalcopyrite-magnetite stockworks, dilational or ‘crackle’ breccias and true breccias. The silica-flooded zones carry the highest grades of copper and gold mineralization encountered to date. They mainly occur within one or more sill-like monzodiorite intrusions and enclosing basaltic flows of the Late Triassic Takla Group.

Photo 1. Looking southeast toward the Douglas Pass and East Cirque areas. Six holes were drilled in the East Cirque bowl area during the second phase of exploration. All 2001 drilling was helicopter-supported.

The quartz-rich core zone grades outward to a silica-sericite zone, a hybrid silica-potassic zone, where biotite > potassic-feldspar, and peripheral argillic and propylitic zones. No supergene enrichment has been recognized. The geometry of the deposit is not fully understood, but the ore zone has a gentle northeast dip in the Central Cirque and Douglas Pass areas, and a northwest trending post-mineral fault running up the East Cirque truncates the deposit. The little-tested Kemess East geochemical anomaly is located on the east side of this structure, some 600 metres to the southeast, and may be a faulted offset of the Kemess North deposit. An expanded drill program is planned for 2002.

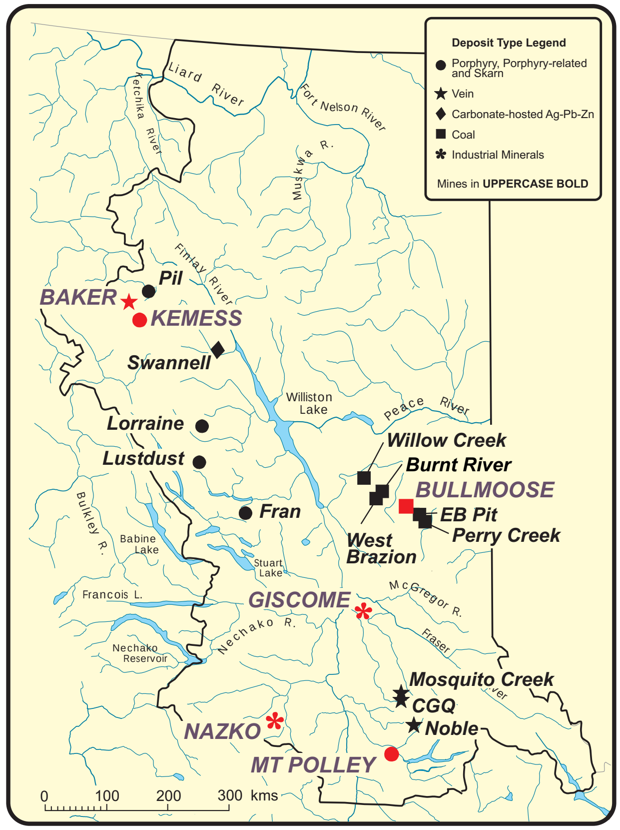

Figure 1. Operating mines and major exploration projects, north-east-central British Columbia - 2001.

MOUNT POLLEY

Due to low metal prices, operations at the **Mount Polley** open-pit copper-gold mine, owned by Imperial Metals Corporation, ceased on October 13, 2001. The mine is located 8 km southwest of Likely and is currently on 'care-and-maintenance' status. There are currently about 8 workers on site compared to a workforce of 240 when the mine was in operation. Mount Polley opened in the fall of 1997, and since start-up has produced approximately 370,700 ounces of gold and 133.9 million pounds of copper from milling 27.7 million tonnes of ore.

Reserves in the Cariboo pit (Photograph 2) were exhausted during 2001, but some reserves remain in the Bell pit. The Springer zone, which has not yet been developed, has been stripped in preparation for mining. Proven reserves at the cessation of mining in October 2001, totaled 31.9 million tonnes grading 0.34 g/t Au and 0.357% Cu.

During the year the company conducted a very aggressive exploration program that was successful in outlining a new zone called the Springer North Extension (SNX). The SNX zone is a 230-metre long, north-northwest trending tabular body that may connect to the Springer zone to the south. It is 50 to 80 metres wide and extends at least 100 metres down dip. The SNX zone is comprised of intrusion breccia associated with albitic, potassic and silicic alteration. The breccia contains very fine-grained disseminations of chalcopyrite and pyrite. Magnetite and actinolite commonly accompany the sulphides.

Photo 2. Reserves at the Cariboo pit, shown here, are exhausted. Development of the Bell pit was well under way when the mine closed.

The company also undertook exploration drilling on the southern margin of the Cariboo pit, on the Southeast zone (discovered in 2000), in the Bell pit, and in the Springer zone area. An 80 000 tonne bulk sample of oxide material was collected from the Springer zone and evaluated for its metallurgy and milling characteristics.

BAKER

Sable Resources Ltd. mined and milled approximately 1300 tonnes of mineralized material from two zones at its **Baker** gold-silver mine located about 40 km north of the Kemess mine in the Toodoggone camp. The ore was mined from surface on the A vein and from an open cut on the B vein. It had an average head grade of less than 44 g/t Au-equivalent. Dore bars were produced from A vein ore and concentrate was generated from the more sulphide-rich B vein ore. Several lines of IP were run over projected extensions of the A and B vein systems and identified several resistivity anaomalies. Six diamond drill holes tested the most promising resistivity anomaly, the TD zone, and intersected a massive quartz-calcite-pyrite vein up to 12 metres wide. While assay results were disappointing, only a portion of the vein was evaluated and drilling will continue in 2002.

COAL MINES

BULLMOOSE

The Bullmoose mine, owned by partners Teck-Cominco (61%), Billiton (29%) and Nissho Iwai (10%), was the only major operating coal mine in the region in 2001. It is located near the town of Tumbler Ridge. It produces medium-volatile bituminous coal from the Gates Formation within the South Fork pit. Production in 2001 increased substantially over last year's level to an estimated 2.1 million tonnes of clean metallurgical coal. Most of the coal produced was sent to Japan to fulfill contract obligations, however, improved coal markets led to several lucrative spot sales. The increased level of production will mean a slightly earlier date of closure, likely in the first quarter of 2003.

Several changes in the mine plan, including a reduction in the strip ratio to 14.7 from 17.4 tonnes of waste per tonne of coal, greatly enhanced the economics of the operation. The current workforce of approximately 250 will gradually be reduced as the operation nears its date of closure. Development of the West Fork pit, which contains 10 to 20 million tonnes of metallurgical and thermal coal, is not expected to proceed.

INDUSTRIAL MINERAL MINES

Canada Pumice Corporation produced 19 000 cubic metres of screened and sized lava from its **Nazko** quarry west of Quesnel. Approximately 11 500 cubic metres was shipped from the site to buyers based mainly in the northwest US and western Canada. The company is continuing to broaden its market base by developing new applications for its products, such as 'green-roof' applications, and by strengthening its existing geotechnical, agricultural and horticultural markets.

In the Prince George area, approximately 300 000 tonnes of railroad ballast were produced from Canadian Pacific Railway's (CPR) **Giscome** basalt quarry and about 200 000 tonnes were produced from British Columbia Railway's (BCR) **Ahbau** basalt quarry.

The region's two limestone quarries, at **Giscome** and **Dahl Lake**, were relatively quiet in 2001 producing minor amounts of crushed limestone for use in local pulp mills and irregular blocks for use in landscaping.

On Highway 16, east of Prince George, Dome Creek Structural Slate Co. drilled, blasted and shipped a limited tonnage of attractive green slate from its **Dome Creek** deposit to markets in Alberta and the Lower Mainland. It is being marketed mainly as a flagstone-type of product.

EXPLORATION TRENDS

Approximately $7.2 million was spent on exploration in the region in 2001 (Figure 2). Figure 3 shows exploration spending (in percent) by deposit type. Exploration drilling increased to 49 900 metres in 2001, up more than 13 000 metres from last year (Figure 4). Approximately 16 100 metres of this total fits into the deposit appraisal category and the remaining 33 800 metres is considered to be exploration drilling (advanced and early-stage). The total number of Notice of Work (NoW) applications received for projects in the region was down slightly from last year (Table 2). This was due primarily to the relatively subdued level of placer activity. There were fourteen major exploration projects (those that involved mechanical disturbance, usually

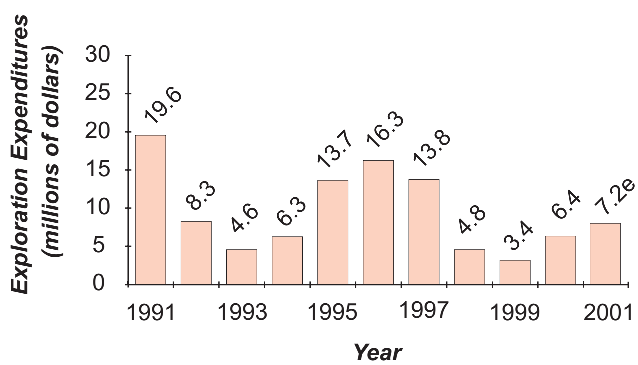

Figure 2. Annual Exploration Expenditures, Northeast-Central Region.

TABLE 1
2001 MINE PRODUCTION AND RESERVES, NORTHEAST-CENTRAL REGION

Mine (Operator)	Employment	Production (approx.)	Reserves (Jan. 1, 2001)
Kemess (Northgate Exploration Ltd.)	440	8615 kg (275 000 oz) Au, 30 000 tonnes (66.3 million lbs) Cu	146 million tonnes grading 0.653 g/t Au and 0.235% Cu
Mount Polley (Imperial Metals Corp.)	240	2070 kg (66 600 oz) Au, 13 600 tonnes (30 million lbs) Cu	32 million tonnes grading 0.357% Cu and 0.34 g/t Au (when the mine closed Oct 13/01)
Baker (Sable Resources Ltd.)	10	1270 tonnes mined with head grade of approx. 44 g/t Au-equivalent	N/A
Bullmoose (Teck-Cominco)	240	2.1 million tonnes of metallurgical coal	Production to continue at 1.7 million tonnes/ year until early 2003
Nazko (Canada Pumice Corp.)	4	19 000 m^3 tephra	44 million tonnes

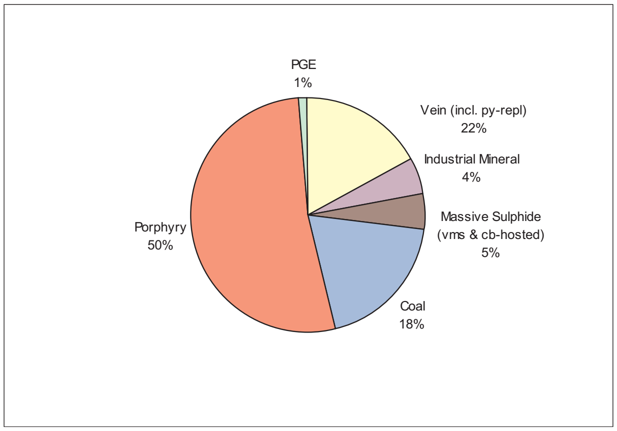

Figure 3. Exploration targets expressed as a percentage of total 2001 expenditures (estimated to be $7.2 million) in the North-east-Central Region.

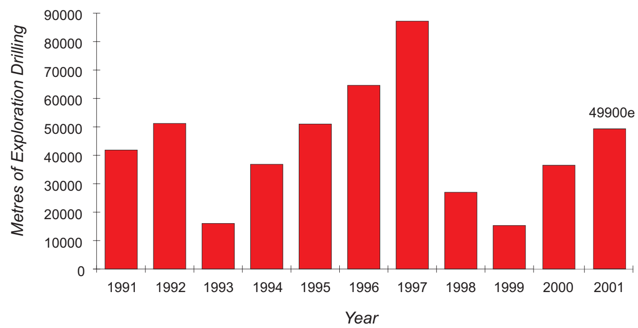

Figure 4. Annual Exploration Drilling, Northeast-Central Region.

diamond drilling and/or trenching, and expenditures in excess of $100 000), two more than in 2000 (Table 3). However, depressed copper and gold prices resulted in several projects being deferred or cancelled (examples are: Gibraltar, Sustut Copper and Pine). Overall, 2001 activity resulted in several excellent exploration successes.

Porphyry copper systems, and in particular those with potential for significant gold enrichment, continue to be the most sought after targets in the region, accounting for more than half of the total exploration spending. Five of the fourteen major projects, including Kemess North, Lorraine, Lustdust, Fran and Mount Polley, focused on gold-enriched porphyry systems and/or related skarn mineralization. Each project generated encouraging drill assay results. They are reviewed in the Exploration Summary section.

There was a 10-fold increase in exploration spending, to about $1.25 million, on metallurgical and thermal coal projects in the Peace River coalfields in 2001 compared to 2000. This increase stemmed from a sudden turn-around in world coal markets and coincided with a re-assessment of the coalbed methane potential of the northeast. The five major coal projects were Burnt River, West Brazion, EB, Perry Creek and Willow Creek. The latter project also included extraction of a bulk sample, or trial cargo, that was sent abroad for test marketing.

EXPLORATION SUMMARY

GATAGA / KECHIKA TROUGH

The Sedex lead-zinc-silver belt was not active during 2001.

TOODOGGONE CAMP

With the exception of the major drill program at Kemess North, exploration activity in the Toodoggone region was limited in 2001. However, there were a number of small programs targeting either epithermal gold-silver vein systems or porphyry copper-gold prospects.

Finlay Minerals Ltd. conducted a multi-disciplinary reconnaissance-style program, consisting of line-cutting, Induced Polarization (IP) and magnetometer surveys, soil geochemistry and prospecting, on their **Pil** porphyry copper-gold property. The property is centered approximately 35 km north of the Kemess mine and is host to numerous copper and/or gold geochemical anomalies and showings, many of which coincide with IP chargeability and magnetic highs. The 2001 program focused on the Pil North area of the property, where intermediate volcanic rocks of the Lower Jurassic Toodoggone formation are in contact with conspicuous, rusty-weathering quartz monzonitic to syenitic phases of the Early Jurassic Black Lake intrusive suite. Limited infill geochemical sampling was also con-

TABLE 2
NOTICE OF WORK (NOW) SUBMITTALS FOR PROJECTS IN THE NORTHEAST-CENTRAL REGION

Type of NoW	**Year**						
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Mineral	221	184	164	115	86	112	109
Placer	498	440	415	403	393	422	397
Coal	3	4	5	5	2	1	9
Other	67	58	57	56	42	33	34
Total NoW	**789**	**686**	**641**	**579**	**523**	**568**	**549**

TABLE 3
MAJOR EXPLORATION PROJECTS, NORTHEAST-CENTRAL REGION

Property (Owner)	MINFILE	NTS	Commodity	Deposit Type	Work Done
Bonanza Ledge (International Wayside Gold Mines Ltd.)	093H 019	93H/4E	Au	replacement(?), mesothermal vein	22ddh, 5156 m; IP, SP, prosp
Burnt River (Western Canadian Coal Corp.)	093P 007-008	93P/5W	coal	sedimentary	14 rdh, 900 m; spot coring
Fran (Navasota Resources Ltd.)	-	93N/1W	Au, Cu	porphyry	5 ddh, 993 m; geol, geochem
Ingenika/Swannell (Cross Lake Minerals Ltd.)	094C 002	94C/11E	Ag, Pb, Zn	manto, carbonate-hosted	3 ddh, 401m; geochem
Kemess North (Northgate Exploration Ltd.)	094E 021	94E/2	Au, Cu	porphyry	16 ddh, 8220 m;
Lorraine (Eastfield Resouces Ltd.)	093N 002	93N/14W	Au, Cu, PGE	magmatic-porphyry	13 ddh, 2508 m;
Lustdust (Alpha Gold Corp.)	093N 009	93N/11W	Au, Ag, Zn, Cu, Pb	skarn, manto, porphyry	18 ddh, 5609 m; geol
Mosquito Creek Gold (Island Mountain Gold Mines Ltd.)	093H 010	93H/4E	Au	pyrite replacement	7 ddh, 1224 m; prosp; geochem; IP
Mount Polley (Imperial Metals Corporation)	093A 008	93A/12E	Au, Cu	porphyry	41 ddh, 6696 m; 170 pdh, 9421m; geol
Noble (Noble Metal Group Inc.)	-	93A/13E	Au	placer, lode	12 pdh, geol
EB (Western Canadian Coal Corp.)	093P 015	93P/3W	coal	sedimentary	20 rdh, 1800 m; spot coring
Perry Creek (Western Canadian Coal Corp.)	093P 015	93P/3W	coal	sedimentary	16 rdh, 2000 m; spot coring
West Brazion (Western Canadian Coal Corp.)	093P 006	93P/5W	coal	sedimentary	8 rdh, 700 m; spot coring
Willow Creek (Pine Valley Coal Ltd.)	093O 008	93O/9E	coal	sedimentary	26 rdh, 1950 m; spot coring; 40,000 tonne trial cargo

ducted in the Pil South area. The Lorne showing at Pil South consists of silicified and fracture-controlled pyrite-chalcopyrite in chloritic augite-phyric volcanics. A one-metre chip sample from the showing assayed 0.928% Cu. The zone is several tens of metres across, sits on the edge of a significant IP anomaly, and is part of a northwest-trending structure whose dimensions are unknown.

Canasil Resources Inc. conducted a modest program of prospecting and geochemistry on its **Brenda** porphyry copper gold property immediately west of the Pil property. The White Pass zone area is marked by intense alunite alteration. Past trenching and drilling have produced impressive gold-copper assays.

A limited program of sampling and geological mapping was conducted by Guardsmen Resources Ltd. on a geophysical anomaly that lies between the Cliff Creek zone, part of the former **Lawyers** mine, and the **Silver Pond** prospect. Guardsmen confirmed the presence of 'bonanza-grade' epithermal gold mineralization and will revisit the property in 2002.

OMINECA MOUNTAINS

The **Lorraine** copper-gold property of Eastfield Resources Ltd., is located in the Swannell Ranges of the Omineca Mountains about 190 km northwest of Fort St. James. The property is under option from Lysander Resources Ltd. and covers 240 square km that is underlain mostly by alkalic rocks of the Early Jurassic Hogem batholith. Sulphide mineralization at Lorraine consists of both net-textured magmatic and disseminated to stockwork porphyry zones. A series of northwest-trending mineralized panels, including the Bishop, Upper Main (Photograph 3) and Lower Main zones, were drilled during the company's 13-hole, 2500-metre diamond drilling program. The most encouraging assays came from holes drilled on the Bishop and Lower Main zones. Hole 2001-58 intersected two mineralized intervals in the Bishop zone, the lower one averaged 0.59% Cu and 0.11 g/t Au over 69.8 metres. Hole 2001-60, drilled just south of the Lower Main zone, intersected 113.2 metres grading 0.76% Cu and 0.49 g/t Au. Both zones are still open to the south; they may connect along strike and could coalesce at depth. The present geological resource estimate for the property is 32 million tonnes grading 0.66% Cu, 0.17 g/t Au and 4.7 g/t Ag. Drilling is expected to continue at Lorraine in 2002.

The **Fran** property, located 70 km northeast of Fort St. James, was drilled by Navasota Resources Ltd. The property hosts several gold-bearing sulphide vein/shear showings that were discovered by Richard Haslinger in 1997. He optioned the claims to Cassidy Gold Corp. early in 2001. Navasota is earning a majority interest in the property from Cassidy through its work program. The 5-hole, 992-metre diamond drilling program was designed to test for gold-bearing porphyry mineralization related to shear/vein zones. Underlying rocks are fine-grained volcanic sediments and cherty argillites of the Upper Triassic Takla Group (Inzana Lake succession) and granodiorite of the Lower Jurassic Kalder pluton. Drilling is taking place in the area between the 'Upper' and 'Lower' showings within a l500 metre long northwest-trending gold geochemical anomaly. Grab samples from the Lower showing graded more than 40 g/t Au. Mineralization occurs in both the intrusive and hornfelsed sedimentary rocks and consists of polymetallic quartz veins and sulphide stockwork zones. The most encouraging result was a 16-metre intersection from hole FR-002 that averaged 2.01 g/t Au (with traces of copper). The company is planning to return to the property early in 2002 for follow-up drilling.

The 40-unit **Duncan** property covers a series of high-grade copper veins and shears hosted by Early Jurassic alkalic intrusive rocks of the Hogem batholith. It is located immediately south of the Lorraine property and south of the Omineca River. The showings were discovered and staked in 2001 by prospector Richard Haslinger.

The **Lustdust** polymetallic prospect of Alpha Gold Corp., located 210 km north-northwest of Prince George, was the target of another aggressive diamond drilling campaign in 2001. The property lies immediately west of the Pinchi fault. It is underlain by deformed sedimentary rocks of the Permian Cache Creek Group that have been intruded and altered by a monzonitic stock and a series of feldspar megacrystic dikes and sills. Age dating has shown that the stock is Eocene (Ray *et al*, 2002), like the productive Babine porphyry suite to the west. Auriferous, polymetallic vein, manto, skarn and porphyry-style mineralization occur over a strike length of 2.5 km.

Photo 3. Project geologist Jay Page standing on the Upper Main zone, Lorraine property.

The company drilled 18 holes for an aggregate length of approximately 5600 metres. Many of the drill-holes tested magnetic anomalies on the north side of Canyon Creek, where porphyry-style alteration and mineralization had been previously identified. The company intersected fracture-controlled molybdenite with pyrite and traces of chalcopyrite within monzonite with weak potassic alteration, but grades were generally low. Other holes targeted auriferous skarn mineralization and produced some very encouraging results, including a 59-metre intersection in hole DDH-44 that averaged 0.67 g/t Au and 0.8% Cu. Drilling in 2002 is expected to focus on the gold-bearing skarn mineralization in the vicinity of Canyon Creek.

Cross Lake Minerals Ltd. completed 3 drill holes totaling 401 metres on its **Swannell** lead-zinc-silver property, located 100 km north-northwest of Germansen Landing. The holes intersected narrow (1.0 to 4.5-metre) intervals of sphalerite-galena-pyrite mineralization within silicified Cambrian dolostone. Assays ranged from 4.5% to 10.8% combined Pb-Zn with up to 28.2 g/t Ag. The company also completed a soil survey over part of the Swannell property and the adjoining Pb-Zn-Ag **Ingenika** property, which lies immediately to the north. Several multi-element anomalies were identified and additional follow-up work is being considered for next field season.

Cross Lake Minerals also drilled 2 holes totaling 146 metres on their **End Lake** carbonate-hosted lead-zinc-silver property, located 48 km north-northwest of Germansen Landing. Drilling took place near two old adits that were driven to evaluate sphalerite-galena-pyrite mineralization in altered Cambrian limestone. Low assay results will result in a thorough review of the property before any further work is conducted.

ROCKY MOUNTAIN FOOTHILLS/ PEACE RIVER COALFIELDS

The exploration boom in the Peace River coalfields during the 1970's and 1980's led to discovery of a number of large coal deposits. Most of the deposits were not developed due to a combination of weak markets and lack of necessary infrastructure (*e.g.* roads, rail and power). Many deposits in the Peace River Coalfields host high quality coking coal that wash well to a low ash content (6-8%), have low sulphur and moderate/low phosphorous contents, and have fluidity characteristics similar to coals from the Quintette and Bullmoose deposits. Other deposits contain coal suitable for Pulverized Coal Injection (PCI), a partial replacement for coke in the steel making process.

There are eleven deposits in the Peace River coalfields with development potential. They are: Saxon, Belcourt, Monkman, EB North, Perry Creek, Sukunka, Burnt River, West Brazion, Lossan, Willow Creek and Carbon Creek. Many of these deposits received an advanced level of exploration decades ago, including extensive drilling, underground development and bulk sampling; in some cases resources were defined. In 2001, the Wolverine Group (EB

North and Perry Creek), the Brazion Group (Burnt River and West Brazion) and Willow Creek deposits were explored and/or developed.

The **Willow Creek** property, which is 45 kilometres west of Chetwynd, has a mine permit. The project is owned by Globaltex Industries (67%) and Mitsui Matsushima of Japan (33%). The operator, Pine Valley Coal Ltd., began to develop the deposit late in 2000 and in 2001 mined and shipped 36 000 tonnes from the '7 seam' in the Peninsula Pit area (Photograph 4). The company also conducted diamond drilling outside of the pit area to guide future development of the property.

The coal measures are within the Cretaceous Gething Formation and occur on the east limb of the Peace River anticline. The coals are low-volatile bituminous in rank and are suitable for PCI and thermal markets. The project is permitted for annual production of 900 000 tonnes per year using a conventional wash plant. However, the company recently produced a revised mining proposal that envisages mining and shipping 200 000 tonnes/year of raw coal from the Peninsula Pit area. The bulk of the coal would come from the low strip-ratio '7 Seam' that is brought close to surface by a series of minor folds. Approximately 830 000 tonnes (run-of-mine) are found in this area. The raw product would have an ash content of 9%, an average of 15.7% volatile matter, an average sulphur content of less than 0.6%, and be suitable for direct shipping. Plans for 2002 include expansion of the Peninsula pit to produce a second trial cargo of approximately 60 000 tonnes. Current established mineable reserves for the property total 15.6 million tonnes.

Western Coal Corp., a 100%-owned subsidiary of Western Canadian Coal Corp., explored four of its properties in the Peace River coalfields in 2001. Most of the work consisted of air-rotary drilling with spot coring of coal seams on the Perry Creek and **EB** deposits. This work is expected to confirm or enhance resources and more accurately characterize the coal quality of the two deposits. These deposits, referred to as the Wolverine Group, lie between the Bullmoose and Quintette mines, some 25 to 30 km west of Tumbler Ridge. The coal measures of particular interest occur in the Lower Cretaceous Gates Formation.

Photo 4. Loading coal in the Peninsula pit, Willow Creek coal project.

The coal is regarded as medium-volatile bituminous of metallurgical quality.

The **Perry Creek** deposit occurs in a broad syncline with gently dipping limbs. Sixteen drill holes were completed in 2001 and targeted the J seam, which is split into the J1, J2 and J3 divisions, that has a cumulative thickness of more than 5 metres. Data from these holes should enable the company to revise the resource for the area; target tonnage is 35 million tonnes.

The EB deposit is about 5 km due west of Perry Creek. Twenty holes were completed for a cumulative length of about 2000 metres. Coal measures occur in multiple seams that are relatively uncomplicated by structure. Seams A to D (same nomenclature as at Bullmoose) have a combined thickness of 12 metres over a 60-metre interval. The EB deposit has an in-place resource of more than 19 million tonnes.

In December, Western Canadian Coal submitted a Stage 1 project report to the B.C Environmental Assessment office for review. The proposal outlines a combined open-pit / underground operation that would produce between 1.5 and 2.0 million tonnes of coal annually. Coal from the Perry Creek underground and EB open pit would supply a centrally located washplant. Proximity to the existing BC Rail line and to other strategic infrastructure greatly reduce development costs. The company plans a late-2003 or early-2004 startup.

Western Canadian Coal also owns coal licenses over the **Brazion**, Burnt River and **West Brazion** deposits, located along the same trend, but further to the northwest.

At the **West Brazion** property six to eight holes tested Upper Gething Formation coal seams that are exposed on the flanks of a plateau immediately south of Brazion Creek. Strata are gently inclined to the south and the coal measures are relatively close to surface. The main target is the 'Discovery' seam that has a cumulative coal thickness of 3.8 metres within a 5.5 m total thickness (including partings). Total coal thickness is 8 to 9 metres within a 70-metre interval. Relatively little exploration has taken place at West Brazion, but limited early work suggests that the coal is coking quality, amenable to low cost mining and worthy of re-evaluation.

The **Burnt River** property is about 10 km east of the West Brazion property. Drilling in 2001 targeted Gething Formation coal seams of the Dillon structure, a narrow northwest-trending syncline that has a gentle southeasterly plunge. This coal-bearing structure occurs immediately northeast of another shallow, broader syncline that was the focus of past exploration by Teck Corporation. Teck conducted a substantial evaluation of the deposit that included drilling of more than 230 drill holes, development of 3 adits and excavation of two small pits from which a 43 000 tonne bulk sample was extracted. This work identified 23 million tonnes of coal at low strip ratios. There are two seams of interest in the Dillon structure, an upper one that is about 3 metres thick and a lower one that is about 6 metres thick. In 2001, fourteen holes totaling 900 metres were drilled. Burnt River coal is classified as low volatile bituminous/semi-anthracite and is suitable for PCI markets.

A number of causes are responsible for recovery of the coal mining sector in British Columbia. They include: the recent and ongoing restructuring and consolidation of the coal mining sector; recovery of the metallurgical and thermal coal markets; increased energy demands (i.e. electric power generation/provision for local and US markets); expanding and/or developing 'niche' markets (i.e. PCI); and coalbed methane potential. Data collected from other coal exploration also benefits the coalbed methane sector.

There is a limited history of **coalbed methane** (CBM) exploration in northeast British Columbia. However, recent increases in the price of natural gas have led to renewed interest in the potential of this untapped resource. The Peace River coalfield contains an estimated 60 to 200 Trillion cubic feet (Tcf) or 1700 – 5700 billion cubic metres of methane. The rights to specifically explore twelve parcels of land in northeast British Columbia for CBM were sold in August 2000, and August 2001, for a total of approximately $13 million. Companies involved are AEC, BP/Northstar and Koch. Seven CBM well locations have been licensed and four of the approved sites were drilled in 2001. Exploration expenditures over 2000-2001 are estimated to have been $10 million.

NECHAKO PLATEAU

The Nechako Plateau area saw little activity in 2001, but several small programs did proceed. Castle Metals conducted limited prospecting on the **Laidman Lake** and **Holy Cross** gold properties located south of Vanderhoof and on the **Clisbako** property located west of Quesnel. The Holy Cross and Clisbako properties host epithermal gold mineralization within altered intermediate to felsic volcanics. Both prospects have potential for bonanza grades. The Laidman Lake property hosts several zones of auriferous quartz vein stockwork within quartz monzonite and is more of a bulk tonnage target.

Prospecting Assistance Program grantee Robin Day outlined a 100-metre wide by 4-kilometre long east-trending zone of hematitic breccia north of Finger Lake, called **Iron Knoll.** Underlying rocks are andesitic volcanics of Jurassic or Triassic age that may be coeval with the Brooks diorite complex. The zone is coincident with an aeromagnetic high, however the breccias exposed at surface are not magnetic, although they are weakly anomalous in copper. The hematite may be the surface expression (oxidized) of a buried magnetite-rich, copper-gold system (i.e. Iron Oxide Gold-Copper model).

CARIBOO

Mineral exploration activity in the Wells-Barkerville area, known for its placer gold mining history and three lode gold mines, slowed somewhat in 2001. Overall, there were fewer programs and a lower level of expenditures. The belt is underlain by isoclinally folded phyllitic argillites, psammites and limestones of the Paleozoic Snowshoe Group

The largest exploration program in the Cariboo region was conducted by International Wayside Gold Mines Ltd. on its **Cariboo Gold Quartz** property located immediately south of Jack of Clubs Lake. The company drilled 25 NQ holes focusing on the high-grade gold **Bonanza Ledge** zone, discovered in 2000, and its potential extensions along trend to the northwest (Wells Trend) and southeast. Encouraging assay results from numerous holes extended the strike length of the 'replacement-style' mineralization and alteration to over 1000 metres. The system has been traced beyond several late brittle structures and has been confirmed in the hanging wall of the BC vein. The best intersections are 6.7 metres in hole BC01-11 that averaged 7.68 g/t Au, and 13.2 metres in hole BC01-15 that averaged 5.97 g/t Au. Three of the holes were drilled on the Wells Trend gold geochemical anomaly, centered approximately four km northwest of Bonanza Ledge. They intersected "Bonanza Ledge-style" alteration and a discrete auriferous quartz vein.

The **Grouse Creek** project of sister company Golden Cariboo Resources Ltd. consisted of a program of prospecting and geochemical sampling of several claim groups that are along strike southeast of the Bonanza Ledge discovery. The program identified 'magnetite porphyroblastic' chlorite phyllite, which forms the hangingwall unit at Bonanza Ledge, but no assays from the program have been released.

At **Mosquito Creek Gold**, Island Mountain Gold Mines Ltd. drilled seven holes focusing mainly on the Kutney zone, an area formerly explored by Newmont Exploration of Canada Ltd. Drilling evaluated the down plunge potential of some high-grade pyrite replacement mineralization in impure limestones in which a 3-metre channel sample assayed 15.8 g/t Au.

Eureka Resources Inc. conducted limited geochemical and geophysical surveys on its **Lottie Lake** volcanogenic massive sulphide property north of Wells. The property is underlain mainly by cherty argillite and basalt of the Mississippian-Permian Antler Formation (Slide Mountain Terrane). Five lines of IP were added to last years survey and delineated two strong east-trending conductive zones. The zones are 300 metres and 400 metres in length, and occur south of the main high-grade float area. Eureka completed two short diamond drill holes to test these targets in late September. Details and assay results have not yet been released.

West of Wells, partners Mel Zeiler and Gary Toop trenched a polymetallic mesothermal vein system on their **GM** property. A series of discrete quartz veins and stockworks carrying galena and pyrite, with lesser sphalerite and chalcopyrite, cut schists and quartzites of the Snowshoe Group. A grab sample from one of the veins assayed 786 ppb Au, 134.6 ppm Ag and >10000 ppm Pb.

LIKELY AND HORSEFLY AREAS

Fjordland Minerals Ltd. outlined two large chargeability anomalies on its **Woodjam** gold-copper property near Horsefly. The property includes the Megabuck prospect, where silicified and propylitized intermediate flows and breccias of Eocene age contain stringers of chalcopyrite and magnetite. The company intends to conduct a diamond drilling program early in 2002.

A three-hole diamond drill program by partners Herb Wahl and Jack Brown-John tested several sulphide-bearing shear zones on their **Rodeo-Luky Jack** porphyry-related prospect south of Horsefly Lake. However, results did not match expectations.

PLACER MINING AND EXPLORATION HIGHLIGHTS

By Ken MacDonald, P.Geo.

INTRODUCTION

The placer sector in the northeast-central region remained at a relatively low level of activity that mirrors the overall general decline encountered over the past several years. Accurate estimates of expenditures on exploration and testing are unavailable but are roughly estimated at between \$1.49 and \$2.24 million, thought to be down from year 2000. There was only one significant production mine recorded in the region (where volume of washed paydirt exceeded 2000 m^3) and fewer mid-sized projects active this year. Many operators were inclined to continue modest testing programs for assessment purposes.

Overall, the amount of new ground explored and material processed decreased. High fuel costs and low commodity prices contributed significantly to the decline. A total of 86 965 hectares of ground was held under placer tenure (excluding crown grants), which is virtually the same coverage from the previous year.

TRENDS

The continued downward turn in placer mining activity is reflected by the relatively low number of Notice of Work (NoW) applications submitted to the Prince George Mines Branch office. A total of 397 placer NoWs were filed, compared to 422 in 2001. Of the total, 213 NoWs were for mechanical testing and 184 comprised handwork. This corresponds to a general shift over time from mechanical testing when commodity prices and fuel costs were more favorable, to the situation today when relatively few operators are inclined to run expensive testing equipment or engage in large-scale production.

Of the programs conducted, all but one program consisted of exploration testing and most tended to be less than the applicant had originally planned. A total of 80 programs were conducted, and ranged from 1 m^3 to 4600 m^3 of paydirt washed. The total volume of production planned was about 121 000 m^3, while actual recorded production amounted to about 30 000 m^3, a decline of 75%.

In terms of significant placer production, only one program exceeded 2000 m^3 of paydirt compared to year 2000 in which six programs exceeded 2000 m^3. No information is available on the quantity of gold recovered or the grade of material washed.

Many operators who failed to conduct their planned program either completed hand testing or paid cash in lieu of assessment work to maintain tenure. Operators have given a variety of reasons for cancelled programs, ranging from under-valued gold prices; lack of capital for equipment, parts, or fuel; inability to raise reclamation security; health issues; or employment in other sectors during the seasonal months.

SIGNIFICANT PROGRAMS

GERMANSEN-MANSON (OMINECA CAMP)

The largest program, and only property from which production was recorded, occurred in the Omineca region. J.M. Thomas of Angel Jade Mining completed bulk testing from ten pits on Manson Creek for a total of about 4600 m^3 of paydirt washed (Photograph 5). Some infill testing is planned for the coming season to continue determination of grade and volume.

On nearby Slate Creek, Robert Gauthier completed a modest program of testing and small-scale mining from three main pits and recorded about 1000 m^3 of paydirt processed. Gauthier also tested ground on Killdare Creek (Manson Creek) where he developed three main mine pits and tested gravels from ten satellite pits.

One noteworthy program on a property located peripheral to the main Germansen-Manson camp was conducted by V. Pogorevc (Photo 6). Mr. Pogorevc tested about 1000 m^3 of gravel on McConnell Creek over a period of sixteen weeks. Using creative welding, fabrication from old sluice parts, and a well-honed and superior knowledge of recovery, Pogorevc has built a unique washplant that incorporates several basic designs to improve recovery rates of fine-grained gold.

WELLS-BARKERVILLE (CARIBOO CAMP)

F. Nestle continued testing his extensive holdings on Summit Creek near Barkerville. Work in the past several years has focused on small, buried, bedrock channels.

Photo 5. Excavating material from paystreak on Manson Creek, Angel Jade Mining.

Photo 6. View of washplant and clean-up jig on McConnell Creek, V. Pogovevc.

However, groundwater and depth of pay continues to frustrate efforts to fully expose the source of auriferous gravels.

R. McMuldroch excavated a couple of test pits on his property near Stanley, on an unnamed southern tributary to Lightning Creek. Many of the historic underground placer workings in the Stanley area targeted bedrock benches and timbered remnants of drifts have been exposed from recent exploration work.

G. Jennex was active on his Burns Creek ground and continued limited testing of about 1500 m^3 of paydirt from an area made famous by the discovery of the Hatton Nugget.

S. Koscis operated immediately west of the Thistle Pit in an attempt to uncover the buried remnant of shallow pay gravels that may have survived glacial erosion. The Thistle pit historically produced 20,000 ounces of gold in the early 1900s. Koscis was also busy testing paleochannel gravels at nearby Eight Mile Lake, where auriferous gravels have previously been documented sandwiched between two till units (Levson and Giles, 1993).

M. Young completed testing in and around the rim of an old hydraulic pit on upper Summit Creek, but recovery is believed to have been hampered by small throughput and undersized equipment.

Further west toward Quesnel, K. Thompson and his partner worked a low terrace on the Cottonwood River, downstream from Cottonwood Canyon. Total throughput was about 1300 m^3 of paydirt from one main mine area. Recovery was hampered by the presence of clay partings.

Upstream of Thompson, R. Krekowski continued testing a dry and abandoned oxbow channel on the south shore of the Cottonwood River. Gold is reported to be very fine and difficult to recover with his conventional washplant. He washed about 1100 m^3 of paydirt over a four-week period.

LIKELY-KEITHLEY CREEK (CARIBOO CAMP)

Noble Metals was unable to complete plans for a major stripping program on its Keithley Creek lease and settled for limited production of about 1400 m^3 of paydirt from their main mine pit. The most recent mining removed thick overburden down to the bedrock surface, with the mine expanding upslope as funds are made available for stripping. Workers were also busy with ongoing reclamation, including the remediation of an old pond and berm road located near the confluence of Keithley and Snowshoe Creek.

K. Green continued limited testing using a very unique aerial slusher to excavate shallow (<1m deep) gravel lenses located in the sub-alpine above Snowshoe Creek. The operator has designed a small bucket conveyance suspended from a spar pole, similar to an underground tugger winch. Using creative welding and ingenuity, Green can single-handedly tug and dump to a conventional trommel using winch controls and hydraulics.

HIXON CREEK AREA

D. Romanow began testing ground adjacent to the old Quesnelle Gold Quartz mine on Hixon Creek. Results were disappointing and no further work is planned. B. Tomm completed several programs of exploration on adjacent leases on Hixon Creek. One program consisted of excavation and processing of 500 m^3 of paydirt from one mine pit. I. Broadfoot and partner B. Prothero continued testing on a large lease located on Terry Creek. About 2000 m^3 of paydirt was processed from three mine pits.

RECLAMATION

Daniel Romanow was awarded the 2001 Placer Citation for meritous placer reclamation by the Technical and Research Committee for Reclamation in BC. Mr. Romanow received the award in recognition of the outstanding reclamation completed on the Grace lease located near Barry Creek in the Tregillus Lake area.

CONCLUSION

Placer activity during 2001 decreased slightly from the level witnessed in the previous year. Following a trend that has continued over the past several seasons the average size of an operation and the total exploration expenditures have continued to decrease, mainly in response to depressed gold prices and rising fuel costs. Other reasons for the decline range from seasonal employment in other sectors, lack of capital and health issues.

It is expected that development and testing in 2002 will remain at about the same levels that the region has experienced during the past several years unless unforeseen events decrease fuel costs and increase gold prices. The major focus will continue to be the traditional streams and creeks in the Wells-Barkerville, Likely, Hixon and Germansen River-Manson Creek placer gold camps.

OTHER INFORMATION

The Prospectors Assistance program awarded grants totalling $79 129 to support nine grassroots exploration projects in the region. The projects targeted a range of commodities including industrial minerals, copper, gold and platinum group elements.

During the 2001 field season, staff of the British Columbia Geological Survey Branch conducted several programs in the region. Fil Ferri and Brian O'Brien examined the stratigraphic and structural setting of massive sulphide mineralization hosted by Late Proterozoic to Paleozoic Snowshoe Group rocks in the Cariboo Lake area of the Wells-Barkerville belt. In the Omineca Mountains, Gerry Ray and Ian Webster completed a detailed examination of styles of mineralization at the Lustdust polymetallic property. In the Peace River coalfields, Barry Ryan evaluated the characteristics of Gething formation coal from the Willow Creek deposit and Andrew Legun reviewed coalbed methane geology of northeast British Columbia. Vic Levson investigated the platinum group element content of placer deposits throughout the province with the intent of identifying unrecognised lode sources. Results from these programs are published in the annual Geological Survey Branch 'Fieldwork' volume (Geological Fieldwork 2001, Paper 2002-1) and/or as 'Open File' maps or reports.

OUTLOOK FOR 2002

The level of exploration is expected to increase sharply in 2002. The main metal targets will be gold-enriched porphyry copper deposits, epithermal and mesothermal gold vein systems, and volcanogenic massive sulphide deposits. Activity in the Peace River coalfields will emphasize advanced exploration and development.

ACKNOWLEDGEMENTS

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SOUTHWEST REGION

Jacques Houle, P.Eng.
Regional Geologist, Nanaimo

SUMMARY

The year 2001 began in the Southwest Region with great anticipation for both a dramatic increase in exploration activity and continued stability in mineral production. However, as happened in many other parts of the world during the latter part of the year, declining metal prices and reduced demand for industrial minerals, along with a bear investor market caused the deferral of some major exploration projects and the suspension of operations at the region's only metal mine. As a result, the overall level of activity is about the same as in 2000 but with one profound difference: the number of major exploration projects increased from three to eight. Most activity took place on Vancouver Island and in the Hope - Harrison Lake area.

Boliden-Westmin (Canada) Ltd. was on its way to an outstanding year at the Myra Falls Cu-Zn-Au-Ag operation within Strathcona Park on central Vancouver Island. The company met or exceeded all production targets during the first three quarters. However, as a result of factors both within and outside of the company, Boliden announced a decision to suspend mining and milling operations at the mine at the end of November 2001. The company also completed corporate re-domiciliation from Toronto to Stockholm, and decided to focus solely on its Scandinavian operations. It is attempting to sell the Myra Falls Operation. Exploration at the mine, which continued to focus on upgrading known resources close to existing infrastructure, was successful in 2001.

Hillsborough Resources Corporation continued mining and shipping coal from the Quinsam Coal Mine near Campbell River on Vancouver Island. Thermal coal produced is sold to markets in the Pacific Northwest. Exploration at the mine resumed in 2001, and was successful in building additional coal reserves in the 7-South Area. Exploration drilling commenced in the Quinsam East area as well. Hillsborough also commenced a major surface and underground exploration program at its T'Sable River Project south of Courtenay on Vancouver Island and are investigating the coal bed methane potential of their land holdings on the island.

Priority Ventures Ltd. initiated a new coal and coal bed methane exploration drilling program at the Dove Creek Project west of Courtenay on Vancouver Island. The initial three-hole program discovered multiple seams of possible coking coal and confirmed the presence of methane gas. Follow-up drilling programs planned for 2002 will target both coal and coal bed methane. It should be noted that coal bed methane exploration and production in British Columbia is monitored by the Oil and Gas Commission, and is not included in Mines Branch statistics.

Several high potential metallic exploration projects are being undertaken by under-funded junior companies on Vancouver Island. Two of these with sporadic activity in 2001 were: SYMC Resources Ltd.'s Macktush and Dauntless Projects near Port Alberni, and Newmex Minerals Inc.'s Privateer and Golden Gate Projects near Zeballos. At Macktush, SYMC completed trenching and shallow diamond drilling of gold quartz vein targets. As well, the company completed successful prospecting for porphyry copper-gold-molybdenum mineralization on the Macktush property and for copper skarn mineralization on the Dauntless property. Bulk sampling and shallow diamond drilling is planned in early 2002 for the Dauntless Project, located immediately north of Macktush. At Privateer, Newmex completed underground exploration drifting and raising on new, high-grade gold quartz veins discovered within the old mine workings. Surface exploration work was commenced on its extensive land position centered on the Golden Gate prospect, near Zeballos, another past gold producer.

In the Hope - Harrison Lake Area, over 1250 new mineral claim units were staked in 2001. This brings the number of new mineral claim units staked in the last two years in this 75 km by 25 km area to over 2000. Most exploration activity targeted Ni-Cu-PGE mineralization hosted within metamorphosed slivers and bands of gabbroic rock in the ophiolitic Cogburn Assemblage. This includes grass-roots work by Garex International Exploration on their Harrison Lake Project, Santoy Resources Ltd. on their Emory Creek Project, and Leader Mining International Ltd. on their Cogburn Project. During the work, Leader discovered a large resource of Mg-bearing ultramafic rocks at Cogburn, and refocused their efforts towards exploring and developing the Mg metal project beginning with definition drilling in late 2001. Also, three prospector assistance grantees sought Ni-Cu-PGE mineralization in the area in 2001. David Haughton successfully optioned the Jason Project, Murray McClaren advanced the Sable Project and discovered new Ni-Cu-PGE mineralization at the Katt Project, and Murray Halliday worked on the Spanky Project, extending the southern limits of the favourable ultramafic belt.

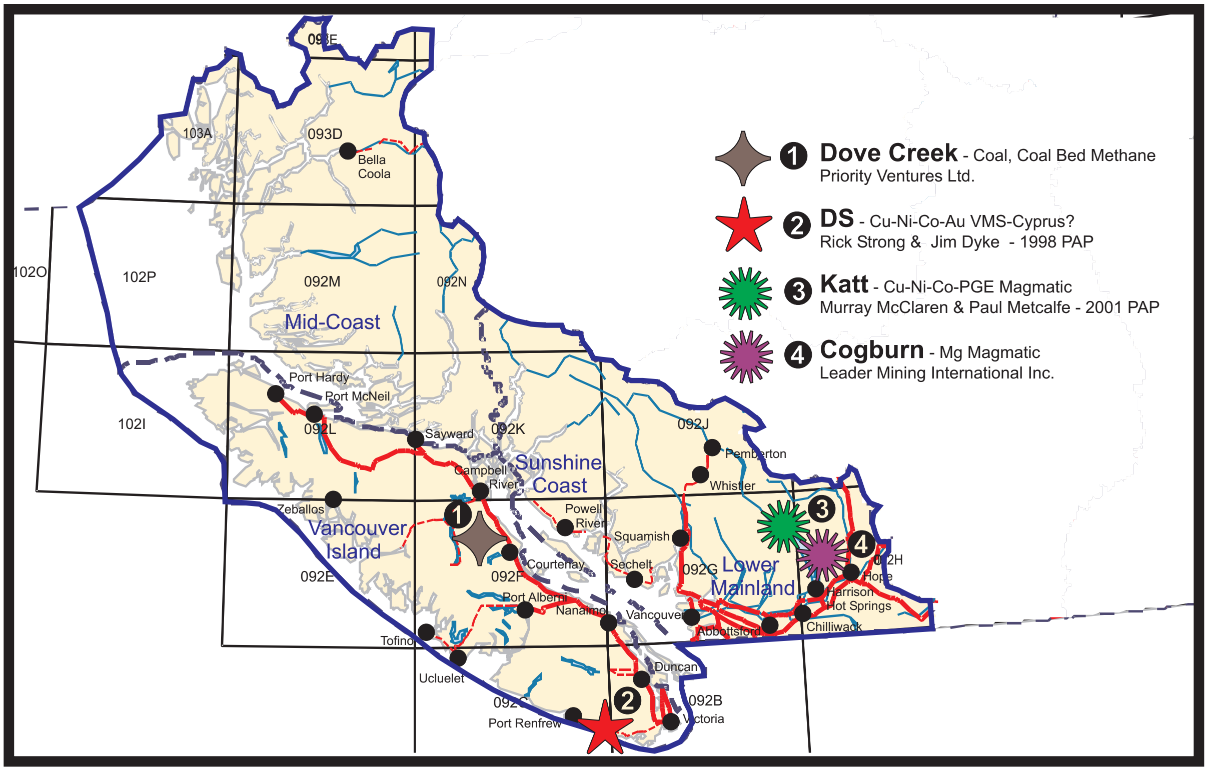

Figure 1. New discoveries in the Southwest region, 2001.

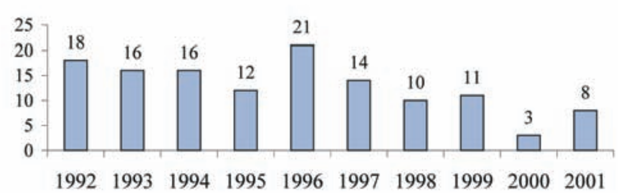

Figure 2. Number of major exploration projects annually Southwest region.

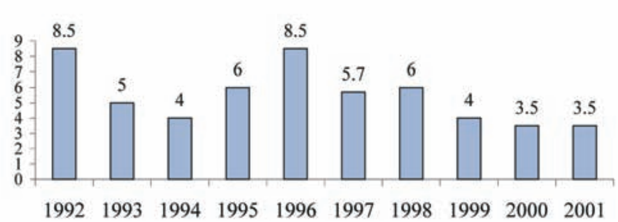

Figure 3. Annual exploration expenditures in C$ millions, Southwest region

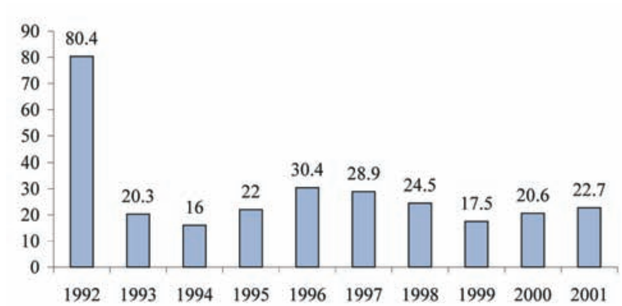

Figure 4. Annual exploration drilling (000's of metres), Southwest region.

EXPLORATION TRENDS

In 2001, there were eight major (>$100,000) exploration projects undertaken in the Southwest Region as shown in Table 1. This is an increase of 167% over the previous year. These major projects targeted a variety of commodities and deposit models, and consisted of grass roots to bulk sampling projects. This contrasts with last year's dominance of massive sulphide oriented mine site exploration at Myra Falls, and industrial minerals projects in northern Vancouver Island. The resurgence of coal exploration and the initiation of coal bed methane projects on Vancouver Island account for almost one third of exploration expenditures in the region in 2001. Several mineral exploration projects also were funded through the new Super Flow-through Share program initiated by the British Columbia government in late 2000. The positive trend is exemplified by four new mineral discoveries in the Southwest Region in 2001 as shown in Figure 1, double the number found last year.

Estimated total exploration expenditures in the region are $3.5 million, the same as in 2000. Estimated total exploration drilling in 2001 is 22,700 meters, representing an increase of 10% over 2000, and the second consecutive year of increased drilling in the Southwest Region. Figures 2, 3 and 4 show key exploration indicators for the region over the past ten years: annual major exploration projects, annual exploration projects, and annual exploration drilling. These indicators clearly show that exploration activity in the Southwest Region reached a low point in 2000; assuming a normal five to seven year exploration cycle, better times are anticipated in the Southwest Region during the next few years.

MINES AND QUARRIES

There were ten major mines and quarries (>100,000 tonnes annual production) operating in the Southwest Region in 2001, the same as the previous year. Refer to Figure 5 for names, locations, owners, and commodities produced by these mines and quarries. In addition, there are many large sand and gravel operations too numerous to mention, and several small dimension stone and industrial mineral producers. In general, production tonnages in the region remained about the same as in 2000, but the value of production by commodity changed significantly in 2001. Base metal values were much lower but coal values were much higher, reflecting the sharply opposing trends in commodity prices over the past year. Major mines and quarries, major exploration projects (Figure 6) and prospector assistance projects (Figure 7) demonstrate the diversity of mineral deposit types and potential, as well as the innovation of operators and explorationists working in the region.

MYRA FALLS OPERATION

Boliden-Westmin (Canada) Ltd. and predecessors have mined a large, geologically complex, series of

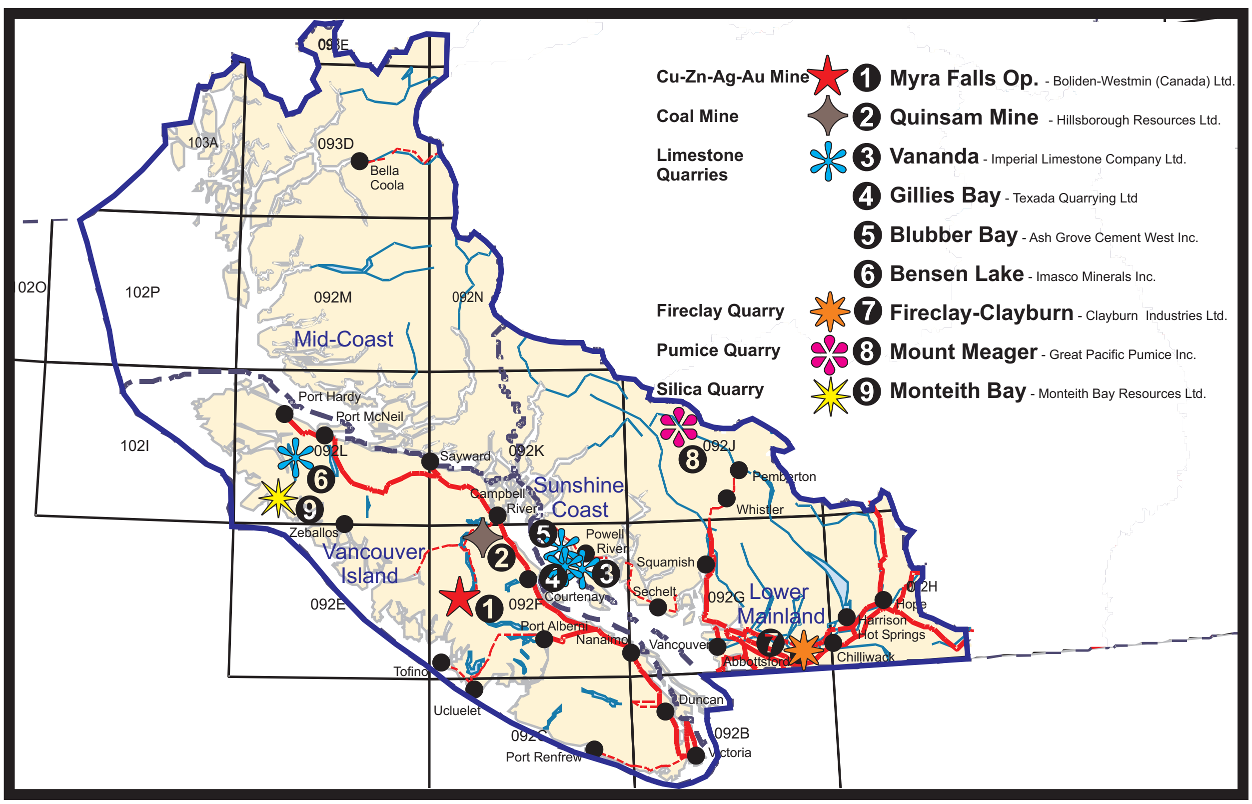

Figure 5. Major mines and quarries, 2001.

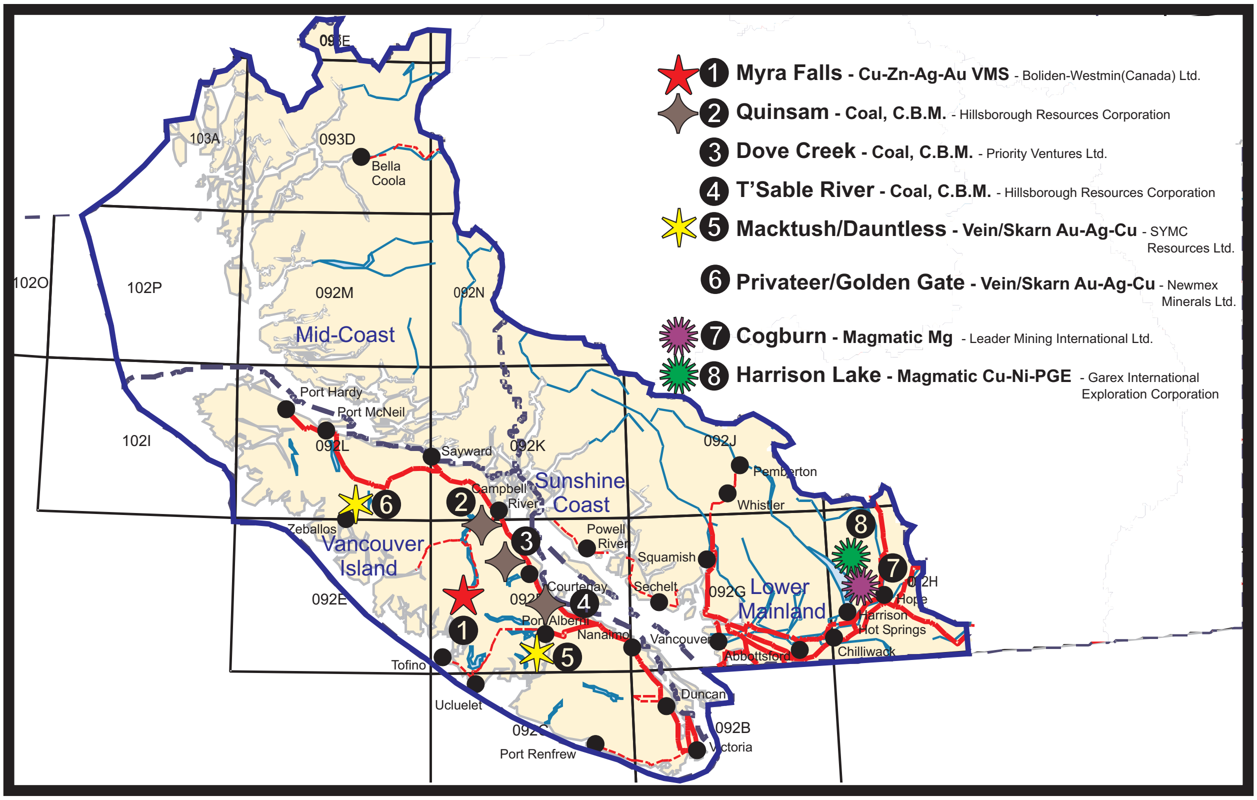

Figure 6. Major exploration projects, 2001.

TABLE 1
MAJOR EXPLORATION PROJECTS, SOUTHWEST REGION - 2001

Property	Operator	MINFILE	NTS	Commodity	Deposit Type	Work Done
Myra Falls Operation	Boliden-Westmin (Canada) Inc.	092F071, 072, 073, 330	092F12E	Cu-Zn-Au-Ag	volcanogenic massive sulphide	68 ddh, 13,291 m. (all underground)
Quinsam Coal Mine	Hillsborough Resources Ltd.	092F319	092F11W	coal, coal bed methane	sedimentary	12 ddh, 2323 m.
Dove Creek	Priority Ventures Ltd.	2001 discovery	092F11E	coal, coal bed methane	sedimentary	3 ddh, 1270 m.
T'Sable River	Hillsborough Resources Ltd.	092F333	092F10W	coal, coal bed methane	sedimentary	5 ddh, 180 m.
Macktush, Dauntless	SYMC Resources Ltd.	092F012, 168	092F02W	Au, Ag, Cu, Mo	vein, skarn, porphyry	20 ddh, 750 m.
Privateer, Golden Gate	Newmex Minerals Inc.	092L008, 009, 010, 011, 012, 005, 038, 155	092L02W, 092E15W	Au, Ag, Cu	vein, skarn, replacement	drift, raise, decline, 60 m.total; grid, 24 km.
Cogburn	Leader Mining International Inc.	092HSW081	092H12E	Mg; Cu-Ni-Co-Au-Ag-Pt-Pd	magmatic	23 ddh, 1360 m.
Harrison Lake	Garex International Exploration Corp.	092NWH040, 45	092H12W	Cu-Ni-Co-Au-Ag-Pt-Pd	magmatic	geochemistry

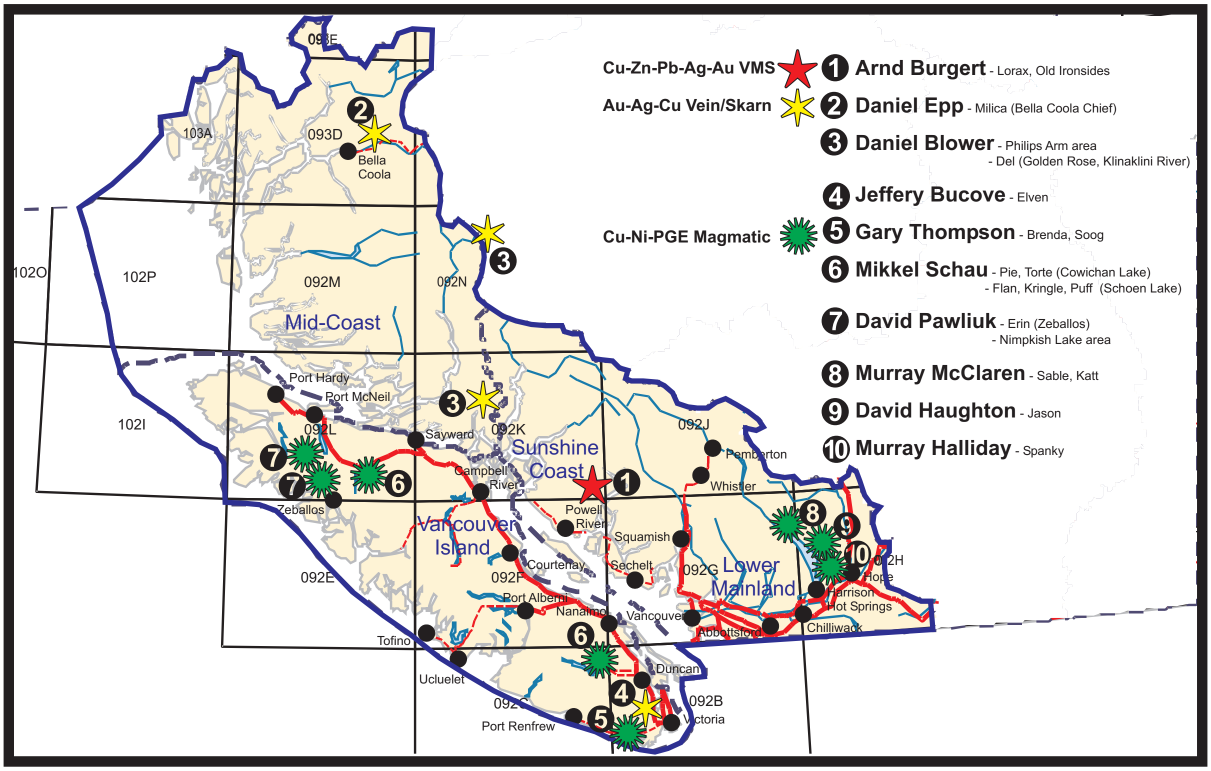

Figure 7. Prospector Assistance projects, 2001.

volcanogenic massive sulphide deposits in Paleozoic Sicker Group rocks at its Myra Falls Operation located in Strathcona Park near Campbell River. Since production began in 1966, over 21 million tonnes of Cu-Zn-Pb-Ag-Au ore have been milled. During the first eleven months of 2001, the mine employed 440 people and operated at a nominal milling rate of 3250 tonnes per day and an average cash cost of US$0.45 per pound of zinc equivalent. Total production for the year was 1,090,000 tonnes @ 1.6% Cu, 6.3% Zn, 1.5g/t Au and 26g/t Ag. Myra Falls had a successful year, meeting all production targets, but drastic reductions in the prices of copper and particularly zinc to near all-time low levels for both commodities made the operation sub-economic.

On November 30, 2001 mining and milling operations at the mine were suspended for a minimum three-month period, to be resumed pending an increase in base metal prices. Other significant issues affecting Myra Falls are high power costs and low precious metal recoveries are. In October of 2001, Boliden announced that Myra Falls was officially for sale, and reduced the carrying value of the operation by US$110 million to reflect its perceived market value. During suspension of operations, selected long term projects were continued, including: continuation of the production ramp from 18th to 22nd Levels, initial construction of the paste tailings system, and hoist and crusher maintenance. Unfortunately, exploration activity was discontinued.

As of January 1, 2001, Myra Falls had a mining reserve of 7.72 million tonnes at 1.3% Cu, 6.6% Zn, 0.4% Pb, 1.3 g/t Au and 36.4 g/t Ag. Geological resources as of January 1, 2001 are 5.85 million tonnes at 1.3% Cu, 7.0% Zn, 0.7% Pb, 1.8 g/t Au and 60.9 g/t Ag. Both mineral inventory categories are roughly the same for January 1, 2002, indicating that mine site exploration, definition drilling and data re-interpretation successfully upgraded resources to replace reserves mined in 2001 primarily from H-W, 43-Block, Battle-Gap and Lynx deposits. A significant aspect of this success was establishing new precious metal and lead rich resources, primarily at the Ridge Zone West deposit located west of Battle-Gap, and at the Price deposit, which is accessed from Thelwood Valley. Exploration diamond drilling at the Myra Falls Operation in 2001 totaled 13,291 meters in 68 holes, and cost $1.23 million. In addition, definition diamond drilling at the mine totaled 37,628 meters in 403 holes.

The future of the Myra Falls Operation is uncertain. A combination of increased productivity, reduced costs and increased metal prices are needed to ensure long term economic viability. What is clear is that Boliden Ltd., the parent company of the current owner, does not perceive Myra Falls as a core asset. In order to make the operation attractive for purchase by new owners, demonstrable productivity increases are required, such as increasing high-grade mill feed from external sources, and by improving mill recovery for precious metals. Reduced costs could be achieved by connecting the operation to the provincial electrical power grid, thereby reducing dependence on costly diesel generators for supplementary power. These improvements, combined with a recovery of base metal prices and continued exploration success would keep the Myra Falls Operation viable for decades.

QUINSAM COAL MINE

Hillsborough Resources Ltd. owns 100% of Quinsam Coal Corporation, which in turn owns and operates the underground Quinsam Coal Mine near Campbell River on Vancouver Island. During 2001, the mine, which continued operating on a single shift basis, produced 315,000 tonnes of clean bituminous grade thermal coal for markets in the Pacific Northwest. Revenues from the mining operations for Hillsborough at Quinsam increased by about 40% through the first 9 months of 2001 relative to 2000, due primarily to increased market prices for coal.

The coal at Quinsam is hosted in numerous, shallow, flat-lying seams within Cretaceous Nanaimo Group sedimentary rocks. The seams are accessed by ramps from surface. In 2001, mine-site exploration diamond drilling resumed at the Quinsam Coal Mine in the 7-South Area, where 2323 meters were completed in 12 holes. Almost all the holes intersected both the deeper No.1 and shallower No.3 seams. Hillsborough also raised exploration funding in 2001 by selling up to $4 million in flow-through shares by private placement. The funds will be used to explore both at Quinsam and T'Sable River.

LIMESTONE QUARRIES

The islands east of Vancouver Island in the Southwest Region host extensive, flat-lying exposures of the Triassic Quatsino Formation, a prime source of limestone. On northern Texada Island, this unit is quarried by three operators, two of which are the largest suppliers of cement-grade limestone in the Pacific Northwest. In 2001 Lafarge Canada Inc. (through Texada Quarrying Ltd.) shipped 3.2 million tonnes from its Gillies Bay Quarry, and Ash Grove Cement Corporation shipped 1.8 million tones from its Blubber Bay Quarry, comparable to production in 2000.

Chemical-grade limestone was produced from Imperial Limestone Co. Ltd.'s Vananda Quarry (200,000 tonnes in 2001) and from a portion of Lafarge's production at Gillies Bay. Proximity of the Texada Island quarries to sheltered ports on Georgia Strait enables highly efficient and inexpensive barge transportation of their products, which helps these operations to maintain profitability during soft market conditions. On northern Vancouver Island, International Marble and Stone Company Ltd. (IMASCO) produced 28,000 tonnes of chemical grade limestone from its Benson Lake Quarry near Port Hardy.

INDUSTRIAL MINERAL QUARRIES

The wide variety of industrial minerals in the Southwest Region continually opens new opportunities for exploration and exploitation by innovative operators. Aggregate producers in the region are too numerous and poorly documented to report, but provide essential products for construction, particularly near major urban areas. Seven major (>10,000 tonne per year) non-aggregate quarries continued operations in 2001. Two operations, which are located near Abbottsford, mine altered sediments of the Eocene Huntington Formation. Lafarge Canada Inc. (through Tilbury Cement Ltd.) produced 450,000 tonnes of shale and sandstone from its Sumas Shale Quarry. The product is trucked to and used at Tilbury's cement plant in Delta. Clayburn Industries Ltd. produced 63,500 tonnes of fireclay at its Fireclay-Clayburn Quarry. The product is used at its nearby plant, which produces refractory bricks, flue line pipe and facing bricks.

In less central parts of the region, during the summer season, quarrying operations extract and transport specialty resources. On northwest Vancouver Island during 2001, Monteith Bay Resources Ltd. (an affiliate of Tilbury Cement Ltd.) produced and barged 37,000 tonnes of hotspring silica from its Monteith Bay Quarry to its Delta cement plant. This operation mines a paleo-hotspring replacement silica, or chalky geyserite deposit in Jurassic Bonanza Group Volcanics, and is located along tidewater. On the mainland northwest of Pemberton, Great Pacific Pumice Ltd. produced and trucked 12,000 cubic meters of volcanic pumice from its Mount Meager Quarry to processing and sorting yards near Meager Creek Hotsprings and Squamish. The material is used for lightweight concrete, as stone washing media and for cosmetics. The operation exploits a stratified deposit of rhyodacitic breccia and ash of the Pliocene to Recent Garibaldi Group Volcanics.

DIMENSION STONE QUARRIES

Several small, seasonal dimension stone quarries operate in the Southwest Region, providing a wide variety of mainly granitic products for dimension stone processors in the lower mainland and on Vancouver Island. Stone processing plants are operated by Westcoast Manufacturing Inc. in Delta, Margranite Industry Ltd. in Surrey, Garibaldi Granite Group Inc. in Squamish and Matrix Marble Corporation in Duncan. These operations market both local products and others from all over the world.

As a result of soft market conditions in 2001, most dimension stone quarries in the region produced only from stockpiles, or not at all. One of the newer operators, Hardy Island Granite Quarries Ltd., produced 2700 tonnes of light grey granodiorite from its Hardy Island Quarry in Jervis Inlet near Powell River. In the Squamish area, Huckleberry Stone Supply Ltd. produced about 3500 tonnes of columnar basalt from a number of small quarries on its Spumoni, Cabin and Freeman claims. Nearby, Garibaldi Granite Group Inc. produced about 3000 tonnes of granitic and volcanic dimension stone products from its Squamish, Ashlu River and Leo quarries.

EXPLORATION ACTIVITY

VANCOUVER AND INSHORE ISLANDS

DOVE CREEK (NEW)

Priority Ventures Ltd. initiated and completed a 1270-meter, three hole exploration-drilling program targeting both coal and coal bed methane in the Comox Formation of the Cretaceous Nanaimo Group at its Dove Creek Project west of Courtenay. The successful program was superbly designed and executed. Priority intersected multiple seams of possible coking coal and confirmed the presence of methane gas, both of which are considered new discoveries for 2001. Additional drilling planned by Priority Ventures in 2002 will delineate coal seams and test methane gas potential.

T'SABLE RIVER (MINFILE 092F333)

Hillsborough Resources Corporation, through its subsidiary T'Sable River Coal Corporation, commenced a major underground coal bulk-sampling program in 2001 at its T'Sable River Project south of Courtenay. An initial 180-meter, five hole groundwater monitoring drill program was completed to help guide the development of twin 650 meter declines from surface planned for 2002. These will test the lowermost No.1 coal seam in the Comox Formation of the Cretaceous Nanaimo Group to a vertical depth of 150 meters. In-situ reserves in all categories at T'Sable River are 38.5 million tonnes of high volatile bituminous A rank coal.

MACKTUSH AND DAUNTLESS (MINFILE 092F012 and 092F168)

South of Port Alberni, along the west shore of Alberni Inlet, SYMC Resources Ltd. has been prospecting and exploring its Macktush Project for over a decade. The project has targeted multiple occurrences and styles of porphyry copper-molybdenum-gold-silver and related vein mineralization within and adjacent to northwest trending Jurassic Island Plutonic Suite granodiorite stocks and dikes that intrude Triassic Karmutson Formation basalt flows. In 2001, about 750 meters in twenty short diamond drill holes tested the Fred, David and Sy veins, which are steeply-dipping, east-west trending, sub-parallel gold bearing quartz-calcite-chalcopyrite-bornite-tetrahedrite veins hosted by altered granodiorite. These epi/mesothermal veins are interpreted to be peripheral to a large porphyry system or cluster of systems.

In 2001, prospecting at the Dauntless property located several steeply dipping, east-west trending, parallel massive chalcopyrite-quartz skarn veins hosted by altered basalt Dauntless is located ten kilometers north of Macktush and immediately above tidewater. Prospecting also identified a quartz-chalcopyrite stockwork zone hosted in altered granodiorite (the Bowl Zone) located in a small cirque two kilometers northwest of the Fred/David/Sy vein system at Macktush. Although not all are new discoveries in 2001, these occurrences clearly suggest the presence of both bulk mineable mineralization and narrow vein potential of significant gold, copper and silver mineralization at the Macktush and Dauntless Projects. In early 2002, bulk sampling and diamond drilling are planned for the target areas identified. Funding will be provided by the sale of Super Flow Through shares and through an arrangement with Sumitomo Corporation of Japan.

PRIVATEER AND GOLDEN GATE (MINFILE 092L008 and 092L005)

Newmex Minerals Inc. continued small-scale underground test mining of gold-sulphide-quartz veins at the past producing Privateer Mine, just north of Zeballos on the West Coast of Vancouver Island. During 2001, 60 meters of exploration drifting and raising were completed on the previously untested 1-2 Vein, locally this yielded spectacular visible gold specimens and sections of high-grade gold samples. Surface work was initiated near the past producing Golden Gate deposit, including 24 kilometers of grid and soil sampling. Planned ground geophysics and soil sample analyses were not completed. Sampling of gold-sulphide-quartz veins in old trenches at Golden Gate yielded high-grade gold samples similar to those at Privateer, which is 3.5 kilometers away. Newmex ceased funding the project in mid-year, and were seeking partners to assist with future exploration financing and direction. Nonetheless, the potential for both narrow vein and replacement types of high grade, low tonnage gold resources at Newmex's Zeballos Project remains very attractive, and worthy of long term exploration interest.

OTHER EXPLORATION ACTIVITY

During 2001, several junior mining companies and prospectors either began smaller exploration projects that yielded positive results, or started projects that could yield positive results and become major projects in the region. In 2001, about 80% of exploration projects and 90% of exploration expenditures in the Southwest Region occurred on Vancouver Island and the inshore islands. These statistics reflect the high potential for metallic, industrial mineral and hydrocarbon deposits in the well-preserved, polyphase island arc and back arc basin setting of the Insular Belt. A perpetual field season and a superb road network on the islands are useful to help explorationists penetrate the dense vegetation covering much of the island.

In southern Vancouver Island near Sooke, Beau Pre Explorations Ltd. utilized the Super Flow through Funding Program to continue prospecting and to start installing a dry gravity test mill at its Valentine Mountain (MINFILE 092B108) gold-quartz vein project. Near Jordan River, Jim Dyke and Rick Strong successfully discovered and exposed the massive sulphide bedrock source of high-grade chalcopyrite mineralization found along logging roads by Mr. Strong during his 1998 Prospectors Assistance Program. West of Cowichan Lake, C.R.C. Explorations Ltd. began an exploration drilling program in late 2001 to test copper-gold skarn potential at its Nit Nat (MINFILE 092C150) Project. In the same area, also in late 2001, Inspiration Mining Corporation commenced a multi-phase exploration program to test for possible polymetallic massive sulphide potential at its Jasper (MINFILE 092C080) Project.

On northern Vancouver Island south of Sayward, Homegold Resources Ltd. trenched and bulk sampled its Iron Ross (MINFILE 092K043) magnetite skarn prospect. Homegold also completed a small drilling program at its Smiley (MINFILE 092I286) project to test a limestone body near Nimpkish Lake. Near Bonanza Lake, Omya California Inc. also tested limestone potential of its Bonanza (MINFILE 092I286) project area. Further north along Holberg Inlet, partners Tilbury Cement Ltd. and Homegold Resources Ltd. conducted small diamond drilling programs to test separate areas on its Apple Bay Property: the Hushamu (MINFILE 092L308) Project for shale and sandstone, and the PEM100 (MINFILE 092L150) Project for silica and kaolin.

On Texada Island, Northstar Mines continued bulk sampling on a number of gold-copper quartz vein projects, such as the Tak 2, which was discovered during 2000, and the Dude (MINFILE 092F276) a porphyry copper-molybdenum-gold project. Chemical Lime Company Ltd. also completed a bulk sampling and diamond-drilling project at its Farmhouse (MINFILE 092F363) project. Mining on Texada Island has a long history for copper and gold mining, a strong current economic base with limestone and aggregate, superb transportation logistics with deep-sea ports, plus excellent future exploration potential for both metals and industrial minerals.

PROSPECTOR ASSISTANCE PROGRAM

In 2001, four of the ten Prospectors Assistance Programs allocated to the Southwest Region were undertaken on Vancouver Island. Near Shawnigan Lake, Jeffery Bucove prospected for the gold-quartz vein bedrock source of the historic Leech River Placer District at his Elven Project. The other three programs targeted tholeiitic intrusion-hosted Cu-Ni-PGE mineralization related to the Triassic Karmutson Formation throughout the island. Gary Thompson worked in the Sooke area on his Bren and Soog claims. Mikkel Schau worked in two different areas: the Pie and Torte claims near Cowichan Lake, and the Flan, Kringle and Puff near Schoen Lake; Dr. Schau discovered new epithermal gold vein mineralization at Flan and new copper skarn mineralization at Kringle. David Pawliuk prospected both in the Zeballos area (Erin claims) and near Nimpkish Lake.

HARRISON LAKE - HOPE AREA

COGBURN (NEW)

In 2001, Leader Mining International Inc. acquired the core of the Cogburn Property from Gerald Carlson and John Chapman for its Cu-Ni-PGE potential associated with the NI prospect (MINFILE 092HSW081). Sampling by Leader on the prospect yielded low Cu-Ni-PGE values, but identified a nearby area measuring 10 kilometers by 2 kilometers of magnesium rich, serpentinized, peridotite and/or dunite averaging 25-30% Mg, which they have named the Emory Zone. Due to the proximity of infrastructure to such a potentially significant deposit, Leader commissioned Hatch Associates Ltd. to perform a scoping study of the feasibility of a magnesium metal mine and plant on the zone. Results were favourable. Leader also completed an initial diamond-drilling program of 1360 meters in 23 holes in late 2001 to define possible zones of higher Mg grades and fewer impurities within the deposit. Additional development work is planned for the next two years, which if successful could lead to a new open pit Mg mine at Cogburn and a new Mg metal plant near the town of Hope by 2003.

HARRISON LAKE (MINFILE 092HNW040, 045)

Garex International Exploration began staking in the Harrison Lake - Hope area in 2000, and continued through 2001. By year-end the company held the largest land position in the area with 1229 mineral claim units representing over 300 square kilometers. Grass roots prospecting, geochemical sampling and mapping on its Harrison Lake Project consumed all the time and 2001 funding available to this private company. Garex targeted Cu-Ni-PGE mineralization associated with gabbroic rocks on the property, both around the AL (092HNW040), Settler Creek (092HNW045) and Swede (092HSW082) MINFILE showings, and over the extensive area of ultramafic rocks exposed. The Harrison Lake Project also lies between the Jason (092HSW076) and Sable (092HNW077) occurrences, recent Cu-Ni-PGE discoveries made under the Prospectors Assistance Program.

OTHER EXPLORATION ACTIVITY

Also in the Harrison Lake - Hope area, Santoy Resources Ltd. commenced grass roots Cu-Ni-PGE exploration on its Emory Creek Project, which is the second largest land position in the area. Emory Creek surrounds Barrick-Homestake's past producing Giant Mascot Property, and includes three MINFILE Cu-Ni occurrences: the Victor Nickel (092HNW039) developed prospect, and the D.C. Nickel (092HNW021) and Citation (092NHW046) showings. To the west near Harrison Hot Springs, Eagle Plains Resources Ltd. staked and optioned properties, and conducted a multi-parameter airborne geophysical survey over its Harrison Gold Project. The program is testing the area of the Harrison Au-quartz vein (MINFILE 092HSW092), a developed prospect. The Harrison Gold property hosts several quartz diorite stocks of Tertiary age that contain zones of gold-bearing quartz-sulphide veins and stockworks that could be open pittable.

PROSPECTORS ASSISTANCE PROGRAM

The Harrison Lake-Hope area was the site of three of the ten programs funded by Prospectors Assistance in the Southwest Region in 2001. These projects helped extend the length of the favourable ultramafic belt to the northwest and southeast. To the north of Harrison Lake, along Big Silver Creek, Murray McClaren and partner Paul Metcalfe continued prospecting the Sable Project (MINFILE 092HNW077) Cu-Ni-PGE occurrence that was discovered in 2000. They also staked and began prospecting the Katt Project, a new Cu-Ni-PGE discovery along Stokke Creek. David Haughton continued his third prospecting season on and successfully optioned his Jason Project (MINFILE

092HNW076) along Cogburn Creek to a new junior exploration company. Murray Halliday from Hope prospected and staked several claims, referred to as the Spanky claims, around the headwaters of American Creek to cover exposed ultramafic rocks containing sulphide minerals and magnetite. The presence of Geological Survey Branch PGE Project team members in the area was of great assistance and motivation to the prospectors and exploration companies working in the area in 2001.

COASTAL MAINLAND AREA

EXPLORATION ACTIVITY

The Coastal Mainland portion of the Southwest Region, which covers the Sunshine Coast and Mid-Coast Forest Districts, saw little exploration activity in 2001. Dimension Stone developers maintained some level of activity, including Arbutus Cove Stone who completed bulk sampling of granitic material from its Brian Project (MINFILE 092JW032) located along Jervis Inlet within the extensive Coast Plutonic complex.

PROSPECTORS ASSISTANCE PROGRAM

The prospectors assistance program supported exploration activity by three individuals seeking metallic minerals in several remote areas of the coastal mainland region in 2001. North of Powell River, Arnd Burgert explored his Lorax and Old Ironsides claims, which cover mineralized portions of Cretaceous Gambier Group roof pendants within the Coast Plutonic Complex. Lorax (MINFILE 092K162) is a 1998/99 Prospectors Assistance Program discovery. It consists of Cu-Zn-Ag-Au volcanogenic massive sulphides in two parallel lenses; these were further delineated in 2001. Old Ironsides is a Au-quartz vein discovery from a 1999 Prospectors Assistance Program. It also was prospected in 2001.

Dan Blower explored for economic sulphide mineralization of any type in two target areas of the coastal mainland, one of which led him out of the Southwest into the South Central Region. Near Bute Inlet, prospecting in 2001 followed up multi-element regional geochemical stream sediment anomalies produced by the Geological Survey Branch. Along the Klinaklini River area, prospecting in 2001 followed up both regional geochemical anomalies and MINFILE occurrences, and led to the staking of the Del claims, covering the Golden Rose (MINFILE 092N046) Au-Cu quartz vein showing in probable Jurassic Hazelton Group volcanics and sediments that are so important in the South Central Region.

In the Bella Coola area, Dan Epp explored for economic sulphide mineralization along steep valleys around his home in Hagensborg, staking the Bella Coola Chief (MINFILE 092D009) Au-Cu-Ag quartz vein showing as the Milica claim. The Bella Coola Chief showing is hosted in possible Jurassic Hazelton Group volcanics and sediments intruded by biotite granite and quartz feldspar porphyry dikes of the Coast Plutonic Complex. The presence of members of the joint GSB/GSC Bella Coola Project team in the area was of great assistance and motivation to Mr. Epp in 2001.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the contributions of the dedicated and skilled prospectors, explorationists, and the personnel of the British Columbia Geological Survey and the Southwest Region Mines Branch to this report. Editing by Bill McMillan improved this paper, and his sharing of skill and expertise with all the contributors to this publication is greatly appreciated.

SOUTH CENTRAL REGION

Michael S. Cathro, P.Geo.
Regional Geologist, Kamloops

HIGHLIGHTS

* Exciting grassroots prospects were explored by drilling or trenching programs at **Silver Lake** (**Worldstock** and **New Discovery**), **Melba**, **Panorama Ridge**, **Spire**, **Broken Hill**, **Fox**, and **Clearwater Platinum**.

* The **Ashcroft** quarry and roofing granule plant (Photo 1) of I.G. Machine and Fiber began operation.

* A bulk sample was mined at the **Tulameen** coal project, which may become the region's next operating mine.

* Exploration indicators were at their **highest levels in four years**. Exploration spending in 2001 totaled $5.0 million, while there were 32 000 metres of drilling and 15 major projects. Nevertheless, there is room for improvement as exploration is still well below 1988-1997 activity levels.

EXPLORATION TRENDS

Exploration activity in the South-Central region was at a four-year high, with indicators at double their levels of the 1998 lows. Exploration and development spending (Figure 1), metres of drilling (Figure 2), and number of major projects (Figure 3) were all up for the third year in a row. Exploration spending for 2001 is estimated at $5.0 million while drilling activity increased to about 32 000 metres. Some 5832 claim units were staked in the region by year-end, on par with the previous four years (Figure 4).

There were 15 major exploration projects in 2001 (Figure 5; Table 1). As was the case last year, the **Afton** project accounted for nearly half the metres drilled and about one-third of all spending. Other moderate-sized drilling projects were carried out on the **Red Hill**, **Silver Lake** (**Worldstock** and **New Discovery**), **Blue River** (**Verity** and **Fir**), **Fox**, and **Broken Hill** properties.

Photo 1. The newly built Ashcroft roofing granule plant of I.G. Machine and Fiber Ltd., a subsidiary of IKO Industries Ltd.

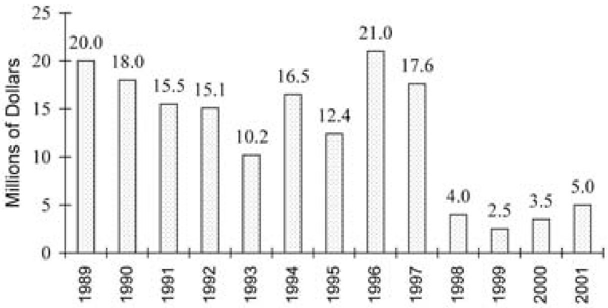

Figure 1. Annual exploration spending, in millions of dollars, South-Central Region

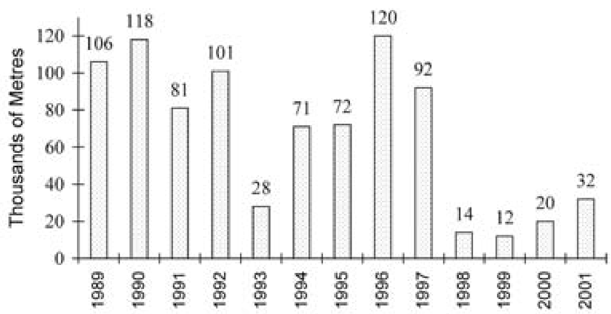

Figure 2. Annual exploration and development drilling, in thousands of metres, South-Central Region.

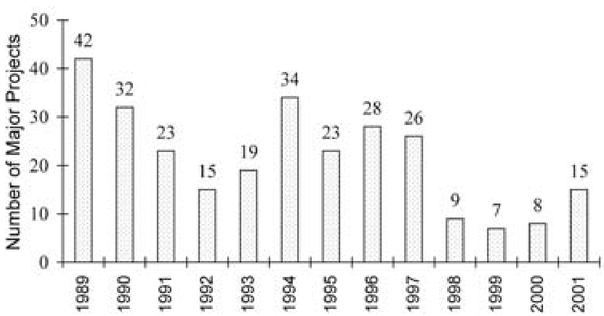

Figure 3. Number of major exploration projects per year, South Central Region. Major projects are defined as those with mechanical disturbance (*e.g.* trenching or drilling) and expenditures exceeding $100 000.

Activity was mainly focused on alkalic copper-gold porphyry, volcanogenic massive sulphide zinc-copper-lead-gold-silver, and gold-silver vein occurrences. In addition, there were several grassroots projects that targeted platinum group metals, specifically on the **Clearwater**, **Tulameen**, and **Allendale Lake** properties.

Junior companies were responsible for perhaps 80 per cent of spending, while major companies (Teck Cominco Ltd., Highland Valley Copper, Imperial Metals Corp.) conducted a few programs.

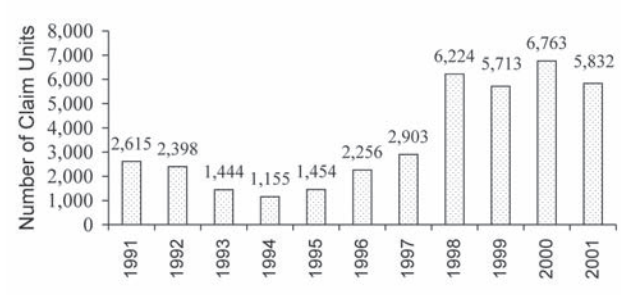

Figure 4. Claim units staked, South-Central Region

MINES

The region's operating and dormant mines are shown on Figure 5.

Production at **Highland Valley Copper** (HVC), a partnership of Teck Cominco Ltd., BHP Billiton Ltd. and Highmont Mining Company was about 5 per cent lower than last year's record metal output. Mining low-grade porphyry copper-molybdenum-gold-silver ore, the open-pit operation employs about 950 people (Photo 2). Metal production for 2001 totaled 180 530 tonnes Cu, 1850 tonnes Mo, 449.09 kilograms (14 439 ounces) Au and 97 539 kilograms (2 136 000 ounces) Ag (Frank Amon, Electronic Communication, February 7, 2002).

Although copper prices were very soft during the year, HVC has remained marginally profitable due to a reduction in operating costs and the drop in the value of the Canadian dollar. With very low strip ratios and a fourth quarter reduction in wages and hydro rates, as stipulated in a Job Protection Agreement, the break-even price for HVC has been lowered to below US$0.60 per pound of copper. On January 1, 2002 the wage cut was increased from three to six per cent.

Groundwater inflow to the Valley pit is increasing and an aquifer-dewatering plan is being prepared to control the problem. In early 2002 the company plans to submit this plan to the BC Environmental Assessment Office for review and approval.

Proven and probable reserves on January 1, 2002 totaled 345.1 million tonnes grading 0.414% Cu and 0.0081% Mo. Mine closure is forecast for March 2009 based on remaining reserves, although the feasibility of a three-year extension is still being studied despite the prevailing low copper prices. That would involve a pushback of the Valley pit and relocation of the conveyor system and crushers to access ore in the southeast part of the pit. According to newspaper reports, a decision to proceed with the pushback would have to be made within a year for the plan to be viable.

In terms of exploration, HVC completed three drill holes to test IP anomalies in the Pimainus Lakes area, ap-

Figure 5. Mines, development projects and major exploration projects, South-Central Region, 2001.

proximately 8 kilometres southwest of the mine. No results were released.

In October, the newly built **Ashcroft** Quarry and Roofing Granule Plant (Photo 1) of IG Machine and Fiber Ltd. began production of roofing granules for shipment to IKO Industries' shingle plants in Sumas, Washington and Calgary. The quarry is permitted to produce up to 250 000 tonnes per year of which about 60% will become finished roofing granules. At full production, the operation could employ 60 people.

The Kamloops cement plant and **Harper Ranch** limestone quarry of Lafarge Canada Inc., with an annual capacity of about 240 000 tonnes of cement, operated at about 60 per cent capacity on an intermittent basis during the year (Jeff Colbourne, Personal Communication, December, 2001). Lafarge also draws materials from the Falkland and Buse Lake quarries which produce gypsum and alumina-silica rock respectively.

At **Pavilion** near Lillooet, Graymont Western Canada Inc. (formerly Continental Lime Ltd.) operates a limestone quarry and lime kiln. The operation produces about 200 000 tonnes of lime per year, mainly for use in pulp mills. Near Merritt, M Seven Industries Ltd. produces magnetite on an intermittent basis by reprocessing tailings from the old

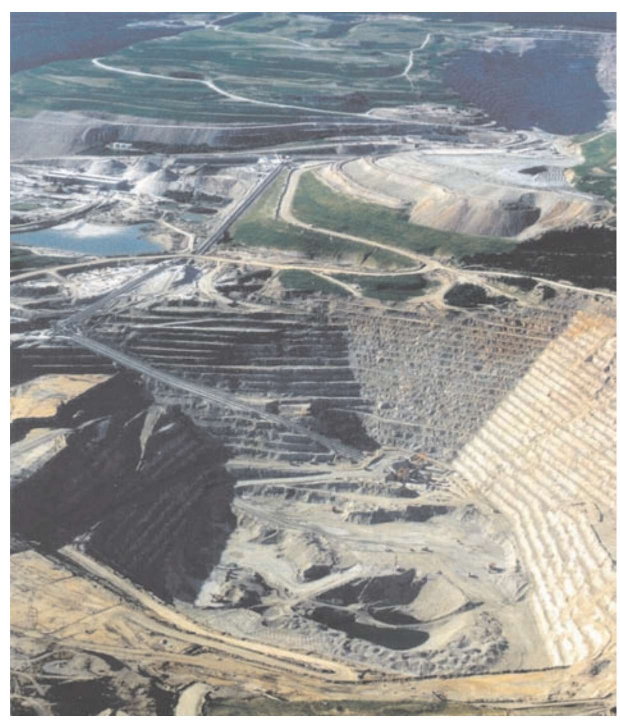

Photo 2. The Highland Valley Copper operation. Photo courtesy of Teck Cominco Ltd.

TABLE 1
MAJOR EXPLORATION PROJECTS, SOUTH-CENTRAL REGION, 2001

Property	Operator	MINFILE	Mining Division	NTS	Commodities	Target Type	Work done
Afton	DRC Resources Corp.	92INE 023	Kamloops	92I/10E	Cu, Au, Pd, Ag	Alkalic Porphyry	28 ddh, 14,480 m
Ann	GWR Resources Inc.	92P 115	Clinton	92P/14W	Cu, Au	Alkalic Porphyry	7 ddh, 847 m; trail; geochem
Broken Hill	Cassidy Gold Corp.	82M 279, 280	Kamloops	82M/14W	Zn, Pb, Ag	Sedex	13 ddh, 930 m; geol; prosp
Fir	Commerce Resources Corp.	83D 035	Kamloops	83D/06E	Ta, Nb, Phosphate	Carbonatite	6 ddh, 1246.54 m; 1 km road; 8.56 km ground mag; geochem; prosp; grid
Fox	Gitennes Exploration Inc.	92ISE 191	Nicola	92I/07E	Zn, Cu, Pb, Au, Ag	VMS	8 ddh, approx 1000 m
Clearwater	Cusac Gold Mines Ltd.	92P 043	Kamloops	92P/08E	Pt, Pd, Au, Ni, Co, Cr	Magmatic	6 ddh, approx. 950 m; 780 m trail
Goldstream	Orphan Boy Resources Inc.	82M 141	Revelstoke	82M/09W	Cu, Zn, Au, Ag	VMS	3 ddh, approx. 600 m; grid; geophys; geochem; geol
Melba	Walloper Gold Resources Corp.	none	Kamloops	92I/07E, 8W, 9W	Au, Ag, Cu, Pb, Zn	Vein	11 ddh, 484.58 m; trenching; grid; geol; geophys; geochem
Pimainus	Highland Valley Copper	none	Kamloops	92I/06E	Cu, Mo, Au, Ag	Porphyry	3 ddh, 877.1 m; 1.8 km trail
Pongo	Verdstone Gold Corp. / Molycor Gold Corp	82M 058	Kamloops	82M/04W	Au, Ag, Zn, Pb, Cu	Vein/Shear	8 ddh, approx 442 m; trenching; geol; geochem
Red Hill	Teck Corp.	92INW 057, 042	Kamloops	92I/11W	Cu, Zn, Au, Ag	VMS	17 ddh, 3643 m; 1.7 km trail
Silver Lake - Discovery A & B zones	Christopher James Gold Corp.	none	Kamloops	92P/09W	Cu, Ag, Au	Vein	14 ddh, 1486 m; trenching; 1 km trail; geol; geophys; geochem
Silver Lake - Worldstock	Christopher James Gold Corp.	92P 145	Kamloops	92P/09W	Cu, Mo, Au	Porphyry / stockwork / shear?	7 ddh, 879 m; 5 trenches; 800 m trail; geophys
Tulameen Coal	Compliance Coal Corp. / Pacific West Coal Ltd.	092HSE 094, 157	Simlkameen	92H/10E, 10W, 7E, 7W	Thermal Coal	Sedimentary	Mined 10,000 t bulk sample; 1000 t shipped; feasibility study
Verity	Commerce Resources Corp.	83D 005	Kamloops	83D/06E	Ta, Nb, Phosphate	Carbonatite	5 ddh, 403.89 m; 4.8 km roads; 34.24 km ground mag; radiometrics; geochem; prosp; grid

Craigmont copper mine (Photo 3). The magnetite is used in coal washing plants throughout western Canada.

Western Industrial Clay Products Ltd. operates the **Red Lake** quarry that supplies diatomaceous earth (fuller's earth) for its plant in Kamloops. The main products are kitty litter, barn deodorizer and industrial absorbents. During 2001, the company also began sales of the "Garden Treasure" line of organic potting soils using Red Lake "leonardite" and diatomaceous earth, combined with peat and perlite from other sources. Leonardite is a carbonaceous material similar to low-grade lignite. Bentonite from the **Bud** quarry at Princeton is used in Western Industrial Clay's clumping cat litters.

The Mountain Minerals Division of Highwood Resources Ltd. owns the **Z1** (Ranchlands) zeolite quarry near Cache Creek. Intermittent production from the quarry supplies the agri-food and industrial absorbents markets. No mining took place during 2001; the company drew from stockpiles.

The nearby **Z2** quarry and Ashcroft processing plant (Photo 4) were sold to Industrial Mineral Processors of Calgary. Formerly owned by C_2C Zeolite Corp., the plant produces deodorizers, feed binders, cat litter and industrial absorbents.

The Kettle Valley Stone Company of Kelowna continued to expand production of its attractive flagstone, ashlar and facing stone products (Photo 5). Dacite ash, granite gneiss and basalt are quarried from the **Nipple Mountain**, **Canyon** and **Gemini** quarries respectively, all located east of Kelowna. The company now employs about 25 people. During 2001 Kettle Valley opened a sales office in northern California to service that growing market.

Okanagan Opal Inc. markets attractive jewelry made from fire opal mined at the **Klinker** property, located west of Vernon.

Photo 3. Processing plant and stockpiles, Craigmont magnetite tailings operation.

Photo 4. Ashcroft processing plant, now owned by Industrial Mineral Processors of Calgary.

Photo 5. Home constructed using "Mountain Ash" (dacitic ash) and "Shadow Ridge" (basalt) facing stone. Photo courtesy of Kettle Valley Stone Company.

Photo 6. Aerial view of Blackdome mill and mine property, owned by J-Pacific Gold Inc. and Jipangu Inc.

Several other moderate to large-sized metal mines remain on care and maintenance status, awaiting higher metal prices or discovery of additional ore. Imperial Metals Corp. owns the **Similco** porphyry copper-gold mine and mill complex at Princeton, and the **Invermay** project near Hope. Similco has a resource of 142 million tonnes grading 0.397% Cu in the area of Pits 2 and 3 on the Copper Mountain side of the property.

The dormant **Blackdome** gold-silver mine of J-Pacific Gold Inc. and Jipangu Inc. remains on care and maintenance after operating in the 1980's and again briefly from October 1998 to May 1999. The 200 tonne-per-day mill (Photo 6) is intact, awaiting a higher gold price and future discoveries. A 2001 structural geology study by SRK Consulting concluded there are three high-priority targets for discovery of new epithermal veins. These could be explored by underground bulk sampling, trenching and drilling. In addition, SRK reviewed and reclassified the existing resource estimate in accordance with CIMM standards. The Inferred Mineral Resource now stands at 124 120 tonnes grading 12.8 g/t Au and 33.7 g/t Ag.

Orphan Boy Resources Inc optioned the **Goldstream** property north of Revelstoke, including the dormant copper-zinc mine and mill (Photo 7). The company drill-tested a combined geochemical, geophysical and geological target east of the mine, and carried out a grassroots surface program in the C-1 grid area, some 10 kilometres west of the mine. The latter discovered massive sulphide float boulders near the projected extension of the Goldstream mine horizon. Named the "Boutwell discovery", these boulders are anomalous in copper. The Goldstream mine operated from 1983 to 1984 and from 1991 to 1996, milling 2.21 million tonnes at a recovered grade of 3.54% Cu, 0.36% Zn, and 11.86 g/t Ag.

Photo 7. Aerial view of the Goldstream mill (centre) and camp/office (upper right). Photo courtesy of Orphan Boy Resources Inc.

Photo 8. Diamond drill (lower left) in the Afton pit.

DEVELOPMENT PROJECTS

The largest exploration and development project in the region in 2001 was the **Afton Mine** porphyry copper-gold-silver-palladium project of DRC Resources Corp. From 1977 to 1987, a subsidiary of Teck Corp. operated the Afton open pit (Photo 8) located ten kilometres west of Kamloops. Subsequent production came from the nearby Crescent, Pothook and Ajax pits prior to final closure in 1997. The original Afton pit exploited mainly "secondary" (supergene) mineralization comprised of native copper and chalcocite with lesser bornite and chalcopyrite.

DRC's drilling in 2000 and 2001 tested the steeply dipping breccia zone (the "primary feeder zone") beneath and adjacent to the open pit. Twenty-eight deep holes in 2001 (approximately 15 000 metres) extended the 80-metre wide mineralized breccia zone to over 800 metres in strike length. Finely disseminated chalcopyrite and bornite with very minor native copper and chalcocite have been intersected from 150 to 950 metres below the surface with the zone remaining open along strike, to surface and to depth (John Ball, Electronic Communication, February 20, 2002).

Significant intersections beneath the southwest pit-rim included hole 2K01-42 that graded 1.53% Cu, 1.2 g/t Au, 0.21 g/t Pd, and 2.5 g/t Ag over a 204 metre core length beginning at 550 m, and hole 2K01-46 that graded 1.43% Cu, 0.82 g/t Au, 0.07 g/t Pd and 2.1 g/t Ag for a 306 metre core length beginning at 324 metres. Also of interest were two holes that intersected high palladium values that do not appear to be associated with significant copper mineralization. Holes 2K01-24 and 2K01-37 each cut 3.05 metre intersections grading 4.11 g/t Pd (with 0.03% Cu) and 7.95 g/t Pd (with 0.19% Cu) respectively.

A February 2001 scoping study by Behre Dolbear & Company Ltd. was based on an Indicated Mineral Resource of 22.7 million tonnes grading 2.0% Cu, 1.54 g/t Au, 6.8 g/t Ag and 0.14 g/t palladium. They determined that the Afton project "has favorable economic possibilities with low production costs, moderate capital requirements, and relatively low environmental concerns. Block Caving at a rate of 4,500 tons per day was selected because of amenable geotechnical conditions" (DRC Resources News Release, February 28, 2001).

In November 2001, DRC released an updated Mineral Resource Study by J.J. McDougall that said the drilling to date "indicates a continuous mineral zone 850 metres in length, with a depth of 775 metres below the upper contact of the primary mineral zone". McDougall estimated that the indicated resource is now 34.07 million tonnes grading 1.83% Cu, 1.4 g/t Au, 0.1 g/t Pd and 5.5 g/t Ag, plus an additional inferred resource of 5.91 million tonnes at a lower grade. In 2002, DRC plans additional drilling to increase the length and depth of the mineral zone and to test the zone towards surface to the southwest.

Also late in the year, Abacus Mining and Exploration Corp., announced that it was negotiating with Teck Cominco Ltd. to acquire Teck's **Afton area** properties which include the Rainbow, Crescent and DM-Audra occurrences, along with the Ajax West and East pits.

Near Princeton, the **Tulameen** thermal coal project of Pacific West Coal (UK) Ltd. was taken over by Compliance Coal Corporation, a private company headed by James O'Rourke. It has now been renamed the **Basin Coal** project. In late summer, Compliance mined a 10 000 tonne bulk sample from a small open cut (Photo 9) and trucked approximately 1000 tonnes to potential customers.

The coal is high volatile bituminous B and C in rank and company studies indicate that it can be cleaned to produce a product with acceptable levels of ash, moisture, sulphur and energy content. Potential markets are industrial users in the Lower Mainland, northwestern United States and overseas. Initially the project could employ up to 30 people.

At year-end, Compliance was finalizing an application to amend their current Mines Act permit to allow a wash plant, and to raise the allowable mining rate to 250 000 tonnes per year from 100 000 tonnes per year. A feasibility

Photo 9. View looking southerly (along strike) across the Tulameen Coal project of Compliance Coal Corporation. The coal measures (black) dip shallowly to east (left).

study is being completed and the company plans a public listing over the winter months. It is anticipated that mining could begin in Spring 2002.

Also at Princeton, the Ministry of Energy and Mines issued a mining lease to Zeo-Tech Enviro Corp. for its proposed **Zeo-Tech** zeolite quarry. No mining was done but the company continued to work towards production of zeolite for use in lightweight specialty concrete and in absorbent products.

Several other projects in the region are on hold awaiting higher commodity prices, financing and/or permits. The largest is the **Prosperity** porphyry gold-copper deposit of Taseko Mines Ltd., located southwest of Williams Lake. Reserves stand at 633 million tonnes grading 0.253% Cu and 0.466 g/t Au.

The **Bralorne** gold project, a joint venture of Bralorne Pioneer Gold Mines Ltd. (50%), Avino Silver and Gold Mines Ltd. (25%) and Coral Gold Corporation (25%), received a Mine Development Certificate in 1995 but has not yet reached commercial production. In 2001, a 21.4 metre raise to surface was mined on the **Peter Vein** (Cosmopolitan Crown Grant). Bralorne reported that the raise averaged 25 g/t gold over an average width of 1.3 metres. The company plans to conduct further test mining in this area, stockpiling the ore for processing when the milling facility is complete.

At the **Getty North** porphyry copper project of Getty Copper Corporation, a small program of geological mapping and soil geochemistry was conducted. Located north of Highland Valley Copper, the Getty North deposit is estimated to contain a resource of 72.1 million tonnes grading 0.31% Cu, which includes an oxide resource of 10.0 million tonnes grading 0.40% Cu. Getty is studying the feasibility of an SX-EW operation to treat the oxide resource.

Near Vernon, the **Lumby** graphite-sericite project of Quinto Technology Inc. was dormant. The company has a permit to produce up to 75 000 tonnes per year.

EXPLORATION PROJECTS

STRATIFORM BASE-METAL TARGETS

Trenching and/or drilling explored several exciting new stratiform base-metal prospects, discovered last year. The most promising remains the **Spire** prospect. The property is located north of Revelstoke, about 7.5 kilometres southwest of the Goldstream mine. Excavator trenching was conducted by Imperial Metals Corp. to follow up on high-grade Besshi-style VMS mineralization discovered in a roadcut in the fall of 2000. The 2001 trenching extended the known strike length of mineralization to approximately 100 metres. The best channel sample returned 7 metres grading 0.9% Cu and 1.8% Zn, including 1 metre grading 3.4% Cu and 2.9% Zn (Imperial Metals website).

The new trenching program was designed to follow-up on results from a late-2000, 7-hole drill program. The best drill intersection in that program was 3.12 metres grading 0.51% copper and 1.08% zinc. Optimism for the Spire prospect remains high because the host rocks, grade, width and style of mineralization suggest a stratigraphic and structural setting similar to the Goldstream mine.

Much-anticipated drilling of the **Blacktop** zone (**Fox** property) of Gitennes Exploration Inc. was completed in April 2001, following a large program of airborne and ground geophysics, and limited geochemical and geological work. The drill program was designed to test geophysical anomalies coincident with the down-dip projection of the high-grade massive sulphide copper-zinc-gold-silver-lead Blacktop zone. This showing was discovered in a Coquihalla highway roadcut, 27 kilometres north of Merritt (Photo 10).

The Blacktop zone is hosted in sheared and altered intermediate volcanic rocks of the Upper Triassic Nicola Group. Mineralized clasts are associated with sericitic, cherty and baritic rock fragments. Gitennes reported that the drill holes intersected fault breccia with sulphide fragments over widths of up to 20 metres, and the best hole cut 0.7 metres grading 16.50% Zn, 1.18 % Cu, 87.4 ppm Ag and 450 ppb Au.

Although about 1200 claim units were staked during the original Fox mini-rush, little or no work was done on tie-on ground by Fjordland Minerals Ltd., Platinova A/S. or other companies and individuals. Gitennes, however, plans to do more fieldwork on their properties in 2002.

Another high-profile project was the **Broken Hill** (**Vista-Navan** showings) zinc-lead-silver project of Cassidy Gold Corporation, located seven kilometres northeast of the village of Avola on the North Thompson River. Staked by Prospectors Assistance grantee Leo Lindinger and optioned to Cassidy in early fall 2000, the property covers high-grade showings of stratiform "Shuswap-style" mineralization along new logging roads that cross the zone intermittently along a strike length of several kilometres. Host rocks are amphibolite-grade metasedimentary rocks of the Shuswap metamorphic complex.

Following a small program of gravity, soil and geological surveys, Cassidy partially drill-tested the two main showings in January 2001. Despite the presence of numerous outcrops of thin (20-40 centimetre wide) flat-lying, massive sulphide (grading up to 24.3% Zn, 4.89% Pb and 62.6 g/t Ag) Cassidy's best drill hole hit only 2.52% Zn over 3.9 metres, with an estimated true width of 2.2 metres. Cassidy returned the claims to Lindinger in late 2001.

On the **Red Hill** property near Ashcroft, Teck Exploration Ltd. (now part of Teck Cominco Ltd.) drilled over 3600 metres in 17 holes to test numerous stratiform copper-zinc-gold-silver targets that occur within a thick package of Lower Triassic bi-modal volcanics with minor shale interbeds. The host rocks are thought to be correlative with rocks which host the Kutcho Creek Cu-Zn deposit in northern BC. Although Teck released no results, previous drill holes at Red Hill have cut up to 20 metres of disseminated to semi-massive sulphides (mainly pyrite). One old hole by BP Selco is reported to have intersected 7.7 metres of VMS-style mineralization grading 2.5% Cu, 2.8% Zn, 77 g/t Ag and 0.37 g/t Au (Photo 11).

Photo 10. Geologists examine a trench with massive sulphides at the Blacktop zone, Fox property.

North of Little Fort, Cassidy Gold Corporation drilled one hole on the **Crazy Fox** (Demers Creek) base-metal prospect. Unfortunately the hole had to be abandoned in a fault zone at 249 metres, before it reached its intended depth. The hole was designed to test coincident EM and copper-in-till anomalies. The property is underlain by mafic volcanic rock and black shale of the Upper Triassic Nicola Group, along with pale buff rhyolitic rock that has not been dated but could be part of the Nicola sequence, or could be a younger (Eocene?) intrusion.

PORPHYRY AND RELATED TARGETS

G W R Resources Inc. drilled seven holes in late 2000 and early 2001 on the **Ann** property. The holes tested alkalic porphyry-style copper-gold mineralization near the Aurizon Gold zone. The best result reported by the company was 46.5 metres grading 0.219% Cu and 0.39 g/t Au

Photo 11. Gossan (light area) on Teck's Red Hill VMS Cu-Zn property south of Ashcroft. The Trans Canada Highway is visible in the distance.

beginning at 80 metres in hole AZ-00-1. The company also acquired the nearby **Tam** property and drilled three holes; the best intersection was 17.4 metres grading 0.61% Cu, 0.18 g/t Au and 6 g/t Ag.

Christopher James Gold Corp. was busy on its large **Silver Lake** (PGR) property north of Little Fort. The **Worldstock** Cu-Ag-Mo-Au-Zn target (Photo 12) was explored with I.P. and magnetic surveys, geological mapping, soil geochemistry, prospecting, excavator trenching and a seven-hole, 879-metre drill program. The work defined a large (greater than 1000 by 700 metre) chargeability anomaly that is partially coincident with copper-in-soil anomalies.

The trenching and drilling showed that the area is underlain by an extensive stockwork of vuggy quartz-carbonate-pyrite veinlets cutting sericite-, carbonate- and locally potassium feldspar- or clay-altered mafic volcanic rocks of the Nicola Group. Higher copper values and potassium feldspar-alteration zones are commonly associated with rare, narrow crowded feldspar dikes. The best hole (#1) cut a 10.4 metre section averaging 0.38% Cu and 2.6 g/t Ag. The mineralization is interpreted to be part of a high-level, zoned porphyry system by company consultant Ron Wells.

Photo 12. Ron Wells (Consultant to Christopher James Gold Corp.) and Paul Schiarizza (BC Geological Survey) examine a trench on the Worldstock copper prospect, Silver Lake property.

In addition to the Afton mine project described above, several other properties in the Iron Mask batholith near Kamloops, were explored by small programs. Planet Ventures Inc. drilled two short holes on alkalic porphyry copper-gold targets on the **Planet** property, and Snowfield Development Corp. conducted surface surveys on the **Galaxy** (DCE) property.

SKARN TARGETS

Near the historic Nickel Plate gold mine at Hedley, Goldcliff Resources Corporation worked on its **Panorama Ridge** gold skarn property. The Nordic, York, Spar and several other prospects were explored by stream sediment and soil geochemistry, geological mapping, prospecting and diamond saw channel sampling. Numerous old trenches and prospect pits were located and extensive areas of skarn with pyrrhotite-pyrite-chalcopyrite mineralization were identified.

The showings are hosted by altered sedimentary and volcaniclastic units (Hedley and Whistle Formations?) of the Upper Triassic Nicola Group that are intruded by diorite of the Hedley intrusions. Goldcliff reported that a trench on the York prospect, dug by Placer Development in 1985, ran 0.81 g/t Au over 45 metres. Additional work, possibly including trenching and drilling, are being planned for next year.

East of 100 Mile House, Starcore Resources Ltd. optioned the **Fox** molybdenum-tungsten property from owner Dave Ridley. This promising new skarn prospect is located about 25 kilometres east of the former producing Boss Mountain molybdenum mine. Mineralization has been traced by prospecting over a strike length of more than two kilometres, and is hosted by Paleozoic metasedimentary rocks near the contact with the Cretaceous Deception stock.

Starcore reported that scheelite (up to 0.69% W) and molybdenite (up to 4.9% Mo in grab samples) appear to occur in separate areas. Garnet, diopside, vesuvianite, quartz and calcite have been identified in the skarn by this author. Soil and rock geochemistry has also identified local anomalous Au and Zn values on the property. This discovery benefited from Prospectors Assistance Program funding support to Ridley during the 1999 and 2000 field seasons.

VEIN TARGETS

On the large **Silver Lake** property, north of Little Fort, Christopher James Gold also discovered narrow quartz-carbonate veins carrying high-grade copper-silver-gold mineralization in the **New Discovery "A"** target area (Photo 13). Following up on high-grade float boulders found in 2000, the company did geophysical surveys, geological mapping, prospecting and excavator trenching to discover the high-grade veins in bedrock.

Subsequent drilling at the New Discovery “A” target returned up to 14.7% Cu, 98.9 g/t Ag and 0.3 g/t Au over 0.55 metres according to company releases. Patchy chalcopyrite and pyrite occur in quartz-calcite veins that cut magnetite-, pyrite-, and chlorite-altered mafic volcanics of the Nicola Group. Similar mineralization was also found in drill holes along trend to the west, some 600 metres west of the Discovery “A” area and 400 metres east of the **New Discovery “B”** area.

South of Kamloops, on the **Melba** property, Walloper Gold Resources Ltd. explored several vein targets in volcanics of the Nicola Group. A new discovery is the **Chalcedonic Quartz Breccia** vein that strikes northerly, dips moderately to the west, is up to 5 metres wide and is exposed over a strike length of 34 metres in one trench. Minor disseminated pyrite is present in the banded chalcedonic quartz, and an epithermal origin is suspected. Walloper conducted diamond saw channel sampling and drilled 11 holes in fall 2001. In February 2002, Walloper reported that only weakly anomalous Au, As, Hg and Mo values were present in the trench and drill samples.

The **Pongo** property (**Kajun** showing) near East Barriere Lake was trenched and drilled by partners Verdstone Gold Corp. and Molycor Gold Corp. The drill holes encountered vein and stockwork-style quartz-carbonate-sulphide mineralization with interesting base and precious metal values. For example, Hole 01-04 cut 3.0 metres grading 0.12% Cu, 4.79% Pb, 3.12% Zn, 107 g/t Ag and 0.72 g/t Au. The mineralization mainly occurs in black phyllite beneath a shallowly dipping thrust fault that has marble in the hangingwall. The partners believe the setting to be similar to the Samatosum mine to the south, and that there is potential for VMS deposits nearby.

At the **Siwash North mine** (**Elk** property) east of Merritt, Fairfield Minerals Ltd. reported discovery of two new high-grade gold-silver veins. In the **Siwash East** area, 1.7 kilometres east of the mine, trenching encountered a 20 centimetre-wide vein that assayed 21.7 g/t Au and 32.9 g/t Ag over a 0.5 by 0.5 metre panel sample. Trenching in the **Gold Creek West** area found a 30 centimetre-wide vein that ran 20.5 g/t Au and 59.6 g/t Ag over a 0.8 by 0.5 metre panel. Mine production (1992-1994) from Siwash North totaled more than 1440 kilograms (51 000 ounces) gold.

Fairfield also reported discovery of gold-bearing epithermal quartz float boulders over an area of one square kilometre in **Prospect Valley**, 50 kilometres west of Merritt. Forty claim units were staked. Grab samples run up to 43.34 g/t Au with anomalous Ag, As, Sb and Mo. Volcanic rocks of the Spences Bridge Group and granodiorite of the Mount Lytton Complex underlie the area. There is no history of previous work here, although a nearby Regional Geochemical Survey silt sample contained 150 ppb gold.

MAGMATIC TARGETS

Relatively strong prices for platinum group metals (PGMs) and tantalum increased interest in magmatic targets. Near Little Fort, Cusac Gold Mines Ltd. drilled several holes at the **Clearwater Platinum** project (**Golden Loon** claims). Unfortunately, results were disappointing and the property was returned to the vendor. The property covers a six to ten kilometre-long, compositionally zoned, ultramafic body that occurs between the Upper Triassic Nicola Group and the Triassic-Jurassic Thuya batholith. The company’s interest in the property was first prompted by a float sample of dunite, collected by J. McDougall in 1999, which assayed 13.7 g/t Pt.

Photo 13. Geologists examine high-grade copper float in a trenched roadcut at the New Discovery “A” target on the Silver Lake property. Trenching below the road to the north (left) discovered vein-style quartz-carbonate-chalcopyrite-pyrite mineralization in bedrock.

At **Tulameen**, Bright Star Ventures Ltd. explored their 9500-hectare claim group in search of the lode source for the district’s historic placer platinum production. The work comprised an airborne magnetic/electromagnetic survey, prospecting and rock sampling. Several copper, chromite and PGM targets have been identified for future drilling including the **Grasshopper Mountain** area.

Unusual syenite-related PGM mineralization was the focus of a small exploration program by Santoy Resources Ltd. at **Allendale Lake**, east of Okanagan Falls. The prospect was optioned from geologist Adam Travis who staked it as part of his 2000-2001 Prospectors Assistance program. The alkalic Allendale Lake stock is approximately 2.5 kilometres in diameter and includes megacrystic syenite porphyry and shonkinite phases. A grab sample from a previously known prospect (the “**Spoon** showing”) assayed 0.31% Cu, 0.93g/t Pd, 0.19g/t Pt and 0.70g/t Au.

The late-2000 rise in spot prices for tantalum to the $US400 per pound range led to renewed interest in carbonatite intrusions in British Columbia. In the **Blue River** area, in particular, these rocks are known to contain highly anomalous values of tantalum, niobium and phosphate. Commerce Resource Corp. staked the Verity, Fir and several other carbonatite deposits late in 2000, and conducted a large exploration program in 2001. Several other companies acquired properties nearby.

At **Verity**, Commerce compiled previous drilling information and calculated a new resource figure. The company reports the inferred resource now stands at 3.06 million tonnes grading 196 g/t Ta_2O_5, 646 g/t Nb_2O_5 and 3.2% P_2O_5. In addition to geological, geophysical and geochemical surveys, five holes were drilled, with carbonatite intersections ranging from 19 to 70 metres and grades comparable with previous drilling. At Verity, pyrochlore contains tantalum and niobium, and apatite is the source of phosphate values.

To the south at the **Fir** property, six drill holes tested two flat-lying carbonatite layers that range in thickness from 6.1 to 50 metres. The company expects grades at Fir will be higher than at Verity based on four holes drilled in the 1980s. Tantalum and niobium values are reported to occur in ferrocolumbite. See the report by Jody Dahrouge in this volume for further details.

The **Perry River** carbonatite belt, northeast of Shuswap Lake, was also the subject of staking and exploration for tantalum-niobium and rare earth elements. Commerce Resources Corp. and Cross Lake Minerals Ltd. staked the largest blocks, with the former acquiring the 231-unit **Perry** property and the latter acquiring the **Myoff Creek** property, which includes the **Ren** occurrence. Four trenches at Ren tested just 410 metres of the known 12-kilometre strike length of the carbonatite. Anomalous amounts of niobium, tantalum, lanthanum, cerium and neodynium were reported over widths of 50 to 120 metres. To the southwest, partners John Kerr and Warner Gruenwald, in part supported by a Prospectors Assistance grant, prospected the **Tan** claims.

COALBED METHANE

In response to the recent California energy crisis and the forecast of increased demand for natural gas, companies are taking an interest in coalbed methane (CBM) potential throughout British Columbia. In the South-Central region, CBM potential appears highest in the **Hat Creek**, **Similkameen (Princeton-Tulameen)** and **Merritt** coal basins. It is likely that the Province will begin issuing CBM tenures for these basins in 2002. In the **Merritt** coal basin, Forum Ventures acquired an option to gain a 50 per cent interest from Imperial Metals Corp. in a 506-hectare property that contains the Coal Gully Hill, Middlesboro and Coldwater Hill collieries. Forum plans to investigate both CBM and conventional coal mining opportunities.

ACKNOWLEDGEMENTS

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KOOTENAY REGION

David A. Terry, Ph.D., P.Geo.
Regional Geologist, Cranbrook

SUMMARY

Exploration expenditures in the Kootenay region during 2001 are estimated at approximately $7.8 million, an increase of 20% over the $6.5 million spent in 2000 (Figure 1). The 2001 total comprises $4.83 million (62%) spent on drilling for coal at, or in the vicinity of, the five producing coal mines in the Elk Valley, a 2.5 times increase over 2000 levels; $1.78 million (23%) spent on metal exploration; and $1.18 million (15%) spent on industrial mineral exploration (Figure 2). The continued strong increase in drilling expenditures by the coal companies reflects the relatively robust market for the high quality metallurgical coal produced in southeastern British Columbia, and increased levels of production at some of the mines over the past several years.

An estimated 88,378 metres of drilling was carried out in the region in 2001, in all categories, up by 26% over 2000 levels (Figure 1). Coal companies carried out 86% of the total metres of drilling using reverse circulation drilling techniques (Figure 3a). The continued sharp decline in metal exploration spending is highlighted by the amount of exploration drilling for metals. Only about 7200 metres in 40 holes were completed in 2001 on metal projects. Overall in 2001, metals drilling accounted for just 8% of the total metres drilled. An estimated 5422 metres of drilling was carried out on industrial minerals projects, making up the remaining 6%. Figure 3b shows the total metres of drilling broken down into three categories. The “mine development” and “deposit appraisal” categories represent drilling carried out in the vicinity of the five coal mines, whereas the “exploration” category is dominated by drilling on metal and industrial mineral projects.

A total of 53 NOTICES OF WORK were submitted to the Kootenay Region Mines Branch office in 2001 for work on mineral projects, 10 NOTICES OF WORK were received for coal exploration programs, and 38 Placer Notices of Work were received. The number of projects worked on last peaked in 1997 and has declined since then to about 97 in 2000 and only 50 in 2001 (Figure 4).

The main focus of interest for metals in the region in 2001 was in the Nelson area where Sultan Minerals Inc. carried out a large exploration program on their Kena intrusion-related gold project. Drilling on the Gold Mountain Zone, located in the northern portion of the Kena property, has identified both low grade and high grade gold mineralization, suggesting the potential for both bulk tonnage and smaller bonanza-grade deposits. Also in the Nelson area, a late season drill program carried out on the Silver Lynx VMS project by Cassidy Gold Corp. intersected altered volcanic and sedimentary rocks with widely distributed sulphide mineralization. Exploration for Sullivan type deposits in the Purcell Anticlinorium declined further from 2000 levels; only two small drill programs by Klondike Gold Corp. targeted sedex mineralization.

Several interesting industrial minerals projects were advanced in 2001. A drilling and trenching program was carried out by Crystal Graphite Corporation on their Black Crystal graphite project in the Slocan Valley. A resource estimate was released, and their on-site pilot plant was com-

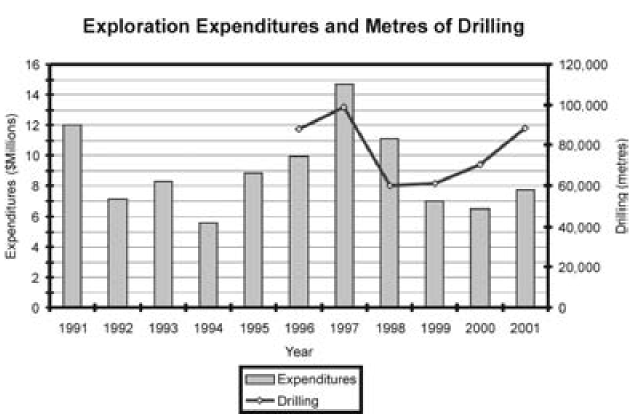

Figure 1. Exploration expenditures and metres of drilling.

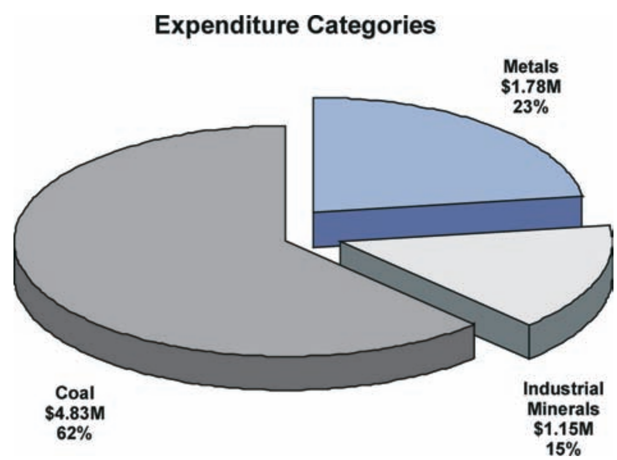

Figure 2. Exploration expenditures by commodity type.

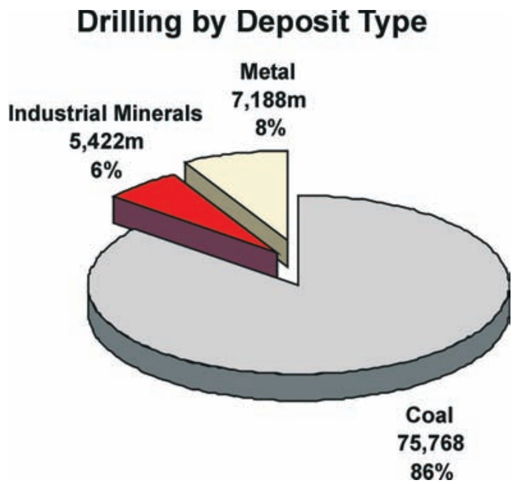

Figure 3a. Drilling metres by commodity type.

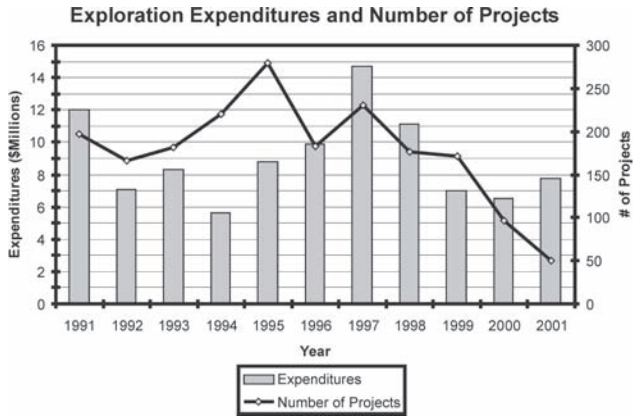

Figure 4. Exploration expenditures and number of projects.

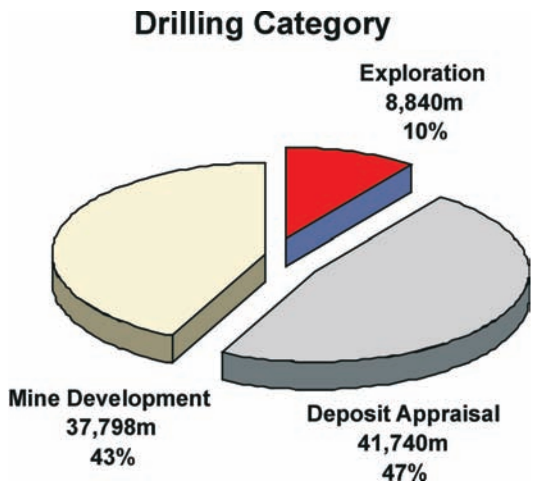

Figure 3b. Drilling metres by category.

missioned. New gypsum resources were identified on the Elkhorn West property, immediately west of Westroc's Elkhorn gypsum mine, and more drilling was carried out on their Kootenay East and West gypsum projects, east of Canal Flats. Tiger Ridge Resources continued underground development, bulk sampling, and exploration drilling on their Jubilee Mountain barite project west of Spillimacheen. As well, a short drill program was carried out on the Ice kimberlite project north of Elkford by Skeena Resources Limited. The company intersected 105 metres of kimberlite but analytical results are not yet available.

One of the most significant events in the region in 2001 was closure of the Sullivan mine in Kimberley on December 21, 2001, after more than a century of continuous production. Teck Cominco Limited celebrated the legacy of the world-class mine with a two-day symposium that included technical talks on the Sullivan Mine and exploration in the Sullivan Camp, underground mine-tours, and poster displays. All the major industrial mineral mines and quarries that were in operation at the beginning of the year maintained steady production levels throughout the year and no significant change is forecast for 2002. Except for Sullivan, there were no other mine closures in the region during the year, and no new mines opened.

EXPLORATION HIGHLIGHTS

The major metals, industrial minerals, and coal exploration projects carried out in the Kootenay Region during 2001 are listed in Table 1. These major projects involved significant levels of expenditures (*i.e.* >$100,000) on exploration drilling, bulk sampling, or underground exploration work. Locations of these projects, and certain other ones that are believed to be regionally significant but had relatively small programs during 2001, are shown on Fig-

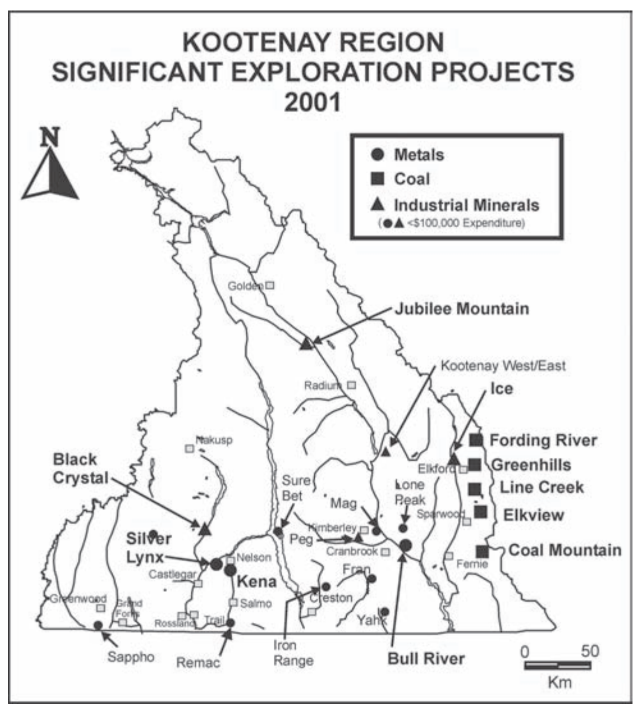

Figure 5. Significant exploration Projects in the Kootenay region, 2001.

TABLE 1
MAJOR EXPLORATION PROJECTS, KOOTENAY REGION, 2001

Property	Operator	MINFILE	NTS	Commodities	Deposit Type	Work Done
Black Crystal	Crystal Graphite Corp.	082FNW 260	82F/13W	Graphite	Metamorphic	2128m diamond drilling in 39 holes; 148 trenches
Coal Mountain Mine	Fording Coal Ltd.	082GSE 052	82G/7E, 10E	Coal	Sedimentary	5848m RC drilling in 21 holes
Elkview Mine	Elkview Coal Corp.	082GNE 015	82G/10W, 15W	Coal	Sedimentary	5900m RC drilling in 57 holes
Fording River Mine	Fording Coal Ltd.	082JSE 009, 10, 12	82J/2W	Coal	Sedimentary	15 552m RC drilling in 73 holes
Greenhills Mine	Fording Coal Ltd.	082JSE 001, 5, 7	82J/2W	Coal	Sedimentary	6650m RC drilling in 59 holes
Ice	Skeena Resources	082JSE 019	82J/2W	Diamonds	Kimberlite	~400m in 5 holes, 4 tonne bulk sample
Jubilee Mountain	Tiger Ridge Resources	082KNE 079	82K/16W	Barite	Veins, Breccias	1203m diamond drilling in 13 holes; 5556 tonne bulk sample
Kena Gold	Sultan Minerals Inc.	082FSW 237, 331, 332	82F/6W	Au, Ag, Cu	Porphyry	~5200m diamond drilling in 28 holes; trenching; geol; gechem; geophys
Line Creek Mine	Luscar Ltd.	082GNE 020, 21, 22	82G/15W, E	Coal	Sedimentary	35 300m RC drilling in ~136 holes
Silver Lynx	Cassidy Gold Corp.	082FSW 378	82F/6W	Au, Ag, Cu, Pb, Zn	VMS	642.5m in 4 diamond drill holes; geol, geochem, geophys

ure 5. There were a total of 11 projects with reported expenditures of more than $100,000 in the Kootenay Region this year. The actual expenditures at Bull River are unknown but have been conservatively placed at $500,000 for statistical purposes.

METALS

Gold City Industries Ltd. carried out geological mapping, and rock and soil sampling on their **Sappho** Cu-platinum group element (PGE)-Au property located south of Greenwood. This structurally complex property is underlain primarily by greenstone, diorite, ultramafic intrusive, and feldspar porphyry. The Cu-Au mineralization is mainly associated with the ultramafic rock, which has been interpreted by past workers to be part of the Tertiary Coryell suite. Outcrop on the property is limited but three areas of historical workings occur over a strike length of 600 metres. Rock samples were collected from all three areas, although most work focused on the southernmost or Main Zone (Photo 1). To test the Main Zone 48 chip samples of 0.5 to 1m in length were collected in 3 fences over a stripped-off area. Assays of up to 6% Cu, 4.6 g/t Pd, and 0.1 g/t Pt were attained. Soil sampling away from the three areas of known mineralization identified a Cu anomaly along the southern property boundary in an area with no outcrop; it is similar to that found around the Main Zone. The property was also studied by Graham Nixon as part of a Geological Survey Branch field program on PGE environments in southern British Columbia. This work identified the ultramafic intrusive host to the mineralization as Jurassic in age.

Cassidy Gold Corp. carried out a program of geological mapping, geophysical surveys, and soil sampling on its **Silver Lynx** VMS property, located 20 kilometres west of Nelson. The property is underlain by argillites and siltstones of the middle Jurassic Ymir Group that overlie a package of phyllitic felsic tuffs. The entire sequence appears to have been folded to form a south-plunging antiform. Two showings, 170m apart, were discovered by prospector Bruce Doyle as part of his Prospectors Assistance Program grant work in late 2000 (Photo 2). The mineralization, which has been interpreted to be VMS-type, appears to be stratabound and occurs within 20 metres of the

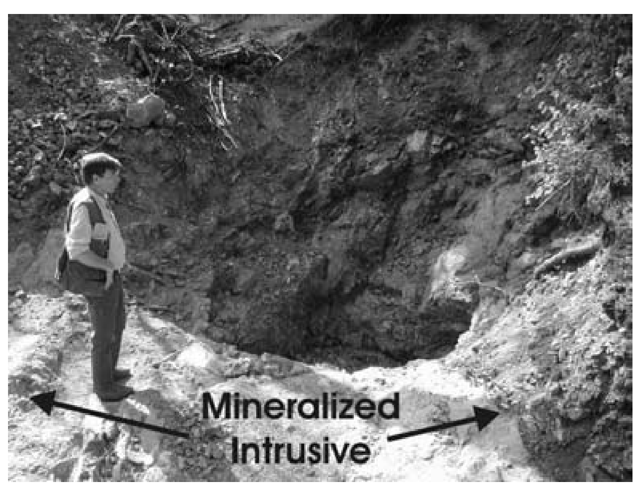

Photo 1. Sappho Main Zone.

volcanic-sediment contact. Selected grab samples assayed up to 24.59% Zn, 22.35% Pb, 0.21% Cu, and 556.4 g/t Ag. Soil sampling on the property identified numerous polymetallic anomalies that coincide with the projected strike of the mineralized volcanic-sediment contact. A late season, 4-hole, 643-metre diamond drill program was carried out to test the main showing area over a strike length of approximately 265 metres. Two distinct mineralized zones with disseminated to semi-massive sphalerite, galena, chalcopyrite, and arsenopyrite, as well as widely distributed sphalerite stringers, were cut in three of the holes; the fourth hole encountered a thick mafic intrusive. Assays graded up to 6.87% Zn, 1.13% Pb, and 42.5 g/t Ag over 0.6 metres. The company is planning a follow-up program for 2002.

Sultan Minerals Inc. carried out a large exploration program comprising diamond drilling, IP surveying, geological mapping, and soil sampling on their Kena intrusion-hosted/related gold project, located north of Ymir. A total of 4800 metres of diamond drilling in 30 holes focused on following up numerous coincident geochemical and IP anomalies within a target area measuring 1400 metres by 500 metres. Holes were drilled to depths of approximately 200 metres (Photo 3). The program identified a number of high-grade gold-bearing structures within a broad envelope of low-grade gold mineralization. Typical assays of the low-grade mineralization, all of which are from samples at or near the surface, include 100 metres grading 1.21 g/t Au in hole 01GM-01, 116.05 metres grading 1.87 g/t gold in hole 01GM-03, 130 metres grading 1.14 g/t Au in hole 01GM-05, 160 metres grading 1.15 g/t Au in hole 01GM-08, and 140.38 metres grading 1.10 g/t Au in hole 01GM-28. This wide zone of low-grade gold mineralization occurs along the eastern margin of the Early to Middle Jurassic aged Silver King Porphyry where it is in contact with mafic volcanic and tuffaceous rocks of the Early Jurassic Elise Formation. Several bonanza-grade gold zones internal to the lower-grade areas (*e.g.* 172.1 g/t Au over 2 metres in hole 01-GM-08 and 240.1 g/t Au over 1.23 metres in hole 01-GM-03) are spatially related to the porphyry-volcanic contact. Gold mineralization is associated

Photo 2. Prospector Bruce Doyle examining mineralized talus, Silver Lynx Project.

Photo 3. Diamond drilling on the Gold Mountain Zone, Kena Project.

with 2-5% disseminated and fracture-filling pyrite in areas of the Silver King monzonite to diorite plagioclase porphyry which have undergone silicification and strong potassic alteration. Fine-grained visible gold has been observed locally in drill core. Regional work covering the extensive 17 kilometre length of the Kena property, which covers the trend of the Silver King Porphyry intrusives, identified a number of new gold showings and gold soil anomalies. Sultan Minerals added to their land position in the area by optioning several properties adjoining the Kena property from local prospectors in the fall. These included the **Great Western, Tough Nut, Cariboo, Princess, and Cleopatra** properties.

No exploration work was carried out this year on the **Remac** Zn Oxide project south of Salmo by project operators Redhawk Resources Inc. and joint venture partners ZincOx Resources PLC. A significant drill program aimed at delineating a resource is currently planned for the spring of 2002.

Eagle Plains Resources Ltd. carried out a program of prospecting and soil sampling on its **Iron Range** property northeast of Creston. They are pursuing Olympic Dam and sedex-type targets. The Iron Range Fault, which bisects the property, extends for more than 40 kilometres in a north-south direction and is bordered by strongly albite-altered middle Aldridge clastic sediments intruded by gabbro sills. The fault zone itself is commonly occupied by foliated gabbro rimmed by albitic alteration. The survey covered a 16-kilometre strike extent of the Iron Range fault that includes 14 hematite-magnetite showings (Photo 4). One survey area covered a hematite-magnetite breccia zone with a strike length of 3 kilometres and widths of 60 to 150 metres. Approximately 2000 soil samples were collected along lines 500 metres apart crossing the structure; a number of anomalous areas with Olympic Dam-type geochemical signatures were identified. Eagle Plains is currently seeking a joint venture partner for the property.

Klondike Gold Corp. completed 303 metres of drilling in 4 holes on its **Sure Bet** property near Crawford Bay on the east side of Kootenay Lake. Two holes testing geophysical targets intersected semi-massive pyrrhotite and graphite, containing minor Cu-Zn mineralization, hosted by metamorphosed shale. Some sulphide mineralization was also observed in carbonate units and biotite-garnet-quartz schists. No assays were reported for this drilling. Klondike Gold also completed two 150-metre drill holes on its **Yahk** sedex property east of Yahk. The holes were designed to test an area with bedded tourmalinite, fragmental and fracture-filling Pb-Zn mineralization, and a coincident multielement soil anomaly. No economic sulphides were intersected. A deeper hole to test the Lower Middle Aldridge Contact (Sullivan time) at a depth of approximately 700 metres was recommended as a follow-up to the drilling. Klondike Gold initiated a drill hole on their **Fran** sedex property northeast of Moyie Lake, also targeting the Lower Middle Aldridge contact. The hole penetrated a significant thickness of overburden without reaching bedrock. The company intends to deepen the hole in 2002.

Early in 2001 Pathfinder Resources Ltd. drilled a single 660-metre hole on its **Mag** property near the Cranbrook Airport. The hole was designed to test a deep-seated magnetic anomaly for Olympic Dam-style Cu-Au-U mineralization. The hole encountered unaltered monzonite to syenite with 1-15% disseminated magnetite, which they believed explained the magnetic anomaly. No anomalous geochemistry was received from core samples and the property was returned to the vendor.

Photo 4. Magnetite lens, Iron Range Project.

Golconda Resources Ltd optioned the **Lone Peak** property, located east of Fort Steele, from a local claim owner. The property is underlain by rocks of the Creston and Kitchener formations of the Purcell Supergroup. The Spar Lake quartzite unit in the Creston Formation is equivalent to the rocks which host the Spar Lake Cu-Ag deposit, 85 kilometres to the south in Montana. This quartzite is 100 metres thick on the property and can be traced for approximately 3 kilometres along strike. Detailed mapping and prospecting carried out on the property as part of Golconda's due diligence, identified a 300 metre wide anticlinal fold in the Spar Lake unit that contains sheeted quartz veins and stockworks. Assays from grab samples collected within this zone contain up to 1% Cu, 27 g/t Ag, and 32 g/t Au. Visible gold occurs in sheeted quartz veins up to 10 centimetres in width. Golconda also optioned the **Bri-Lin** and **Sully** claims to the north of Lone Peak. The company intends to start drilling early in 2002.

INDUSTRIAL MINERALS

Insulation and mineral wool manufacturer Roxul (West) Inc. continued exploration for new raw materials to optimize their mineral wool operation in Grand Forks. A 10,000 tonne bulk sample of diorite was collected and processed from the **Winner** property near the past-producing Phoenix mine west of Greenwood to provide plant feed. Near the end of the year the company applied for a Mine Lease for the Winner Quarry. Plans call for approximately 50,000 tonnes to be produced every second year from the Winner Quarry as feed for the mineral wool plant.

In the Hoder Creek area of the Slocan Valley, Crystal Graphite Corporation continued exploration work on its **Black Crystal** project, and made progress toward commissioning its Koch Creek graphite pilot plant, 25 kilometres to the south. The Black Crystal property is underlain by the Paleozoic rocks of the Valhalla Gneiss complex. Calc-silicate gneiss intruded by pegmatitic dykes host crystalline and flake graphite on the property. The zone of graphite mineralization dips to the southwest and extends more than 400 metres in an east-west direction and 300 metres in a north-south direction at the Hoder Creek quarry site (Photo 5). During 2001 the company completed 1900 metres in 42 diamond drill holes on the Black Crystal project site at Hoder Creek. A further 233 metres in 5 holes and 216 metres in two percussion drill holes were drilled on the "Beauzone" adjacent to the pilot plant at Koch Creek. A total of 1855 metres of linear trenching tested the weathered "Regolith" horizon. A 10,000 tonne bulk sample was collected in the fall from trenches traversing across the graphite zone. Based on the work to date, Mine Design Systems Ltd. of New Zealand calculated a resource for the Black Crystal project of 12,974,900 tonnes grading 1.34% graphite. Of this, 1,922,100 tonnes are classified as measured, 10,196,500 tonnes are indicated, and 856,300 tonnes are inferred. Based on the resource figure, the total in situ graphite resource on the property is 174,400 tonnes. Included within this resource is the higher grade "Regolith Zone" which comprises 1.01 million tonnes of measured and indicated resources at surface averaging 1.7% graphite. The

Photo 5. Hoder Creek quarry site, Black Crystal Project.

bulk sample material collected this year together with that collected in 2000 resulted in a stockpile of 20,400 tonnes of material at the pilot plant site. Some 2000 tonnes of this stockpile was successfully processed, producing a final product grading 94% to 97.5% graphite. The plant will now progress through three commissioning phases.

Chapleau Resources Ltd. carried out a small drill program to explore the Hellroaring Creek pegmatite stock, southwest of Kimberley, for beryllium, rubidium, tantalum and rare earth elements. Late in the 2000, the company drilled eight short holes to test the Pakk property. In 2001, four short holes totaling 99 metres were drilled on the **Peg** property by Chapleau under a joint venture agreement with Naneco Minerals Ltd.. Highlights from this drilling included up to 6 metres grading 1133 g/t BeO, including 1 metre with 2908 g/t BeO, and up to 4 metres grading 66 g/t Ta_2O_5. The property was subsequently returned to the vendor, Supergroup Holdings.

Tiger Ridge Resources Ltd. continued underground development and surface exploration drilling on its **Jubilee Mountain** barite project west of Spillimacheen. The property is underlain by Middle-Upper Cambrian Jublilee Formation massive dolomite and limestone. Barite and sulphide mineralization are hosted in solution breccias and related veins in the Jubilee Formation. More than 200 metres of drifting and 70 metres of raising were carried out in the Heli and Grizz adits and a 5500 tonne bulk sample was collected. This was processed with an on-site jig concentrator to produce 4000 tonnes of barite. A total of 1203 metres of diamond drilling in 13 holes were carried out to the northeast of the adits in the "Nose" area. Preliminary investigations were made into the potential for extracting barite from underground workings and recovering it from tailings from the adjacent, past producing Silver Giant mine, which is held as part of the Jubilee Mountain property by Tiger Ridge. A total of 840,000 tonnes of barite-sulphide ore was mined from the deposit in the 1940s and 1950s, and 180,000 tonnes of barite were produced from the tailings in the 1960s and 1970s by Baroid of Canada. Tiger Ridge is planning further underground development, bulk sampling, and exploration drilling for 2002.

Westroc Inc. carried out 842 metres of drilling in 18 holes on its **Elkhorn West** gypsum project, 10 kilometres east of Invermere and immediately west of their Elkhorn gypsum quarry operation, outlining a 2.5 million tonne resource. Gypsum deposits in the area are hosted by the Burnais Formation, a sequence of Devonian carbonates and evaporites. Westroc also drilled 126 metres in 3 holes on their **Kootenay West** project and 674 metres in 15 holes on their **Kootenay East** project; both are located northeast of Canal Flats. Over the last three years Westroc has drilled 4400 metres in 98 holes on the Kootenay West project, delineating a resource of 16.7 million tonnes of gypsum.

Stralak Resources Inc. and their joint venture partner Magna Precious & Industrial Metals Inc. took control from Cominco of the **Marysville Magnesite** sparry magnesite deposit, near Marysville. In 1961 Cominco estimated that the deposit contains a resource of 14 million tonnes grading 88% $MgCO_3$. No significant exploration work was carried out on the property this year.

In the fall, Skeena Resources Limited carried out a short drilling and bulk sampling program on their **Ice** diamond project north of Elkford (Photo 6). The property is underlain by Lower Carboniferous to Triassic carbonates and clastic rocks of the Rocky Mountain Fold and Thrust Belt. A cluster of four known kimberlite pipes occurs on the property. At surface the kimberlite is commonly clay altered and heavily contaminated with underlying and bordering lithologies. Unweathered kimberlite is commonly cut by numerous irregular calcite veinlets and contains many xenoliths of carbonate, shale, and ultramafic material, as well as xenocrysts of minerals like spinel and garnet. A total of 3 diamond drill holes were completed on the RAM 6 kimberlite this year. Holes 1 and 2 intersected 3.9 metre and 14.4 metre wide kimberlite breccia intervals, respectively, and hole 3 intersected a 20.8 metre interval (0 to 20.8 metres) and a 105.2 metre interval (41.8 to 147.1 metres). The lower and thicker interval in hole 3 has been interpreted to be hypabyssal facies kimberlite. The nar-

Photo 6. Drilling on the Ice diamond project.

rower kimberlite breccia intercepts in all three holes have been interpreted to be parts of a sill that is peripheral to the main hypabyssal intrusive center. Two short drill holes on the RAM 5 kimberlite, 1km to the south, failed to locate any significant kimberlitic material, even though the drill was collared in a weathered kimberlite outcrop. However, steep topography did not allow optimal collar location and Skeena considers that the target has untested potential. In 1996, a 20-ton bulk sample, comprising 90 to 95% non-kimberlite material, was collected from the Ram 6 kimberlite. It yielded 3 poor quality macro-diamonds, the two largest stones weighing a combined 0.23 carats. A 1996 bulk sample from the Ram 5 kimberlite yielded 3 good quality macro-diamonds weighing a combined 0.255 carats from 35 tons of surface material of which 95% was reportedly non-kimberlitic. A 4 tonne bulk sample was collected this year from fresh material at the Bonus kimberlite pipe, 3 kilometres west of RAM 6, because there was not enough water in the area for drilling due to unusually dry conditions. Samples of kimberlite from this year's program will be analyzed for microdiamonds by caustic dissolution. No results were available at the time of writing.

COAL

The large majority of the coal drilling activity in the region took place within or adjacent to existing open pit mining operations. The coal companies carried out a total of 75,768 metres of reverse circulation drilling in 447 holes. Of this, 37,970 metres in 100 holes were classified as "deposit appraisal", and 37,798 metres in 347 holes were classified as "mine development" (Figure 3b). Most of the drilling that was carried out away from existing pits was conducted by the Line Creek and Fording River operations.

At the **Fording River** mine, 1800 metres of development drilling were carried out in 27 holes. In the "deposit appraisal" category, 7020 metres in 47 holes were drilled within existing open pits. Exploration licenses on the east side of Fording River acquired by Fording Coal were the focus of some of the "development" drilling. At Fording's **Greenhills** mine there was no "development" drilling but 7500 metres of in-pit drilling was carried out in 47 holes. At the **Coal Mountain** mine, another Fording operation, the company drilled 5848 metres 21 holes; all were in-pit holes. At Teck Comnico's **Elkview** mine, 5430 metres in 64 holes were drilled in producing pits. Approximately 8 holes totaling 3370 metres were drilled outside of operating pits to delineate long-term reserves. A major exploration and development program that was undertaken at the **Line Creek** mine, owned by Luscar Ltd., is aimed at increasing its resource base. A total of 16,600 metres in 65 exploration holes were drilled, mainly in the Saddle area north of the MSA North pit (Photo 7). In-pit drilling accounted for 150 holes with a cumulative length of 12,000 metres.

PRODUCING MINES AND QUARRIES

The locations of producing mines and quarries in the Kootenay Region for 2001 are shown on Figure 6 and listed on Table 2. Production data is included where it is available.

Photo 7. Looking north from MSA North pit to Saddle area, Line Creek mine.

METALS

The only producing metal mine in the Region, the giant **Sullivan** Pb-Zn-Ag mine, closed in December 2001 after more than a century of continuous production. The mine was discovered in 1892 and acquired by Consolidated Mining and Smelting Company of Canada (Precursor to Cominco Limited) in 1909. Cominco developed the "differential flotation process" to produce separate lead and zinc concentrates. Since this process was implemented in 1916, the mine produced more than 17 million tonnes of Zn and Pb metal and more than 285 million ounces of Ag. During 2001 approximately 1.5 million tonnes were mined, yielding 75,768,069 kilograms Zn, 32,849,159 kilograms Pb, and 17,743 kilograms Ag. Over the next year the mine will be decommissioned and reclamation work begun.

INDUSTRIAL MINERALS

All of the major industrial mineral producers in the region maintained production levels at roughly the same levels as in 2000. Westroc Inc. produces approximately 500,000 tonnes of gypsum annually from its Elkhorn quarries near Windermere. Discovery of the Elkhorn West gypsum resource west of the **Elkhorn** quarry may extend the life of that operation beyond the projected 2005 exhaustion of current reserves. Georgia Pacific Canada Inc. ships approximately 100,000 tonnes of gypsum per year to Edmonton from its **Four J** quarry on the Lussier River, near Canal Flats. Both Westroc and Georgia Pacific operate wallboard plants in the Vancouver area.

Baymag Mines Company Ltd. produces high quality magnesite from the **Mount Brussilof** pit at a rate of about 200,000 tonnes annually. The magnesite is transported by truck to Exshaw, Alberta where the company has two plant sites that produce sintered, calcined, and fused magnesia. The Silica Division of Highwood Resources Ltd. produces approximately 120,000 tonnes of silica annually at **Moberly,** near Golden; they ship product to Springfield,

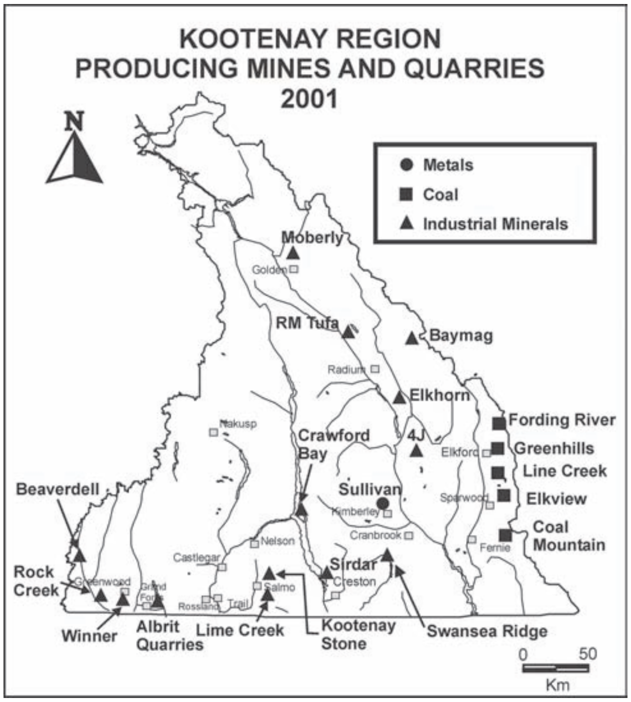

Figure 6. Producing Mines and Quarries, 2001.

Oregon, to Lavington, British Columbia and to other destinations.

IMASCO Minerals Inc. processes a variety of specialized industrial mineral products at its plant at Sidar, north of Creston. Raw materials include dolomite from the underground **Crawford Bay** mine on Kootenay Lake, and calcium carbonate from the **Lime Creek** quarry on Lost Creek, which is south of Salmo. Dolomite is used for soil conditioning, as a white ornamental aggregate, for stucco and roofing, as a fine aggregate, and for synthetic marble products. White calcium carbonate is used as filler in paper, paint and plastics. The company also produces crushed granite and quartzite products from material mined at **Sidar** and near Crawford Bay.

Dolomite is also quarried and processed by Mighty While Dolomite Ltd. at **Rock Creek**. Quadra Stone Ltd. produced approximately 1000 tonnes of Cascade Coral blocks from a new quarry near **Beaverdell**. Flagstone has been quarried by **Kootenay Stone Centre** and other small operators in the West Kootenays. Canadian Pacific Railway mined, crushed and shipped railroad ballast from its **Swansea Ridge** gabbro quarry south of Cranbrook.

COAL

Aside from routine seasonal shutdowns all five coal mines in the Elk Valley maintained steady production through 2001. The **Fording River** mine expects to produce 9.45 million tonnes in 2001 and 2002. Production has increased at the Greenhills mine over the last few years and is now stable at 4.7 million tonnes for 2001 and 2002. The plant is being expanded to a capacity of 5 million tonnes per year. Production at the **Coal Mountain** mine in 2001 is estimated to be 2.4 million tonnes and the same for 2002. The **Elkview** mine has doubled production since 1999 to 5.6 million tonnes in 2001 and is planning to increase production further to 6 million tonnes in 2002. The present mine plan contains over 260 million tonnes of coal, which repre-

TABLE 2
PRODUCING MINES AND QUARRIES, KOOTENAY REGION, 2001

Mine	Operator	Deposit Type	2001 Production
Fording River	Fording Coal Limited	Metallurgical coal	9.4 million tonnes
Elkview	Teck Corporation	Metallurgical coal	5.6 million tonnes
Greenhills	Fording Coal Limited	Metallurgical coal	4.7 million tonnes
Line Creek	Luscar Ltd.	Metallurgical coal	2.8 million tonnes
Coal Mountain	Fording Coal Limited	Metallurgical coal	2.4 million tonnes
Sullivan	Teck Cominco	Sedex	1.5 million tonnes
Elkhorn	Westroc Inc.	Gypsum	~500,000 tonnes
Mount Brussilof	Baymag Mines Co. Ltd.	Magnesite	~200,000 tonnes
Four J	Georgia Pacific	Gypsum	~100,000 tonnes
Rocky Mountain Tufa	Alan Wolfenden	Tufa	~1000 tonnes
Moberly	Highwood Resources Ltd.	Silica sandstone	
Crawford Bay	IMASCO Minerals Inc.	Dolomite	
Sirdar	IMASCO Minerals Inc.	Crushed granite	
Kootenay Stone	Kootenay Stone Centre	Flagstone	
Lime Creek	IMASCO Minerals Inc.	Limestone	
Rock Creek	Mighty White Dolomite Ltd.	Dolomite	
Swansea Ridge	CPR	Railroad Ballast	

sents a mine life of more than 40 years. Production at the **Line Creek** mine in 2001 is estimated to have been 2.8 million tonnes and production of 3.5 million tonnes is planned for 2002.

ACKNOWLEDGEMENTS

I would like to thank all of the industry geologists and prospectors who have provided me with data and access to their exploration properties and mines, thereby making the compilation of this paper possible. A great deal of the information pertaining to industrial minerals in this report came from George Simandl of the Geological Survey Branch, and likewise much of the data on coal was provided by Barry Ryan, also of the Geological Survey Branch. Despite the current downturn in the metal exploration sector, the interactions I have had with industry participants in the region, with GSB staff, and the Kootenay Region Mines Branch staff have made the first year of my tenure as Regional Geologist in the Kootenays an interesting and instructive experience.

PART B

PLATINUM GROUP ELEMENTS IN ALKALINE PORPHYRY DEPOSITS, BRITISH COLUMBIA

By John F.H. Thompson[1], James R. Lang[2] and Clifford R. Stanley[3]

INTRODUCTION

The alkaline suite is a distinctive group of porphyry copper-gold deposits that occur in the Cordillera of British Columbia (Barr *et al.*, 1976; Lang *et al.*, 1995a). These deposits are associated with alkaline to subalkaline plutons, small stocks, dikes and sills, which were emplaced into two allochthonous terranes, Quesnellia and Stikinia, prior to accretion of these terranes onto the ancient continental margin of North America (McMillan *et al.*, 1995). Textural and geological evidence suggest that these intrusions were emplaced at a variety of paleodepths. Mineralization occurs in sulfide/oxide vein systems, breccias and disseminated zones. The deposits or camps consist of several discrete zones that cumulatively amount to significant tonnages (Lang *et al.*, 1995a). The Copper Mountain and the Iron Mask Batholith have been mined extensively and significant resources exist at Galore Creek, Mt. Polley and Mt. Milligan. In addition to the petrological association and the style of mineralization, these deposits are characterized by unusual alteration assemblages that include potassic (orthoclase, biotite, magnetite), calc-potassic (garnet, diopside, biotite, orthoclase), and sodic/sodic-calcic (albite, diopside) all showing a distinct lack of associated quartz veining. The relationships among these styles of alteration are complex but all are directly associated with mineralization (Lang *et al.*, 1995b).

MDRU, The University of British Columbia, 6339 Stores Road, Vancouver, B.C. V6T 1Z4
[1] Teck Cominco Limited, 200 Burrard St., Vancouver, BC V6C 3L9
[2] Lang Geoscience Inc.,10556 Suncrest Drive, Delta, BC V4C 2N5
[3] Dept. of Geology, Acadia University, Wolfville, Nova Scotia, B0P 1X0

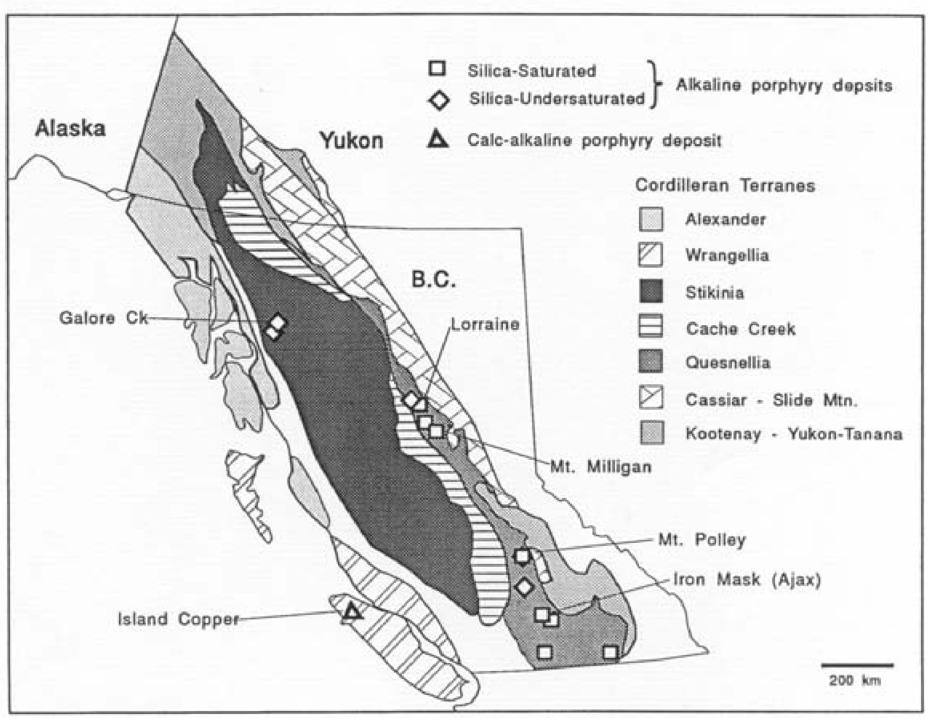

Figure 1. Map of the Cordillera of western Canada showing the major allochthonous terranes, the location of porphyry deposits belonging to the alkaline suite, and the deposits sampled for this study. The location of the Island Copper deposit, associated with calc-alkaline intrusions, is also identified.

Petrological characteristics of the alkaline intrusions permit definition of silica-saturated and silica-undersaturated subtypes (Lang *et al.*, 1995a). The silica-undersaturated intrusions are characterized by both modal and normative feldspathoids, and by the presence of igneous melanitic garnet (Lueck and Russell, 1994; Lang *et al.*, 1995c). Silica-saturated intrusions cover a more normal range of compositions (diorite, monzonite and locally syenite). The petrogenetic relationship between silica-saturated and silica-undersaturated intrusions is uncertain but some complexes contain individual intrusions of both subtypes (*e.g.,* Mt. Polley). The spatial, temporal and metallogenic association between subtypes suggest that they define a single suite of alkaline magmas. Mineralogy, geochemistry and isotopic data indicate that this suite of intrusions belong to a distinctive variety of alkaline arc magmas that were largely derived from an enriched mantle source region (Lang *et al.*, 1995c). The majority of the intrusions in Stikinia and Quesnellia are Early Jurassic in age (~205-195 Ma) although some intrusions in Quesnellia are distinctly younger (~185 Ma; Mortensen *et al.*, 1995). Based on these ages and other geological evidence, Lang *et al.* (1995c) suggest that alkaline intrusions were emplaced during collisional events (arc-arc or arc-continent) that resulted in the cessation of active subduction, a model that has also been proposed for other belts of alkaline arc magmatism (*e.g.*, McInnes and Cameron, 1994).

Deposits associated with alkaline intrusions in Quesnellia and Stikinia contain significant Cu in the form of chalcopyrite and/or bornite. In addition, mineralization is always enriched in Au, and to a lesser extent Ag, but rarely contains significant Mo (Lang *et al.*, 1995a). The Cu/Au ratio varies among districts, and among and within zones in individual districts (Lang *et al.*, 1995a). These relationships suggest that alkaline porphyry systems are enriched in these elements primarily as a result of magmatic and magmatic-hydrothermal processes (from source region to volatile generation), but that the absolute Cu and Au concentrations and Cu/Au ratio of mineralization are dependent on processes and conditions at the site of deposition.

Elevated levels of platinum group elements (PGE), particularly Pd and Pt, have been reported from mineralization associated with several of the alkaline porphyry deposits (O'Neill and Gunning, 1934; Mutschler *et al.*, 1985; Evenchick *et al.*, 1986; Rublee, 1986). At least three prospects hosted by alkaline intrusions in British Columbia have been explored for their Pd-Pt potential (the Python, Maple Leaf and Sappho prospects). Until recently, published analytical data for the deposits in B.C. are limited to those presented by Mutschler *et al.* (1985) from Copper Mountain-Ingerbelle, Galore Creek, Franklin Camp and Sappho. Although this is a small dataset, and consists of a mixture of concentrates and ore samples, the results suggest locally elevated Pd and Pt. Mutschler *et al.* (1985) also report elevated Pd and Pt values from mineralization related to alkaline intrusions in other areas. Analyses for the full spectrum of PGEs, with moderate levels of Pt, Pd and Au, have also been reported from the Skouries porphyry deposit in northern Greece (Eliopoulos and Economou-Eliopoulos, 1991) and limited data have been reported from Santo Tomas II in the Philippines (Tarkian and Koopmann, 1995).

The purpose of this communication is to present new PGE data from several of the alkaline porphyry deposits in British Columbia. In addition, analyses from the calc-alkaline Island Copper deposit of Jurassic age are provided for comparison. These reconnaissance results add to the small existing database and indicate that more data are needed.

PLATUNUM GROUP ELEMENT DATA

SAMPLE SUITE

Samples were collected from five deposits or prospects associated with alkaline intrusions between 1991 and 1993; four deposits are in Quesnellia (Lorraine, Mount Milligan, Mount Polley and Ajax East), and one is in Stikinia (Galore Creek; Figure 1). Descriptions of the deposits that were sampled in this study have been published in papers in CIM Special Volume 46 (Schroeter, 1995). Following the initial results, four additional samples from Mount Milligan were analyzed; these samples were composites from several drill holes prepared by Placer Dome for metallurgical testing and each is representative of a mineralized zone. Two samples were also collected from the Island Copper deposit on Vancouver Island (Perello *et al.*, 1995). Island Copper is a porphyry Cu-Mo-Au deposit associated with a rhyodacite porphyry of calc-alkaline affinity. These samples were included for comparative purposes. The locations and descriptions of the samples are given in Table 1.

ANALYTICAL METHODS

Each sample was crushed to approximately -80 mesh except the composite samples from Mount Milligan which were pulverized previously. In order to improve analytical detection, samples were prepared as heavy mineral concentrates using a Wilfley table. The concentrates were inspected microscopically and estimates made of modal mineralogy. Samples contained a mixture of sulfides (bornite, chalcopyrite and/or pyrite), oxides (magnetite and hematite), and less than 5% silicates (Table 1). No attempt was made to generate pure sulfide concentrates because fine-grained mixtures of sulfides and oxides were noted in polished sections from some deposits and the host for Au and PGE was unknown. The heavy mineral concentrates were analyzed by Activation Laboratories, Ancaster, Ontario using a nickel sulfide fire assay followed by instrumental neutron activation analysis (INAA) for PGE and Au, Leco infrared spectrometry for S, and aqua regia extraction and ICP finish for Cu. Estimates of analytical detection limits for the PGE and Au are 0.1 ppb for Ir, Os and Rh, 0.5 ppb for Au, 2 ppb for Pd, and 5 ppb for Ru and Pt.

RESULTS

Results for analyses of the concentrates are presented in Table 2. The Cu and S data are plotted in Figure 2, which also shows the composition of stoichiometric chalcopyrite

TABLE 1
LOCATION AND DESCRIPTION OF SAMPLES ANALYZED FOR COPPER, GOLD AND PLATINUM GROUP ELEMENTS

Sample Number	Deposit and Location	Description
GC92-1500	Galore Creek: Central zone, DDH 395	Disseminated/veinlet Cp-Py in garnet-biotite-Kfeldspar alteration
GC92-1523	Galore Creek: Central zone, DDH 120	Disseminated Bn(-Py) in biotite-Kfeldspar-magnetite alteration
GC92-1541	Galore Creek: Central zone, DDH 97	Disseminated/veinlet Cp-Py-Bn in biotite-Kfeldspar alteration
GC92-1553	Galore Creek: Southwest zone, DDH 381	Disseminated Cp-Py-Bn in biotite-Kfeldspar-magnetite alteration
L91-4	Lorraine: Extension zone, DDH L91-4	Disseminated/veinlet Bn(-Py) in pyroxene-biotite alteration
MBX	Mt. Milligan: MBX zone, bulk sample	Disseminated/veinlet Py-Cp in biotite-magnetite alteration
66Z	Mt. Milligan: 66 zone, bulk sample	Disseminated Py in biotite-chlorite-albite-epidote alteration
WBX	Mt. Milligan: WBX zone, bulk sample	Disseminated/veinlet Py-Cp in biotite-magnetite alteration
SST	Mt. Milligan: Southern Star zone, bulk sample	Disseminated/veinlet Py-Cp in biotite-magnetite alteration
MMSS-1	Mt Milligan: Southern Star zone, DDH 771	Disseminated/veinlet Py-Cp in biotite-magnetite alteration
88-148	Mt. Polley: Main zone, DDH 88-148	Disseminated Bn-Cp-Py in magnetite-rich alteration
89-143	Mt. Polley: Main zone, DDH 89-143	Disseminated/veinlet Cp-Py in biotite-Kfeldspar-magnetite breccia
89-150	Mt. Polley: West zone, DDH 89-150	Veinlet Cp-Py in Kfeldspar-actinolite-magnetite altered breccia
AE-1	Ajax: East deposit: 930m Bench	Disseminated/veinlet Cp-Py in albite-rich alteration
ICU-1	Island Copper: -200 Level	Veinlet Cp-Py in biotite-magnetite alteration
ICU-2	Island Copper: -200 Level	Veinlet Cp-Py in biotite-magnetite alteration

All samples are from Triassic-Jurassic alkaline porphyry deposits in British Columbia with the exception of the Jurassic calc-alkaline Island Copper deposit on Vancouver Island (*see* Figure 1). Bulk samples from Mt. Milligan are composites of samples from several drill holes representing typical mineralization.

TABLE 2
COPPER, GOLD AND PLATINUM GROUP ELEMENT CONTENTS OF HEAVY MINERAL CONCENTRATES FROM ALKALINE PORPHYRY DEPOSITS AND ONE CALC-ALKALINE DEPOSIT (ISLAND COPPER) IN BRITISH COLUMBIA

Sample	S %	Cu %	Au	Pd	Pt	Rh	Os	Ir	Ru ppb
Galore Creek									
GC92-1500	13.16	7.63	5200	407	17	0.1	n.d.	0.1	5
GC92-1523	10.25	21.54	68000	1039	54	0.5	n.d.	0.1	9
GC92-1541	23.2	18.06	3600	103	15	0.1	n.d.	0.1	n.d.
GC92-1553	13.16	13.16	60000	1581	107	0.5	n.d.	0.2	5
Lorraine									
L91-4	6.48	13.32	940	19	11	1.7	2	1.2	6
Mt. Milligan									
MBX	49.06	0.71	6923	112	28	0.7	0.7	0.2	n.d.
66Z	39.14	0.01	2705	51	17	0.3	0.3	0.1	8
WBX	15.71	1.59	5322	124	23	2.2	1.9	1.3	32
SST	38.34	0.56	7339	588	62	0.9	0.6	0.3	33
MMSS-1	34.2	6.75	18500	6312	111	2.1	0.7	0.6	7
Mt. Polley									
88-148	17.43	20.6	23600	320	33	0.2	n.d.	n.d.	n.d.
89-143	1.28	1.15	6200	83	17	0.7	n.d.	0.2	n.d.
89-150	2.43	1.91	1600	23	7	0.3	n.d.	0.1	n.d.
Ajax									
AE-1	33.1	26.25	990	140	8	1.5	n.d.	0.4	5
Island Copper									
ICU-1	9.41	2.85	63	21	n.d.	0.3	n.d.	0.1	n.d.
ICU-2	18.79	3.45	320	38	12	0.9	n.d.	0.2	n.d.

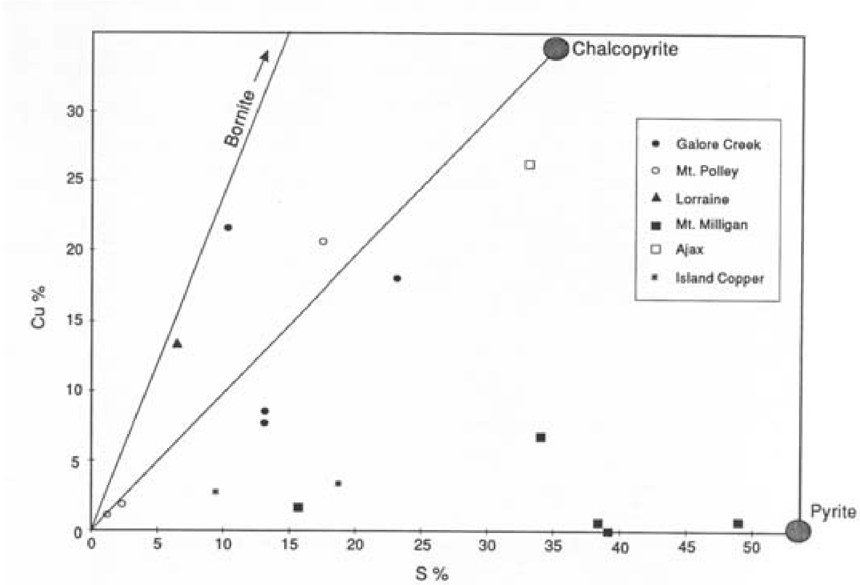

Figure 2. Cu versus S plot for samples analyzed for PGE and Au.Stoichio- metric chalcopyrite and pyrite are plotted. Lines connecting stoichiometric bornite (not shown on the figure) and chalcopyrite to the orogin provide a relative indication of the sulfide mineralogy in the samples.

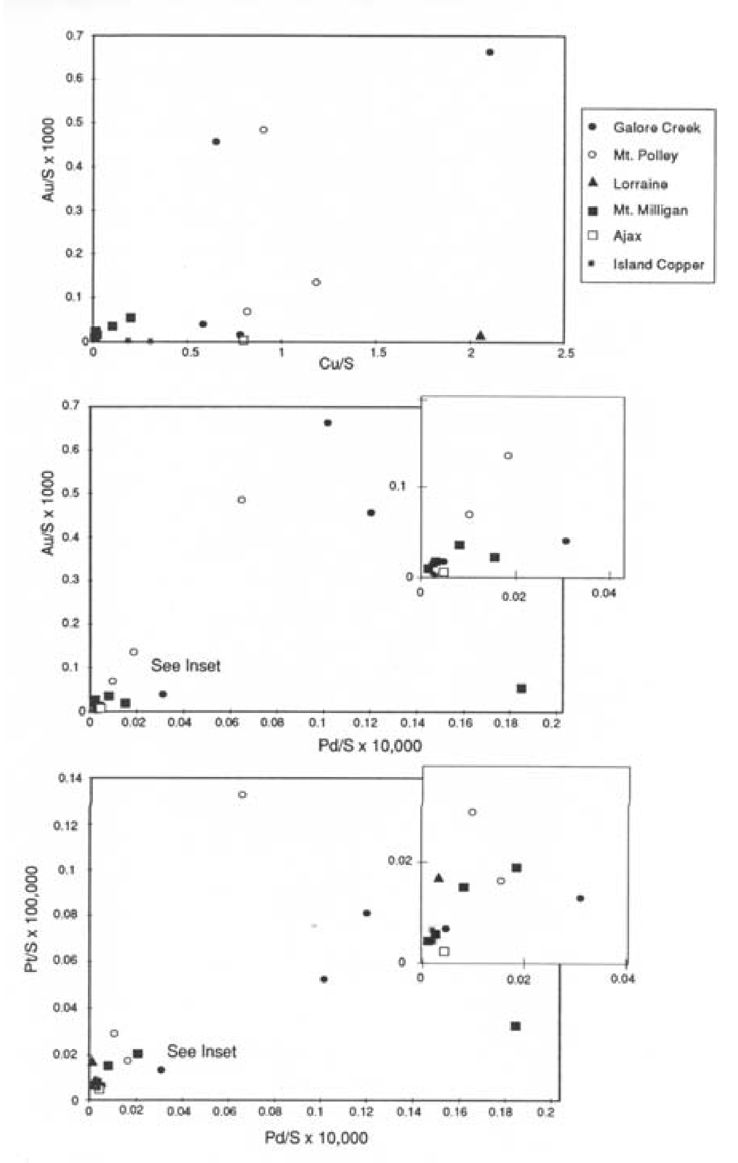

Figure 3. Binary plots of Cu/S, Au/S, Pd/S and Pt/S ratios from analyses from this study. Ratioing the raw data to the sulfur content of the sample provides a means of normalizing the variable sulfide content in the samples.

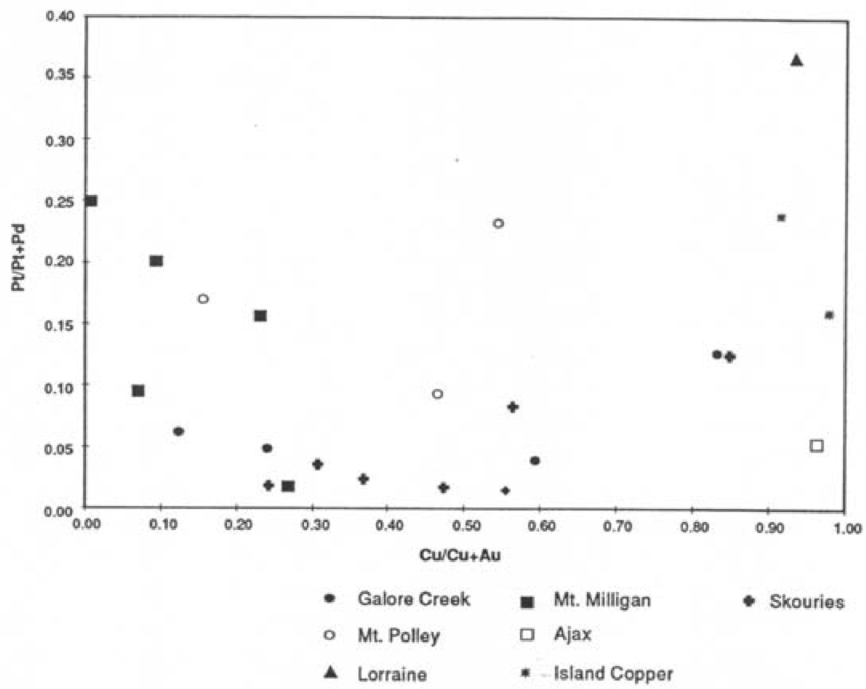

Figure 4. Ratio plot of Pt/Pt+Pd versus Cu/Cu+Au for analyses obtained in this study. Data from the Skouries porphyry deposit in Greece (Eliopoulos and Economou-Eliopoulos, 1991) are shown for comparison.

and pyrite, and lines connecting the composition of chalcopyrite and bornite to the origin. Figure 2 demonstrates that the sulfide mineralogy in the samples varies from bornite-dominant (one sample from Galore Creek and the sample from Lorraine) to pyrite-dominant (three samples from Mount Milligan). Most of the samples plot as mixtures of sulfides that, based on microscopic examination of the concentrates, consist largely of chalcopyrite and pyrite (Table 1). All the samples contain non-sulfide minerals, predominantly iron oxides; hence only two samples plot close to pure sulfide compositions on Figure 2.

High concentrations of Au occur in all samples consistent with the Au-enriched character of the alkaline suite of porphyry deposits. Elevated values of Pd also occur in several samples while Pt is present at lower concentrations. In most cases, Pd concentrations are two to three orders of magnitude lower than Au with Pt approximately one order of magnitude lower than Pd. With the exception of occasional elevated Ru and modest Rh, most of the other PGEs have low concentrations. The two samples from the Island Copper deposit have concentrations of Au and PGE well below those in most of the samples from the alkaline suite deposits. These reconnaissance data support the suggestion that the alkaline porphyry deposits in British Columbia contain Pd and Pt.

The results are presented on simple binary plots (Figure 3) and as a ratio plot (Figure 4). The binary plots (Figure 3) suggest weak correlations between Cu, Au, Pd and Pt, but with considerable scatter, particularly at high values. The ratio plot (Figure 4) demonstrates more variation in Cu:Au compared to Pt:Pd, both between deposits and within deposits. These observations are consistent with the variation in Cu/Au ratios reported from the alkaline deposits in British Columbia by Lang *et al.* (1995a). Data from the Skouries deposit (Eliopoulos and Economou-Eliopoulos, 1991) are also plotted on Figure 4 and show similar large variations in Cu:Au at relatively constant Pt:Pd.

DISCUSSION

SOURCE OF PGE

The reconnaissance dataset presented herein confirms the existence of Pd and Pt, locally at appreciable levels, as well as minor amounts of other PGEs in mineralization hosted by and related to alkaline intrusions in British Columbia. The data also suggest an association with Cu and Au.

Geochemistry and isotopic data indicate that the Triassic-Jurassic alkaline intrusions in British Columbia were derived from an enriched mantle source region (Cassidy *et al.*, 1996), possibly following a hiatus in active subduction. This model is supported by the timing of crystallization of alkaline intrusions, which corresponds with regional tectonic events in both host terranes (Lang *et al.*, 1995c). A collision model has been proposed for similar alkaline rocks in the Tabar-Lihir-Tanga-Feni islands, northeastern Papua New Guinea (McInnes and Cameron, 1994). Evidence from xenoliths from this area suggests that slab dehydration following stalled subduction resulted in a large fluid flux into the overlying mantle wedge. This led to partial melting of the enriched mantle and generated oxidized alkaline magmas (B.I.A. McInnes pers. comm., 1996).

Lihir island hosts significant Au mineralization, the Ladolam deposit, which has indications of porphyry-style mineralization at depth (Moyle *et al.*, 1990). Although other petrogenetic models have been proposed for alkaline arc magmas (*e.g.*, Carmichael, 1991), the McInnes and Cameron (1994) model provides a mechanism for incorporating precious metals into the magmas by the destabilization of Fe-Ni-Cu sulfides in the mantle.

In addition to Cu, Au and PGE, the magma must also contain sufficient sulfur to form sulfide minerals in the porphyry environment. Sulfur concentrations must not exceed sulfur saturation, however, because PGE and Au will partition strongly into magmatic sulfides (Bezmen *et al.*, 1994) hence removing them prior to the formation of a volatile phase in the porphyry environment. McInnes and Cameron (1994) argue that the oxidized nature of alkaline magmas in the Tabar-Lihir-Tanga-Feni chain inhibited formation of magmatic sulfides during fractionation; hence the magmas retained elevated Cu, Au and Pd. The solubility of sulfur in alkaline melts is significantly higher than in quartz-saturated melts (Ducea *et al.*, 1994), and high oxidation states both increase the solubility of sulfur and cause sulfate to exsolve in preference to sulfide at saturation (Carroll and Rutherford, 1985). Evidence for the oxidized nature of alkaline intrusions in British Columbia includes the presence of abundant magnetite, Fe^{3+}-rich amphibole and pyroxene, igneous andraditic garnet (melanite), and the local presence of the sulfate-bearing feldspathoids - vishnevite/cancrinite possibly after haüyne (Lueck and Russell, 1994; Lang *et al.*, 1995c).

Weak correlations among Cu, Au, Pd and Pt at low concentrations (Figure 3) may reflect the primary magmatic environment and source region. Unfortunately, the reconnaissance nature of this dataset is inadequate for testing this hypothesis and there is little comparative published data from deposits that formed in different environments. Although Pd and Pt concentrations are lower, the Pt:Pd ratios in the samples from the calc-alkaline Island Copper deposit are similar to ratios from the alkaline porphyry deposits (Fig 4). The Cu:Au, Cu:Pd and Cu:Pt ratios, however, differ from most of those of the alkaline deposits.

Based on the preceding discussion, PGE enrichment in porphyry deposits probably requires a mantle source region, liberation of mantle sulfides during partial melting in the source region, and an oxidized melt that effectively prohibits the formation of magmatic sulfides during fractionation. The petrogenesis of alkaline arc magmas appears to fit closely with these prerequisites, although other arc-related magmas may also satisfy some or all of these conditions in specific cases.

PGE TRANSPORT

The availability of PGE in the magma is the first step in providing elevated concentrations in porphyry-style mineralization. The second step requires the transport of PGE to the site of deposition. Due to the lack of hydrothermal minerals containing good fluid inclusions, the temperature of deposition in the alkaline porphyry systems is poorly constrained. The Galore Creek deposit is the exception where fluid inclusions in hydrothermal garnets contain moderate to high salinities and homogenize between 300-550°C (Dunne *et al.*, 1994), typical of the porphyry environment. Under acid and oxidizing conditions and temperatures up to 300°C, both Pd and Pt may be transported as chloride complexes (Gammons *et al.*, 1992; Wood *et al.*, 1992) with these complexes becoming increasingly important for Pd at higher temperatures (Sassani and Shock, 1990). Chloride transport is generally invoked for Cu and Au in the porphyry environment (*e.g.*, Sillitoe, 1993) and therefore the association of Cu, Au, Pd and Pt may be explained in part by a similar transport and deposition mechanism. Pd and Pt may also be transported as bisulfide complexes, but at levels one to three orders of magnitude lower than Au under the same conditions (Wood *et al.*, 1992). This difference in the efficiency of transport is similar to the relative difference in concentration between Au and Pd in the samples analyzed in this study. Therefore, in addition to the importance of the primary concentrations derived from the source region, hydrothermal processes probably influence the ratio of Pd and Pt to Cu or Au.

Although hydrothermal transport of Pd and Pt in the alkaline porphyry systems is strongly indicated by their association with Cu and Au in zones of hydrothermal alteration, pre-concentration in magmatic sulfides within associated intrusions is not ruled out. As discussed previously, early fractionation of sulfides may remove precious metals including Pd and Pt from the magma and hence from involvement in subsequent magmatic-hydrothermal processes. There is, however, evidence in some cases for sulfide precipitation during crystallization of high level intrusions or lavas, possibly as a result of the degassing of SO_2. Magmatic sulfide blebs have been reported from submarine alkaline volcanic rocks in the Tabar-Lihir-Tanga-Feni chain (McInnes and Evans, 1996) and from latite dikes related to the Bingham porphyry deposit (Keith *et al.*, 1995). In both cases, these blebs locally contain elevated Au and Pd. Magmatic sulfide blebs may be subsequently oxidized or altered resulting in release of the metals to the volatile phase during magmatic-hydrothermal activity (Candela, 1989). If these sulfide blebs are enriched in precious metals, the hydrothermal fluid and resultant porphyry system may also be enriched. Bishop *et al.* (1995) report petrographic evidence for the existence of magmatic sulfides at the Lorraine alkaline porphyry prospect. In all other localities studied during the course of research on the alkaline porphyry deposits in British Columbia, intense hydrothermal alteration has destroyed any record of possible magmatic sulfides, and therefore the importance of pre-concentration by magmatic processes is difficult to evaluate.

VARIATION IN PGE VALUES

The Cu, Au, Pd and Pt concentrations reported in this study are erratic. Variation within deposits or camps is as great as the variation between them. This strongly suggests that local depositional processes influenced the concentration of these metals, particularly at higher levels. If all of these metals were transported as chloride complexes, changes in $\sum Cl$, $\sum S$, T, fO_2, and pH could result in deposition (Gammons *et al.*, 1992). Differences in the final concentrations of these metals reflect the relative efficiency of deposition for each metal under changing conditions. An evaluation of these processes is not possible in this case due to a lack of understanding of the mineralogical and paragenetic distribution of all of the precious metals and a limited thermodynamic database above 400^{o}C for Au, Pd and Pt.

An alternative to the co-precipitation of Cu, Au, Pd and Pt with variations in depositional efficiency explaining different metal ratios is to invoke selective remobilization of individual metals. Some of the alkaline deposits show evidence for low temperature alteration overprinted on the high temperature mineral assemblages (Lang *et al.*, 1995a). Under lower temperature conditions (<300^{o}C), bisulfide complexes may be important for remobilizing all of the precious metals and the relative efficiency of remobilization of individual metals may explain local enrichment. In contrast, Cu is unlikely to be mobile under these conditions. Evaluation of this possibility, with reference to the data reported herein, requires additional information on the mineralogical distribution of the metals, a subject for future work.

CONCLUSIONS

This study reports the presence of PGE, particularly Pd and Pt, in heavy mineral concentrates prepared from samples from the alkaline suite of porphyry Cu-Au deposits in British Columbia. The results support previous work that indicated the existence of Pd and Pt and suggests concentrations are higher than in other types of porphyry deposits. A much larger database is needed to confirm the latter hypothesis.

The presence of Pd and Pt in mineralization associated with the alkaline suite of porphyry deposits is consistent with petrogenetic models for alkaline arc magmas. The models suggest that these magmas are derived from an enriched mantle source region, possibly following collision and the cessation of subduction. It is argued that partial melting destabilized mantle-hosted Fe-Ni-Cu sulfides rich in precious metals, which allowed them to be incorporated into the melt. The oxidized nature of alkaline arc magmas inhibits fractionation of sulfide; hence precious metals remain in the magmas and are available for transport by magmatic-hydrothermal fluids in the porphyry environment.

Variations in the levels of Cu, Au, Pd and Pt within and between the deposits indicate that transport and depositional processes influenced the final concentration of these metals regardless of the petrogenetic processes that supplied them initially. The mineralogical distribution of these metals has not been studied during this research. Without this information, and knowledge of the paragenesis and hydrothermal conditions for each sample, it is difficult to evaluate the processes that might favor one metal in preference to another. The limited thermodynamic database for conditions appropriate to the porphyry environment presents further problems.

This study clearly demonstrates the potential for further research. This includes the generation of comparative data from other types of porphyry deposits, detailed work on the distribution of precious metals among host minerals, and further research on the hydrothermal transport of PGE at elevated temperatures. Results from this kind of research may have implications for the evaluation of source regions and magmatic processes in different types of porphyry environments, provided that the effects of hydrothermal processes in controlling metal budgets and ratios can be more fully understood. If this is possible, the PGE concentration of fresh samples from volcanic rocks coeval with porphyry mineralization may indicate the sulfide fractionation history of the sequence and the potential for precious metal-rich porphyry mineralization.

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RDN: A SHALLOW MARINE VMS PROSPECT

By Henry J. Awmack and Mark E. Baknes[1]

KEYWORDS: *Early to Middle Jurassic, Eskay Creek, Hazelton Group, low-sulphidation epithermal, shallow marine volcanogenic massive sulphide deposits.*

INTRODUCTION

The RDN property, owned 100% by Rimfire Minerals Corporation, is a shallow marine volcanogenic massive sulphide (VMS) prospect with striking similarities to Barrick Gold Corporation's high-grade Eskay Creek deposit 40 kilometres to the south. The RDN property covers 68 square kilometres of mountainous terrain, approximately 120 kilometres northwest of Stewart, British Columbia. Access to the property is by helicopter from Bob Quinn airstrip, which lies on the Stewart-Cassiar highway 20 kilometres to the east. The Eskay Creek access road passes fifteen kilometres southeast of the RDN property.

Eskay Creek, with production plus reserves of 3.9 million ounces Au and 175 million ounces Ag (Rogers, 2002), is considered to be the product of a low-sulphidation epithermal system venting to the sea-floor in a shallow marine setting. As such, it combines some of the features of Kuroko-style VMS deposits with those of low-sulphidation epithermal precious metal deposits. The RDN property shares a number of geological and geochemical characteristics with Eskay Creek, that form the basis for the RDN exploration model.

EXPLORATION HISTORY

Prior to 1987, no work had been recorded on the area covered by the current RDN property. Extensive exploration, including 3,633 metres of diamond drilling in 30

[1]*Equity Engineering Ltd., 700-700 West Pender Street, Vancouver, B.C., V6C 1G8*

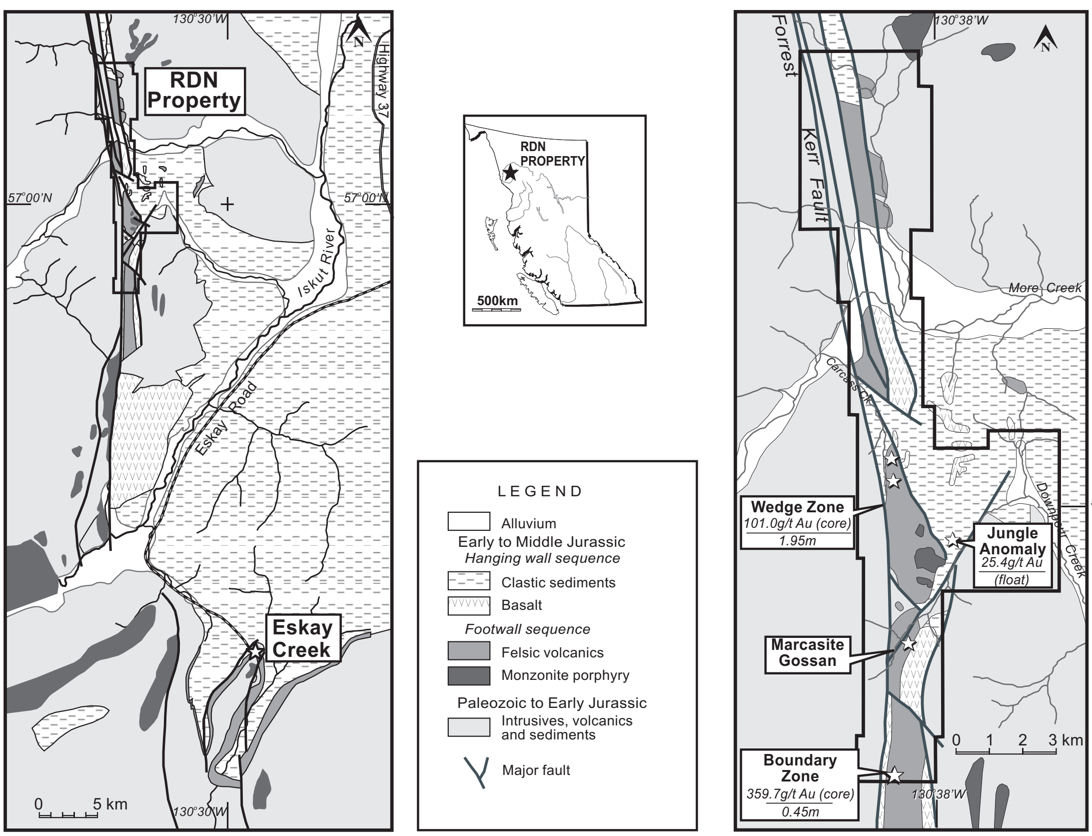

Figure 1. RDN regional and property geology (regional geology adapted from Logan *et al.*, 2000 and Alldrick *et al.*, 1989).

holes, was carried out on it from 1988 to 1992 by Noranda and others, directed almost entirely at Au-bearing quartz-sulphide veins. At that time, quartz-sulphide veins were being developed into the Snip and Skyline mines, 40 kilometres to the southwest, and there was considerable exploration for vein mineralization throughout the Iskut River district. The Eskay Creek deposit, 40 kilometres south of the RDN property, was discovered in 1988, but its VMS nature was not widely recognized until 1990. Despite recognition that the strata that host Eskay Creek continue north and underlie the RDN property, the potential for Eskay Creek-style mineralization was barely investigated during this flurry of exploration.

Pathfinder Resources Ltd. carried out three small exploration programs on the RDN property from 1994 to 1996 and confirmed the basic features of the Eskay Creek analogy. Rimfire Minerals Corporation continued to focus on this model with extensive fieldwork from 1997 through 1999, culminating in a 9 hole, 574 metre drill program.

Newmont Exploration of Canada Limited optioned the RDN property in early 2000 and carried out a ground UTEM survey over 6.7 kilometres of "Eskay-equivalent" stratigraphy. In 2001, Newmont drilled 13 holes totalling 2,222 metres to test UTEM conductors in the vicinity of the "Eskay-equivalent" stratigraphic contact.

GEOLOGY

The RDN property extends for more than 20 kilometres along the east side of the Forrest Kerr Fault, a northerly-trending, steeply-dipping normal fault of regional extent. Paleozoic metasediments, metavolcanic rocks and plutons lie west of the Forrest Kerr Fault. East of the fault Mesozoic rocks of the Upper Triassic Stuhini Group and Lower to Middle Jurassic Hazelton Group predominate. The Stuhini Group and the base of the Hazelton Group consist mainly of andesitic to basaltic volcanic rocks and clastic sediments.

The upper part of the Hazelton Group correlates with Eskay Creek deposit strata. It consists of felsic volcanic rocks, basalt and clastic sediments. On the RDN property, the Hazelton Group felsic volcanic rocks can be split into two packages. The first package consists of rhyolitic flows and tuffs which are widespread north and west of More Creek; these are generally unmineralized and will not be discussed further. The other felsic rocks are associated with a separate felsic centre south of More Creek that extends for 13 kilometres south to the southern property boundary. This package consists dominantly of dacite and trachyte tuffs and flows, with very minor amounts of rhyodacite and rhyolite. Feldspar porphyries, locally K-spar megacrystic, form both extrusive and intrusive phases in this felsic package. The felsic rocks are generally carbonate-altered; locally they are flooded by sericite, silica and/or potassium feldspar alteration. The main feldspar porphyry intrusive body is pervasively altered to sericite, clay, pyrite and local alunite. It forms a very prominent gossan with a large associated ferricrete deposit. Lithogeochemistry shows this second package of felsic volcanic rocks to be similar to the Footwall Volcanic Unit at Eskay Creek and the K-spar megacrystic feldspar porphyry to the Eskay Porphyry (Eskay Creek nomenclature from Roth *et al.*, 1999); consequently, this package is referred to here as the "footwall" felsic sequence.

Tholeiitic basalt flows and lesser volcaniclastic rocks overlie the felsic volcanic rocks south of More Creek. Pillows are prominent, particularly in the vicinity of the Marcasite Gossan and south to the southern property boundary, indicating submarine deposition. The basalt is essentially unaltered, and chemically and texturally similar to the hanging wall basalts at Eskay Creek.

Clastic sediments, mainly argillites and siltstones, are interbedded with the basalts and become dominant up section. Together, the basalt and clastic sediments are referred to here as the "hanging wall" sequence. The argillites near the base of the hanging wall sequence are commonly carbonaceous and locally graphitic; pyrite is preserved as laminae and within pyritic clasts. Based primarily on lithogeochemical and textural similarities in the basalt at Eskay Creek and RDN, the contact between the felsic and basalt/sediment sequences is considered correlative to that which hosts Eskay Creek's 21 Zone stratiform orebodies, and is referred to here as the "Eskay-equivalent contact".

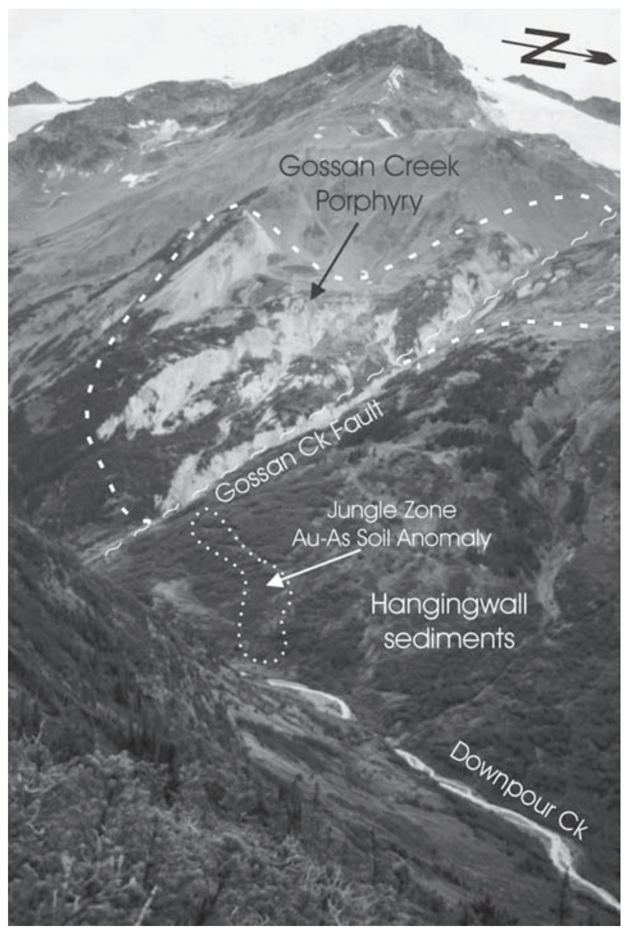

Photo 1. Looking southwest at altered and pyritized feldspar porphyry, forming prominent gossan, intruding comagmatic dacitic volcanic rocks in Downpour Creek.

The RDN property is structurally complex. The Hazelton Group is dominated by northerly trending, locally overturned, anticline-syncline pairs with steep axial surfaces. The main fault trends are northerly (parallel to the Forrest Kerr Fault), northwesterly and northeasterly. These are high angle faults, chopping the RDN property into a mosaic of fault blocks.

ESKAY CREEK-STYLE VMS PROSPECTS

Most pre-1994 work on the RDN property focused on Au-rich quartz-sulphide veins in the altered footwall felsic volcanic rocks. This veining and alteration are thought to be integral parts of a VMS hydrothermal system, both at Eskay Creek and RDN. The submarine hydrothermal systems produced base and precious metal-rich fluids which altered the footwall felsics and deposited sulphide-bearing quartz veins, stockworks and silicified zones in structural traps. Where these fluids vented to the sea floor, they became available for deposition as stratiform sulphide layers.

The “Eskay-equivalent” contact between variably altered and mineralized footwall felsic volcanic rocks and unaltered “hanging wall” clastics and mafic volcanic rocks can be traced for 9 kilometres north from the southern boundary of the RDN property. Because of its recessive nature, this contact is rarely exposed on surface and has only been penetrated in 7 drill sections: one at the Boundary Zone, one at the Marcasite Gossan, and five in the Wedge Zone. The following table summarizes significant drill intersections from the 52 drill holes. With the exception of hole RDN99-01, all intersections are within the footwall felsics.

WEDGE ZONE

Wedge Zone veining is within an 800 x 2,600 metre Au-Ag-As-Pb-Sb-Zn soil geochemical anomaly that overlies altered dacitic volcanic rocks on the eastern side of the Carcass valley. Noranda discovered a number of discontinuous quartz-sulphide breccia veins in the Wedge Zone and directed most of their drilling at them. These veins are generally hosted by barren sericite alteration, pinch and swell dramatically, and are offset by extensive small-scale cross-faults. Locally they carry very high grades, such as intersections of 1.95 metres of 101 g/tonne Au and 0.85 metres of 138 g/tonne Au in hole RG91-21. Generally, these veins are located 50 to 200 metres stratigraphically below the top of the felsic volcanic rocks.

A few of Noranda’s westernmost holes were collared in, or bottomed in, hanging wall argillite. This suggested that the “Eskay-equivalent” contact runs northerly down the Carcass valley. Newmont drilled 10 of their 13 holes in this Wedge Zone contact area, however, by targeting UTEM conductors rather than stratigraphy, half of these holes were drilled entirely in either footwall dacite or hanging wall clastics.

From the 2001 Newmont drilling it is clear that the Wedge Zone stratigraphy is overturned; it dips steeply to the east but tops are to the west, and is located on the west limb of a north-south trending anticline cored by footwall dacites. The stratigraphy corresponds to a shallow marine setting, with bivalves and belemnites in the hanging wall clastics and local maroon volcaniclastic units. There are two distinct volcanic cycles at the stratigraphic top of the footwall dacite sequence. The best VMS potential is considered to be at the top of each cycle in carbonaceous and tuffaceous strata. Cycle 1 consists of a sulphide-bearing and veined subvolcanic porphyry within an emergent dome and may represent a volcanic/hydrothermal source to the

TABLE 1
SIGNIFICANT RDN DRILL INTERSECTIONS

Drill Hole	Zone	From (m)	To (m)	Length (m)	Au (g/t)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
RG90-6	Wedge	18.60	19.30	0.70	11.30	9.3	0.24	0.14	1.72
RG90-7	Wedge	56.70	61.10	4.40	11.66	16.4	0.57	0.65	1.70
		64.30	64.55	0.25	38.50	42.3	1.99	0.39	1.44
RG90-11	Wedge	26.05	26.45	0.40	18.19	8.4	0.61	0.01	0.01
		51.00	51.40	0.40	11.57	9.7	1.43	0.00	0.01
RG90-15	Wedge	26.10	26.40	0.30	17.89	10.6	0.48	0.05	0.29
RG91-16	Boundary	55.50	55.95	0.45	359.70	N/A	0.22	N/A	N/A
		56.20	56.70	0.50	3.77	13.4	2.31	0.04	0.67
RG91-20	Wedge	142.20	143.00	0.80	4.42	3.1	0.20	0.02	3.26
RG91-21	Wedge	140.75	141.60	0.85	137.80	22.3	0.87	0.10	0.31
		158.80	160.75	1.95	101.00	62.4	2.70	0.48	1.88
RG91-22	Wedge	86.50	88.50	2.00	8.22	20.7	0.45	0.75	2.29
RDN99-01	Jungle	38.00	39.10	1.10	5.19	2.0	0.01	0.05	0.09
RDN01-17	Wedge	71.50	72.00	0.50	4.17	6.4	0.31	0.09	5.67
		111.00	112.50	1.50	3.75	9.0	0.52	0.07	0.18
RDN01-20	Wedge	90.30	91.30	1.00	3.88	6.8	0.15	1.62	5.56
		125.20	125.50	0.30	7.06	10.4	0.30	0.03	4.62

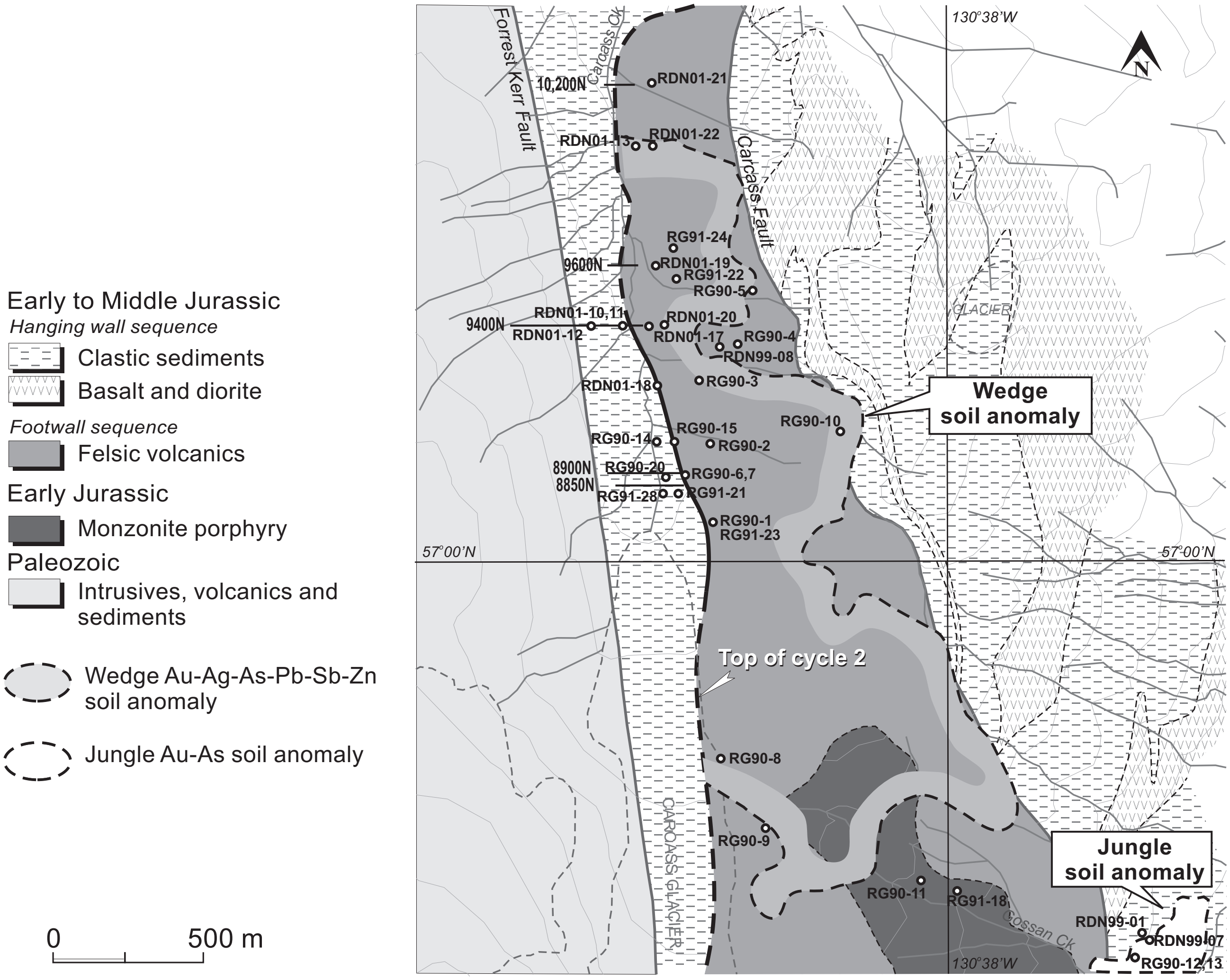

Figure 2. Wedge Zone geology, soil geochemical anomaly, and drill holes.

mineralizing system (only one hole intersected the top of Cycle 1). Widespread alteration and mineralization were developed synchronously with deposition of Cycle 2 and do not extend above the top of Cycle 2. The carbonaceous unit at the top of Cycle 2 is a preferential locus for faults, but the volcanic-sedimentary depositional contact appears to be preserved in some of the holes. Alteration and mineralization in the upper part of the footwall dacites is quite different from that related to deeper footwall veining drilled by Noranda. In the shallower setting, sulphide mineralization (including sphalerite, galena, tetrahedrite and orpiment) is more pervasive and diffuse throughout broad alteration zones, rather than in discrete, well-defined quartz-sulphide veins. A siliceous breccia, with a massive chalcopyrite clast, at the top of Cycle 2 (RDN01-17, 111.0-112.5m, 3.8 g/tonne Au) could represent a volcaniclastic breccia partially derived from stratiform sulphides.

The Wedge Zone represents a footwall alteration zone that is more than 2.5 kilometres long in a shallow marine setting. Newmont's 2001 drill campaigns targeted the top of Cycle 2 and intersected it on 3 sections in the Carcass valley. Noranda also intersected this contact further south, so it has been cut on a total of 5 sections (8850N, 8900N, 9400N, 9600N and 10200N). This leaves gaps from south to north of 50, 500, 200 and 600 metres of untested potential. Only section 9400N has been drilled sufficiently to obtain a reasonable picture of the stratigraphy and structure. Evidence of increasing metal values (including Cu) and increases in unit thickness toward possible growth faults favour drilling into the 500 metre gap south of section 9400N. More than 2 km of the "Eskay-equivalent" contact at the top of Cycle 2 remains undrilled south from section 8850N to Coal Creek, and most of this area is within the Wedge Zone soil anomaly.

JUNGLE ANOMALY

The Jungle Anomaly is a pronounced 100 x 450 metre Au+As±Ag±Pb soil geochemical anomaly in an area with little outcrop. Within the anomaly area, a cobble of pyritic, silicified argillite that is cut by quartz veinlets assayed 25.4

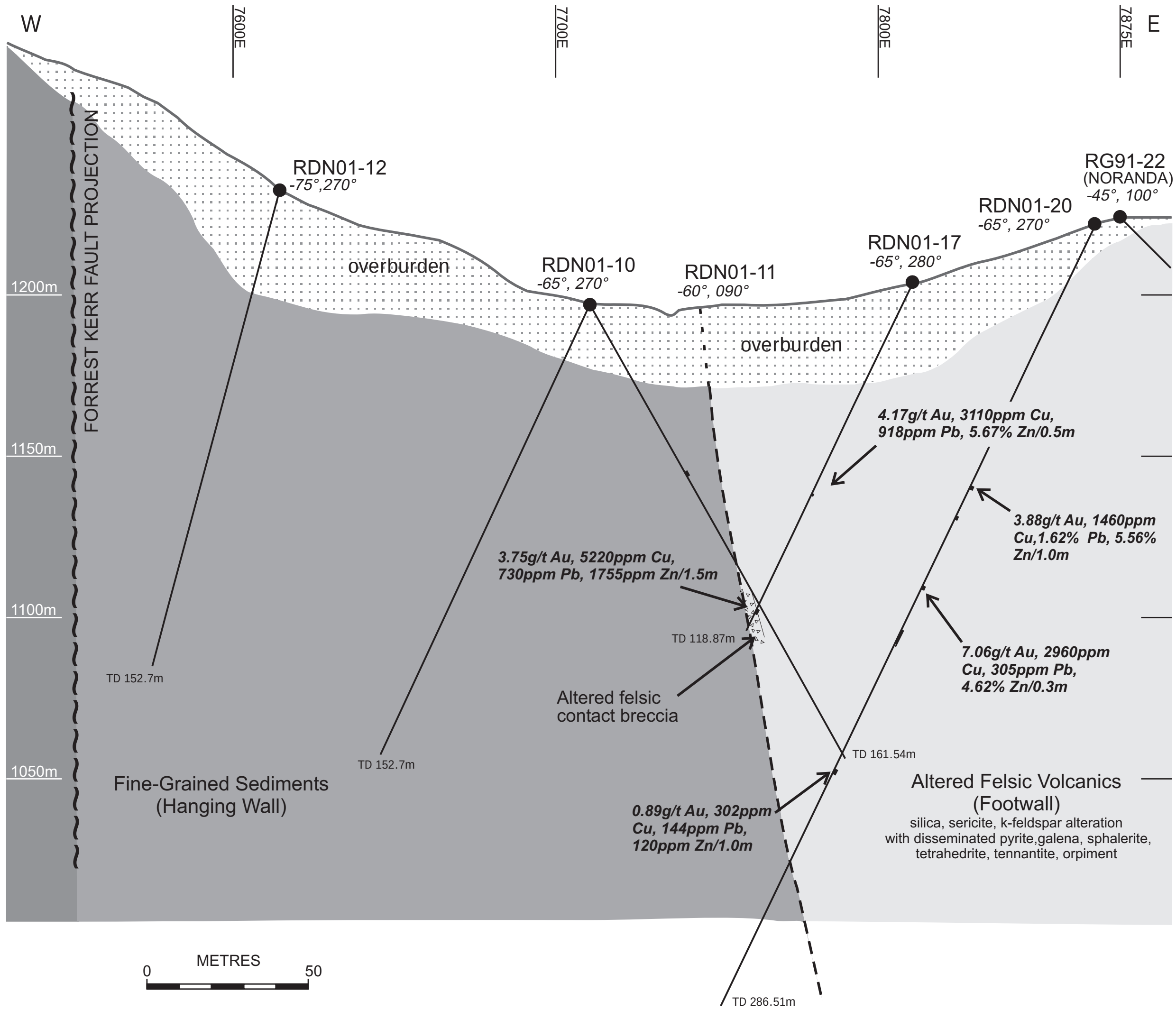

Figure 3. Wedge Zone section 9400N, looking north.

g/tonne Au with elevated As, Hg, Pb and Zn. A cluster of pyritic, slightly carbonaceous chert boulders, that could represent a silica-pyrite exhalite, were found nearby. The Jungle Anomaly is underlain by the hanging wall clastic/mafic volcanic sequence. It is stratigraphically down-section from the only exposures in the area and the contact with underlying felsic volcanic rocks might be relatively shallow.

Two holes were drilled into the Jungle Anomaly in 1999 to test the hypothesis that it represented “leakage” from an Eskay Creek-style VMS system into the overlying clastic/mafic hanging wall sequence. Due to ground conditions, both holes had to be abandoned before reaching their target depth. The holes intersected weakly elevated levels of Au and As, including 5.19 g/tonne Au across 1.1 metre, but concentrations were not high enough to explain the soil anomaly. Except for the Wedge zone area, the hanging wall sequence in this area contrasts sharply with that elsewhere on the property. Elsewhere the hanging wall sequence is devoid of both veining and anomalous metals. Although the Jungle Anomaly could simply reflect epigenetic mineralization, its potential for stratiform sulphides remains untested.

MARCASITE GOSSAN

The Marcasite Gossan, located just to the east of Downpour Creek, consists of two stacked footwall dacite flow-domes that have been altered and are cut by stockwork mineralization. Peperitic contacts indicate emplacement at or near the sea floor. Late magmatic to hydrothermal alteration of the dacite, vein stockworks and preservation of clastic pyrite-marcasite are evidence of venting of hydrothermal fluids to the sea floor. Epithermal affinities are shown by: the presence of chalcedony, pyrobitumen and marcasite; by colloform vein textures; by elevated As, Sb and Hg levels; and by the irregular, anastomosing, morphology of the vein stockworks.

Holes RDN99-05 and -06 cut a complete section across the Marcasite Gossan, from the hanging wall pillow

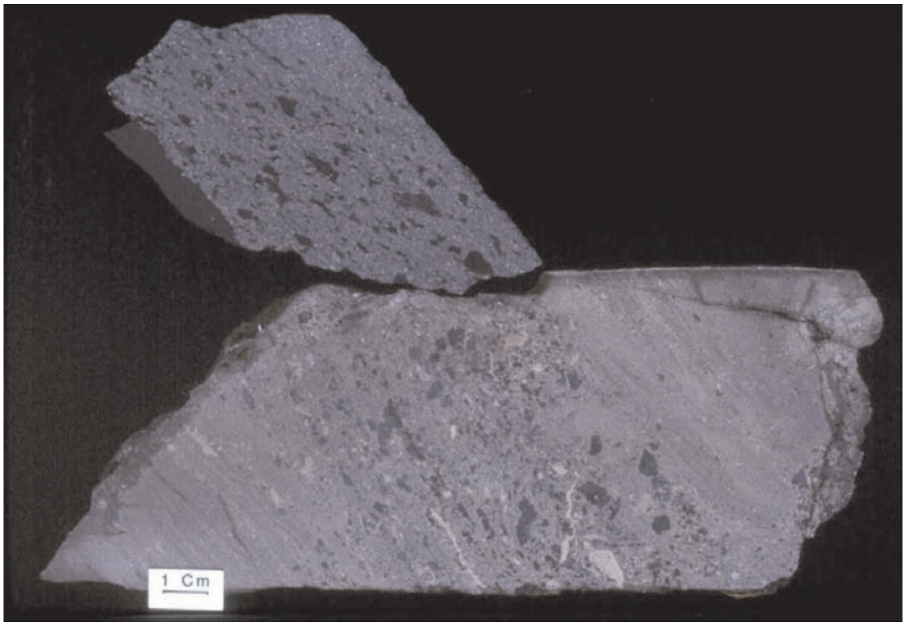

Photo 2. Clastic massive pyrite-marcasite float from Marcasite Gossan (bottom). For textural comparison, clastic massive sulphide-sulphosalt ore from 21B Zone at Eskay Creek (top).

basalts to the footwall Lower Marcasite Gossan flow-dome. The drill core shows that contacts are depositional rather than tectonic, and stratigraphy is upright with moderate east dips. The property geology indicates that the holes cut the east limb of an anticline whose western limb was truncated by faulting along Downpour Creek. A 70-metre thick basin of variably graphitic and pyritic mudstone, siltstone and wacke lies between the footwall Upper Marcasite Gossan flow-dome and the base of the hanging wall pillow basalts. Eskay Creek's "Contact Mudstone", which hosts the 21 Zone orebodies, is in a similar stratigraphic position. An altered felsite sill within the clastics above the Upper Marcasite Gossan is chemically identical to the low-titanium Eskay Rhyolite and occupies a similar stratigraphic position.

Despite elevated As, Sb and Hg levels, precious metal values to date at the Marcasite Gossan are very low. Holes RDN99-05 and -06 were drilled through the apex of the footwall dacite domes and did not encounter any stratiform massive sulphides. Better potential for accumulation of massive sulphides might be found along the flanks of the dome.

BOUNDARY ZONE

The Boundary Zone, located immediately north of the RDN property's southern boundary, consists of a group of narrow, discontinuous chalcopyrite-pyrite-quartz-calcite veins. These are hosted by maroon felsic volcanic rocks and have chlorite-hematite alteration envelopes. Some veins are planar, with local cockade textures but others contain blebby aggregations of sulphides. Veins average just a few centimetres in width and their wallrocks are not auriferous. Gold values can be extremely high; hole RG91-16 intersected 45 centimetres grading 360 g/tonne Au.

The "Eskay-equivalent" felsic/basalt contact is projected to lie <100 metres stratigraphically above the Boundary Zone veining, but is not exposed and has not been drilled. The possibility that the Boundary Zone veining represents a footwall stockwork to Eskay Creek-style Au-rich stratiform sulphides is suggested by its position near the top of the felsic volcanic sequence, chloritic alteration, high sulphide abundance relative to quartz content of veins, and high Au and Cu concentrations.

Hole RDN01-16 was drilled 130 metres north of the RDN's southern boundary, into a series of debris flows near two faults that are interpreted to be synvolcanic. Although this may represent part of the "Eskay-equivalent" contact, it sheds little information on its potential in the Boundary Zone area because veining and alteration are entirely southeast of the synvolcanic faults.

DISCUSSION AND CONCLUSIONS

The Eskay Creek VMS deposit contains 3.9 million ounces Au and 175 million ounces Ag. Given its exceptionally high Au and Ag grades and low production cost, it forms a very attractive exploration target. The key to finding a similar deposit is to locate shallow marine rocks in a similar environment within a precious metal-rich volcanic arc. The RDN property, located 40 kilometres north of Eskay Creek, is underlain by strata that correlate with the Eskay sequence and fulfils these criteria. In addition, it demonstrates a number of regional-scale indicators considered important for the development of a stratiform, shallow marine volcanogenic massive sulphide Au-Ag deposit like Eskay Creek. Underlying strata correlate with the top of the Early to Middle Jurassic Hazelton Group. The property lies on the Harrymel/Forrest Kerr regional fault system, which may have localized felsic centres and rifting. Bimodal volcanism occurs with felsic and basaltic end members. The basalt analysed from RDN is chemically and texturally similar to Eskay Creek's, indicating local rifting. As well, the felsic volcanic rocks include a felsite sill that is chemically similar to the Eskay Rhyolite. Evidence of shallow marine deposition is strong: pillows in the basalts, peperites and shallow water fossils. Volcanic centres are indicated by potassic feldspar-megacrystic porphyry intrusions. These are pyritic and highly altered, indicating hydrothermal activity. Chemical analyses indicate that they are very similar to the Eskay Porphyry. Other favourable indicators include: widespread alteration of the felsic volcanic rocks and structurally-controlled Au-Ag-base metal veining within them; synvolcanic faulting that led to formation of restricted basins; low-sulphidation epithermal features, including elevated As-Sb-Hg contents and presence of orpiment, sulphosalts, chalcedony and pyrobitumen.

On the RDN property, the contact between footwall felsic volcanic rocks aging wall sequence of fine marine clastics and mafic volcanic rocks has been traced more than 9 kilometres. Drilling in 1999 and 2001 showed that this contact is depositional rather than tectonic and strengthened the stratigraphic and lithogeochemical analogy with Eskay Creek. Four targets on the property with potential for Eskay Creek-style stratiform sulphides are: the Wedge Zone, Jungle Anomaly, Marcasite Gossan and Boundary Zone. Compelling evidence at the Marcasite Gossan indicates that the two dacite domes identified were emplaced at or near the sea floor. Subsequent late magmatic to early hydrothermal fluids passed through the domes, causing widespread Kspar-silica flooding and stockwork veining, and vented to the sea floor where they deposited clastic massive sulphides. Although the Marcasite Gossan is deficient in base and precious metals, it demonstrates that volcanogenic massive sulphides were being deposited on the RDN property at the same felsic/basalt contact as stratiform orebodies at Eskay Creek. Evidence from the 2001 Wedge Zone drilling is less conclusive but the Wedge Zone appears to represent another shallow-marine hydrothermal system. At the Wedge Zone, however, Au and base metals are enriched, and a clast of massive chalcopyrite, possibly derived from stratiform sulphides, is present in a gold-bearing breccia at the top of the felsic section. The Jungle Anomaly and Boundary Zone have geochemical anomalies and high-grade veining in the vicinity of the "Eskay-equivalent" stratigraphic contact and require further testing.

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BLUE RIVER CARBONATITES, BRITISH COLUMBIA - PRIMARY EXPLORATION TARGETS FOR TANTALUM

By George J. Simandl [1,2], Peter C. Jones[3] and Melissa Rotella[2]

KEYWORDS: *Carbonatite, columbite, pyrochlore, tantalum, niobium, Fir, Verity, Blue River.*

INTRODUCTION

Prices for tantalum raw materials skyrocketed in 2000 to US$350.00/lb, and as a result, unconventional tantalum resources such as carbonatites came into the spotlight (Simandl, 2002). British Columbia hosts several carbonatite and alkaline complex-type occurrences, specialty granites and pegmatites (Pell, 1994; Pell and Hora 1990). The carbonatites are well known for associated niobium, rare earth elements (REE), phosphate, vermiculite, fluorite, zirconium, uranium, thorium, titanium, copper and iron mineralization (Richardson and Birkett, 1996; Birkett and Simandl, 1999).

The tantalum content of the minerals pyrochlore and columbite in carbonatites is generally low. Exceptional Ta concentrations in pyrochlore hosted by carbonatites are typically associated with high UO_2 or Th_2O_5 contents. Uranium-bearing pyrochlores from Siberia are reported to contain up to 26.9% Ta_2O_5 (Pozharitskaya and Samoylov, 1972; Hogarth, 1989). For this reason, some of the tantalum-rich uranpyrochlore deposits were previously investigated as sources of tantalum in the former USSR (Kapustin, 1974). Pyrochlore group minerals, hosted by carbonatites, with high tantalum content were also reported at Sokli in Finland (Lindqvist and Rehtijarvi, 1979), at Crevier in Quebec (Laplante, 1980) and elsewhere.

This paper outlines some observations and results of a two-day field visit of the Verity, Fir and Serpentine carbonatite deposits in the Blue River area. Nine representative surface samples, collected by the senior author, were studied using polarizing and reflecting microscopes.

The composition of ore minerals was determined using electron microprobe. The methodology and whole rock analytical methods are described in Annex I.

Pyrochlore and columbite are the main Ta-bearing minerals and the tantalum and niobium content of the whole rock samples are within the range of previously reported analyses.

[1] BC Ministry of Energy and Mines
George.Simandl@gems2.gov.bc.ca
[2] University of Victoria
[3] Carleton University

BLUE RIVER CARBONATITE DEPOSITS

LOCATION AND PREVIOUS WORK

At least 12 carbonatite and syenite occurrences are known to occur in the Blue River area of central British Columbia (Figure 1). The Verity, Fir and Serpentine carbonatites are part of this cluster located to the east of both the North Thompson River and the Canadian National Railway, approximately 35 km north from the community of Blue River. The Verity and Fir carbonatites outcrop on logging roads, while the Serpentine carbonatite is within 500 metres of an active logging road. Shallow overburden

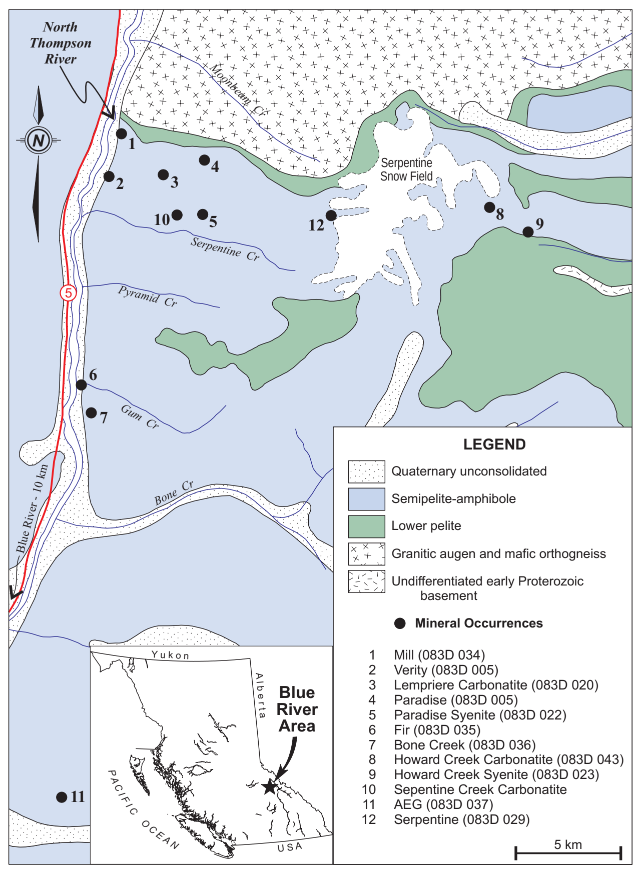

Figure 1. Location and geological setting of the Blue River carbonatite and syenite occurrences. The Verity, Fir and Serpentine carbonatites are discussed in this paper. BC MINFILE numbers are listed in parentheses. Modified from Mountjoy (1992).

and dense underbush cover most of the area surrounding the Fir, Verity and Serpentine occurrences and consequently the carbonatites are exposed only as isolated outcrops.

The area containing the carbonatites was originally staked in 1950 for vermiculite and was subsequently explored for uranium. Follow-up exploration resulted in the discovery of pyrochlore. The property has been intermittently prospected since the fifties. Details of the exploration history of the area are provided by Dahrouge (2002). The Verity and Fir carbonatites are currently being re-evaluated as a potential source of Ta and Nb (Dahrouge, 2002; Simandl, 2002).

GEOLOGICAL SETTING

The Blue River occurences are part of a broad zone of carbonatites that follow the Rocky Mountain Trench. They are located within the Omineca Belt and more precisely within the northeastern margin of the Shuswap Metamorphic Complex mapped by Campbell (1968). These carbonatites are hosted by the semipelite-amphibolite unit (Figure 1) of the Hydrynian Horsethief Creek Group (Mountjoy, 1992). The complexly deformed rocks have reached amphibolite facies metamorphism and both sillimanite and kyanite are reported in this area (Campbell, 1967; Diegel, 1989). Some of the carbonatites, including the three carbonatites that we examined, appear to predate deformation and peak metamorphic conditions.

VERITY DEPOSIT

The Verity carbonatite was traced over 800 metres by a combination of extensive trenching and drilling (Smith, 1952 and Rowe, 1958), but most of the trenches have since collapsed. Carbonatite outcrops as a beige, fractured and rubble-like rock (Photo 1a). This appearance is due to severe chemical and physical weathering. Surface samples from the Verity deposit were classified petrographically as beforsite (a dolomite-carbonatite). Beforsite in outcrops consists mainly of dolomite (>65%, 1-4mm), apatite (3-20%, 2-3 mm), calcite (<10%), and light green to blue-green alkali amphibole (<10%, 1-3 mm). Pyrochlore and columbite (ferrocolumbite) are present as minor constituents.

Vermiculite was reported at Verity by McCammon (1953). The beforsite-semipelite contacts are marked by fenite (Rowe, 1958); however, they are not exposed in the areas visited. In 1981 and 1982 an exploration program by Anschutz (Canada) Mining Ltd. resulted in resource estimates of 2 million tonnes of 0.118% Nb_2O_5 and 0.020% Ta_2O_5 (Aaquist, 1982). During the early part of 2001, the inferred resource of the Verity-Paradise project was estimated at 3.06 million tonnes grading 196 ppm Ta_20_5, 646 ppm Nb_2O_5 and 3.20% P_2O_5 (Dahrouge, 2002, this volume). Additional drilling and bulk sampling was completed late in 2001 by Commerce Resources Corp.

LITHOGEOCHEMISTRY

Major and trace element content of the nine samples are summarized in Table 1.

The Verity carbonatite plots in the magnesiocarbonatite field on the CaO - MgO - ($FeO+Fe_2O_3+MnO$) ternary diagram (Figure 2) developed by Woolley and Kempe (1989). This confirms our terminology based on petrographic observations.

Verity samples Ver-1, 2 and 3 contain 192.8, 158.5 and 287.7 ppm of Ta respectively. The Nb content of these samples is 585.6, 1996.2 and 2421.6 ppm respectively and their P_2O_5 content is 2.89, 2.62 and 1.07 %. W, Mo, Sb and Sn are at or below instrument detection limits and are therefore not shown in Table 1.

NIOBIUM AND TANTALUM MINERALS

The main ore minerals of the Verity deposit, pyrochlore and columbite, were previously identified by Rowe (1958), Hogarth (1961), Heinrich (1962) and Jones (1957). Both of these minerals were determined to contain some UO_2 (Rowe, 1958 and Heinrich, 1980). It was suggested that the radioactivity in the Verity columbite is caused by submicroscopic inclusions of metamict pyrochlore (Heinrich, 1962). Van der Veen (1963) also identified fersmite and columbite replacing pyrochlore; however, the mineral paragenesis remains controversial (Mariano, 1989).

The most striking ore mineral appears to be a coarse, dark, reddish black euhedral to subhedral pyrochlore (Photo 1b). Similar pyrochlore samples, with abundant mineral inclusions, have been described in the literature (Hogarth, 1961). However, most pyrochlores and columbites from the Verity carbonatite observed in thin section are finer-grained and are not euhedral (Photos 1c and 1d). Results of microprobe analysis of the pyrochlore

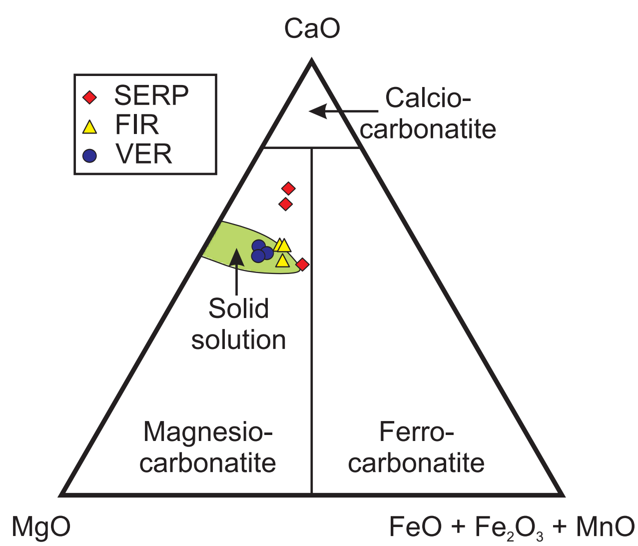

Figure 2. Chemical composition of the Verity, Fir and Serpentine carbonatites; classification as proposed by Woolley and Kempe (1989). Shaded area represents dolomite-ankerite solid solution field.

Photo 1a.

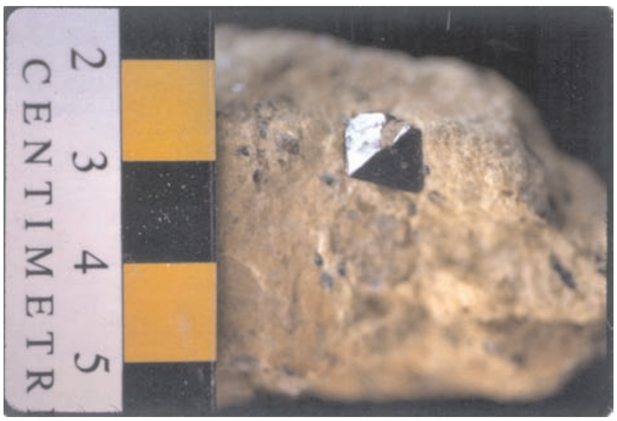

Photo 1b

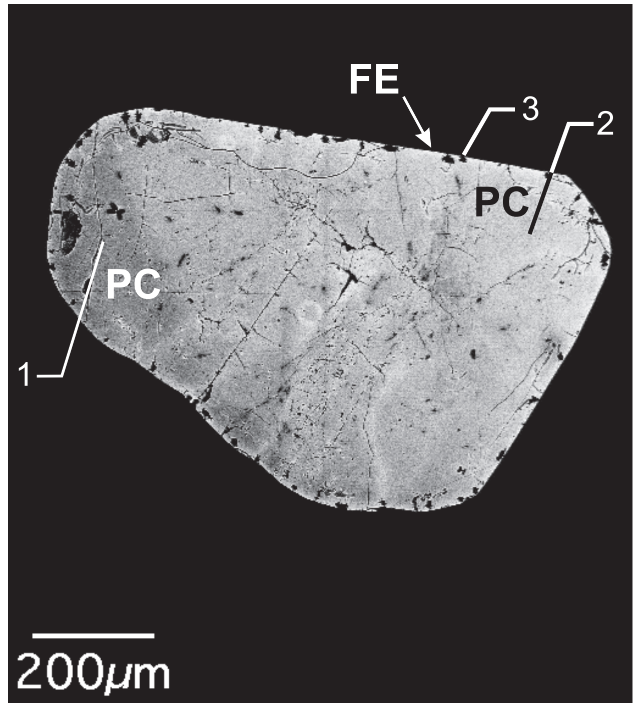

Photo 1c

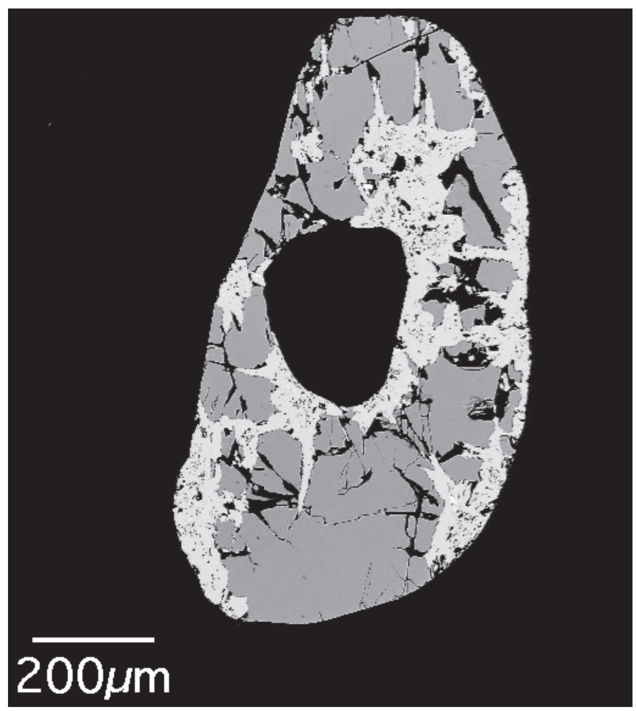

Photo 1d

Photo 1. The Verity deposit, a) Specimen pit (photo by Mike Cathro); b) Euhedral pyrochlore in beforsite, Specimen pit; c) Tantalum/uranium-bearing pyrochlore (PC), backscatter electron photomicrograph (microprobe analyses 1 and 2 correspond to Ver1-2A#1, #2 in Table 2; microprobe analysis 3 corresponds to an iron oxide rim; silicates and carbonates are black; d) Pyrochlore (dark gray) is being replaced by columbite (light gray), carbonates in black; backscatter electron photomicrograph.

crystals are given in Table 2. The elements MgO, MnO, K_2O, WO_3 and ZrO were at, or below the detection limit of the instrument and are not provided in this Table. Pyrochlore crystals are commonly zoned (Photo 1c), and chemical variations within the same grain may be seen in Table 2. These variations suggest that the highest Ta concentrations in pyrochlore are associated with the highest UO_2 content. There are two clusters on Figure 3. Cluster A is formed by analyses from both Verity and Fir deposits, cluster B represents exclusively Ta- and U-rich pyrochlore from the Verity deposit. Based on the above microprobe data, pyrochlore group minerals belong to the pyrochlore subgroup as defined by Hogarth (1989) and plot within the pyrochlore field on the Ti-Nb-Ta diagram (Figure 3).

Columbite, or more precisely its iron-rich variety called ferrocolumbite, is also present within the Verity deposit. Until recently columbite from the Blue River area was not believed to contain detectable tantalum concentrations (Mariano 1989). Microprobe analysis of columbite (Table 3) indicates that its Ta_2O_5 content ranges from 1.51 to 3.33 wt%. The elements F, K_2O, SrO and ZrO are at or below the detection limit of the instrument and are not shown in this Table. The UO_2 and Th_2O_5 contents of colum-

TABLE 1
MAJOR AND TRACE ELEMENT ANALYSES OF THE VERITY, FIR AND SERPENTINE CARBONATITES (FOR THE DESCRIPTION OF ANALYTICAL METHODS, *SEE* THE TEXT)

Element	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**MgO**	**CaO**	**Na_2O**	**K_2O**	**TiO_2**	**P_2O_5**	**MnO**	**Cr_2O_3**	**Ba**	**Ni**	**Sc**	**LOI**	**TOT/C**	**TOT/S**	**SUM**
Units	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm	ppm	%	%	%	%
Method	ICPES	ICPES	ICPES	ICPES	ICPES	ICPES	ICPES	ICPES	ICPES	ICPES	ICPES	ICPES	ICPES	ICPES	FUS	LECO	LECO	SUM
Field No.																		
SERP-1	7.04	0.18	6.04	11.94	36.73	0.15	0.29	1.68	0.03	0.10	0.005	283	< 20	19	35.5	9.99	0.07	99.72
SERP-3	43.10	3.06	8.93	10.66	22.32	0.50	0.43	0.21	1.11	0.14	< 0.001	27	< 20	14	9.3	2.19	0.05	99.77
SERP-4	5.38	0.38	5.16	10.25	37.35	0.11	0.04	1.46	0.06	0.10	0.003	253	21	19	39.5	10.77	0.03	99.83
FIR-1	2.55	0.05	7.14	14.51	30.34	0.37	0.05	0.01	3.23	0.60	0.008	71	< 20	5	39.5	10.96	0.06	98.37
FIR-2	2.64	0.07	8.60	15.58	29.19	0.38	0.04	0.02	1.12	0.63	0.005	49	< 20	5	40.7	11.83	0.12	98.98
FIR-3D	2.77	0.04	7.63	14.03	30.16	0.48	0.06	0.03	3.27	0.57	0.013	34	< 20	6	38.3	10.77	0.04	97.36
VER-1	1.82	< 0.03	5.56	17.10	30.59	0.16	0.13	0.03	2.89	0.20	0.025	103	87	14	40.7	11.83	0.01	99.24
VER-2	2.85	< 0.03	6.69	16.35	29.19	0.22	0.20	0.07	2.62	0.22	0.007	119	< 20	26	39.9	11.25	0.03	98.35
VER-3	1.49	< 0.03	5.96	17.49	28.97	0.19	0.09	0.03	1.07	0.23	0.015	136	32	16	42.7	12.42	0.01	98.27

Element	**Co**	**Cs**	**Ga**	**Hf**	**Nb**	**Rb**	**Sr**	**Ta**	**Th**	**Tl**	**U**	**V**	**Zr**	**Y**	**La**	**Ce**	**Pr**
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Method	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS
Field No.																	
SERP-1	35.1	0.2	2	4.6	87.9	12	1509.1	15.2	1.4	0.2	0.2	57	151.0	31.1	102.2	208.7	25.17
SERP-3	24.6	0.9	9.4	1.2	29.9	7.6	621.8	9.1	3.6	0.2	5.3	111	44.7	20.6	85.6	170.1	18.78
SERP-4	28.8	0.2	3	4.6	90.9	2.5	1599.0	16.3	1.0	0.1	0.1	58	165.7	31.6	108.3	219.7	26.08
FIR-1	11.4	< 0.1	0.9	< 0.5	1450.2	< 0.5	4783.7	188.9	18.9	0.2	9.2	< 5	7.3	32.4	150.1	333.7	39.83
FIR-2	15.9	< 0.1	0.8	< 0.5	1294.3	0.6	4310.5	107.7	2.1	0.1	1.3	5	7.1	16.2	75.4	160.4	18.44
FIR-3D	11.2	0.1	< 0.5	< 0.5	4009.5	< 0.5	4626.1	251.2	38.0	0.1	7.9	< 5	7.6	33.2	164.6	367.0	42.95
VER-1	22.9	0.1	4.9	< 0.5	585.6	2.8	3660.6	192.8	2.0	0.1	158.1	12	4.8	19.6	158.1	334.7	38.84
VER-2	22.1	0.2	3.5	0.8	1996.2	6.5	4271.7	158.5	11.1	0.1	52.2	48	17.0	20.0	167.2	355.1	40.7
VER-3	27.8	0.1	1.1	0.9	2421.6	1.8	4408.1	287.7	10.3	0.1	197.2	21	19.0	13.0	117.2	245.4	27.05

Element	**Sm**	**Eu**	**Gd**	**Tb**	**Dy**	**Ho**	**Er**	**Tm**	**Yb**	**Lu**	**Cu**	**Pb**	**Zn**	**Ni**	**As**	**Cd**
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Method	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	LMBMS	ARIC	ARIC	ARIC	ARIC	ARIC	ARIC
Field No.																
SERP-1	18.2	5.39	12.37	1.51	7.39	1.34	2.91	0.36	1.96	0.23	118	< 3	18	22	2	< 0.2
SERP-3	10.0	2.82	6.82	0.85	4.69	0.84	2.28	0.29	1.94	0.28	2	4	12	6	< 2	< 0.2
SERP-4	16.5	5.46	13.20	1.60	7.85	1.29	2.94	0.34	1.80	0.25	135	< 3	14	18	3	0.3
FIR-1	25.6	7.81	17.29	1.97	9.16	1.51	3.26	0.38	2.00	0.26	< 1	< 3	32	< 1	< 2	1.0
FIR-2	10.9	3.54	7.67	0.91	4.16	0.73	1.75	0.21	1.15	0.14	< 1	< 3	31	< 1	< 2	0.9
FIR-3D	26.3	8.10	17.82	2.08	9.66	1.54	3.38	0.35	2.11	0.23	< 1	< 3	29	< 1	< 2	0.9
VER-1	23.5	6.61	13.82	1.45	6.30	0.96	1.86	0.17	1.00	0.10	3	< 3	19	1	< 2	0.5
VER-2	23.2	6.82	14.90	1.53	6.67	0.96	1.95	0.16	0.92	0.10	1	< 3	23	< 1	< 2	0.7
VER-3	14.2	4.17	8.53	0.97	4.31	0.61	1.27	0.12	0.76	0.09	1	< 3	19	< 1	< 2	0.7

TABLE 2
MICROPROBE ANALYSES OF PYROCHLORE FROM THE VERITY (VER) AND FIR (FIR) DEPOSITS

ANALYSIS	Nb_2O_5	Ta_2O_5	TiO_2	FeO	ThO_2	UO_2	La_2O_3	Ce_2O_3	Y_2O_3	CaO	SrO	PbO	Na_2O	F	Total
FIR3A-A2#1	60.04	3.68	1.51	0.00	0.54	0.03	0.15	0.24	0.15	13.95	0.73	0.00	7.71	5.29	94.05
FIR3A-A2#2	70.18	1.36	1.58	0.06	0.47	0.02	0.18	0.24	0.22	15.31	0.77	0.01	7.42	5.72	103.54
FIR3A-A2#3	66.38	5.24	1.60	0.02	0.52	0.01	0.18	0.29	0.15	14.92	0.67	0.00	7.24	5.48	102.70
FIR3A-A3#1	64.35	3.39	1.60	0.00	0.63	0.00	0.00	0.33	0.17	14.96	0.78	0.05	7.77	5.03	99.14
FIR3A-A3#2	66.01	5.80	1.53	0.00	0.65	0.03	0.14	0.41	0.08	14.72	1.00	0.05	7.72	4.99	103.13
FIR3A-A3#3	65.60	4.66	1.55	0.03	0.44	0.07	0.21	0.38	0.15	14.98	1.00	0.00	7.75	5.33	102.15
FIR3D-A1#1	67.68	3.81	1.74	0.00	0.40	0.00	0.00	0.25	0.20	15.24	0.73	0.00	7.69	4.94	102.68
FIR3D-A1#2	66.81	5.58	1.62	0.00	0.39	0.06	0.14	0.32	0.17	14.89	0.85	0.00	7.74	4.91	103.49
FIR3D-A1#3	65.42	6.27	1.67	0.01	0.45	0.17	0.05	0.22	0.17	15.25	0.69	0.00	7.53	4.95	102.90
FIR3D-A1#4	68.14	3.80	1.78	0.02	0.48	0.07	0.10	0.29	0.17	15.33	0.78	0.04	7.62	4.90	103.55
FIR3D-A1#5	68.11	3.71	1.72	0.04	0.54	0.03	0.12	0.29	0.18	15.09	0.75	0.00	7.72	5.12	103.53
FIR3D-A1#6	63.23	4.83	1.51	0.03	0.38	0.00	0.01	0.31	0.16	13.79	0.83	0.00	7.71	5.46	98.26
FIR3D-A2#1	69.45	1.66	1.77	0.01	0.65	0.00	0.16	0.12	0.00	15.38	0.88	0.00	7.80	5.32	103.20
FIR3D-A2#2	65.73	6.00	1.65	0.06	0.52	0.12	0.22	0.21	0.04	14.64	1.03	0.00	7.50	5.20	102.92
FIR3E-A1#1	65.70	6.40	1.59	0.03	1.12	0.00	0.02	0.17	0.07	14.41	0.85	0.00	7.66	4.92	102.95
FIR3E-A1#2	66.42	4.21	1.67	0.00	1.41	0.00	0.00	0.16	0.18	14.94	0.71	0.00	7.78	5.19	102.69
FIR3E-A1#3	66.10	5.01	1.69	0.01	1.47	0.01	0.07	0.14	0.11	15.00	0.74	0.08	7.66	5.05	103.15
FIR3E-A1#4	65.63	5.75	1.63	0.03	1.26	0.00	0.07	0.17	0.14	14.77	0.94	0.00	7.61	4.86	102.87
FIR3E-A3#6	67.70	2.84	1.50	0.06	1.16	0.00	0.08	0.25	0.15	14.91	0.84	0.00	8.02	5.22	102.78
FIR3E-A3#7	65.46	5.70	1.45	0.01	1.06	0.00	0.10	0.19	0.21	14.96	0.71	0.01	7.97	5.07	102.99
MEAN	**66.21**	**4.49**	**1.62**	**0.02**	**0.73**	**0.03**	**0.10**	**0.25**	**0.14**	**14.87**	**0.81**	**0.01**	**7.68**	**5.15**	**102.13**
VER1-A1#1	55.95	11.86	2.86	0.03	0.21	7.22	0.00	0.29	0.00	11.89	0.00	0.00	7.23	3.01	100.59
VER1-A1#2	54.91	12.04	2.86	0.00	0.16	7.70	0.08	0.03	0.13	11.92	0.00	0.19	6.78	2.88	99.72
VER1-A1#3	54.17	11.99	2.92	0.37	0.02	7.67	0.16	0.19	0.00	11.68	0.58	0.00	6.76	2.95	99.52
VER1-A2#1	53.53	12.05	2.98	0.16	0.02	9.83	0.08	0.16	0.13	11.77	0.36	0.13	6.95	3.00	101.26
VER1-A2#2	52.18	12.05	3.00	0.13	0.00	9.72	0.02	0.13	0.14	11.67	0.37	0.13	6.96	2.90	99.46
VER2-A1#1	68.10	2.09	2.28	0.05	0.31	0.20	0.00	0.28	0.15	15.91	0.66	0.10	7.44	5.47	103.13
VER2-A1#2	67.69	2.06	2.30	0.04	0.18	0.13	0.30	0.45	0.14	15.51	0.79	0.04	7.43	5.32	102.45
VER2-A2#1	66.42	1.58	2.56	0.05	0.35	0.12	0.21	0.39	0.19	15.86	0.54	0.00	7.50	5.22	101.07
VER2-A3#1	65.34	1.61	2.58	0.08	0.35	0.09	0.21	0.41	0.22	15.63	0.67	0.01	7.42	5.47	100.16
VER2-A3#2	64.97	1.56	2.50	0.05	0.18	0.09	0.08	0.36	0.19	15.46	0.66	0.03	7.40	5.52	99.13
MEAN	**60.33**	**6.89**	**2.68**	**0.10**	**0.18**	**4.28**	**0.11**	**0.27**	**0.13**	**13.73**	**0.46**	**0.06**	**7.19**	**4.17**	**100.65**

(The analytical total as shown here was not adjusted for the oxygen equivalent of fluorine. such an adjustment can be made by multiplying the F value by 0.42 (at wt O/ 2x at wt F) and subtracting this number from the "Total")

TABLE 3
MICROPROBE ANALYSES OF COLUMBITE FROM THE VERITY (VER) AND FIR (FIR) DEPOSITS

ANALYSIS	Nb_2O_5	Ta_2O_5	TiO_2	SiO_2	FeO	ZrO_2	ThO_2	UO_2	La_2O_3	Ce_2O_3	Y_2O_3	MgO	CaO	MnO	PbO	NA_2O	WO_3	TOTAL
FIR3A-A2#4	79.34	1.12	1.25	0.00	15.70	0.00	0.00	0.06	0.00	0.00	0.38	3.24	0.04	1.32	0.00	0.00	0.04	102.49
FIR3A-A2#5	77.67	1.46	1.40	0.00	15.60	0.00	0.08	0.04	0.00	0.00	0.38	3.31	0.05	1.29	0.00	0.02	0.00	101.30
FIR3A-A3#4	78.50	1.25	1.17	0.00	15.99	0.01	0.03	0.00	0.12	0.01	0.31	2.11	0.04	1.40	0.00	0.02	0.07	101.03
FIR3D-A2#1	78.12	1.07	1.73	0.00	15.97	0.00	0.04	0.00	0.00	0.01	0.25	2.39	0.05	1.25	0.00	0.00	0.00	100.89
FIR3D-A2#2	78.43	0.67	1.62	0.00	16.20	0.00	0.00	0.00	0.00	0.06	0.31	2.45	0.05	1.32	0.00	0.00	0.00	101.12
FIR3E-A1#5	77.23	1.59	1.39	0.00	16.41	0.00	0.00	0.02	0.00	0.00	0.35	1.75	0.04	1.28	0.00	0.00	0.00	100.06
FIR3E-A1#6	76.99	1.73	0.98	0.00	17.18	0.00	0.00	0.00	0.05	0.00	0.28	1.09	0.24	1.58	0.06	0.02	0.04	100.25
FIR3E-A2#1	78.04	0.31	1.84	0.00	16.12	0.07	0.00	0.02	0.00	0.00	0.22	1.75	0.05	1.20	0.00	0.00	0.07	99.70
FIR3E-A2#2	76.91	2.29	1.57	0.00	15.79	0.00	0.05	0.00	0.00	0.00	0.27	1.77	0.03	1.23	0.03	0.00	0.00	99.94
FIR3E-A2#3	77.42	1.91	1.39	0.00	16.03	0.00	0.00	0.07	0.00	0.00	0.26	1.64	0.04	1.25	0.00	0.02	0.00	100.03
FIR3E-A2#4	77.50	2.14	1.47	0.00	15.47	0.00	0.08	0.00	0.01	0.00	0.23	1.75	0.05	1.29	0.09	0.00	0.04	100.14
FIR3E-A3#1	76.48	1.82	1.52	0.00	15.99	0.00	0.12	0.00	0.00	0.02	0.28	2.93	0.05	1.30	0.07	0.00	0.00	100.58
FIR3E-A3#2	78.44	1.23	1.32	0.00	15.89	0.00	0.00	0.00	0.05	0.00	0.31	2.83	0.05	1.24	0.05	0.02	0.00	101.43
FIR3E-A3#3	77.18	2.87	1.42	0.00	15.91	0.00	0.03	0.06	0.10	0.00	0.33	2.83	0.04	1.22	0.00	0.00	0.00	102.01
FIR3E-A3#4	77.32	1.29	1.24	0.00	16.01	0.00	0.01	0.08	0.01	0.00	0.30	2.91	0.10	1.30	0.02	0.00	0.00	100.60
FIR3E-A3#5	77.72	0.98	1.35	0.00	16.20	0.01	0.06	0.00	0.00	0.01	0.33	2.87	0.05	1.30	0.00	0.00	0.00	100.90
FIR3E-A4#1	78.46	0.84	1.62	0.00	16.19	0.04	0.00	0.00	0.01	0.00	0.29	2.48	0.03	1.29	0.01	0.01	0.12	101.39
FIR3E-A4#2	77.91	1.76	1.66	0.00	15.97	0.00	0.04	0.00	0.00	0.00	0.33	2.32	0.05	1.32	0.01	0.02	0.03	101.42
FIR3E-A4#3	78.03	1.74	1.36	0.00	15.97	0.00	0.00	0.01	0.03	0.00	0.29	2.24	0.06	1.35	0.05	0.01	0.00	101.14
MEAN	**77.76**	**1.46**	**1.44**	**0.00**	**16.03**	**0.01**	**0.03**	**0.02**	**0.02**	**0.01**	**0.30**	**2.36**	**0.06**	**1.30**	**0.02**	**0.01**	**0.02**	**100.85**
VER1-A2#3 *	0.03	0.01	0.00	1.87	73.67	0.03	0.03	0.02	0.01	0.02	0.01	0.40	0.80	0.00	0.00	0.74	0.04	77.77
VER1-A2#4 *	3.36	0.08	0.07	5.38	69.49	0.00	0.02	0.00	0.05	0.04	0.00	1.30	1.39	0.13	0.01	0.07	0.00	81.40
VER2-A1#3	74.12	1.92	2.65	0.00	20.18	0.00	0.15	0.14	0.08	0.01	0.35	0.30	0.10	0.18	0.00	0.05	0.00	100.23
VER2-A1#4	73.95	3.33	1.94	0.00	19.44	0.00	0.33	0.06	0.01	0.00	0.29	0.25	0.25	0.18	0.00	0.00	0.00	100.05
VER2-A1#5	75.92	1.51	1.70	0.00	19.73	0.00	0.23	0.11	0.00	0.00	0.30	0.17	0.23	0.24	0.11	0.01	0.04	100.30
VER2-A2#2	71.96	1.67	2.86	0.08	20.28	0.00	0.24	0.03	0.03	0.05	0.28	0.28	0.12	0.11	0.01	0.02	0.40	98.42
VER2-A2#3	72.96	1.79	2.94	0.00	20.13	0.00	0.21	0.18	0.05	0.06	0.30	0.31	0.22	0.28	0.00	0.00	0.12	99.56
VER2-A2#4	72.54	2.43	2.55	0.00	20.41	0.00	0.09	0.03	0.00	0.04	0.34	0.16	0.12	0.15	0.00	0.02	0.12	99.01
VER2-A3#3	70.54	1.55	2.65	0.00	20.60	0.00	0.29	0.00	0.10	0.00	0.35	0.16	0.11	0.11	0.00	0.02	0.00	96.50
VER2-A3#4	70.19	1.88	2.79	0.00	20.62	0.00	0.33	0.04	0.13	0.14	0.33	0.13	0.17	0.21	0.09	0.00	0.00	97.06
MEAN	**72.77**	**2.01**	**2.51**	**0.01**	**20.17**	**0.00**	**0.23**	**0.07**	**0.05**	**0.04**	**0.32**	**0.22**	**0.17**	**0.18**	**0.03**	**0.02**	**0.09**	**98.89**

* Iron oxide rims were not used to calculate the mean

bite from the Verity deposit, as indicated by our microprobe analyses, do not exceed 0.18 and 0.33% respectively. The tapiolite and columbite-tantalite compositional fields and the gap that separates these fields are shown on Figure 4. These compositional fields represent a compilation of pegmatite-hosted columbite-tantalite data by Černý *et. al*. (1992). This figure permits us to illustrate the restricted Ta/Nb and Mn/Fe ratios of columbites from the Blue River area relative to columbite-tantalite that occurs in pegmatites. All the samples from the Verity carbonatite plot near the ferrocolumbite end-member. Furthermore, columbite from the Verity carbonatite appears to have lower Nb and higher TiO_2, ThO_2 and FeO content than that from the Fir carbonatite (Table 3).

The zoning of the pyrochlore and columbite crystals and their heterogeneity is readily observed on backscatter electron photomicrographs, see Photo 1c as an example. In some cases, columbites have rims consisting of iron oxide with a very low Ta and Nb (Table 3).

The REE contents of both pyrochlore and columbite are relatively low, therefore it is likely that a substantial proportion of the total REE indicated in whole rock analyses is accounted for by other minerals. One such mineral was tentatively identified as a fluorocarbonate based on semiquantitative microprobe analysis (36.36% Ce_2O_3, 18.94% La_2O_5, 9.63% F, 4.49% ThO_2, 3.54% Nb_2O_5, 2.94 % CaO, 1.27% FeO, 0.5% SrO_2 and 0.19% TiO_2).

Detailed studies could determine if the paragenetic relationship between columbite and pyrochlore that we observed are consistent on the deposit scale. However, this aspect lies outside the scope of this study.

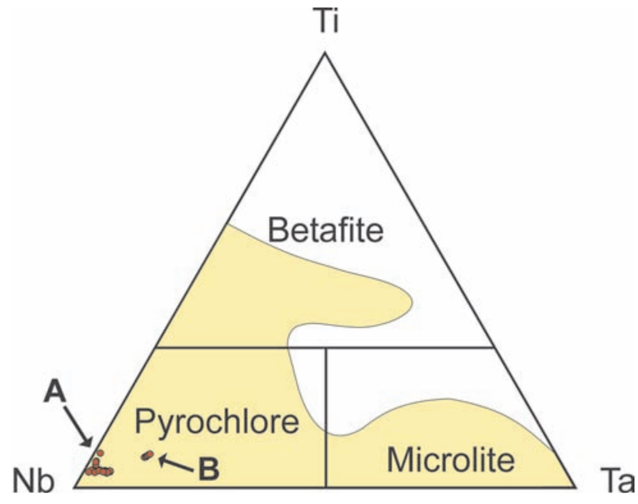

Figure 3. Composition of pyrochlores from the Verity and Fir deposits. Fields of pyrochlore subgroup, microlite and betafite are from Černý and Ercit (1986). Shaded area represents a known compositional range of pyrochlore group minerals.

FIR DEPOSIT

Outcrops of the Fir deposit result from breaks in the topography on the steep, west-facing slope of Mount Chedale. The best surface exposure measures 4.5 by 2.5 metres and appears to have been moved by gravity or frost heaving. However, diamond drilling has proved the presence of mineralized carbonatite at depth. Dahrouge (2002)

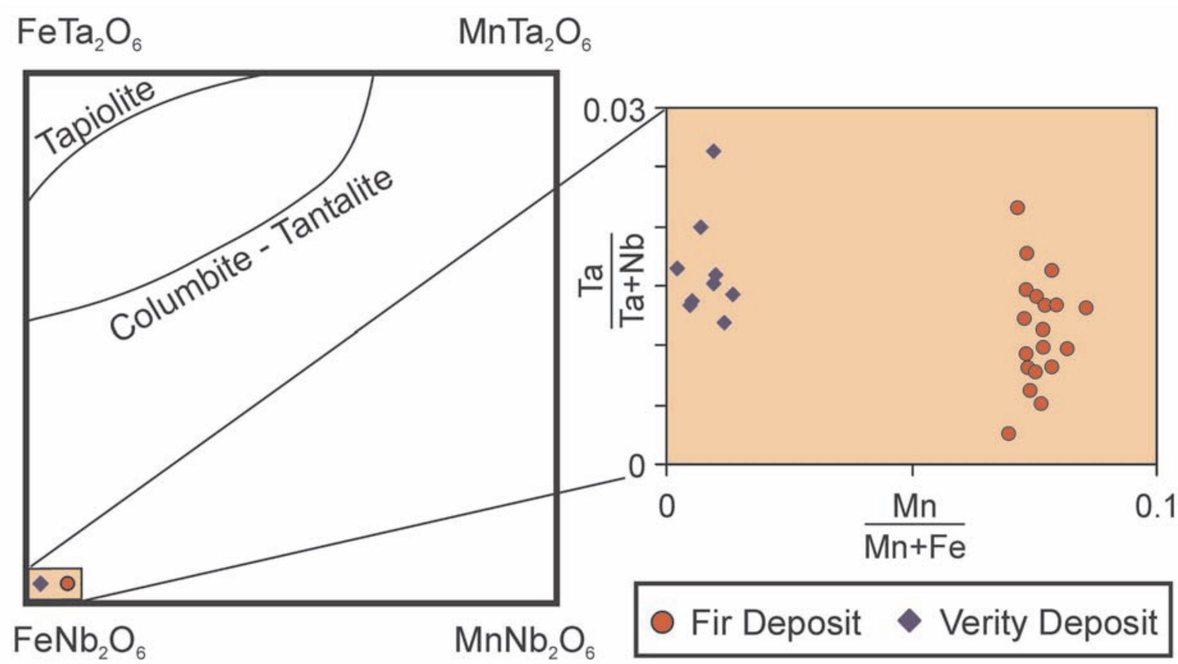

Figure 4. Columbites from the Verity and Fir deposits appear to form two distinct populations. Fir deposit contains columbite with higher Ta content, but all samples correspond to the ferrocolumbite end member. The grid is based on the composition of natural minerals (Černý *et al*., 1992).

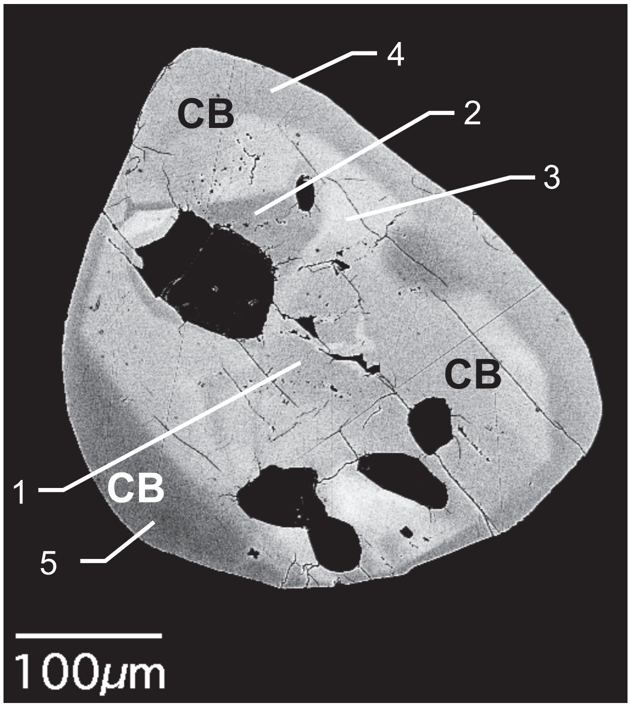

Photo 2a

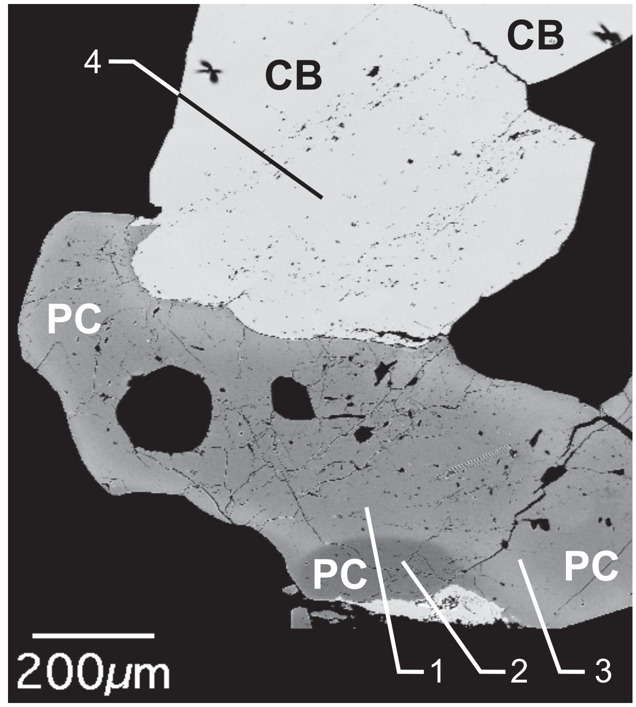

Photo 2b

Photo 2. Backscatter electron photomicrographs from the Fir carbonatite; a) Columbite set in dolomitic carbonatite, dolomite in black. Note the strong zoning. Locations 1, 2, 3, 4 and 5 correspond to microprobe analyses FIR3E-A3#1, #2, #3, #4 and #5 in Table 3
b) Pyrochlore (PC) and columbite (CB) in dolomite; Locations of microprobe analyses 1, 2, 3 and 4 correspond to microprobe analyses Fir #A-A2#1, #2, #3 in Table 2 and Fir 3A-A2#4 in Table 3.

indicates that the Fir deposit consists of two subparallel, sill-like bodies within a nearly flat-lying metasedimentary sequence. The Fir deposit has been intersected by ten drill holes over an area of 350 by 450 metres. According to Dahrouge (2002), drilling results indicate values of 200 to 250 ppm Ta_20_5, 500 to 1000 ppm Nb_2O_5 and 3 to 4 % P_2O_5. In outcrop, this carbonatite is less weathered than the Verity carbonatite and displays moderate to well-developed centimeter-scale layering. This may be due to original magmatic texture, but is more likely metamorphic in origin. This carbonatite (beforsite) consists mainly of dolomite (>80%, 1-3 mm), calcite occurring mainly as fracture fillings or coatings (<5%), amphibole (<7%, < 4mm, prismatic) and colorless to very pale green apatite (<20%).

LITHOGEOCHEMISTRY

Whole rock and trace element analyses of the samples collected during our study are given in Table 1 and as expected, the samples plot within magnesiocarbonatite field (Figure 2). The Fir carbonatite was reported to have higher Ta content than the Verity deposit, including 8.2 metres assaying 319 ppm Ta_2O_5, 1400 ppm Nb_2O_5 and 3.15 % P_2O_5 (Dahrouge, 2002). The data confirm the Fir deposit's unusual tantalum concentrations and results are in line with previously reported chemical analyses (Table 1).

NIOBIUM AND TANTALUM MINERALS

Similar to the Verity deposit, the main Ta-Nb ore minerals which were identified in polished thin sections of the Fir deposit are columbite (Photo 2a) and pyrochlore (Photo 2b). According to Dahrouge (2002), the high Ta/Nb ratio and high Ta content of the Fir deposit is explained by a high columbite to pyrochlore ratio, estimated at 20:1. Microprobe analyses presented in this study suggest that there is compositional difference between the columbite from the Verity and Fir deposits.Columbite from the Fir deposit has lower TiO_2, FeO, ThO_2, UO_2, CaO and higher MnO and MgO content than the Verity columbite. Columbite from Fir analyzed during this study contains less than 0.08 and 0.12 % of UO_2 and Th_2O_5 respectively. The composition of pyrochlore from the Fir deposit is shown on Figure 4 and in Table 2. Fir pyrochlores show less variation in Ta_2O_5, and appear to have lower TiO_2, UO_2 and higher SrO, CaO and ThO_2 content than pyrochlores from Verity.

"SERPENTINE" CARBONATITE

A carbonatite showing was found 1 km from the intersection of Serpentine Creek Forest Service Road and Road 752 on the side of the decommissioned road. It may correspond to the "Serpentine" occurrence, first reported by Digel *et al*. (1989). The exposed carbonatite is strongly fractured and may be referred to as rubble or scree rather than a outcrop, in which the largest fragments are less than

10 centimetres in longest dimension. Most of the scree consists of particles 1 centimetre or less in size. Fresh surfaces appear pale gray and weathered surfaces appear beige or rusty brown. The carbonatite consists mainly of calcite (> **85**%, <6mm), olivine (<5%, <2cm), bronze-colored biotite, possibly vermiculite (<5%), apatite (<2%), ilmenite / magnetite (<4 %), amphibole (<2%) and dolomite (< 2%). Pyrite and chalcopyrite (< 0.5% combined) are minor constituents. The contacts between the carbonatite and the host rock are not exposed, however, green amphibole-rich blocks and rubble within the overburden. These blocks consist mainly of mafic minerals (mainly amphibole and clinopyroxene,<75%) and carbonates (<25%), typical skarn mineralogy. Chemical analyses of calcitic carbonatite and fenite ruble are given in Table 1. The Serpentine carbonatite has a much lower Nb and Ta content than the two previously described occurrences and it contains bronze-colored mica (possibly vermiculite). Visual estimates from this single outcrop, suggest that mica content is too low to be of economic interest.

The samples from the Serpentine carbonatite were described as sövite (coarse calcite-carbonatite) in the field, microscope examination confirmed that they consist mainly of calcite, but contain also small proportion of dolomite. Although they plot as magnesiocarbonatites (Figure 2), they should be called sövites based on their mineralogy. The third sample (SERP-3), from the Serpentine carbonatite plots also in the magnesiocarbonatite field, but based on large proportion of silicate minerals, it should be referred to as skarn rather than carbonatite. The term skarn is preferred to fenite, based on mineralogy and on low NaO and K_2O content of amphiboles forming this rock.

DISCUSSION

This study confirms that Ta and Nb concentrations in representative samples from the Verity and Fir carbonatites are similar to concentrations reported in literature (Dahrouge 2002). When compared to typical carbonatites, Fir and Verity have relatively high Ta/Nb ratios.

Most of the Ta and Nb at the Verity and Fir deposits is contained in columbite and pyrochlore. There is a variation in the composition of pyrochlore and columbite within both the Verity and Fir deposits, as some pyrochlores are strongly zoned and some of the Verity pyrochlores have a relatively high UO_2 and Ta_2O_5 content (Table 2). The highest U and Th concentrations in columbite obtained during this study correspond to 0.18 and 0.33 % UO_2 and ThO_2 respectively (Table 3), however, the mean UO_2 and ThO_2 contents of columbite are much lower. Our analyses suggest that columbites from the Fir and Verity deposits are chemically distant (Table 3, Figure 4).

Although the Verity deposit is renown for large museum quality, pyrochlore crystals (Photo 2b)**,** a large proportion of the pyrochlores observed under binocular microscope and in thin section appear to be in the 0.2 to 1.5 mm size range. Overall, columbite, which in some cases appears to replace pyrochlore, is probably finer-grained than pyrochlore, but it can be still considered as "coarse" compared to some other unconventional tantalum resources discussed by Simandl (2002).

Further research would be required to confirm our observations, describe and understand the zoning of ore minerals and their chemistry and paragenesis. Variations in Ta, Nb, U and Th compositon of pyrochlore and columbite on deposit and regional scales also remain to a large extent unexplained.

The uranium and thorium content of columbite and pyrochlore is not being overlooked by the Commerce Resources Corp., since the company is considering the potential of uranium recovery as a tantalum and niobium byproduct (Commerce Resources Corp., News Release, February 18, 2002). They plan to complete bench scale metallurgical testing that may provide an important contribution to understanding the metallurgy and ore mineralogy of the Fir and Verity deposits.

SUMMARY

The Verity and Fir deposits represent significant Ta resources. The economic viability of these resources will depend on environmental and metallurgical constraints (including U and Th content of the concentrate), acceptability of the Ta/Nb concentrate by processors and refiners, Ta and Nb market conditions and defining ore reserves with further exploration and engineering studies, (Simandl, 2002). It is possible that other carbonatites with high tantalum values will be discovered in British Columbia.

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ANNEX I

CHEMICAL ANALYSES

All samples were ground using a steel mill. Major element chemistry was determined using lithium metaborate fusion followed by Inductively Coupled Plasma Emission Spectrometry (ICPES). Lost on ignition (LOI) was determined during the sample fusion (at 1000°C). Total carbon and sulphur were determined using the Leco combustion method. Most of trace elements were analysed by lithium metaborate fusion followed by Inductively Coupled Plasma Mass Spectrometry (ICPMS). The comparison with the known standard suggests that REE and possibly Nb extraction was incomplete, but that the level of Ta extraction was more than acceptable for the intended purposes. Concentrations of W, Mo, Cu, Pb, Sn, Zn, Ni, As, Cd, Sb, Bi and Ag were determined using Aqua regia digestions followed by ICPES.

W, Mo, Sb, Sn are at or below instrument detection limits and are therefore not shown in Table 1.

MICROPROBE

Quantitative analyses were made on fully automated Camebax MBX electron probe by wavelength dispersive x-ray analyses (WDX). Operating conditions were 20kv accelerating potential and a beam current of 35 nano-amperes (nA) for pyrochlore and columbite. Peak counting times were 30-60 seconds or 40,000 counts, depending upon which came first. X-ray ray lines were chosen to minimize or eliminate possible elemental interferences. Corrections were made for any instances of overlap. Raw x-ray data were converted to elemental weight % by the Cameca PAP matrix correction program. A suite of well characterized natural and synthetic minerals and compounds were used as calibration standards. Analyses are accurate to 1-2 % relative for major elements, 3-5 % relative for minor elements (< 1 wt %). Elements at or near minimum detection limit MDL (0.02-0.06 wt %) have relative errors approaching 100%.

THE FIR CARBONATITE A POTENTIAL TANTALUM - NIOBIUM RESOURCE

By Jody Dahrouge[1]

INTRODUCTION

Within the Blue River area of east-central British Columbia are a number of sill-like carbonatites that intrude gneissic metasedimentary rocks of the Proterozoic Horsethief Creek Group. These occurrences, which include the Bone Creek, Fir, Gum Creek, Howard Creek, Mill, Mud Lake and Verity-Paradise carbonatites, lie within a northerly trending belt of carbonatites that straddles the western side of the Rocky Mountain Trench.

The Fir Carbonatite, consists of a series of contemporaneously emplaced sills with nearly identical petrological, mineralogical and geochemical properties. The host gneisses have a general strike of north and dip 10^o to 15^o east. Although outcrop exposure is poor, the Fir Carbonatite has been traced at surface over an area of about 350 m by 450 m. Drilling indicates that the average thickness is about 40 m. It constitutes a very large resource of tantalum, niobium and phosphate, and remains open for expansion to the north, east and south. The economic significance of the Fir Carbonatite was first recognized during the early 1980's, while recent exploration by Commerce Resources Corp. confirmed the Fir Carbonatite as having very good potential for large tonnages with highly anomalous concentrations of tantalum and niobium..

The carbonatite is composed almost exclusively of beforsite, with primary magmatic mineralization that includes apatite, ferrocolumbite and pyrochlore. Ferrocolumbite and pyrochlore concentrations are at levels equivalent to many of the worlds known primary tantalum deposits. Tantalum mineralization is typically coarse grained with a fairly even distribution. Grades of individual samples collected from across the carbonatite range from 100 to 400 ppm Ta_2O_5.

LOCATION AND ACCESS

The Fir Carbonatite is located within North Thompson River valley of east-central British Columbia. It is accessible from Gum Creek logging road which branches from Highway 5, about 23 km north of the community of Blue River. Additional infrastructures within the area include the main line of the Canadian National Railway which is less than 1 km west of Fir and a B.C. Hydro Line about 1 km to the east (Figure 1).

The Fir Carbonatite is exposed on steep, west-facing slopes of Monashee Mountains at about 900 m elevation. Thick forest cover, variable sequences of unconsolidated overburden, and the recessive nature of the carbonatite rocks, have resulted in poor bedrock exposure.

PREVIOUS WORK

Exploration for carbonatites within the Blue River area began in about 1949 with the discovery of a vermiculite-bearing carbonate by Mr. Oliver E. French (Mariano, 1982). Subsequent exploration programs between about 1950 and 1980 included geologic mapping, geophysics, prospecting, stripping and trenching, and sampling for niobium, phosphate, vermiculite, uranium and tantalum.

Exploration culminated in 1980 and 1981 with a series of drill programs conducted by Anshutz Mining of Canada Ltd. This work was directed at the identification of carbonatite hosted tantalum mineralization, and included drilling the most promising of the known carbonatites: Bone Creek, Fir, Mill and Verity. Based primarily upon the 1980 and 1981 drill programs Aaquist (1982a, p.1) concluded

"The carbonatite occurrences at Blue River, British Columbia have the highest tantalum concentrations of any carbonatite in the world."

And (Aaquist, 1982b; p. 12),

"The Verity area, that was drilled in 1981, is the best defined and most continuous zone of carbonatite to date. About 2.13 million tons averaging 0.02% Ta_2O_5 and 0.126% Nb_2O_5 occur in the area..."

During 1987 and 1988, Digel et. al. (1989) located two new carbonatites within the Blue River area. The first along Serpentine Creek, is exposed by a logging road at about 1370 m elevation. The second carbonatite occurs at about 2040 m elevation on a small ridge just south of Gum Creek. It forms an approximately 10 m thick layer, concordant with the surrounding host rocks.

During February 2000, Commerce re-staked the known carbonatites and conducted a small surface sampling program to confirm the known tantalum mineralization at both Fir and Verity, and to locate new exposures on recently constructed logging trails. McCrea (2001) completed a re-evaluation of existing information, including 30

[1] *Dahrouge Geological Consulting Ltd.*
#18, 10509 – 81 Ave, Edmonton, AB T7X 3W6

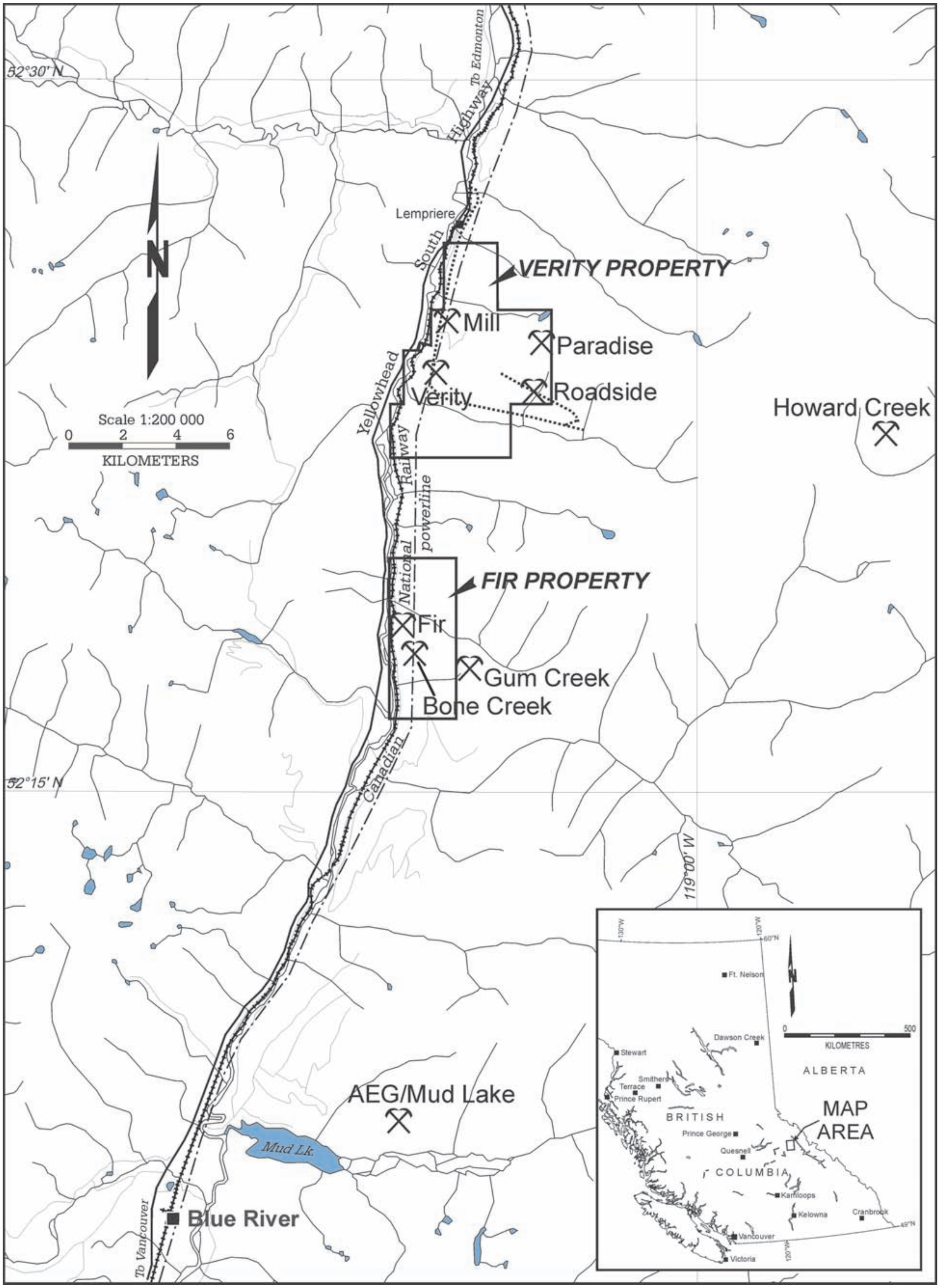

Figure 1. Locations of carbonatites within the Blue River area.

drill holes totalling 2,060 m and 715 samples. It resulted in updated resource-estimate for the Verity Carbonatite, as follows:

Grade Cut-Offs	Tonnes °	Composition		
(g/t Ta_2O_5)		Ta_2O_5 (g/t)	Nb_2O_5 (g/t)	P_2O_5 (%)
200 - 400	944,000	243	555	3.63
150 - 200	3,063,000	196	645	3.2
50 - 200	6,260,000	137	511	3.38

° Tonnages are cummulative

* After McCrea (2001, p.25)

Commerce Resources Corp. undertook additional reconnaissance scale exploration during 2001 within the Blue River area. Work included collection of rock, soil and stream sediment samples, and ground magnetic and radiometric surveys. These efforts were followed by drilling of six HQ holes totalling 1246.5 m at the Fir Carbonatite, and five NQ holes totalling 403.9 m at the Verity Carbonatite.

REGIONAL GEOLOGY

The Blue River area encompasses upper amphibolite facies (kyanite to sillimanite) metasedimentary rocks of the Proterozoic Horsethief Creek Group. These rocks were described by Campbell (1968) as: gritty feldspathic quartzite, phyllite, quartz-mica schist, garnet-staurolite and kyanite-mica schist, biotitic and/or horneblendic quartzo-feldspathic gneiss, minor marble and amphibolite and minor pegmatite with staurolite-kyanite schist.

Complex regional scale structures within this part of the Monashee Mountains include a mylonitic fault contact between Horsethief Creek Group rocks and Malton Gneiss to the north, and a northerly trending regional scale fault along the North Thompson River Valley. Pell and Simony (1981) describe the North Thompson fault as a major west side down normal fault, that forms a metamorphic and structural discontinuity between the Monashee Mountains and the Cariboo Mountains to the west.

The eastern flank of the Cordillera within British Columbia has previously been recognized as a locus of alka-

TABLE 1
WHOLE ROCK AND TRACE GEOCHEMISTRY OF VARIOUS LITHOLOGIES (FROM THE BONE CREEK, FIR AND GUM CREEK CARBONATITES)

Samples*	Bone Creek		Fir				Gum
Composition	15028A	15028B	15601	15603	15629	15651	15038
Major Elements (weight %)							
CaO	13.79	16.82	0.85	31.63	25.97	29.64	45.22
MgO	2.96	12.26	2.4	14.44	13.12	14.08	3.67
SiO_2	24.73	48.61	59.64	2.53	21.79	2.99	2.41
TiO_2	0.35	0.53	0.81	0.02	0.08	0.03	0.08
Al_2O_3	7.06	4.35	18.02	0.08	2.05	0.07	0.1
Fe_2O_3	23.84	10.72	8.49	7.65	9.16	9.18	4.1
Na_2O	1.23	2.02	4.8	0.17	0.46	0.38	0.42
K_2O	0.92	0.23	3.15	0.03	0.76	0.08	0.03
P_2O_5	9.6	1.73	0.2	3.97	3.5	3.97	1.82
Trace Elements (ppm)							
Ta_2O_5	576	137	5	255	154	415	75
Nb_2O_5	1907	610	133	651	439	2411	3,211
Cu	78	19	85	4	37	2	101
Ni	211	26	36	3	85	2	22
Rb	52	5	165	2	50	1	3
Sr	1694	615	313	3683	2334	4289	13077
Th	32	5	27	3	3	8	12
U	231	23	3	134	67	29	4
V	84	143	86	< 5	23	9	31
Zr	200	36	201	105	36	6	18
Ratios							
Nb_2O_5 / Ta_2O_5	3.31	4.45	26.6	2.55	2.85	5.81	42.81
Ta_2O_5 / U	2.49	5.96	1.67	1.9	2.3	14.31	18.75

*Samples 15028A: Carbonatite; 15028B: Amphibolite; 15601: Fenitized Gneiss 107.62 - 108.62 FDH1; 15603: Upper Beforsite Sill 109.62 - 110.62; 15629: Fenite / Amphibolite 146.37 - 147.37; 15651: Lower Beforsite Sill 169.03 - 170.03; 15038: Sovite.

*Major and Trace Element analysis were by ICP-MS (Inductively Coupled Plasma Mass Spectrometer) after lithium metaborite fusion. Tantalum and Uranium were by INAA (Instrumental Neutron Activation Analysis).

line igneous activity (Currie, 1976), which Pell (1987) subdivided into three northwest trending belts:

- an eastern belt, that encompasses most of the Main and Western Ranges of the Rocky Mountains,
- a central carbonatite belt, that includes the Rocky Mountain Trench and parts of the Omineca, Crystalline Belt, and
- a south-central belt centred around Frenchmans' Cap Gneissic Dome.

The central carbonatite belt, which extends about 50 km westerly and approximately parallel to the Rocky Mountain Trench, generally hosts multiply deformed and metamorphosed, sill-like bodies (Pell, 1987). Within the Blue River area the carbonatites typically have thin ampbhibole-rich haloes of fenite, and some are associated with syenites. Carbonatites within the Blue River area, include: Bone Creek, Fir, Gum Creek, Verity-Paradise, Serpentine Creek, Howard Creek and Mud Lake-Blue River.

PROPERTY GEOLOGY

The Fir Carbonatite area, is underlain by a sequence of near flat-lying to shallow easterly dipping metasediments and interlayered metabasites of the Proterozoic Horsethief Creek Group. Pegmatite dykes, lenses and sills, each of which may attain several meters across, intrude the sequence and cut all lithologies. The pegmatites generally consist of white feldspar and quartz with accessory muscovite. A number of flat-lying, sill-like, carbonatites are known to intrude the Proterozoic Horsethief Creek Group; they include Bone Creek, Fir and Gum Creek. The main carbonatite body, Fir, has been identified in outcrop and intersected by ten core holes over an area measuring about 350 m east-west and 450 m north-south. It consists of two subparrallel sills, a lower beforsite sill that varies from 26 to 50 m thick, and an upper beforsite that is up to 22 m thick (Figure 2).

According to Mariano (1982) the Fir Carbonatite is almost exclusively beforsite composed predominately of ferroan dolomite with minor apatite and dark-green amphibole. Both outcrops and drill core display primary igneous layering formed with bands richer and poorer in non-carbonate minerals. Fenitized country rock associated with the carbonatite appears limited to narrow intervals. Layers and pods up to 1 m thick, with greater than 50 per cent amphibole are common (Table 1).

Macroscopic textures such as a diffuse gneissocity, augen gneiss and tectonic brecciation indicate (Mariano, 1982 p.1)

"extensive tectonic deformation and post-emplacement metamorphism with significant mineralogical and geochemical redistribution."

Although a considerable thickness of carbonatite is noted at Fir, poor bedrock exposure with vast covered intervals, probable concealed internal structures and the lack of a readily recognized marker horizon, hinders accurate correlation of stratigraphy.

Prior ore mineralogical studies by Mariano (1982) identified two primary Ta-bearing phases: ferrocolumbite

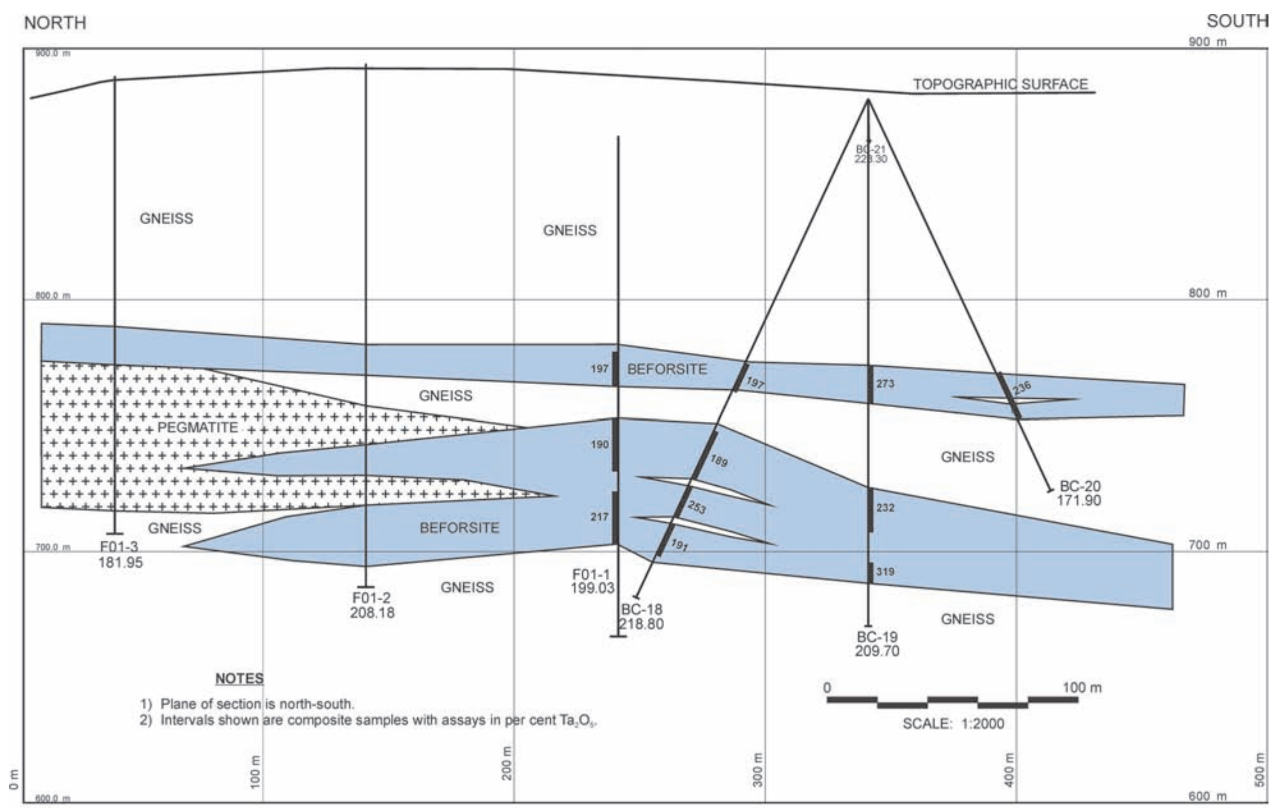

Figure 2: North-South Cross-Section Through the Fir Carbonatite.

($Fe(Nb,Ta)_2O_6$) and pyrochlore [$(Ca,Na)_2(Nb,Ta)_2O_6(OH,F)$]. For rocks examined from the Fir Carbonatite Mariano (1982) noted an approximate ratio of 20:1, columbite to pryochlore. In addition, (Mariano, 1982, p. 64)

"all pyrochlores examined from BC-19 are relatively low in U and high in Ta. They are light yellow in color and occur as grains intimately crystallized with ferrocolumbite and as isolated crystals in the dolomite ground mass. ... Unlike BC-19, BC-21 core at 173.6 m contains jet black pyrochlore that is strongly radioactive indicating high U content."

Microprobe analysis provided by Mariano (2001) for ferrocolumbite and pyrochlore from the Fir Carbonatite, follows:

Constituent* (Wt. %)	Ferrocolumbite	Pyrchlore
CaO	-	7.2 - 15
F	-	2.4 - 5.6
FeO	14 - 17	-
MgO	1 - 3.7	-
MnO	0.5 - 1.5	-
Na_2O	-	6.1 - 7.9
Nb_2O_5	66 - 77	43 - 70
Ta_2O_5	1.7 - 14	2 - 31
ThO_2	-	< 1.4
TiO_2	1.0 - 5.5	1.1 - 3.8
UO_2	-	0.8 - 19

* Typical amounts from BC-19 167.4 m (Sample T-619Z)

TABLE 2
SUMMARY OF DRILL RESULTS FOR THE FIR CARBONATITE

Hole Number	From (m)	To (m)	Length (m)	Ta_2O_5 (g/t)	Nb_2O_5 (g/t)	P_2O_5 (%)
COMMERCE RESOURCES CORP. (2001)						
FDH-1	108.62	122.32	13.7	197	1153	3.64
	135.37	156.16	20.79	190	1122	3.09
	164.03	185.09	21.06	217	1287	3.28
(inclusive)	*108.62*	*185.09*	*55.55*	*202*	*1178*	*3.28*
FDH-2	111.86	124.05	12.19	Assays Not Complete		
	151.49	163.68	12.19	Assays Not Complete		
	175.56	199.95	24.38	Assays Not Complete		
FDH-3	99.67	121.04	21.34	Assays Not Complete		
FDH-4	157.88	188.36	30.48	Assays Not Complete		
	192.94	199.03	6.09	Assays Not Complete		
FDH-5	157.58	188.98	31.4	Assays Not Complete		
	201.47	207.57	6.1	Assays Not Complete		
FDH-6	169.77	197.21	29.22	Assays Not Complete		
ANSCHUTZ MINING (CANADA) LTD. (1981)						
BC-18	116	128.2	12.2	197	566	3.11
	145.4	166.6	21.2	189	534	3.17
	169.7	183.3	13.6	253	797	3.68
	186.2	200.1	13.9	191	675	3.26
(inclusive)	116	*200.1*	*60.9*	*205*	631	3.29
BC-19	106.3	121.5	15.2	273	615	3.04
	154.5	172.3	17.8	232	1393	3.05
	184.4	192.6	8.2	319	1400	3.15
(inclusive)	106.3	*192.6*	*41.2*	*265*	*1108*	*3.06*
*BC-20**	*120.7*	*140.7*	*20*	236	*1231*	*2.67*
BC-21	129.10	142.90	7.70	165	750	2.32
	162.20	200.60	38.40	200	418	4.36
(inclusive)	129.10	200.60	46.1	194	473	4.02

**Hole BC-20 appears to have been terminated short of the lower intervals of carbonatite*

Of the ten drill holes to intersect the Fir Carbonatite, four were completed during 1981 (Aaquist 1982a) and six were completed during 2001 (Table 2). Results indicate a consistently mineralized body, with between about 200 and 250 g/t Ta_2O_5, 500 and 1000 g/t Nb_2O_5, and 3 to 4 per cent P_2O_5.

The Bone Creek Carbonatite is approximately 200 m stratigraphically above the Fir Carbonatite (Table 1). It has been trace intermittently, at an apparently continuous stratigraphic level, by soil and stream sediment geochemistry, and drilling over an approximate strike length of over 2,000 m. It is generally less than 5 m thick.

The Bone Creek Carbonatite is composed primarily of apatite beforsite with coarse pyrochlore and only minor ferrocolumbite (Mariano, 1982). Most pyrochlores are dark-mahogany-brown to jet-black with major tantalum and uranium. Analytical results indicated that the Bone Creek Carbonatite may have the greatest concentrations of tantalum and uranium (Table 1), for all the carbonatites in the Blue River area.

About 2000 m east of Fir, the Gum Creek Carbonatite occurs as a layer about 10 m thick at about 2040 m elevation on a ridge south of Gum Creek. During 2001 a single sample of sovite was collected from the Gum Creek Carbonatite (Table 1), it showed low to moderate grades of tantalum with highly elevated concentrations of niobium.

DISCUSSION AND CONCLUSIONS

Carbonatites generally occur as intrusive bodies that are exploited for a variety of commodities, including rare earth elements, niobium, vermiculite, fluorite, iron, copper, phosphate; while other products including nickel, uranium, gold, silver, platinum group elements, baddeleyite, zircon, magnetite and lime. Of the approximately 330 carbonatite systems known worldwide, none are currently exploited for tantalum. However, they do offer excellent potential for large tonnages.

The known carbonatites within the Blue River area contain highly anomalous concentrations of tantalum and niobium, with variable concentrations of accessory commodities that include phosphate, rare earth elements, uranium and vermiculite. This association provides an attractive exploration target not only for those commodities, but other potentially unique occurrences.

Tantalum concentrations for the Fir Carbonatite range from about 200 and 250 g/t Ta_2O_5, which are comparable to other primary tantalum operations. For instance, the Greenbushes Pegmatite in Australia contains about 90.7 Mt at 226 g/t Ta_2O_5, while the Woodgina Pegmatite deposits contains about 65.3 Mt at 371 g/t Ta_2O_5 (Sons of Gwalia, 2002). Although recoveries are not reported for the Greenbushes Pegmatite, those at Woodgina averaged varied from 64 to 77.9% for the years 1990 to 1995 (Roskill Information Services Ltd., 1999). Low recoveries for these pegmatite hosted deposits may in part be due to complex mineralogy, including the fine grain size of the tantalum minerals.

Some regional exploration has been completed within the Blue River area; however, much of the area remains under explored and more reconnaissance scale work is required. Results to date at Fir indicate a very large resource of coarse-grained, homogeneously mineralized beforsite carbonatite, with between about 200 and 250 g/t Ta_2O_5, 500 and 1000 g/t Nb_2O_5, and 3 to 4 per cent P_2O_5. The intrusive body, which remains open to the north, east and south, requires additional drilling to define its limits.

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THE BILL PROPERTY - A MESOTHERMAL GOLD TARGET IN NORTH-CENTRAL BC

By Jason S. Weber[1] and Henry J. Awmack[2]

KEYWORDS: *Gold, Toodoggone, Devonian-Permian Asitka, Group, Jurassic intrusions, carbonitization, sericitization, silicification, mesothermal gold veining, intrusion-related gold veining.*

INTRODUCTION

The Bill property lies on the Spatsizi Plateau in the Liard Mining Division of north-central British Columbia, approximately 150 kilometres southeast of Dease Lake and 330 kilometres north of Smithers (Figure 1). The Bill property covers two distinct gold-bearing prospects. The T-Bill prospect is a 3 km^2 area of carbonate alteration, highly anomalous Au-As soil geochemistry and gold-bearing quartz-sulphide veining. The Park prospect, located 3 kilometres to the north, is a poorly explained 0.5 km^2 Au-Cu soil geochemical anomaly centred on a prominent gossan.

PROPERTY EXPLORATION HISTORY

Exploration leading to the discovery of the T-Bill and Park prospects dates back to the 1970's when Cominco conducted regional silt sampling programs through the Toodoggone area. Cominco staked the Bill claims to cover the drainages of 10 samples exceeding 50 ppb Au. Contour soil sampling in 1980 identified the T-Bill prospect, a widespread Au-As soil geochemical anomaly (Sharp, 1981). In 1981 and 1982, Cominco collected rock and soil geochemical samples.

In 1980, Du Pont of Canada Exploration Limited collected field-sieved bulk samples for heavy mineral concentrate analysis that identified anomalous samples from streams draining what is now the Park prospect. Mapping identified a number of gossans on the claims (Eccles, 1981). The next year, mapping and soil sampling identified a small gold anomaly (>100 ppb Au) coincident with the westernmost gossan (Drown 1982). In 1982, Du Pont continued work on the Park, including blast trenching, soil sampling and rock sampling. Bedrock sampling in the blast trenches yielded lower Au, As, and Cu values than the overlying soils and the claims were allowed to lapse (Copland, 1982).

Also in 1982, Du Pont optioned the Bill property from Cominco and conducted mag-VLF and IP surveys, detailed soil sampling of the core of the soil anomaly and blast trenching. The geophysical surveys highlighted NNW-trending linear magnetic lows and VLF conductors, as well as an IP chargeability high that is unrelated to soil geochemical anomalies. Trenching did not reach fresh bedrock and chip samples returned lower values than the soils immediately above (Copland and Drown, 1983).

In 1983, Du Pont extended the mag/VLF survey and drilled six holes in the >500 ppb Au portion of the T-Bill soil anomaly; four were directed to the east across the northerly-trending VLF conductors. Core was sampled in 2-metre intervals. All holes intersected quartz-arsenopyrite veining with the best intervals assaying 35.0 g/tonne Au over 2.0 metres (83-2) and 11.0 g/tonne Au over 4.0 metres (83-6). With this program, Du Pont's option was vested and they formed a 50/50 joint venture on the Bill with Cominco (Forbes and Drown, 1984).

It appeared from the 1983 drilling that the east-west holes were subparallel to the bulk of veining, so the follow-

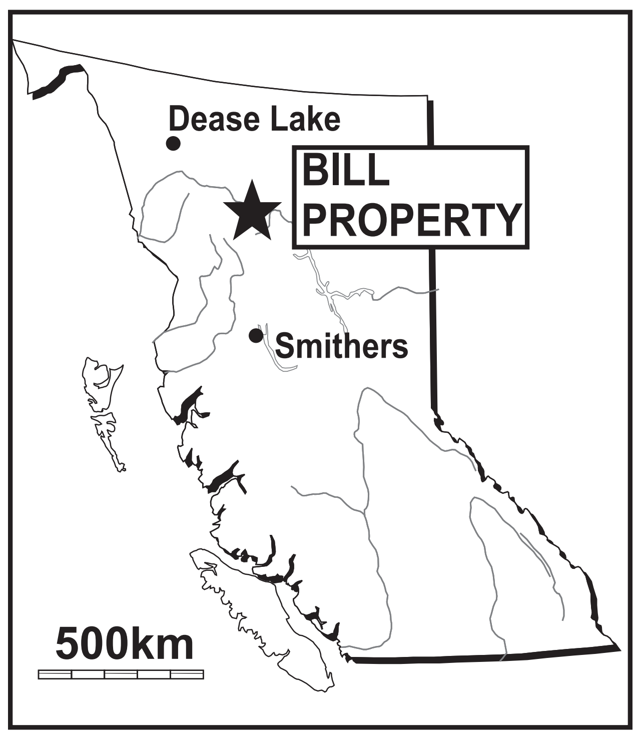

Figure 1. Bill Property Location.

[1]*Rimfire Minerals Corporation, Suite 700 - 700 West Pender St., Vancouver, BC V6C 1G8*
[2]*Equity Engineering Ltd. Suite 700 - 700 West Pender Street, Vancouver, BC V6C 1G8*

ing year Du Pont and Cominco carried out a new VLF-EM survey on north-south lines and drilled seven of nine holes to the north or south. Each of their holes cut intervals with >1 g/tonne Au, with the best sections assaying 16.5 g/tonne over 2.0 metres (84-2), 24.7 g/tonne over 1.5 metres (84-5) and 24.8 g/tonne over 2.0 metres (84-8). In addition, soil sampling extended the main T-Bill Au-As soil geochemical anomaly 600 metres to the northwest in the West Bowl and revealed a new 400 x 900 metre Au-As soil anomaly in the North Cirque (Kowalchuk, 1984). A structural study by Paterson (1985) indicated that ESE-trending quartz-carbonate-arsenopyrite veining was related to but post-dated doming and subsequent carbonate alteration of a highly deformed intermediate to mafic volcanic package. No further work was carried out by Du Pont, its successor companies, or Cominco on the Bill property and their claims were allowed to lapse in 2001.

The claims covering the Park prospect were re-staked in 1987 by Comox Resources who then optioned them to Skylark Resources Ltd. Skylark established a detailed 250 x 400 metre grid for prospecting, soil geochemical and VLF-EM surveys (McAtee and Burns, 1988).

AGC Americas Gold Corp. staked the Park gossan in 1995 and carried out soil sampling over a 900 x 1000 metre grid. This survey showed the Au-Cu soil geochemical anomaly to be much larger than previously known, covering an area of 500 x 900 metres and open to the east and west (Krause, 1996). No further fieldwork was carried out on the Park property, but in 1997, AGC Americas and Antares Mining and Exploration Corporation participated in a joint GSC-industry airborne magnetic survey over the entire Toodoggone area, including the Park prospect (Hawkins, 1998).

2001 EXPLORATION PROGRAM

Rimfire Minerals Corporation optioned the Bill property in May 2001, attracted by its large, poorly explained soil and silt geochemical anomalies, by the extent and high Au grades of the T-Bill mesothermal veining and by a large magnetic low centred immediately southeast of the T-Bill prospect. An initial program of prospecting, silt and soil geochemistry and core re-examination and sampling was carried out in July.

The 1983 core and holes 84-6 to 84-9 were inaccessible, due to collapse of their core racks. The first five 1984 holes could be recovered, but were in poor condition from animal disturbance. They were examined and 14 previously unsampled sections split for analysis.

REGIONAL GEOLOGY

The Bill property lies near the eastern edge of the Intermontane Belt in a fault mosaic of: Devonian to Permian Asitka Group carbonates and volcano-sedimentary rocks; the Carboniferous to Lower Triassic Cache Creek oceanic assemblage, including the Kutcho Formation; Triassic Stuhini volcano-sedimentary rocks; Lower Jurassic Toodoggone (subaerial) and undifferentiated Hazelton vol-

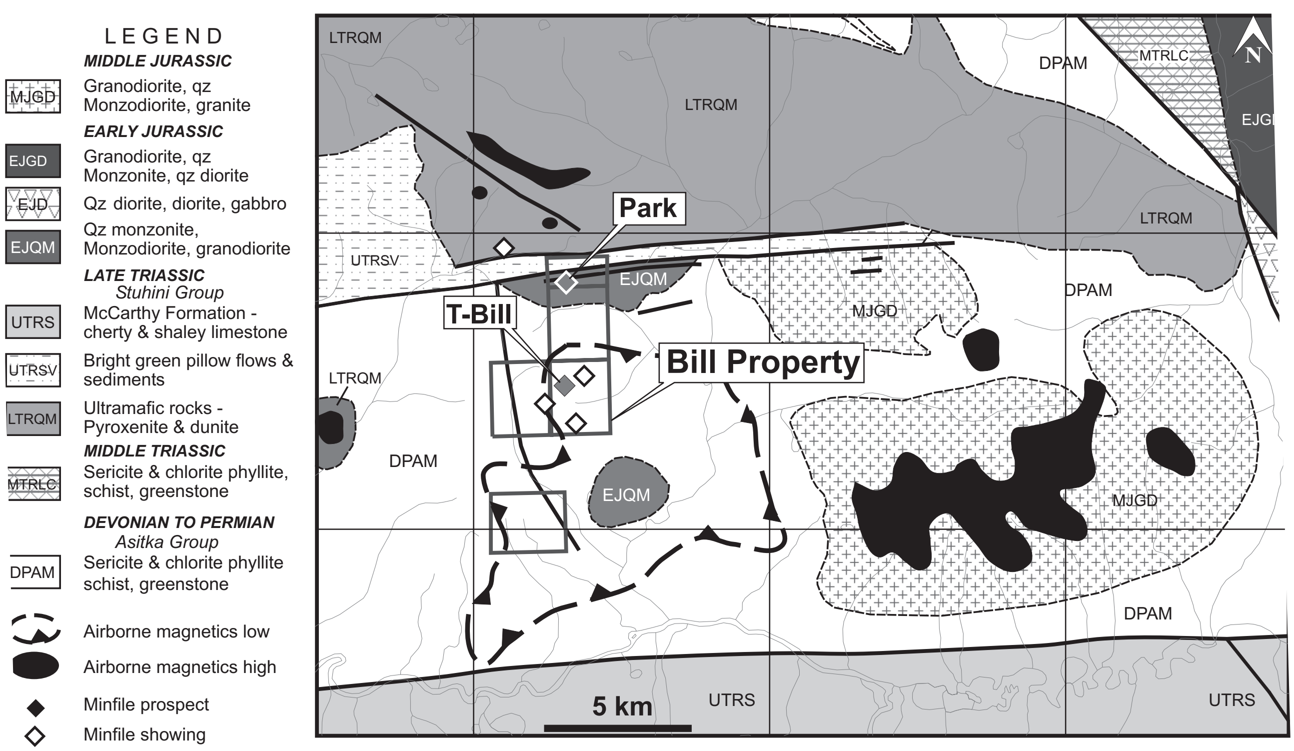

Figure 2 - Regional Geology in the vicinity of the Bill property with airborne magnetic anomalies and BC Minfile occurrence locations indicated.

canic rocks and Laberge Group volcanic and epiclastic rocks (Figure 2).

The stratified rocks are intruded by a variety of Late Triassic and Early to Middle Jurassic stocks and batholiths of felsic to ultramafic composition. Most of the Early Jurassic quartz monzonites, granodiorites and quartz diorites are characterized by a distinctive magnetic high; in particular, this applies to the intrusive immediately northeast of the Bill property. The quartz monzonite stock exposed on the southern part of the Bill property is the exception to this rule; it coincides with a distinctive magnetic low that is almost ten kilometres across.

The Pitman Fault is a major E-W fault that is about 30 kilometres north of the Bill property. Alldrick (2000), who traced the Pitman Fault for 300 kilometres, states that there is 3 kilometres of left-lateral movement along it with minimal vertical offset, and that movement occurred during Eocene to Oligocene time. Three major E-W faults have been mapped at the northern and southern boundaries of the Bill property, one along the Stikine and Chukachida Rivers four kilometres south of the Gos claim and the other two passing through the BT 3 claim, north of the Park occurrence. A fourth could reasonably be inferred along the valley between the T-Bill and the Park prospects, dropping undeformed Upper Triassic Stuhini Group volcanics down to the north against deformed Paleozoic Asitka Group rocks to the south.

PROPERTY GEOLOGY

Most of the Bill property is underlain by phyllites and schists of the Devonian-Permian Asitka Group (Figure 3). These have been penetratively deformed; primary textures and protoliths are not generally obvious. Schists in the vicinity of the T-Bill prospect consist of a sequence of chlorite schists and quartz-chlorite-feldspar schists; it has undergone extensive carbonatization and sericitization and hosts the quartz-arsenopyrite veining at the T-Bill prospect (Paterson, 1985). Paterson recognized two phases of Triassic(?) penetrative deformation and a Mesozoic or Tertiary kinking. The kink folding accompanied a northeasterly-elongated doming of the foliation, centred on the T-Bill prospect.

Northeast of the property, the Asitka Group is dominated by dark grey chert with lesser tuffaceous sediments and andesitic volcanics (Drown, 1982). Further west, green, aphyric to feldspar-phyric volcanics are assigned to the Upper Triassic Stuhini Group. In the immediate vicinity of the Park prospect, these are represented by siliceous tuffs. The contact between the Asitka and Stuhini Group rocks has not been mapped.

An unfoliated quartz monzonite to granodiorite stock intrudes Asitka Group schists on the GOS claim and immediately southeast of the BT claim. The stock is generally medium-grained and equigranular, but has local pegmatitic and aplitic phases; it is quite variable in composition. A pronounced magnetic low associated with this stock suggests that it may be about ten kilometres in diameter at depth, and centred two kilometres southeast of the BT claim. However, part of this magnetic low could be related to magnetite-destructive alteration like that at the T-Bill prospect.

Another felsic stock intrudes Asitka Group cherts northeast of the Bill property. It is fine- to medium-grained, with phases ranging from rhyolite to granodiorite (Drown, 1982). A medium-grained diorite body mapped immediately to the west may constitute a separate phase of this stock. A crowded feldspar porphyry intrusive lies a little further west, along the north edge of the Park gossan; its extent is unknown, but it too is thought to be another phase of this stock. The entire stock, like almost all Jurassic intrusions in the Toodoggone area, is characterized by a broad magnetic high, but no magnetic susceptibility work has been done to separate the effects of the stock from those of it's enclosing pyrrhotite-bearing hornfels. No dating has been carried out on any of the intrusives and their ages are a conjectural.

ALTERATION AND MINERALIZATION

Two main styles of alteration and gold-bearing mineralization occur on the Bill property; mesothermal arsenopyrite-bearing veins and disseminations (T-Bill prospect); and intrusive-related veining and silicification (Park prospect).

T-BILL PROSPECT

Asitka Group chlorite schists have been extensively altered to a muscovite-carbonate-quartz assemblage in a northeasterly-trending area of 1,200 x 2,300 metres. On a large scale, this alteration appears mainly controlled by foliation (S1) and by steeply-dipping NE-SW structures. It is largely confined to the core of the structural dome. In detail, the muscovite-carbonate-quartz alteration follows joints, fractures and foliation planes. It appears to pre-date deposition of gold from an evolving hydrothermal fluid. Cominco dated the alteration at 136+/-5 Ma (Early Cretaceous), using K-Ar methods on muscovite collected at 110 metres depth in hole 84-1.

The three styles of gold mineralization recognized on the T-Bill Prospect are spread over an area of 1,800 x 2,400 metres that roughly coincides with the muscovite-carbonate-quartz alteration. The styles are:

- Disseminated and vein pyrite-arsenopyrite in carbonatized rock adjacent to mineralized veins (*e.g.* Showing D): Up to 20% sulphides in quartz-carbonate-muscovite schist is accompanied by <1 g/tonne Au;
- Brecciated quartz veins or carbonatized rock associated with movement on faults or joints (*e.g.* Showings A, F). These breccias are related to post-carbonatization, pre-mineralization faulting. Quartz-arsenopyrite-pyrite-carbonate+/-chalcopyrite comprise the breccia matrix; gold values are moderate.
- Quartz-carbonate-arsenopyrite-pyrite veins: These are responsible for all high-grade surface and core assays. They are planar tension veins, 0.2 to 30 centimetres wide, and occur in swarms. They commonly cross-cut foliation and are present in both chlorite schist and muscovite-carbonate-quartz alteration. In the chlorite schist the

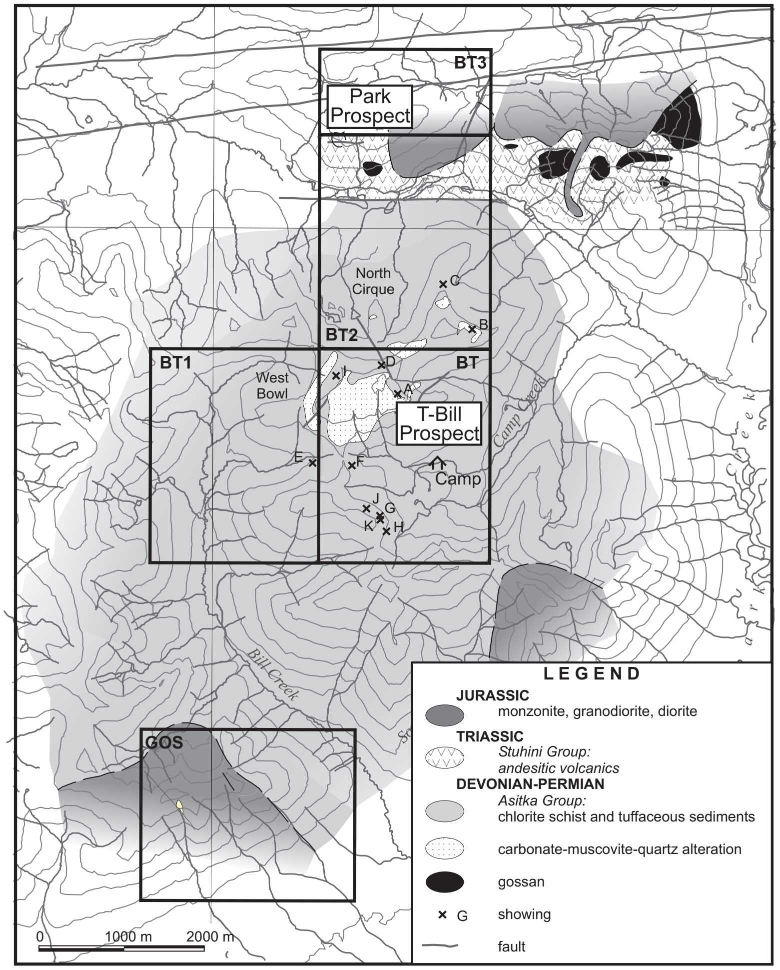

Figure 3 - Property scale geology showing T-Bill and Park prospects, showings and carbonate-muscovite-quartz alteration zones.

TABLE 1
INTERSECTIONS GREATER THAN 1 G/TONNE AU FROM THE 1983-1984 DRILL PROGRAMS

Hole	From (m)	To (m)	Length (m)	Au (g/tonne)	Ag (ppm)	As (ppm)	Cu (ppm)	Pb (ppm)	Sb (ppm)	Zn (ppm)
83-1	102.0	104.0	2	12.5	N/A	300	N/A	N/A	N/A	N/A
83-2	52.0	54.0	2	35	N/A	11500	N/A	N/A	N/A	N/A
	94.0	96.0	2	11.9	N/A	4000	N/A	N/A	N/A	N/A
83-6	60.0	62.0	2	13.8	N/A	5500	N/A	N/A	N/A	N/A
	116.0	120.0	4	11	N/A	2300	N/A	N/A	N/A	N/A
	126.0	128.0	2	12	N/A	7400	N/A	N/A	N/A	N/A
84-2	183.2	186.7	3.5	10.3	0.1	633	21	3	1	37
	212.4	214.4	2	15.6	0.2	850	38	1	1	66
84-4	172.5	173.0	0.5	25.6	6.2	28300	12	178	74	144
84-5	48.5	51.5	3	12.7	0.4	2500	64	4	1	44
84-7	111.8	113.3	1.5	15.5	0.3	>5000	18	1	1	40
84-8	31.9	33.9	2	24.8	0.1	3000	24	4	1	70

veins have narrow bleached or carbonate-pyrite alteration envelopes. Although some of these veins lie outside the pervasive carbonate-muscovite alteration, most are within the alteration zone. Based on a study of vein orientations relative to foliation in drill core, Cominco calculated that most of these veins strike 100-120° and dip 60-90° to the north. Foliation-parallel shear locally offsets veins. Visible gold is present in higher-grade veins, and grades in some exceed 100 g/tonne Au.

Most mineralization in the T-Bill prospect is characterized by elevated Au and As and background levels of Ag, Cu, Pb, Sb and Zn. The Au:Ag ratio is 1:1 or higher and the As:Sb ratio is commonly >100:1. However, mineralization in showings on the periphery of the T-Bill prospect, Showing C (at the northern boundary) and Showings H, J and K (at the southern boundary) indicate the possibility of zonation from the Au-As core outwards to mineralization with much higher Ag (Showings C and K), Ba (Showing J), Pb (Showing C), Sb (Showings C and K) and Zn (Showings C, H and K) contents.

1983-84 CORE RELOGGING AND SAMPLING

About a third of the 1983-84 drill core was re-examined in 2001, with an emphasis on holes 84-3, -4 and -5. A few more sections were split for analysis, to cover previously unsampled mineralized zones and to clarify sampling problems. Including the new samples, Table 1 summarizes significant intersections (>1 g/tonne Au over 2 metres) from this early drilling.

Table 2 summarizes intersections that are >50 metres wide and have Au values exceeding 0.5 g/tonne. Some examples are simply an artefact of a few gold-rich intervals within a broad zone. However, some drill holes contain significant widths of low-grade gold values due to multiple vein swarms and gold-bearing alteration (Figure 4). Despite the incomplete assaying for the 1984 holes, which lowers the average gold grade reported below, these broad low-grade intersections indicate that there is potential for a bulk-mineable target at the T-Bill prospect.

PARK PROSPECT

A multi-phase stock that extends east from the north end of the Bill property is responsible for several geochemically anomalous gossans near its contacts. Of these, only the Park prospect was examined in 2001, but previous workers ascribed the others to bleaching and pyritization of chert adjacent to the intrusive.

The main Park gossan is an intense goethite-jarosite gossan developed along the contact between a crowded feldspar porphyry intrusive and siliceous tuff. A few hundred metres from the contact, the siliceous tuff is hornfelsed and variably chloritic; within a few tens of metres of the contact, it is intensely silicified and the weathered surface has boxwork developed after sulphides. Locally, the silicified rock has a frothy texture, with drusy quartz lining some of the abundant voids. Float from the strongest zone of silicification returned up to 2960 ppb Au. A weaker gossan extends a few tens of metres into the porphyry, with little silicification or sulphides. Blocks of ferricrete indicate the abundance of sulphides in the unweathered intensely silicified zones.

A subtle gossan is apparent through the trees and scrub about 500 metres southeast of the main Park gossan. Although outcrop is limited, this gossan also appears related to hornfelsing and pyritization. Only 5 rock samples were collected, but two altered and pyritic grab samples, taken 300 metres apart, returned 1405 and 3590 ppb Au respectively. Similar looking but untested hornfelsing and pyritization is common, leaving open the possibility for extensive low-grade Au mineralization in this area.

Mineralization sampled in each gossan is accompanied by elevated Cu and Mo (max. 731 ppm Cu, 93 ppm Mo) and variable As levels. Both gossans are accompanied

TABLE 2
SUMMARY OF BROAD, LOWER-GRADE INTERSECTIONS (AU>0.5 G/TONNE AND WIDTH > 50 METRES)

Hole	From (m)	To (m)	Length (m)	Au (g/tonne)	Ag (ppm)	As (ppm)	Cu (ppm)	Pb (ppm)	Sb (ppm)	Zn (ppm)
83-1	60.00	176.00	116.00	0.58	N/A	93	N/A	N/A	N/A	N/A
83-2	50.00	198.73 [5]	148.73 [5]	1.17	N/A	2381	N/A	N/A	N/A	N/A
83-6	60.00	224.00	164.00 [1,5]	0.73	N/A	1383	N/A	N/A	N/A	N/A
84-2	57.80	218.20 [5]	166.40	0.62	0.1	809	12	1	1	25
84-3	29.00	113.50	84.50 [2]	0.56	0.5	1544	35	15	1	43
84-5	48.50	135.50	87.00 [3]	0.61	0.5	682	60	5	4	34
84-7	65.80	129.20	63.40 [4]	1.02	0.1	1272	9	1	0	16
84-8	9.70	85.00	75.30	1.07	0.2	1043	12	15	0	122

[1] Only 92.7 metres have been sampled; the remaining 73.7 metres were assigned zero grade.

[2] Only 60.3 metres have been sampled; the remaining 26.7 metres were assigned zero grade.

[3] Only 21.0 metres have been sampled; the remaining 42.4 metres were assigned zero grade.

[4] Only 31.5 metres have been sampled; the remaining 43.8 metres were assigned zero grade.

[5] End of hole (bottomed in mineralization)

Bill Property - T-Bill Prospect

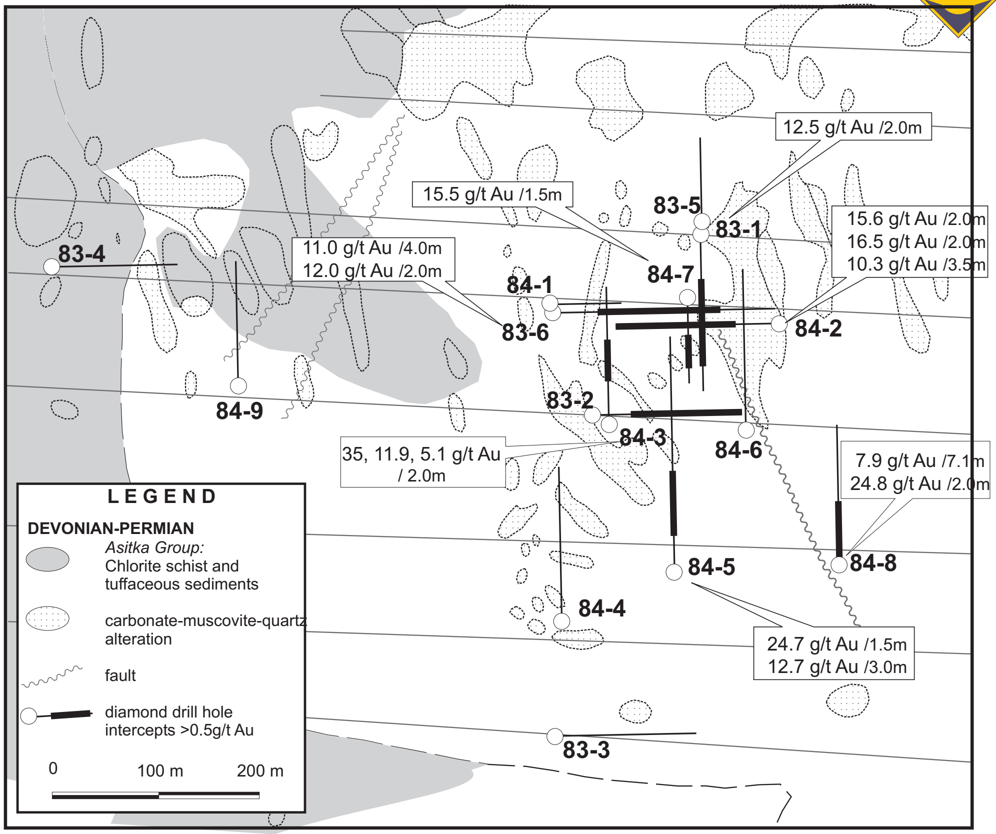

Figure 4. T-Bill prospect diamond drilling plan showing significant intersections and broad, lower-grade intersections.

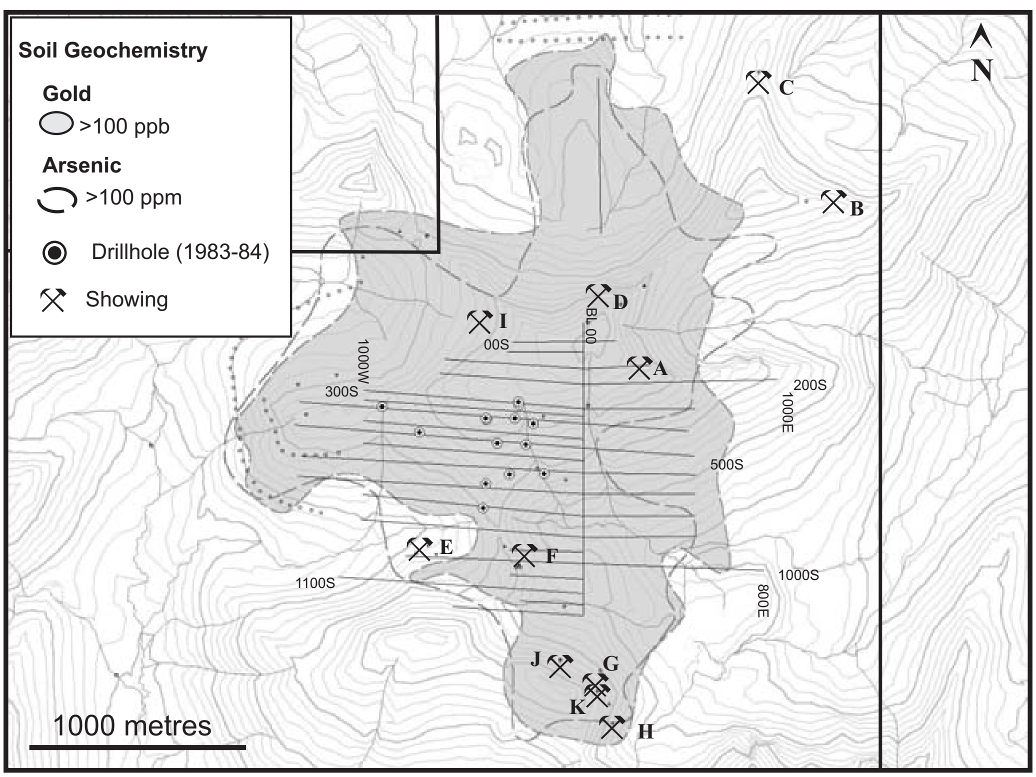

Figure 5. T-Bill soil gold and arsenic soil geochemistry with drillholes and surface gold showings located.

by Au+Cu+/-As soil geochemical anomalies which remain incompletely explained by rock sampling to date.

SOIL GEOCHEMISTRY

More than 1750 soil samples have been collected from the Bill property (Figure 5). As would be expected from the character of the mineralization seen on the property, the soils show strong correlations between Au-As (characteristic of the T-Bill prospect) and Au-Cu (especially prominent at the Park and Gos prospects). There is an excellent correlation in soils between Pb and Zn, neither of which is associated with precious metals, and a good correlation between them and Cu-Mo. As and Sb are not correlated.

A strong Au-As soil geochemical anomaly, defined by >100 ppb Au and >200 ppm As, covers an area of 2 x 3 km over the T-Bill prospect. The majority of this anomaly lies above tree-line on gentle to moderate grassy slopes; solifluction lobes are common. Rock outcrop is sparse throughout most of the area of the soil anomaly, although float is present in frost boils and talus patches. In 2001, soil sampling was carried out at the northern and western tips of the T-Bill anomaly, because previous sampling had not closed off the anomaly. Results extend the T-Bill geochemical anomaly 500 metres to the west and 200 metres to the north. The northern, eastern and western boundaries of the soil anomaly appear to be a function of till cover rather than metal-deficient bedrock.

The Park soil anomaly is an Au-Cu+/-As geochemical anomaly covering a 900 x 500 metre area that is tree covered with very little outcrop (figure 6). This open-ended anomaly is defined by coincident copper (>100 ppm) and gold (>100 ppb) in soil geochemistry from an area underlain by hornfelsed, silicified and pyritized volcanics. The anomaly remains largely unexplained, however limited prospecting in 2001 successfully identified gold mineralization from a subtle gossan 500 metres east of any previously known mineralization.

DISCUSSION

Two distinct, but possibly related, styles of gold mineralization, mesothermal and intrusion-related, characterize the Bill property. Most previous exploration has been focused on the mesothermal mineralization of the T-Bill prospect, where a package of Devonian to Permian metavolcanics has been altered to carbonate-muscovite-quartz schist over an area of 1,200 x 2,300 metres. This alteration is confined to the core of a northeasterly-trending structural dome and is controlled both by foliation and by steep cross-cutting structures. Gold-rich quartz-arsenopyrite veins are broadly co-spatial with the carbonate-muscovite alteration, although they extend into bordering unaltered chlorite schist where veins have only centimetre-scale alteration envelopes. Individual veins generally cut across foliation and are rarely wider than 30 centimetres, but vein swarms are common. The best drill intersections include 2.0 metres @ 35.0 g/tonne Au (83-2), 4.0 metres @ 11.0 g/tonne Au (83-6) and 2.0 metres @ 24.8 g/tonne Au (84-8). The T-Bill prospect is marked by a strong 2 x 3 kilometre Au-As soil geochemical anomaly along a grassy slope; its limits reflect masking by till and talus cover rather

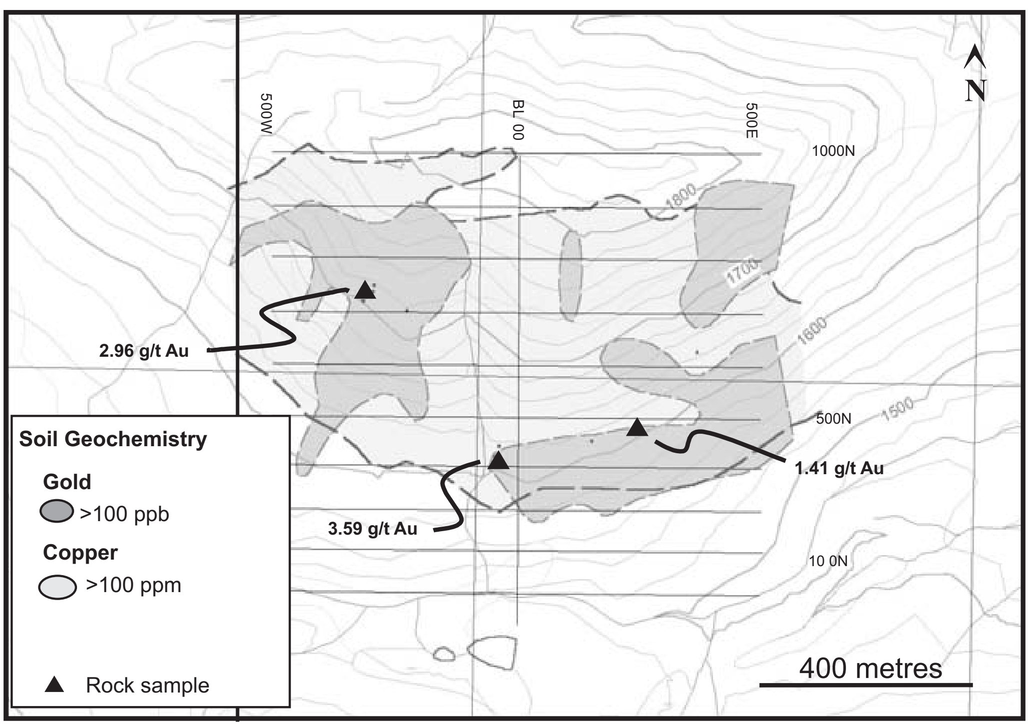

Figure 6 - Park prospect gold and copper soil geochemistry.

than changes in alteration and mineralization in the bedrock.

The 1983 and 1984 diamond drilling programs on the T-Bill prospect cut dozens of gold-bearing intervals but failed to define controls governing the location and intensity of the quartz-arsenopyrite veining. Understanding the ore controls is made more difficult by the lack of surface exposure, however on a very broad scale, there appears to be metal zonation outward from Au-As in the heart of the prospect to higher Ag, Ba, Pb, Sb and Zn toward its periphery. Showings C, H, J and K, each of which has elevated levels of one or more of these elements, are located to the north and south of the carbonate-altered schists and may mark the limits of the hydrothermal system in these directions. No equivalent "peripheral" veining has been found to the east or west, implying that the system could extend in these directions under till and talus cover.

To date exploration on the T-Bill prospect has been oriented toward identifying high-grade veins or vein swarms amenable to underground mining. While this should remain the highest priority, drilling has indicated potential for broad zones of lower-grade mineralization. As an example, hole 84-2 averaged 0.62 g/tonne Au across 166 metres, despite assuming zero grade for unsampled sections, and hole 83-2 averaged 1.17 g/tonne Au across 149 metres; both holes bottomed in mineralization.

Although visible gold was noted in core, no metallics (screen) assaying was carried out on it prior to the current program. Four of the 2001 rock and core samples exceeded 5000 ppb Au on initial analysis and were subjected to metallics assaying. Three of the four samples showed coarse gold to be a significant factor, with the grade increasing by 22 to 113% with metallics assaying. It is very likely that some of the better intersections previously reported by Du Pont and Cominco were substantially under-reported by not recognizing the presence of coarse gold.

The intrusion-related gold mineralization at the Park prospect has received less exploration and is not as well understood as the mesothermal T-Bill veining. At the Park prospect, a 500 x 900 metre open-ended Au-Cu+/-soil geochemical anomaly overlies hornfelsed, silicified and pyritized volcanics. Limited prospecting in 2001 in this anomaly yielded up to 3590 ppb Au in grab samples of fairly mundane-appearing rocks, indicating potential for extensive low-grade mineralization.

The T-Bill and Park prospects represent kilometre-scale gold-mineralizing systems within a few kilometres of each other. The T-Bill prospect contains high-grade quartz vein structures localized within an area of lower grade alteration and mineralization measuring 1200 metres by 2300 metres. The Park prospect shows similar widespread gold mineralization and has yet to be tested by drilling. The large magnetic low, and coincident alteration, anomalous soil geochemistry and high-grade gold values in rock sampling and diamond drilling programs indicate the presence of a large, gold-bearing hydrothermal system at the Bill Property.

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FIRESTORM: PRECIOUS OPAL RELATED TO RHYOLITE IGNIMBRITE

By Paul Wojdak[1]

KEYWORDS: *Eocene, Buck Creek Formation, Ootsa Lake Group, basalt, rhyolite, ignimbrite, precious opal.*

LOCATION: Lat. 54°09'00"N,
Long. 126°00'60"W (93L/1E)

OMINECA MINING DIVISION. The property is 20 kilometres west of Burns Lake on the east side of Maxan Creek, 8 kilometres south of Maxan Lake.

CLAIMS: LODE 1-2 (2-post claims),
BOO (grid claim, 20 units)

ACCESS: Northwest from Burns Lake on Highway 16 for 15 kilometres to Decker Lake Forest Products Ltd. and then 27 kilometres south via the Maxan and Colleymount forest service roads.

OWNER: Dennis Schaefer (80%), Ross Beebe (20%)

OPERATOR: Cantec Ventures Inc.

DEPOSIT TYPE: Volcanic-hosted Precious Opal

COMMODITIES: Precious Opal

INTRODUCTION

Opal is hydrated amorphous silica consisting of spherical microcrystallites of α-cristobalite with 3-10% water trapped in the sub-microscopic centres of the spheres. In common opal the microspheres are randomly arranged but in precious opal they are ordered so that their diameter and spacing causes the trapped water to diffract light producing a play in bright flashes of red, green and blue colours. This feature imparts the value to precious opal. Opal can have a range in body colour, from clear ("jelly") to opaque black that may enhance the diffracted light and produce unique aspects to the stone. Precious opal contains more water than common opal and, because it is variably softer (Moh's hardness scale of 5.5-6.5), can be scratched. Precious opal from some areas is unstable. The included water, which is not chemically bound, may be lost with time or in a dry environment causing the opal to craze and negate the stone's value.

The Lode 1-2 claims are located on the east side of Maxan Creek valley where Goat Creek enters from the east (Figure 1). Opal exploration has focused in a small area of gently west-sloping, pine-forested land south of Goat Creek. The area has sparse outcrop but outcrop is more abundant in the steep-sided valley of Goat Creek where the open, sparsely vegetated north wall contrasts with the shaded and damp south wall. Thick moss and devil's club on the south wall mask important outcrops but, with careful work, lend insight into the genesis of the nearby precious opal. A short distance up Goat Creek, at the junction shown in Figure 2, a dramatic canyon incised by the stream is impassable.

HISTORY

In August 1998 Dennis and Lois Schaefer discovered opal, with a colourful play of internal reflection, in blocks of bedrock alongside the Colleymount Forest Service road about 250 metres south of the Goat Creek bridge. Common opal occurs on Eagle Creek (Minfile 93K 095) 10 kilometres to the east and is open to hobbyists and the general public under a No Staking Reserve. Dennis Schaefer staked the LODE 1 and 2 two-post claims and subsequently, the BOO 20-unit claim that encloses the LODE claims on the north, east and south sides. The discovery sparked staking of adjoining claims by Angel Jade Mines (OPAL claims), B.G. Miller (BJ claims) and Bruce Anderson (HOO claims).

In 1999 and 2000, the Schaefer family hand-trenched upslope from the road (Figure 2, Trench C) and recovered precious opal up to 92 carats in size with a suggested market value of $Cdn 15 000. The potential value of the material was recognized by various people, including George Simandl of the British Columbia Geological Survey and

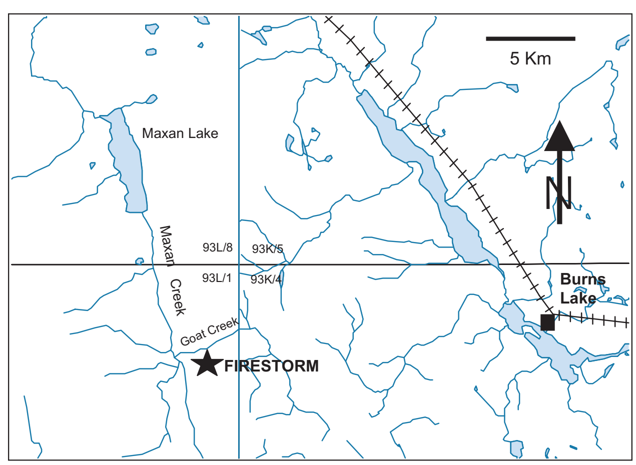

Figure 1. Location of Firestorm Opal property.Maxan Creek valley.

[1] *Regional Geologist, British Columbia Ministry of Energy and Mines*

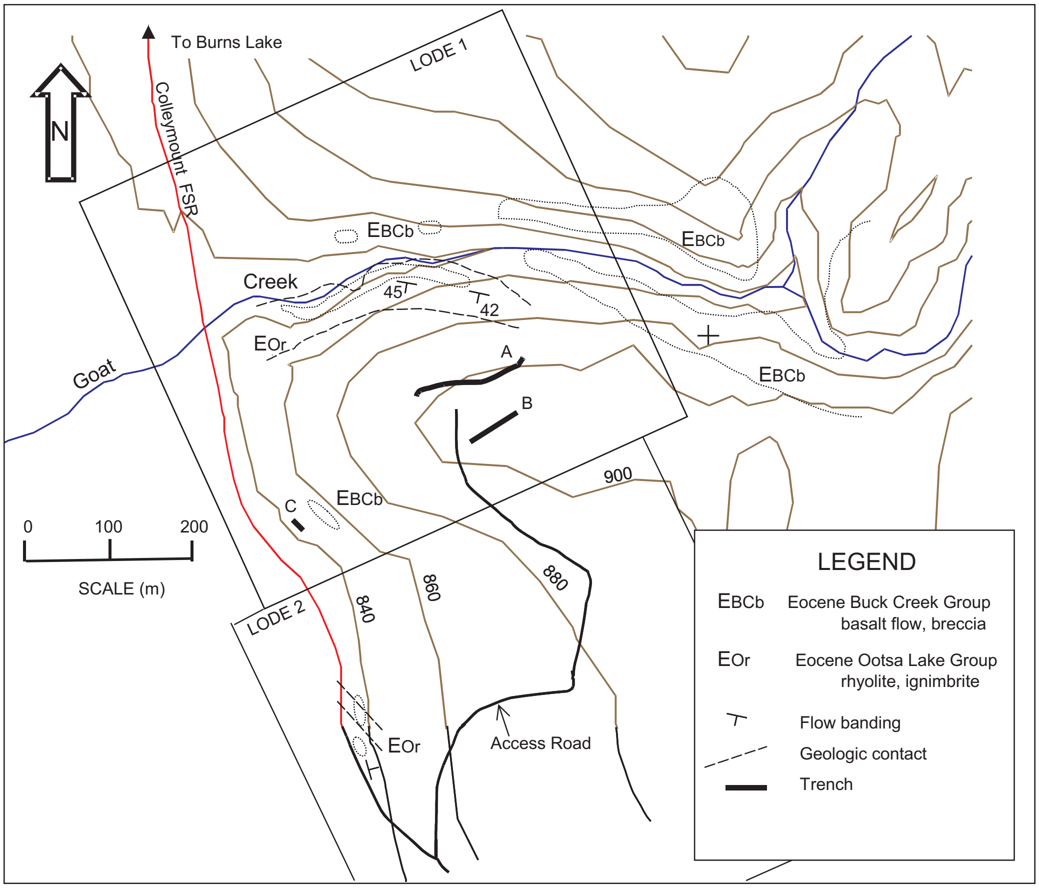

Figure 2. Geology of the Lode claims, Firestorm Opal property.

gemologist David S. Barclay. In 2000, Ross S. Beebe, of Westbank British Columbia, acquired 20% interest in the LODE and BOO claims. In 2001, Schaefer and Beebe reached agreement with Cantec Ventures Inc. to explore, develop and market precious opal from the Lode claims. During August and September 2001, Daniel Ethier supervised excavation and testing of a bulk sample at a site 250 metres from the discovery zone (Figure 2, trenches A and B), in an area located by Schaefer and Ethier in 2000.

REGIONAL GEOLOGY

The Burns Lake-Houston area is underlain primarily by an extensive cover of early Tertiary volcanic rocks that overlie volcanic, minor sedimentary and intrusive rocks of Mesozoic age (Church, 1972; Church and Barakso, 1990). Basement stratigraphic units comprise the Jurassic Hazelton Group, the lower Cretaceous Skeena Group and, in the eastern part of the area, the Early Jurassic Topley granite batholith. The Tertiary volcanic rocks mask Tertiary stocks, some of which are genetically related to overlying coeval flows. The Tertiary stock at the Equity Silver mine, 15 kilometres to the east, where erosion removed the Tertiary cover is an example. In conjunction with Tertiary volcanic activity, central British Columbia was subject to crustal extension that resulted in block faulting along an orthogonal set of northwest and northeast trending faults. A northwest fault of this set, with probable east-side-down displacement, trends along Maxan valley immediately west of the LODE claims (referred to herein as the Maxan fault).

Church and Barakso (1990) estimated that the Tertiary volcanic sequence is about 1500 metres thick. It consists of the Eocene Buck Creek, Goosly Lake and Tip Top Hill Formations (Church, 1972). The rocks are mainly andesite and basalt that other workers correlate with the Endako Group. Other workers correlate rhyolite in the area with the Ootsa Lake Group. Church (1972) concluded that the felsic volcanic rocks underlie the mafic lavas and inferred late Cretaceous age but he acknowledged that his interpretation was problematic. Church postulated reverse faulting to account for the inferred stratigraphic relationship but noted that the rhyolite could be Tertiary in age and intercalated with the Buck Creek assemblage. This is an important point because newly recognized rhyolite in the Goat Creek valley is intercalated with mafic lavas mapped as Buck Creek Formation by Church.

GEOLOGY OF THE LODE CLAIMS

The predominant lithology on the Lode claims is vesicular lava and flow breccia of mafic composition, called basalt herein but determined regionally to be basaltic andesite

Photo 1. Basalt flow breccia on the open slopes north of Goat Creek.

Photo 2. Precious opal, about 1.5 cm in size, fills vesicle in basalt. Nearby vesicle contains only a thin rind of silica (photo courtesy of George Simandl).

by Church (1972). Colour ranges from dark grey to chocolate brown to brick red. The texture ranges from aphanitic to very fine grained with feldspar microlites. Locally, the rock contains abundant spherules, up to 1 cm in size, of dark brown to black volcanic glass or palagonite (hydrated glass). Some spherules exhibit concentric banding, a bubbled interior surface and a hollow core. These textures superficially resemble agate and opal, which are also present in the basalt.

Vesicular lava is the main lithology along the Colleymount road, both on the Lode claims and to the north. Flow breccia predominates in Goat Creek valley and comprise poorly bedded outcrops up to 5 metres high (Photo 1). The clasts are up to 10 centimetres in size and consist of aphanitic to vesicular basalt similar to the lava flows. In a few places where individual flows can be discerned, they are two to three metres thick and consist of vesicular lava that passes upward into oxidized, red flow breccia. The flows are sub-horizontal in attitude. Dip ranges from flat in Goat Creek canyon to 10° north in Trench B (Daniel Ethier, pers. comm., 2001).

Vesicles comprise up to 20% of the basalt. The cavities are typically 5 mm in size but range up to several centimetres. Their shape varies from spherical to flat (almond-like). Large flat cavities tend to be interconnected or branching. In Trench C, opalized vesicles are adjacent to a vertical opal-filled fracture (A.E. Soregaroli, pers. comm., 2002).About 5% of the vesicles are filled, apparently on a random basis, with blue-green celadonite, agate, opal, calcite and, rarely, an unidentified zeolite. Common opal is abundant and, locally, fine specimens of precious opal are found (Photo 2). Precious opal is generally translucent (“jelly” colour) with flashes of red and green colour.

Rhyolite crops out for about 200 metres along Goat Creek, some 40 to 50 metres in elevation below Trenches A and B. Typically pale grey in colour, the rock contains 5-10% quartz phenocrysts (1-6 mm in size), 5% feldspar and 1% biotite (both 1-3 mm in size). At one locality, columnar jointing is well developed (Photo 3) and several outcrops exhibit flow-banding (Photo 4). The columnar joint set is perpendicular to the flow bands and indicates a

Photo 3. Columnar jointed rhyolite ignimbrite on Goat Creek, outcrop obscured by moss.

Photo 4. Fluid banding in rhyolite ignimbrite, same outcrop as Photo 3.

moderate southerly dip (40° to 45°), an orientation that is inconsistent with the basalt flows. An interesting, highly irregular contact of the rhyolite with underlying basalt is well displayed for a 20 metre distance in Goat Creek. The basalt is decomposed to a red, soft and friable material. At each end of the 20 metre span, the contact with the rhyolite is vertical but within a few metres becomes horizontal. There is no evidence of a faulted contact. The rhyolite is interpreted to be a flow that was deposited on the uneven, perhaps channeled surface of the basalt. The upper contact of the rhyolite is not exposed.

Throughout the Goat Creek body, the rhyolite has a spongy, porous texture and a related streaky, mottled fabric that is subtly distinct from flow banding. Feldspar and some quartz phenocrysts are corroded leaving pitted pseudomorphs (Photo 5). Corrosion begins in the core of the crystal, and preserves a fresh, euhedral rim. Under a microscope, the spongy pores and corroded crystals are seen to be lined with minute quartz crystals. This texture is interpreted to have formed by streaming of magmatic vapour through the rhyolite. Normally, rhyolite magma is viscous and does not flow well but gas-charged rhyolite is very fluid. Such eruptions are called ash flows, or ignimbrites, and produce laterally extensive, columnar-jointed deposits (Ross and Smith, 1961).

Rhyolite also crops out in the cutbank of the Colleymount road (Figure 2). It is compositionally similar to the Goat Creek body but does not exhibit columnar jointing, flow banding or spongy texture. It might be a dike rather than a flow. Its contact with nearby basalt is obscured but appears to trend southeast. Ten kilometres north of the Lode claims, near Maxan Lake, very similar quartz-feldspar-biotite porphyritic rhyolite is well exposed in a small quarry adjacent to the Colleymount road. Church and Barakso (1990) mapped it as a north-northwest trending body adjacent to the Maxan fault.

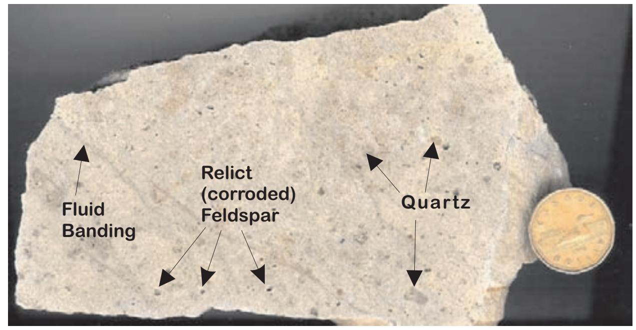

Photo 5. Rhyolite ignimbrite, showing phenocrysts of quartz and corroded feldspar.

DISCUSSION

The geological characteristics of volcanic-hosted precious opal has been summarized by Paradis *et al* (1999). The mechanism of formation of siliceous deposits (agate and opal) in silica-deficient basalt has been a subject of debate for many years. Pabian and Zarins (1994) carried out an international study and derived a model for the formation of basalt-hosted agate deposits. They argue that rhyolite ash flow tuff (ignimbrite) is a necessary component of the volcanic sequence. Diagenesis of the glassy ash is the primary source of silica. Groundwater from alkaline lakes, heated by on-going volcanic activity, can leach silica from the ignimbrite and transports it as a gel. Redeposition of the silica as spherulitic layers in basalt vesicles is triggered by an electrochemical reaction.

No pumice fragments have not been identified in rhyolite on the Lode claims. Ross and Smith (1961) state that pumice fragments provide the single most important criterion for identifying the pyroclastic origin of ash-flow tuff (ignimbrite). However, they go on to point out that the recognition of pumice fragments may be obscured by welding, devitrification and vapour-phase crystallization. Pumice fragments might be present in the Goat Creek rhyolite, but hidden by vapour-phase leaching and the resultant mottled, streaky texture. Ignimbrites commonly have a very uneven base, due to eruption onto uneven topography, and a nearly level top in contrast to the blanketing of topography by ash fall tuffs.

The Pabian and Zarins model implies that the best area to search for precious opal is in vesicular basalt proximal to rhyolite ignimbrite. In the Burns Lake area, these eruptions may have been controlled by Tertiary down-drop faults, such as the Maxan fault.

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COLLIERY HERITAGE PROJECT: EXPLORATION AND REHABILITATION OF COMOX NO.3 MINE AS AN UNDERGROUND EDUCATIONAL SITE

By C.G. Cathyl-Bickford[1]

KEYWORDS: *Comox Colliery, No.3 Mine, Comox No.2 coal bed, Cumberland Member, Dunsmuir Member, Comox Formation, industrial heritage, tourist mine, coal geology, mining conditions, measured sections, underground geological methods, coal balls, Nanaimo Group.*

INTRODUCTION

This report is part of a series of geological and mining studies of the coalfields of Vancouver Island, begun in 1987. Knowledge of the geology and mining conditions of the coalfields is a prerequisite to informed decisions on current and future land-use and resource planning on the Island. In contrast to previous years' work, this study considers the industrial heritage and educational potential of one of the oldest coal mines in British Columbia, opened near the village of Cumberland in 1889 and abandoned in 1893. Comparisons are drawn between the educational and industrial consequences of various features of local coal geology, as exemplified by the No.3 Mine of Comox Colliery.

While researching mining activities in the Cumberland area as a retirement project in the summer of 1999, former colliery surveyor Robert Williams BCLS (retired) recognised No.3 Mine's potential for development as an industrial heritage and tourism site. The Village of Cumberland provided labour and equipment to briefly reopen three of the mine's portals for initial examination in September of 2000, and for a more detailed exploration of the underground workings in January of 2002.

HISTORY

First Nations people walking along creeks and rivers near Comox Lake may have observed coal outcrops several thousand years ago, but neither oral histories nor archaeological evidence are available to suggest that they made any use of the coal. In 1870 a British emigrant, Samuel Cliffe, prospected coal outcrops southeast of Comox Lake, for the Union Coal Company. Mine development was delayed until after the Union Coal Company was taken over by Dunsmuir, Diggle & Co. in 1881 (Isenor and others, 1987). The new owners traced the coal along the hillside east of Perseverance Creek (locally known as Coal Creek), and drove two adits and two airways into the uppermost of three coal beds in 1888 (Dick, 1889). Substantial surface facilities, including a weighing house and a long loading trestle, were constructed outside the lowest of the mine's portals. Mining continued until 1893 (Dick, 1894), at which time all equipment was withdrawn from the mine in favour of expanded production from thicker coal beds elsewhere on the property.

Although the mine was originally known as "The Adit Levels" or "Nos.1 and 2 Tunnels," (B. Nicholas, personal communication, 2001) from 1922 onwards it was known as No.3 Mine of Comox Colliery. No.3 was not officially reported as a producing mine after its closure in 1893, but further undocumented working was done in the 1930s and 1940s by Chinese miners who hauled sacks and wheelbarrow loads of coal from the mine down to Cumberland's Chinatown (W. Moncrief, personal communication, 2001). Despite the great age of the mine, its workings remained open and accessible until at least 1985, at which time it was still possible to enter one of the adit levels and conduct geological exploration (Cathyl-Bickford, 1988). In 1987 the mine's portals were blasted shut, and entry further discouraged by piling soil and rock over their mouths (R. Bone, personal communication, 1987).

LOCATION AND ACCESS

No.3 Mine is situated adjacent to the Village of Cumberland in the eastern foothills of the Beaufort Range, southeast of Comox Lake on Vancouver Island. The mine is served by recently-constructed all-weather gravel road, Rocky's Main, which branches from the Hamilton Lake logging road about one kilometre south of the village. Access to the mine may also be gained by means of a network of hiking and cycling trails which radiate from Cumberland's old Chinatown. The minesite was selectively logged during the summer and autumn of 2001, and many bedrock ledges are newly visible through openings in the forest cover. Most of the outcrops can easily be accessed by foot from the roads or trails, although getting to some requires scrambling through logging debris and thick underbrush.

GEOLOGICAL SETTING

The coals of the Comox coalfield are hosted by the Cumberland and Dunsmuir members of the late Cretaceous Comox Formation (Bickford and Kenyon, 1988; Mustard, 1994). The Comox Formation consists of interbedded sandstone, siltstone, mudstone and coal, with occasional thin beds of oil shale and conglomerate (Cathyl-Bickford, 2001). Most of the thick coal beds lie within the predomi-

[1]*Project Manager, No.3 Mine, Village of Cumberland*

nantly nonmarine Cumberland Member of the formation, which contains six coals numbered 4, 3A, 3, 2A, 2 and 2R from base to top. Thinner but perhaps more laterally-continuous coal beds lie within the overlying predominantly marine Dunsmuir Member, which contains six coals numbered and lettered 1L, 1, 1R, Z, Y and X from base to top. Of the twelve correlatable coal beds within the Comox Formation, only the thickest four, presently known as the Nos. 4, 3A, 2 and 1 coal beds, have been mined (Graham, 1924).

PREVIOUS WORK

James Richardson (1872; 1873) first examined the Comox coalfield in detail for the Geological Survey of Canada. His work was followed-up by J.D. MacKenzie (1922), who measured several closely spaced sections of the Comox Formation along Perseverance Creek. Muller and Atchison (1971) compiled a regional synthesis of coal geology, including a structural map of the Comox coal mines. None of these workers did appreciable work underground in the Comox mines, with the exception of a few days' sectioning and sampling done by MacKenzie in the No.4 and No.5 mines on the north side of the Village of Cumberland. The bulk of MacKenzie's work remained unpublished owing to his sudden death in 1923, but many of his maps and notes have been preserved in the British Columbia Archives in Victoria, as part of Additional Manuscript 436.

More recent regional geological mapping is available for the Comox coalfield, including the vicinity of No.3 Mine, at 1:20,000 scale (Cathyl-Bickford and Hoffman, 1998). A detailed geological map (Figure 1) of the minesite area at 1:5000 scale was compiled during the summer of 2001 in support of the Village of Cumberland's application for a mine reclamation permit (Cathyl-Bickford and Williams, 2001).

DETAILED GEOLOGY

No.3 Mine was initially understood to have worked the Comox No.1 coal bed (Muller and Atchison, 1971; Saunders and others, 1974), but it is now thought to have worked the underlying No.2 coal bed. Reinterpretation of the stratigraphic position of No.3 Mine is based on comparison of marker beds exposed along the mine's access road (*see* Measured Section 9, in Appendix A) with the more complete section of the formation exposed in the canyon of Trent River above the Inland Island Highway (*see* Measured Section 10, in Appendix B). Eight previously-reported stratigraphic sections are contained in pa-

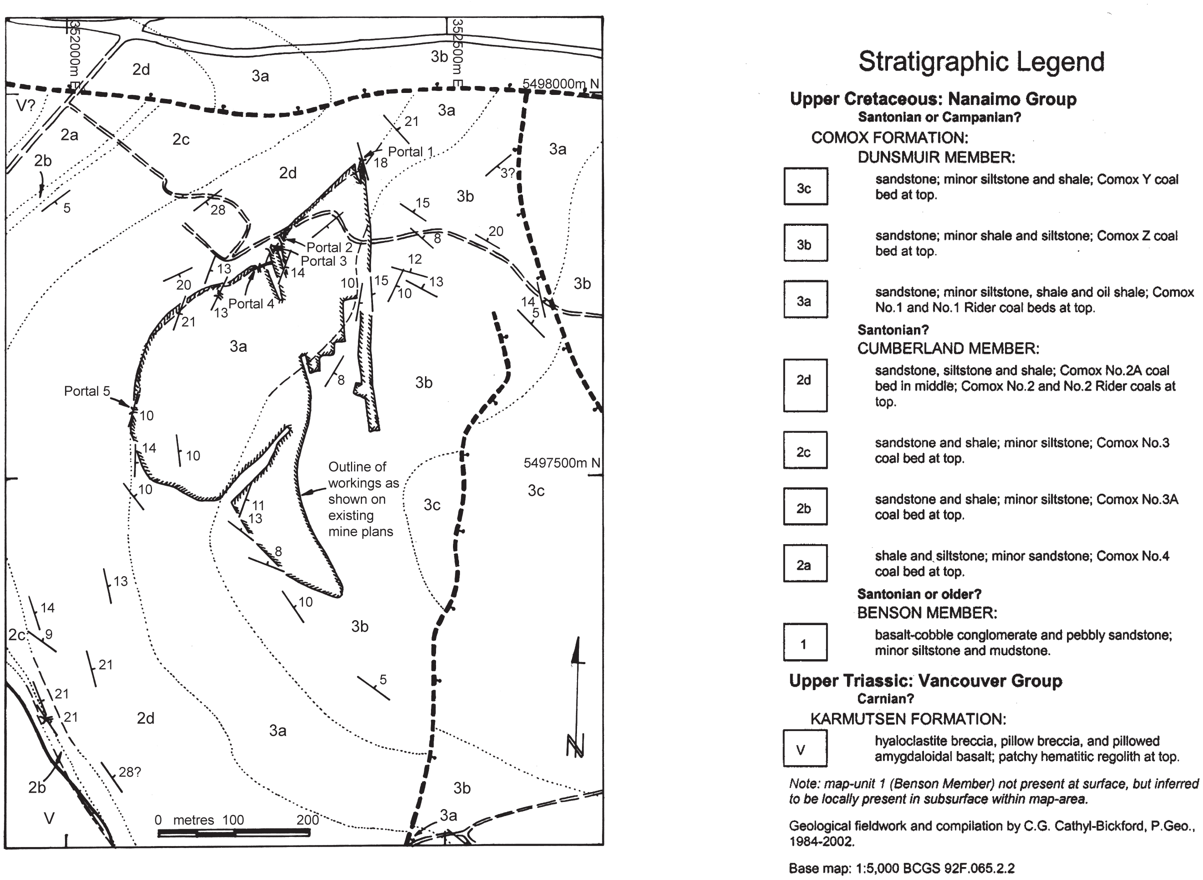

Figure 1. Geological map of No.3 minesite, showing reported extent of mine workings in relation to bedrock geology.

Photo 1. View southward into workings inbye Portal 4. Timber posts are 20 to 30 cm in diameter, and have single cap-pieces to spread load against carbonaceous mudstone roof of coal bed.

pers by Kenyon and others (1991) and Cathyl-Bickford (2000).

The main roof of the No.2 coal bed at No.3 Mine consists of at least 6 metres of thin- to thick-bedded sandstone of the basal Dunsmuir Member of the Comox Formation. The sandstone contains locally-abundant coalified wood fragments and shell debris, with occasional large but poorly-preserved mollusc fossils (tentatively identified as *Inoceramus* sp.) The immediate nether roof of the No.2 coal bed consists of 30 to 50 centimetres of interbedded dark grey to black canneloid, carbonaceous and silty mudstone with occasional thin and thick bright coal bands, representing the uppermost part of the Cumberland Member of the Comox Formation.

The Comox No.2 coal bed itself has a gross thickness of 1.05 to 1.2 metres where exposed near the mine portals, but it probably thins to the south within the mine workings, as alluded to in inspector's reports (Dick, 1889; 1894). The coal bed consists of 80 to 90 centimetres of very hard, blocky, bright banded coal with thin but laterally-persistent partings of mudstone and siltstone. Partings were observed in surface exposures and within mine pillars, where some of the parting material has squeezed out into the adjacent workings, perhaps due to loading of the pillars. Coal balls, consisting of ellipsoidal masses of silicified plant material, are occasionally present within the No.2 coal bed. Plant-fossil preservation appears to be quite good: details of wood grain, including knots and compression wood, are evident in the coarser plant material within the coal balls.

The floor of the No.2 coal bed consists of thinly-interbedded mudstone, siltstone and sandstone, much of which contains fossilised plant roots and occasional entire coalified logs as well as coalified stumps in their growth position.

The coal-measures near No.3 Mine are gently folded into an east-plunging open syncline about 700 metres wide. Mine workings lie within the western nose of the fold where dips range from 8 to 14 degrees to the east and southeast.

Photo 2. Original firewall of brick and stone, on north side of underground ventilation furnace, inbye Portal 5. Sandstone roof above furnace has been baked and reddened, and shows minor flaking.

Two minor extensional faults and one bedding-plane shear zone were observed during mapping, but none of these structures appear to be particularly extensive and the greatest fault displacement observed is just slightly over 2 metres.

MINING CONDITIONS

During the underground exploration in January 2002, observations were made of the performance of the roof and floor of the mine workings, as well as the support methods employed by the miners.

The basal Dunsmuir sandstone appears to form a very strong roof, standing unbroken across spans up to 20 metres wide, which is a creditable performance even considering the shallow cover (generally less than 10 metres) over the mine workings. Of greater significance, perhaps, is the apparent strength of the uppermost Cumberland mudstones, which form the immediate nether roof of the mine. In most cases these mudstones have been used as the working roof of the mine, and they are standing well with minimal bed separation despite the lack of effective artificial roof support in the mine.

Good roof performance has allowed the old workings of No.3 Mine to stand open for more than a hundred years, which provides some encouragement for the prospect of rehabilitating the mine for underground tours and education. However, such strong roofs might provide problems for future mines located deeper within the Comox coalfield, since delayed caving of mine roof can cause overloading of modern mechanised support systems, and can also cause severe air blasts within the mine workings.

The hard coal of the No.2 coal bed appears to form strong pillars, which have probably also contributed to the apparent long-term stability of the mine workings. When the mine portals were dug out in January 2002, the coal broke out as very large blocks across the full thickness of the coal bed, each weighed between one and several hundred kilograms. During the period of main working of the mine in the 1890s, and indeed up until the end of the domestic coal era in the 1950s, such hard coal would have formed a high proportion of large lumps. Miners put considerable effort into increasing the proportion of lump coal within run-of-mine production, since the larger sizes of coal could be sold at much higher prices than the finer coal. However, modern coal markets do not place such a premium on large product sizes, and the No.2 coal's hardness could be detrimental to its economic value since machine power requirements and cutting-pick consumption are increased when working harder coal.

Piles of fine coal found during recent exploration of the mine suggest that the miners screened or raked the coal underground, discarding material smaller than 25 mm, and hauling only the larger lumps out of the mine.

The No.2 coal displays a well-developed face cleat striking 028 to 033, and dipping 70 to 80 degrees to the northwest, and an irregular butt cleat striking 115 to 125. The face cleat forms subparallel planes of weakness within the coal, affording a means for shearing of the coal face with hand tools. Unlike other still-accessible mine workings of similar vintage in the Vancouver Island coalfields, such as the Sage Mine on Newcastle Island and Dunsmuir's Original Entry in the northern part of the City of Nanaimo, the accessible coal faces of No.3 Mine do not show many pick marks or other tool marks. The original miners probably found it quite easy to wedge the well-cleated coal down from the coal faces.

Coal balls within the No.2 coal bed afford the possibility of an unusually-detailed view of Late Cretaceous flora, since their contained plant material was cemented and preserved prior to compaction of the coal-measures. On the other hand, the presence of coal balls is a detriment to future mining, since the coal balls are prone to sparking when encountered by coal-cutting equipment. Furthermore, coal balls are a potential source of instability in coal faces, and constitute an additional body of unsaleable waste to be handled and disposed of.

The floor of the No.2 coal bed is markedly softer and weaker than its roof. The floor appears to have heaved and rolled up into some of the workings, partially blocking the circulation of air within the mine and reducing travel within the workings to a muddy exercise of crawling on one's belly. The floor heaves may be due to load transfer from the mine's pillars into its floor, or may also be due to swelling of moisture-sensitive clays.

Although in the 1890s it might have been reasonable to expect miners to travel through workings no more than 90 cm high, modern mining equipment can only traverse and work such thin coal with difficulty. Even the most adventurous of tourists is unlikely to want to crawl through workings that have been partially blocked by floor heaves. On the other hand, the soft floor of the No.2 coal bed could be excavated with greater ease than the sandstone roof. Sufficient height for comfortable passage of visitors could be gained by lifting 1.2 to 1.5 metres of the mine's floor.

Pillars of remnant coal within the mine workings are surprisingly uncommon. Most of the mine's roof support appears to have been provided by timber props, 25 to 50 centimetres in diameter and 0.9 to 1.1 metres long, set on 1.2-meter centres. Along the sides of underground roadways, randomly-spaced rock-filled cribs supplemented the props. Not surprisingly, given the mine's great age, nearly all of the timbers were found to be rotten during the most recent examination of the mine, and most of the rock-filled cribs had partially or completely collapsed owing to failure of their timber frames.

No.3 Mine, like several other old collieries on Vancouver Island, was ventilated by means of an underground furnace. Furnaces typically were built within a coal bed, close to the bottom of an airshaft or the mouth of an adit. Because of the obvious risk of setting fire to the adjoining coal pillars, brick or stone firewalls were customarily built along either side of the furnace, and its grate was set between the walls. Remains of the No.3 furnace are preserved in the most southerly of the mine's five known portals. The furnace's firewalls were constructed with mortared stone blocks and bricks, paralleling each side of the portal and situated a few metres inside its mouth. The walls show signs of baking and heat-induced spalling, as does the mine's roof immediately between the walls. No sign of the furnace's grate is visible, but remnants of it may remain beneath the piles of rubble, which partially block the passageway between the furnace walls.

EXPLORATION METHODS AND RESULTS

Reopening of the mine entrance was easily accomplished by means of a tracked excavator provided by the works crew of the Village of Cumberland. About two hours of machine time were required to windrow logging debris that covered the minesite, and to dig out two portals which had been blocked by piles of earth and rock. One hour of machine time was devoted to reinforcing the covering over an existing gated access structure. Two hours of machine time were required to backfill and regrade the portals, ensuring that unsupervised visitors could not easily gain access to the mine. The total cost of a day's work at the mine was probably less than a thousand dollars, including volunteer labour that was donated on the Village's behalf.

Underground exploration was conducted by a party of three persons, led by a certificated fireboss, accompanied by a colliery surveyor and a mining geologist. Mine air was tested for carbon monoxide by means of Draeger tubes, and for methane by means of a portable methanometer. Several sets of tests were conducted, but neither gas was detected in the mine. Bearings and distances within the mine were determined by tape and compass, supplemented by laser rangefinder observations from the mine's portals. Progress within the mine was hampered by mounds of debris and heaved floor material, and by concerns for roof stability within untimbered areas. Nevertheless, three hour's work underground was sufficient to establish the general conditions near the mine entries, and assess whether the proposed rehabilitation of the mine was feasible. Appropriate safety equipment such as hard hats, approved mine lamps and knee pads were used. Knee pads, although often forgotten, lend a precious level of comfort to underground geological mapping of thin coal beds.

Crawling about in a coal mine is exhausting work, made more difficult by the occasional need to belly one's way over piles of rock, or squeeze through a tight spot. Most of the mapping and safety equipment was carried by hand (requiring great dexterity to move it and use it effectively), or attached to work belts (thus affording considerable potential for jamming its owner between rocks and hard places). A lesson learned from trying to work within the mine is that tools and equipment should be attached to shoulder-straps or lanyards, so that they can be effectively dragged by one's feet as well as one's hands while crawling through the mine.

Large steel spikes that had been painted bright orange for easy recognition and retrieval temporarily marked geological control points within the mine. In an inactive mine such as No.3 Mine, spikes make good place-markers for mapping as well as for measurement of stratigraphic sections of coal pillars and exposed roof and floor strata. However, their use in an active mine might be less desirable, since any spikes left underground could puncture the tires of mobile equipment, or wreak havoc within a coal-preparation plant in the event that they found their way into the mined product.

Very few plans of the mine remain in existence, and the most detailed of them (held by the Cumberland Museum and Archives) was at some time in the past trimmed in such a manner as to cut off most of the workings of No.3 Mine. None of the various plans, at whatever scale, show internal details of No.3 Mine's pillars and underground roadways.

EDUCATIONAL POTENTIAL

No.3 Mine is unusual among coal mines, in that its current value is as an accessible example of Vancouver Island's industrial heritage, rather than a potential source of saleable coal. Based on the limited underground examinations done to date, the mine appears to be in good shape except for the condition of its timbers. The fact that the mine is still standing open is a rather encouraging sign for its prospects as a tourist site; good roof conditions will ensure the safety of visitors to the mine.

The most likely route for underground tours would be along the inside edge of the remnant barrier pillar that bounds the outcrop edge of the No.2 coal bed. Educational possibilities of No.3 Mine include demonstrating of the evolution of mining methods in the Comox coalfield (ranging from hand-hewing through early machine mining to modern continuous-miner and shuttle-car systems), seeing geological structures within coal-measures, and the palaeontology of animal and plant fossils, particularly the Cretaceous coal-ball flora. No.3 Mine, once it has been made safe, would be an excellent locale for teaching surface and underground geological mapping, since just enough geology is exposed to make an instructive, solveable puzzle to a would-be mapper.

As the mine currently exists, considerable rehabilitation would be needed before visitors could safely enter it. Although the roof conditions are remarkably good for a coal mine of its vintage, the timbering is unstable owing to rot and localised crushing by roof pressure. Mounds of fine coal, discarded rock, and heaved floor strata that litter the mine, make it impassable locally. In the absence of an accurate plan of the mine's workings, it is not possible to assess the extent to which pillars have been robbed, or the proportion of supported to unsupported roof.

Challenges to rehabilitation of the mine include: the possibility of spontaneous combustion when adequate ventilation is established; the unassessed potential for acid mine drainage from the workings or acid generation from any loose materials loaded out of the mine; and the unknown dimensions and locations of the mine's remaining pillars. Nevertheless, No.3 Mine affords the prospect of educating its visitors in the historic practices of coal mining in British Columbia, as well exposure to the emerging art and science of coal-mining geology.

ACKNOWLEDGEMENTS

Robert Williams brought the educational potential of the well-preserved workings of No.3 Mine to the Village's attention in the autumn of 2000, and since then he has been a hard-working and diligent colleague and an outspoken advocate for the mine. The Cumberland woods crew of Mike Hamilton Logging Ltd. built the access road to the mine and were most accommodating to a geologist's urgent, albeit unfathomable, need for better exposure of the Comox coal measures. Cumberland Mayor William Moncrief and Councillor Leslie Baird, underground manager Bruce Fairbrother, and mine inspector Ed Taje of the British Columbia Mines Branch have unstintingly given their support and wise counsel to this project. Peter Mustard of Simon Fraser University offered some insights into the geology of the Comox Formation at Trent River, but the sections accompanying this paper represent my own views on the subject. Clarity of expression within this paper was considerably improved by William McMillan's editorial ministrations.

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Appendix A

Measured Section No. 9

Comox Formation, Number Three Mine, Comox Colliery

Top of section: in cut on south side of Hamilton's logging road, at UTM (Zone 10, NAD 83) 352495 E., 5497820 N.
Base of section: in roadbed, outside No.4 portal of mine, at UTM (Zone 10, NAD 83) 352240 E., 5497797 N
NTS 92 F/11. TRIM 92F.065

Measured by: C.G. Cathyl-Bickford, May 5, May 8, June 30, July 2 and July 3, 2001.

Unit	Description	Thickness (m)	Height (m)
	Comox Formation: Dunsmuir Member (53.58 m - incomplete):		
92	Sandstone - fine- to medium-grained, light grey to white, brown-weathering quartz-feldspar; feldspars mostly weathered to clay; clean but chalky due to weathering, thin to medium irregular beds; top covered by soil and sandstone debris; abrupt base.	1.45	59.85
91	Sandstone - medium-grained, clean, light grey, greenish-grey-weathering, quartz-feldspar, feldspars partially weathered to clay but in fresher zones this rock has fair to good intergranular porosity; thick-bedded, platy-weathering, with occasional finely-broken plant debris at bed tops; abrupt base.	1.80	58.40
90	Sandstone - fine-grained, light greenish-grey, brown-weathering, fair intergranular porosity; thin to medium-bedded, large-scale trough cross-beds; abrupt base.	2.83	56.60
89	Sandstone - very fine-grained, light greenish-grey, brown-weathering, quartz-feldspar-basalt, very silty, moderately- to intensely-bioturbated, thin-bedded, planar-laminated; gradational base.	0.87	53.77
88	Sandstone - fine- to medium-grained, light to medium grey, brown-weathering, quartz-feldspar, minor basalt, clean, no visible porosity, thick-bedded to massive, very thick planar lamination; hard; abrupt base.	1.05	52.90
87	Sandstone - very fine- to fine-grained, light greenish-grey, brown-weathering quartz-feldspar-basalt, trace disseminated pyrite; no visible porosity; very thin irregular beds, some shallow swaly cross-beds, prominently platy-weathering; forms a resistant ledge; abrupt base.	2.42	51.85
86	Sandstone - fine- to medium-grained, light to medium greenish-grey, brown-weathering, quartz-feldspar-basalt, no visible porosity; sparsely- to moderately-bioturbated; medium to thick-bedded, hummocky cross-laminated; abrupt base.	1.70	49.43
85	Sandstone - medium- to coarse-grained, medium olive drab, brown-weathering, silty, moderately- to intensely-bioturbated, occasional ellipsoidal concretions; thick-bedded, platy to blocky-weathering; gradational base.	1.28	47.73
84	Sandstone - fine- to medium-grained, light olive drab, brown-weathering, quartz-basalt, clean, thin to medium irregular beds, platy- to flaggy-weathering; partly covered by sandstone debris; base not seen.	2.35	46.45
83	(Concealed) - sandy loam and sandstone debris.	2.80	44.10
82	Sandstone - fine-grained, light greenish-grey, grey-weathering, quartz-basalt; flaggy-weathering; sparsely-bioturbated, with occasional *Ophiomorpha*; gradational base.	3.55	41.30
	----- Fault, probable; attitude: 118/65 SW; displacement 1.50 m down to southwest; beds matched across fault -----		
81	Sandstone - fine- to medium-grained, medium greenish-grey, brown-weathering, quartz-basalt, thick- to very thick-bedded, blocky-weathering to massive; tight; erosional base.	2.40	37.75
80	Sandstone - fine-grained, silty; mostly concealed by sandstone rubble; gradational base.	0.22	35.35
79	Sandstone - very fine- to fine-grained, medium grey, silty, intensely-bioturbated, with many large burrows filled with medium- to coarse-grained sandstone; abrupt base.	0.45	35.13
78	Mudstone - dark brown, carbonaceous, hard, platy-weathering; abrupt base.	0.13	34.68
	----- Roof of Comox No.1 Rider coal bed -----		
77	COAL - dull, stony, blocky-weathering; abrupt base.	0.04	34.55

76	Mudstone - black, coaly, with occasional large sand-filled burrows; weathered, soft; abrupt base.	0.03	34.51
75	COAL - dull banded, intensely-weathered, soft; abrupt base.	0.16	34.48
74	Mudstone - black, coaly, with occasional sand-filled burrows; abrupt base.	0.03	34.32
73	COAL - dull and bright, intensely-weathered, soft; abrupt base.	0.15	34.29
----- Floor of Comox No.1 Rider coal bed -----			
72	Mudstone - olive drab, intensely rusty-weathering, rooty, soft; gradational base.	0.04	34.14
71	Mudstone - light grey, rooty, soft; probable seatearth; gradational base.	0.28	34.10
70	Mudstone - dark brown, carbonaceous, fissile, rubbly-weathering, with abundant finely-broken plant debris; abrupt base.	0.12	33.82
----- Roof of Comox No.1 coal bed -----			
69	COAL - dull lustrous, hard; abrupt base.	0.04	33.70
68	COAL - dull and bright, clean, weathered; face cleat: 122/85 SW (5 to 8 mm spacing); butt cleat not seen; abrupt base.	0.18	33.66
67	COAL - dull and bright, intensely weathered, powdery; abrupt base.	0.13	33.48
66	COAL - dull banded, stony, weathered; abrupt base.	0.07	33.35
----- Floor of Comox No.1 coal bed -----			
65	Mudstone - light brown, rooty, very soft; probably a seatearth; gradational base.	0.25	33.28
64	Mudstone - dark brown, carbonaceous, with occasional very thin bright coal bands; abrupt base.	0.18	33.03
63	Siltstone - dark grey, very thin-bedded, blocky-weathering, hard; abrupt base.	0.18	32.85
62	Mudstone - light brown, rooty, soft; probably a seatearth; gradational base.	0.11	32.67
61	Mudstone - dark brownish-grey, silty, with occasional thick bright coal bands; rooty at top, rubbly-weathering; abrupt base.	1.08	32.56
60	Mudstone - dark brown, very carbonaceous, brown- to reddish-brown-weathering; papery lamination, very thin planar beds; possibly an oil shale; abrupt base.	0.64	31.48
59	Mudstone - dark brownish-grey, very silty, spheroidal-weathering; gradational base.	0.32	30.84
58	Siltstone - dark brown, spheroidal-weathering, sandy, splintery, hard; attitude: 030/14 NE (locality A.2044); abrupt base.	0.47	30.52
57	Sandstone/Siltstone Laminite (60:40) interlaminated very fine-grained medium grey, rippled sandstone and dark brownish-grey siltstone with abundant finely-broken plant debris; abrupt base.	1.25	30.05
56	Sandstone - fine- to medium-grained, medium greenish-grey, quartz-basalt; plane-laminated at top, massive below; erosional base. Thickness varies from 0.51 to 0.58 m.	0.55	28.80
55	Sandstone/Siltstone/Coal Laminite (60:15:25) - interlaminated very fine to fine, light greenish-grey, quartz-feldspar-basalt sandstone and medium to dark grey sandy siltstone with abundant thin bands of dull and bright coal; abundant finely-broken plant debris throughout; sands are mostly clean; abrupt base. Thickness varies from 0.15 to 0.22 m.	0.18	28.25
54	COAL - dull, stony, with occasional sandy flaseroid ripples; slightly sheared; a persistent seamlet; abrupt base. Thickness varies from 0.01 to 0.02 m.	0.01	28.07
53	Sandstone - medium- to coarse-grained, medium greenish-grey, quartz-basalt, plane-laminated at top; massive below; rooty at top; abrupt base.	0.62	28.06
52	Siltstone - dark brownish-grey, slightly carbonaceous, with occasional flaseroid sandy lenses; very thin-bedded; some shell debris and possible insect fossils, and occasional finely-broken plant debris; base not seen.	0.71	27.44
51	(Concealed) - stony gravel and sandstone debris in gully.	(2.79)	26.73
	[**Note:** beds 40 through 50 are measured along the south side of the road, east of No.2 portal of the mine.]		
50	Sandstone - medium- to coarse-grained, light to medium greenish-grey, quartz-basalt, clean, platy-weathering; very hard and strong, forming ledge north of road; base not seen.	2.65	23.94
49	(Concealed) - sandy loamy soil and sandstone debris.	(1.80)	21.29

48	Sandstone - fine-grained at base, fining-upward to very fine-grained at top, silty throughout; medium grey, brown-weathering, quartz-feldspar-basalt, moderately to intensely-bioturbated throughout, massive; base not seen.	1.05	19.49
47	(Concealed) - sandy stony loam and sandstone debris.	(0.35)	18.44
46	Sandstone - coarse-grained, light greenish-grey, light grey-weathering, quartz-feldspar-basalt, cleaner than stratigraphically-lower beds, fair intergranular porosity, thick-bedded, with shallow trough cross-sets; sparsely- to moderately-bioturbated; base not seen.	0.90	18.09
45	(Concealed) - sandstone rubble.	(1.40)	17.19
44	Sandstone - medium- to coarse-grained, drab to brown-weathering, quartz-feldspar-basalt, medium- to thick-bedded; large-scale trough cross-laminated at base; plane-laminated above; erosional base. Thickness varies from 1.41 to 1.48 metres.	1.45	15.79
43	Sandstone - fine- to medium-grained, light to medium-greenish-grey, brown- to drab-weathering, quartz-basalt, cleaner than underlying beds; flaggy-weathering; abrupt base. Thickness varies from 0.68 to 0.75 metres.	0.71	14.34
42	Sandstone - fine- to medium-grained, medium greenish-grey, brown-weathering, very thin planar beds with a few silty laminae; markedly platy-weathering; no visible porosity; abrupt base.	1.44	13.63
41	Sandstone - fine-grained, medium greenish-grey, brown-weathering, quartz-basalt, very thin irregular beds with occasional silty laminae; locally-abundant finely-broken plant debris; gradational base; partly concealed by sandstone rubble.	1.40	12.19
40	Sandstone - medium- to coarse-grained, light greenish-grey, brown-weathering, quartz-feldspar-basalt, thin irregular beds, sparsely-bioturbated, flaggy-weathering; abrupt base.	1.13	10.79
	[**Note:** beds 21 through 39 are measured at locality A.1957 at and above the No.3 portal of the mine.]		
39	Sandstone - fine to medium-grained, orange-brown-weathering, granitic, very thin-bedded, platy-weathering, with abundant finely-broken plant debris; sparsely to moderately bioturbated; gradational base.	1.47	9.66
38	Sandstone - medium-grained, light grey, orange-brown-weathering, granitic, clean, medium-bedded, prominently planar-laminated; exfoliates into thin rounded shells; abrupt base.	1.19	8.19
37	Sandstone - medium to coarse-grained, light grey, brown-weathering, granitic, clean, thick-bedded, plane-laminated at top, massive below; sparsely bio-turbated (*Ophiomorpha?*); very widely-spaced joints; abrupt, rolly, probably erosional base. Attitude: 015/6E (fair).	0.73	7.00

Comox Formation: Cumberland Member (6.27 m - incomplete):

36	Mudstone - dark brownish-grey, slightly carbonaceous, with abundant silty flaseroid laminae and ripples; rubbly to platy-weathering; abrupt base.	0.07	6.27
----- Roof of Comox No.2 Rider coal bed (horizon only) -----			
35	Mudstone - black, canneloid, rubbly-weathering; abrupt base.	0.07	6.20
----- Floor of Comox No.2 Rider coal bed (horizon only) -----			
34	Mudstone - black, carbonaceous, with occasional thin bright coal bands; rubbly-weathering; abrupt base; parts freely at base.	0.04	6.13
----- *Bedding-plane shear zone, possible* -----			
33	Mudstone - dark grey, carbonaceous, slightly silty, rooty, with abundant thin bright coal bands; rubbly-weathering; abrupt base.	0.19	6.09
32	Mudstone - black, coaly, fissile, with abundant thick bright coal bands; platy-weathering; abrupt base.	0.12	5.90
	[**Note:** beds 32 through 36 form the nether roof of No.3 Mine]		
----- Roof of Comox No.2 coal bed -----			
31	COAL - dull and bright, closely-cleated; face cleat: 122/75 SW (8 to 20 mm spacing); butt cleat poorly developed: 007/80 W (20 to 30 mm spacing); platy to blocky-weathering.	0.13	5.78

30	COAL - bright banded, hard, blocky; abrupt base.	0.10	5.65
29	Mudstone - dark brown, carbonaceous, slightly sheared, soft, compact; abrupt base.	0.04	5.55
28	COAL - dull and bright, hard.	0.10	5.51
27	COAL - bright banded, slightly sheared.	0.18	5.41
26	Mudstone - dark brownish-grey, carbonaceous, with occasional thin bright coal bands; rooty; abrupt base.	0.21	5.23
25	COAL - dull, stony, hard, with overhanging base.	0.05	5.02
24	Mudstone - black, coaly, with abundant thin bright coal bands; platy.	0.04	4.97
	[**Note:** beds 21 through 23 are measured at locality A.1983 on the east rib of No.4 portal of the mine.]		
23	COAL - bright banded, moderately hard; attitude at top: 025/13 SE (fair); abrupt base.	0.32	4.93
----- Floor of Comox No.2 coal bed -----			
22	Mudstone - dark brownish-grey, carbonaceous, with occasional thin bright coal bands; moderately soft; gradational base.	0.18	4.61
21	Mudstone - medium grey, brown-weathering, very thin-bedded, rooty, moderately soft; occasional poorly-preserved angiosperm leaves; abrupt base.	0.31	4.43
	[**Note:** beds 10 through 20 are measured along the west side of the side road to the No.3 portal of the mine]		
20	Siltstone - medium brownish-grey, sandy, slightly ferruginous, with occasional rootlets; very thin-bedded, platy-weathering, hard; abrupt base.	0.09	4.12
19	Mudstone - dark brown, slightly carbonaceous, rubbly-weathering, hard; gradational base.	0.05	4.03
18	Siltstone - dark brownish-grey, brown-weathering, sandy, spheroidal-weathering, thin-bedded, with occasional rootlets; abrupt base.	0.51	3.98
17	Mudstone - dark brown, dark brown-weathering, silty, fissile, flaky-weathering, very soft; abrupt base.	0.21	3.47
16	Sandstone - very fine-grained, medium grey, brown-weathering, silty, finely ripple-laminated, blocky- to rubbly-weathering, hard; abrupt base.	0.20	3.26
15	Siltstone - dark brown, brown-weathering, very sandy, very thin-bedded, hard; gradational base.	0.08	3.06
14	Sandstone - very fine-grained, medium grey, brown-weathering, silty, thick-bedded, with vague planar-lamination at top; moderately- to intensely-bioturbated, hard; abrupt base.	0.48	2.98
13	Sandstone/Siltstone Laminite (50:50) - very fine-grained sandstone and siltstone; medium grey, brown-weathering, platy-weathering, with occasional angiosperm leaves; slightly sheared; abrupt base.	0.06	2.50
12	Siltstone - dark grey, grey-weathering, slightly carbonaceous; gradational base.	0.04	2.44
11	Sandstone - very fine-grained, brown-weathering, silty, very thin-bedded, hard; abrupt base.	0.16	2.40
10	Siltstone/Sandstone Laminite (70:30) - dark grey siltstone and medium grey, very fine-grained sandstone; brown-weathering, trace disseminated pyrite, platy-weathering; abrupt base.	0.04	2.24
	[**Note:** beds 1 through 9 were measured in a temporary trench, excavated by Hamilton Logging during exploration for road-construction material.]		
9	Sandstone - very fine-grained, medium grey, brown-weathering, silty, quartz-basalt, spheroidal-weathering; gradational base.	0.22	2.20
8	Siltstone - dark brown, sandy, spheroidal-weathering, intensely-weathered, soft; abrupt base.	0.21	1.98
7	Sandstone/Siltstone Laminite (90:10) - medium grey, fine-grained silty sandstone and dark grey siltstone; patchy brown-weathering, with occasional carbonaceous laminae; thin-bedded, hard; abrupt base.	0.44	1.77
6	Sandstone - very fine- to fine-grained, medium grey, silty, quartz-feldspar-basalt, moderately bioturbated, hard; gradational base.	0.52	1.33
5	Sandstone - very fine-grained, medium brownish-grey, rusty-weathering, very silty, quartz-feldspar-basalt; massive, intensely-bioturbated; abrupt base.	0.26	0.81
4	Mudstone - light brown, brown-weathering, soft; probable seatearth; gradational base.	0.05	0.55

3	Siltstone/Sandstone Laminite (50:50) - very fine-grained brown-weathering sandstone and siltstone, platy-weathering; abrupt base.	0.10	0.50
2	Siltstone - sandy, medium brown, rusty-weathering, massive; abrupt base.	0.10	0.40
----- *Bedding-plane shear zone, possible* -----			
1	Siltstone - brownish-weathering, sandy, medium-bedded, blocky-weathering; sheared and soft at top, hard below; base not seen.	>0.30	0.30
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Measured Section No. 10

Comox and Trent River formations, along Trent River and Idle Creek

Top of section: at top of cliff in southeast bank of river, 150 m upstream from site of old Van West Logging bridge, at UTM (Zone 10, NAD 27) 356210 E., 5494830 N.

Base of section: on Idle Creek, 75 metres upstream of right-angle bend, at UTM (Zone 10, NAD 27) 354000 E., 5492820 N.

NTS 92 F/10 and 92 F/11. TRIM 92F.055 and 92F.056.

Measured by: C.G. Cathyl-Bickford and A. Inglis, 1983 (coals and associated shales); C.G. Cathyl-Bickford and C.R. Day, 1987 (units 1 through 130); C.G. Cathyl-Bickford, 2000 (units 131 through 164). Petrographic sampling by C. Kenyon, 1987.

Unit	Description	Thickness (m)	Height (m)
	Trent River Formation: Puntledge Member (incomplete):		
164	Siltstone - dark grey, rubbly, with occasional large ellipsoidal concretions; forms top part of cliff; abrupt base.	6.00	314.97
163	Sandstone - fine-grained, light brown-weathering, pinches and swells as if boudined; thickness varies from nil to 15 cm; abrupt base.	0.10	308.37
162	Siltstone - dark grey, rubbly; gradational base.	2.20	308.27
161	Siltstone - dark grey, rubbly, with ellipsoidal concretions to bed height; gradational base.	0.20	306.07
160	Siltstone - dark grey, rubbly, with occasional sandstone dykes; abrupt base.	3.20	305.87
159	Sandstone - fine-grained, light brown-weathering, cherty, a prominent resistant bed which appears to be the source of sandstone dykes; thickness varies from nil to 60 cm; abrupt base.	0.20	302.67
158	Siltstone - dark grey, thin-bedded, platy; with occasional sandstone dykes; gradational base.	2.38	302.47
157	Siltstone - dark grey, rubbly-weathering, with abundant spheroidal concretions to bed height, and occasional sandstone dykes; gradational base.	0.30	300.09
156	Siltstone - dark grey, massive, rubbly-weathering, with occasional sandstone dykes; gradational base.	2.90	299.79
155	Siltstone - dark grey, thin-bedded, rubbly-weathering, with abundant large spheroidal concretions; gradational base; this bed forms riverbed at upstream end of bend around to north (section here continues upward in cliff on southeast bank) and reappears just upstream of the Van Logging Road ford.	1.28	296.89
154	Siltstone - dark grey, massive, rubbly, with occasional sandstone dykes; gradational base.	3.35	295.61
153	Mudstone - dark grey, hematitic-weathering, rusty in part, flinty, splintery; intensely-bioturbated at top; abrupt base; possible ash band.	0.03	292.26
152	Siltstone - dark grey, sandy, massive, rubbly-weathering, with occasional large ellipsoidal concretions; intensely bioturbated at top, gradational base; possible hardground.	1.57	292.23
151	Siltstone / Sandstone, very fine-grained - very thin to medium fining-upward interbeds of medium grey cherty, slightly bioturbated sandstone and dark grey siltstone; abrupt base.	0.95	290.66
150	Mudstone - dark grey, very silty, intensely bioturbated, with occasional sandstone dykes; occasional large ellipsoidal concretions at base; gradational base.	1.05	289.71
149	Sandstone - very fine-grained, medium grey, cherty, moderately bioturbated; concretionary; abrupt base; thickness varies from 5 to 8 cm.	0.07	288.66
	----- Extensional fault, established (attitude: 050/56 NE; displacement: 2.4 m down to northeast; beds matched across fault); locality A.1788-----		
148	Mudstone - medium grey, hematitic-weathering, rusty, flinty, fissile, moderately bioturbated, slightly sheared; abrupt base; thickness varies from 3 to 7 cm; probable ash band.	0.05	288.59

147	Mudstone - dark grey, very silty, intensely bioturbated, with occasional small irregular concretions; abrupt base.	1.33	288.54
146	Siltstone - dark grey, sandy, with occasional large ellipsoidal concretions to bed height; gradational base.	0.33	287.21
145	Siltstone / Sandstone, very fine-grained - thin fining-upward interbeds of dark grey siltstone and medium grey sandstone; moderately bioturbated; abrupt base.	0.43	286.88
144	Mudstone - dark grey, silty, rubbly, intensely bioturbated, with occasional large ellipsoidal concretions; gradational base.	0.50	286.45
143	Sandstone - very fine-grained, medium grey, cherty, intensely bioturbated; pinches out near larger sandstone dykes, and thins eastward to 1 cm; erosional base.	0.05	285.95
142	Mudstone - dark grey, very silty, thin to medium-bedded, slightly spheroidal-weathering, slightly bioturbated, with occasional shell fragments, occasional large ellipsoidal concretions and occasional sandstone dykes; gradational base.	1.38	285.90
141	Siltstone - dark grey, thin-bedded, rubbly, slightly spheroidal-weathering, with a few large concretions at top and occasional sandstone dykes throughout; gradational base.	1.95	284.52
140	Mudstone - dark grey, silty, platy to rubbly, with occasional large ellipsoidal concretions and occasional sandstone dykes; gradational base.	1.60	282.57
139	Mudstone - dark grey, silty, with occasional sandstone dykes; gradational base.	1.40	280.97
138	Siltstone - dark grey, platy, with occasional sandstone dykes; erosional base.	0.80	279.57
137	Mudstone - dark grey to black, rusty-weathering, silty, splintery, trace glauconite; abrupt base; thickness varies from 5 to 12 cm.	0.08	278.77
136	Mudstone - dark grey, very silty, rubbly to platy-weathering at base, spheroidal-weathering towards top; occasional small irregular concretions and occasional sandstone dykes; abrupt base.	2.02	278.69
135	Siltstone - dark grey, sandy, spheroidal-weathering, with abundant large ellipsoidal concretions to full bed height; occasional sandstone dykes; gradational base.	0.27	276.67
134	Siltstone - dark grey, rubbly, moderately bioturbated, with occasional large ellipsoidal concretions and occasional sandstone dykes; gradational base.	1.70	276.40
133	Siltstone - dark grey, sandy, rubbly, hackly fracture, intensely bioturbated; intensely sheared at base.	0.85	274.70

Trent River Formation: Cowie Member (1.50 m - complete):

132	Sandstone - fine to very fine-grained, ferruginous-weathering, intensely bioturbated, with some disrupted heavy-mineral laminae, and streaks of finely-broken plant debris; gradational base; possible hardground.	0.15	273.85
131	Sandstone - fine-grained, light grey, trough cross-bedded (indicated paleoflow is bi-directional at 185 and 005 -- possibly due to ebb and flood tidal flows?); gradational base.	0.75	273.70
130	Sandstone - fine-to-medium-grained, light grey, buff-weathering, medium-bedded, cross-laminated, clean, with *Thalassinoides* burrows.	0.60	272.95

Trent River Formation: Cougarsmith Member (9.20 m - complete):

129	Mudstone - dark grey, rusty-weathering, silty, with scattered finely-broken plant debris. Gradational base.	0.15	272.35
128	Siltstone - dark grey, sandy, rubbly.	1.05	272.20
127	Siltstone - as above, intensely-sheared (bedding-plane faulting), incomplete exposure.	8.00	271.15

-----Listric extensional fault, probable -----

Comox Formation: Dunsmuir Member (103.77 m - complete):

126	Sandstone - fine to medium-grained, white, composed of subequal amounts of quartz and kaolinised feldspar with minor volcanic rock fragments; clean		

	and well-sorted, but devoid of visible intergranular porosity. Massive-appearing, with local large-scale but subtle hummocky cross-stratification; gradational base.		8.70	263.15
125	Sandstone - medium-grained, light grey, clean, massive.		3.50	254.45
124	Siltstone - dark brownish-grey, orange to red-weathering, sandy, thin low-angle cross-beds; gradational base. Sample 83/S.562.		0.38	250.95
123	Sandstone - fine-grained, medium to dark grey, silty, organic-rich, intensely-bioturbated; gradational base.		0.50	250.57
122	Sandstone - fine-grained, light grey, clean, with large dark-rimmed, oblique, gently-curving burrows; gradational base.		4.40	250.07
121	Sandstone - as above but medium grey, rusty-weathering, soft, burrowed, blocky, with coaly plant trash and *Teredolites* burrows at base; erosional base.		0.60	245.67
-----Roof of Comox X coal bed -----				
120	COAL - bright banded, sheared at top; weathered.	) Channel sample:) CK 87-34/1	0.20	245.07
119	Sandstone - fine-grained, grey, soft, forms flaseroid ripples.		0.02	244.87
118	COAL - dull banded, parts freely at base.	) Channel sample:) CK 87-34/2	0.20	244.85
117	COAL - dull.	) Channel sample:) CK 87-34/3	0.12	244.65
-----Floor of Comox X coal bed -----				
116	Mudstone - dark brown, carbonaceous, soft, with abundant thin bright coal bands.		0.15	244.53
115	Sandstone - fine-grained, medium grey, with scattered fine plant debris; very thick planar beds; gradational base.		10.20	244.38
114	Sandstone - fine-grained, light greenish-grey, silty, ill-sorted, with much organic matter and occasional lenses of plant-bearing siltstone. Large vertical burrows (*Pelecypodichnus*?) and bivalves, including *Inoceramus* and *Mytilus*?; gradational base. Fossil collection FZ.51 (locality Z.51).		1.50	234.18
113	Sandstone - fine-grained, grading down to coarse-grained at base; light grey, arkosic, with scattered large dark-rimmed worm burrows at top. Massive-appearing but planar-laminated and friable, particularly in basal 1.2 m which is rusty-weathering.		10.70	232.68
-----Roof of Comox Y coal bed -----				
112	COAL - sheared and contorted.	) Channel sample:	0.15	221.98
111	COAL - bright banded, sheared.	) CK 87-40	0.03	221.83
110	Sandstone - medium-grained, black, coaly.	) [taken across beds	0.02	221.80
109	COAL - bright banded, sheared.	) 109 through 112]	0.10	221.78
-----Floor of Comox Y coal bed -----				
108	Mudstone - black, carbonaceous, rusty-weathering, sandy, fissile, with abundant thin bright coal laminae; gradational base.		0.03	221.68
107	Mudstone - brown, carbonaceous, rusty-weathering, sandy, fissile, with occasional thin bright coal laminae; gradational base.		0.07	221.65
106	Siltstone - dark grey, rusty-weathering, platy, with scattered plant debris; gradational base.		0.13	221.58
105	Sandstone - medium-grained, medium grey, rusty-weathering, bioturbated, with scattered plant fragments; gradational base.		0.20	221.45
104	Sandstone - medium-grained, light grey, cleaner than above, very thick-bedded to massive, with small coarsely-ribbed bivalves near base.		14.20	221.25
103	Sandstone - medium to coarse-grained, medium grey, herringbone cross-bedded, with heavy mineral bands; worm trail casts at base.		1.40	207.05
102	Mudstone - dark grey, very silty, thinly-laminated, platy, with sandy ripples and abundant finely-broken plant debris; occasional large thin-shelled pelecypods; gradational base. Geochemical sample 83/S.563.		1.20	205.65
101	Mudstone - as above, but dark grey to brownish-grey, thin-bedded and weak.		0.29	204.45
-----Roof of Comox Z coal bed ----				

100	COAL - bright banded.	) Channel sample	0.08	204.16
99	Sandstone - medium-grained, light grey, rooty, with coal spars; pinches and swells from 0.10 to 0.15 m.	) CK 87-41, of coal only) [taken across beds	0.13	204.08
98	COAL - bright banded.	) 96, 98 and 100]	0.03	203.95
97	Mudstone - brown.	)	0.01	203.92
96	COAL - bright banded.	)	0.04	203.91
-----Floor of Comox Z coal bed -----				
95	Sandstone - medium-grained, dark grey, bright orange-weathering, carbonaceous, rooty; undulating at top with coalified logs and bark chips; gradational base.		0.20	203.87
94	Sandstone - medium-grained, light grey, cleaner than above; thin to medium-bedded near top, becoming massive below. Some burrowed zones; gradational base.		16.80	203.67
93	Sandstone - fine to medium-grained, light grey, slight greenish tinge, with occasional heavy mineral laminae and a few disarticulated, coarsely-ribbed plicate pelecypod valves; gradational base.		1.80	186.87
92	Sandstone - coarse-grained, light grey, rusty-weathering, arkosic, with sulphate bloom. Undulating base marked by large ripples and *Teredolites*-burrowed coalified stumps; possible vertebrate tracks at base.		1.20	185.07
-----Roof of Comox No.1 Rider coal bed -----				
91	COAL - dull, dirty, with numerous sand-filled *Teredolites* burrows at top; many lenses of black, canneloid mudstone. Thickens from 0.10 to 0.13 m southwards along river bank.		0.08	183.87
-----Floor of Comox No.1 Rider coal bed -----				
90	Mudstone - brown to dark brownish-grey, delicately colour-banded, planar-laminated; in places papery-weathering; with scattered lenses of brown, orange-weathering calcareous sandstone. Distinctive low density and blocky cleat; occasional broad angiosperm leaves and phosphatic fish-scales; erosional base; probable oil shale.		5.60	183.79
89	Siltstone/Sandstone Laminite - composed of dark grey siltstone and medium grey, fine-grained sandstone; locally intensely bioturbated. Cut-and-fill scours within this unit are 0.4 m deep and 1.5 m broad, striking 120, with linguoid ripples showing paleoflow to ESE.		1.00	178.19
-----Roof of Comox No.1 coal bed -----				
88	COAL - bright banded, blocky, parting readily at thickness varies from 0.14 to 0.21m.	) channel sample) CK 87-42/1	0.17	177.19
87	COAL - dull and bright.	) channel sample) CK 87-42/2	0.14	177.02
-----Floor of Comox No.1 coal bed -----				
86	Mudstone - black, carbonaceous, with abundant thin bright coal bands; gradational base.		0.60	176.88
85	Siltstone - dark grey, carbonaceous at top, becoming sandy at base; thin-bedded; gradational base.		0.75	176.28
84	Sandstone - fine-grained, dark grey, silty, carbonaceous, thin-bedded; intensely-bioturbated: bedding mostly obliterated.		0.45	175.53
----- Roof of Comox No.1 Lower coal bed (horizon only) -----				
83	Mudstone - black, carbonaceous, rusty-weathering, silty; with locally-abundant plant debris and 10% thin bands of fine-grained rusty sandstone.		3.70	175.08
----- Floor of Comox No.1 Lower coal bed (horizon only) -----				
82	Sandstone - fine-grained, black, carbonaceous; gradational base.		0.30	171.38
81	Sandstone - fine grained at top, grading down to medium-grained below; light grey, clean, with *Thalassinoides*? burrows at top; gradational base. Hand-specimen 87/Z.65 at 168.08 m.		8.00	171.08
80	Sandstone - fine-grained at top, grading down to medium-grained below; light grey, clean, very thick-bedded, flaggy, with thick planar laminae containing heavy mineral streaks; some large-scale low-angle cross-lamination.		3.55	163.08

79	Sandstone - medium to coarse-grained, rusty-weathering, rippled at base; erosional base.		0.15	159.53

Comox Formation: Cumberland Member (157.88 m - complete):

78	Mudstone - black, canneloid, lustrous, with thin bright coal bands.		0.08	159.38
-----Roof of Comox No.2 coal bed -----				
77	COAL - bright, hard, clean.	) channel samples) CK 87-35 and) CK 87-36	0.32	159.30
-----Floor of Comox No.2 coal bed -----				
76	Mudstone - black, carbonaceous, with scattered thin bright coal bands.		0.09	158.98
75	Mudstone - light brown, soft, with finely broken plant debris; possible seatearth.		0.18	158.89
74	Siltstone - medium grey, becoming sandy at base.		0.37	158.71
73	Sandstone - fine-grained, light grey, clean, with some silty streaks and large worm burrows; medium hummocky beds.		6.70	158.34
72	Mudstone - dark grey, silty, with sandy streaks; thoroughly bioturbated.		0.61	151.64
71	Sandstone - fine to medium-grained, light grey, with dark silty lenses; thick-bedded, trough cross-laminated; large dark-rimmed worm and pelecypod burrows.		4.60	151.03
70	Sandstone - coarse-grained, white, rusty-weathering at base; arkosic, clean, medium-bedded, blocky; contains *Teredolites* burrows at base; erosional base cuts down 0.6 m into underlying beds, across a width of 3.7 m.		7.60	146.43
-----Roof of Comox No.2A coal bed -----				
69	COAL - dull and bright, sheared at base.	) channel sample) CK 87-43/1	0.15	138.83
68	Mudstone - brownish-grey, weak, rooty; possible seatearth.		0.12	138.68
67	COAL - dull and bright, with pyrite lenses.	) channel sample) CK 87-43/2	0.18	138.56
66	COAL - bright, contorted.	) channel sample) CK 87-43/3	0.23	138.38
65	Mudstone - black, coaly, intensely sheared, soft.		0.06	138.15
64	COAL - dull.	) channel sample) CK 87-43/4	0.17	138.09
63	Mudstone - black, coaly, sheared.		0.09	137.92
62	COAL - dull banded.	) channel sample) CK 87-43/5	0.17	137.83
61	Mudstone - dark brown, carbonaceous, hard.		0.08	137.66
60	COAL - inaccessible under water.		0.09	137.58
59	Mudstone - brownish-grey, sandy, with plant debris.		0.06	137.49
58	COAL - bright.	) channel sample) CK 87-43/6	0.15	137.43
-----Floor of Comox No.2A coal bed -----				
57	Sandstone - fine to medium-grained, light grey, coaly and rooty at top, with abundant plant debris.		4.60	137.28
56	(Concealed) - stony till. Comox No.3 coal bed may subcrop beneath till.		(19.20)	132.68
55	Sandstone - medium to coarse-grained, light grey, arkosic, medium to thick-bedded, large-scale low-angle cross-laminated; large swales at top; large worm burrows throughout.		12.00	113.48
54	Sandstone/Siltstone/Mudstone Laminite (70:30:0 at top, fining down to 10:60:30 at base) - very thin fining-upward beds; mudstones are black and carbonaceous.		4.60	101.48
53	(Concealed) - gravel.		(6.90)	96.88
52	Sandstone - fine-grained, dark grey, muddy, carbonaceous, platy, burrowed.		0.60	89.98

51	Sandstone - medium to coarse-grained, medium grey, arkosic, thick-bedded, with abundant coaly plant trash along bedding near top; intensely burrowed at top.	7.50	89.38
50	(Concealed) - gravel, with occasional small exposures of sandstone as above.	(9.10)	81.88
49	Sandstone - very fine-grained, medium grey, silty, hematitic-weathering, with locally-abundant muddy laminae; medium irregular beds with small burrows and scattered plant debris; cleaner at top; gradational base.	3.70	72.78
48	Siltstone - dark grey, hematitic-weathering, rubbly, with abundant plant debris including small coalified logs and twigs; gradational base.	1.76	69.08
47	Mudstone - dark grey, with abundant fine plant debris; some listric surfaces; minor shearing.	1.04	67.32
-----Roof of Comox No.3A coal bed -----			
46	COAL and Shale -interbedded bright coal and black mudstone; sheared; recessive.	0.21	66.28
45	COAL - bright banded, hard, clean.) channel samples) V.566 and CK 87-37/1	0.27	66.07
44	Mudstone - dark brown to black, carbonaceous, rusty-weathering; scattered coalified logs at top.	0.17	65.80
43	COAL - bright banded, hard, clean.) channel sample) CK 87-37/2	0.44	65.63
42	Mudstone - black, coaly, jarositic, with large coalified root masses near base, and coalified logs toward top.	0.66	65.19
41	COAL - bright banded, blocky, hard.) channel sample) CK 87-37/3	0.24	64.53
40	Mudstone - dark brown to black, coaly, hard.	0.05	64.29
39	COAL - dull, stony, hard.	0.05	64.24
38	Mudstone - dark brown to black, coaly, hard, with scattered thin bright coal bands; abundant coalified logs in basal 0.06 m.	0.33	64.19
37	COAL - bright banded, platy.) channel sample) CK 87-37/4	0.40	63.86
-----Floor of Comox No.3A coal bed -----			
36	Mudstone - black, carbonaceous, rooty; gradational base.	0.15	63.46
35	Mudstone - brown, rooty.	0.15	63.31
34	Sandstone - very fine-grained, dark grey, silty, rooty.	0.30	63.16
33	Sandstone - fine-grained, light grey, arkosic, thin-bedded, platy, with scattered large worm burrows; rooty at top.	1.50	62.86
32	Sandstone - coarse-grained, medium grey, arkosic, thin to medium-bedded, with scattered burrows. This unit is folded and sheared, and is poorly exposed.	9.30	61.36
-----*Fault, possible* -----			
31	Sandstone - medium-grained, medium grey, arkosic, thin to medium-bedded at top, becoming thick-bedded and blocky at base.	12.70	52.06
30	Sandstone - coarse-grained, light to medium grey, rusty at base, arkosic; a single very thick bed; erosional base.	1.50	39.36
-----Roof of Comox No.4 Rider coal bed -----			
29	COAL - dull and bright, blocky; slightly weathered.) channel sample) CK 87-47	0.21	37.86
-----Floor of Comox No.4 Rider coal bed -----			
28	Mudstone - dark brown, carbonaceous, hard.	0.14	37.65
27	Sandstone - very fine-grained, light brown, silty, soft and rooty at top; gradational base.	0.15	37.51
26	Sandstone - fine-grained, light grey, clean, arkosic, with occasional silty streaks; medium-bedded, large-scale festoon cross-bedded.	1.20	37.36
25	Mudstone - dark grey, carbonaceous, with a few thin bright coal bands.	0.30	36.16
24	Siltstone - dark grey, sandy, very thin-bedded.	0.80	35.86
23	Mudstone - dark grey, slight hematitic tinge, faint colour banding near base (silty streaks?), otherwise massive.	0.60	35.06

22	Sandstone - fine-grained, medium grey, arkosic, muddy, with 30% thin bands of dark grey silty mudstone; occasional rootlets; intensely bioturbated toward base.		1.10	34.46
21	Siltstone - dark grey, sandy, with abundant coalified logs and fine plant trash; gradational base.		2.10	33.36
20	Mudstone - dark grey, hematitic-weathering, rubbly, weak, with a few coalified stumps and large roots.		0.43	31.26
-----Roof of Comox No.4 coal bed -----				
19	COAL - bright banded; abundant calcite on cleats.	) channel sample	0.15	30.83
18	COAL - dull and bright, blocky, hard.	) CK 87-48 [across	0.20	30.68
17	COAL - dull banded, weathered.	) beds 17 through 19]	0.11	30.48
-----Floor of Comox No.4 coal bed -----				
16	Mudstone - black, coaly, hard.		0.24	30.37
15	Mudstone - dark grey, carbonaceous, hard.		0.33	30.13
14	COAL - dull, stony, pinches out to east. Thickness varies from nil to 0.12 m.		0.06	29.80
13	Mudstone - dark grey, carbonaceous, hard, fissile, with large concretions at base.		0.64	29.74
12	Sandstone - fine-grained, medium grey, with abundant muddy laminae; gradational base.		1.20	29.10
11	Sandstone - medium-grained, buff-weathering, arkosic, cleaner than above, with scattered large dark-rimmed worm burrows; gradational base.		2.40	27.90
10	Sandstone - medium-grained, as above, with abundant dark shaly streaks.		0.90	25.50
9	Siltstone - dark grey, sandy, intensely bioturbated, with a few coalified logs. Gradational base.		0.60	24.60
8	Sandstone - fine-grained, medium grey, intensely bioturbated, silty; gradational base.		0.60	24.00
7	Sandstone - medium to coarse-grained, orange-weathering, arkosic, medium-bedded, with minor silty streaks; gradational base.		1.80	23.40
6	Sandstone - medium to coarse-grained, as above but cleaner, thick-bedded; gradational base.		6.00	21.60
5	Sandstone - medium-grained, arkosic, very thin-bedded, low-angle cross-laminated, flaggy.		9.00	15.60
4	Mudstone - dark grey, silty, fissile, planar-laminated.		3.30	6.60
3	Mudstone - black, carbonaceous, with thick bright coal bands and occasional thin partings of sandstone.		0.60	3.30
2	Sandstone - medium-grained, orange-weathering, arkosic.		1.20	2.70
1	(Concealed) - gravel.		(1.50)	1.50

Karmutsen Formation (incomplete):

Basalt - dark green, amygdaloidal.

2000-2001 BRITISH COLUMBIA PROSPECTORS ASSISTANCE PROGRAM

By Garry Payie[1]

HIGHLIGHTS

Prospectors in this year's program were successful at finding a number of new mineral occurrences in BC. Six prospectors have entered into agreements with exploration companies that will see the following properties explored further.

- **Alley –** a platinum-palladium-gold-copper prospect near Okanagan Falls. Optioned to Santoy Resources by Adam Travis in early 2001.
- **Bell** – a copper-zinc-lead-silver-gold property found in the Prince Rupert area by Shawn Turford. Optioned by Doublestar Resources in May 2001.
- **Broken Hill –** a new lead-zinc deposit discovered by Leo Lindinger near Avola. Optioned to Cassidy Gold Corp. in late 2000.
- **Fox -** a promising skarn prospect near 100 Mile House discovered by Dave Ridley. Optioned to Starcore Resources Ltd. in 2001
- **Peg** – a beryl crystal occurrence staked by Peter Klewchuk near Kimberly was optioned to Chapleau Resources Ltd. for its potential as a beryllium-rubidium-Rare-Earth-Element-tantalum-niobium prospect.
- **Silver Lynx –** Bruce Doyle discovered a new silver-lead-zinc deposit southwest of Nelson. Optioned to Cassidy Gold Corp. in 2001.

Prospectors funded by the 2000-2001 program made several other significant new discoveries that also have excellent potential for being optioned. There is also ongoing exploration on Prospectors Assistance discoveries made in previous years. For example, a total of $850,000 was spent on the Lottie Lake property since its discovery in 1997.

INTRODUCTION

Energy and Mines Minister Dan Miller announced the renewal of the 2000-2001 Prospectors Assistance Program (PAP) on April 5, 2000. The $500,000 program was designed to promote grassroots prospecting for new mineral deposits in British Columbia. The program continued in 2001-2002 with a report planned for next year's Exploration in BC. The Prospectors Assistance Program was cancelled in January 2002 as part of a government-wide initiative to eliminate subsidies that favour particular individuals or companies.

The Program was available to individual prospectors who hold a valid British Columbia Free Miners Certificate. Successful applicants were allotted a maximum of $10,000 to cover 75% of their eligible expenses. The grant was paid in 2 installments, an initial 50% award on approval of the project proposal and a final 50% award upon approval of the final report.

PROSPECTING PROGRAMS

Deadline for applications was set for the third Monday in April - this year, April 20, 2000. A total of 135 applications were received by the deadline. This is a similar total to last years, which was up significantly from the 102 received in 1998. This may reflect the downturn in the mineral industry sector, the general lack of work and the difficulty that prospectors have in selling their properties.

The Victoria office initially reviewed all applications to ensure that they met the criteria as outlined in the guidebook. Qualifying applications were then sent to the appropriate Regional Geologist by May 15 where they were to be rated according to the following distribution:

- 45% Quality and documentation of proposal
- 25% Financial commitment of applicant
- 10 % Experience and training of applicant
- 20% References and past performance

Evaluation guidelines were adhered to during this process.

Grant amounts were determined by allowing the 20 highest rated applicants 100 per cent of their maximum allowable grant (to a maximum of $10,000) and the following 34 applicants, 75 per cent of the maximum allowable grant (up to $7,500). A total of 54 grants averaging $8,104 were approved in fiscal year 2000/2001

The most significant change to the program this year was the reduction of the minimum number of prospecting days required from 30 days to 21. This change was made to enable high cost programs to occur that might otherwise have been discouraged by a long-term requirement. An example of this would be helicopter-only accessible prospecting in remote areas.

The prospecting programs were distributed throughout the province as shown in Figure 1. Of the 135 applicants, 63

[1] *Program Coordinator*
British Columbia Ministry of Energy and Mines

(47%) had never received a grant before. Of the 54 applicants receiving grants, 19 (35%) had never received grants before.

Final prospecting reports were due in the Victoria office no later than January 31, 2001. These reports were logged in and sent to the specified regional geologist for evaluation. The quality of the program was assessed by the regional geologist in terms of the commitment and ability of the grantee to carry out his or her program as originally proposed. Program elements looked for in the report included the plotting of sample locations and other data on suitable maps, a good diary of day to day prospecting activity, a summary of overall results and a list of actual expenditures along with major receipts

The final report evaluation form was returned to Victoria where a final payment cheque was issued to those grantees who had successfully completed their program.

Thirty-Five of the 52 active grantees staked mineral claims while working under the terms of their grant. A total of 898 units were staked (Table 1). When measured against the number of grantees in the program, this is up more than 20 per cent from the last two years (*see* Figure 2). This may indicate a recovery to staking levels by program participants to those of the 1980s.

RESULTS TO DATE

The following notable developments and prospecting discoveries are an indication of the program's value in the search for untapped mineral wealth, the first step towards developing tomorrow's mines for British Columbia.

NEW DISCOVERIES AND DEVELOPMENTS

Steve Bell located a significant copper-lead-zinc soil anomaly that warrants further work. Bell staked the **Stardust** and **Palamino** claims near Houston.

Dave Bennett located several unstaked gold anomalies west of Avola during the 1999 field season and followed up in 2000 by staking the **Readymix** claims to cover a new intrusion-related(?) gold prospect. Till sampling outlined a 3.5 by 2 kilometre gold anomaly, which occurs northeast of several mineralized, angular float samples. This float yielded gold values of 8.54 to 29.35 grams per tonne.

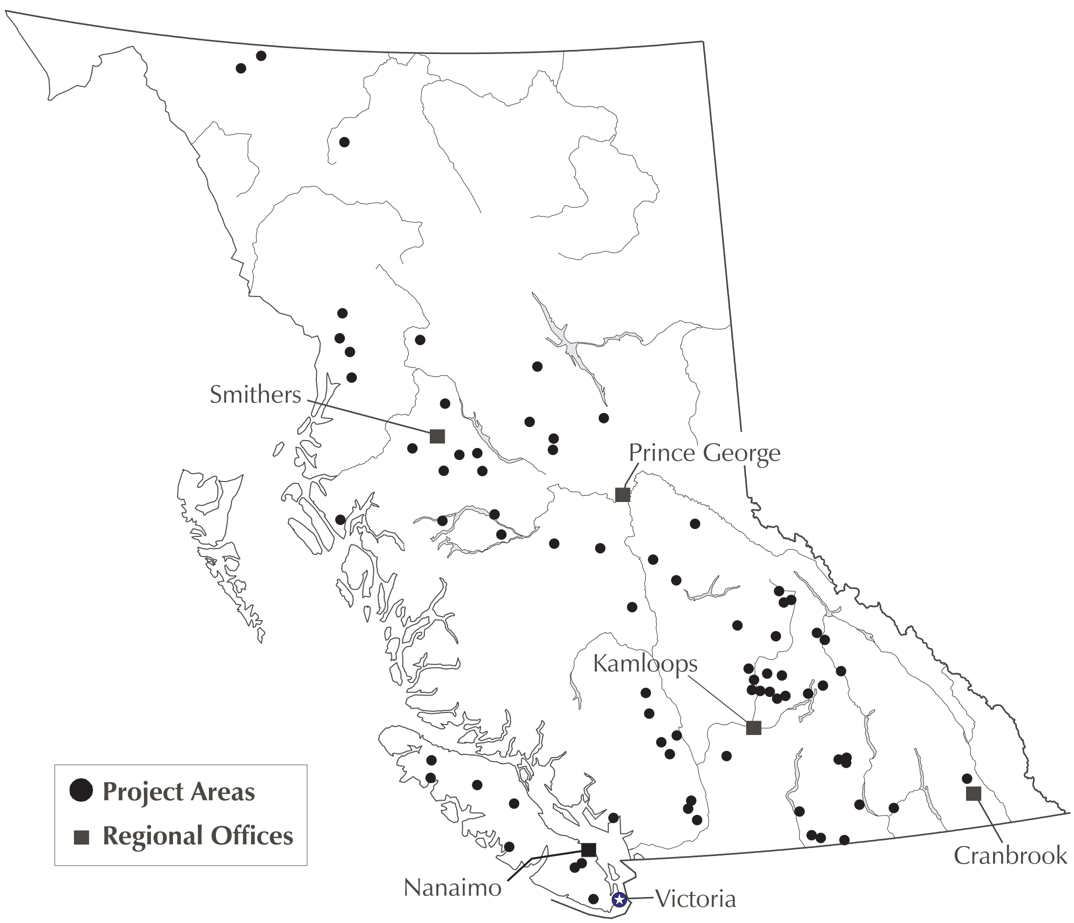

Figure 1. Distribution of year 2000 projects. Some programs have multiple prospecting locations and have been assigned more than one plot synbol.

TABLE 1
SUMMARY OF PROSPECTING ACTIVITIES

Item	1988-89	1989-90	1990-91	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-2001
Total Prospecting days in the field	4709	3414	2672	2816	2440	3102	1846	2459	2704	2247
Average prospecting days in the field, active grantees	37	46	35	45.4	41.3	51.7	45	50	55	43
No. of Active Grants	128	74	76	62	59	60	41	49	49	52
No. of claim units staked during/after prospecting activity	1860	1483	1843	816	604	759	403	672	687	898
No. of Units Staked/Active Grantees	14.5	20	24	13	10.2	12.6	9.8	13.7	14	17.3
No. of Option agreements	23	8	6	15	16	14	2	8	6	6

Arne Birkeland conducted an exploration program on the **Tofino Nickel** (Deer Bay) gabbroid Cu-Ni-Co-Au-Ag-PGE property near Tofino. A grab sample from a small massive sulphide zone, taken at the previously known Main showing, containing pyrrhotite, chalcopyrite, pyrite, magnetite, violarite, and millerite yielded greater than 10% Cu, 0.30% Ni, 612 ppm Co, 487 ppm Cr, 20 g/t Ag, 1 g/t Au, 2 g/t Pt and 12 g/t Pd. A magnetometer survey conducted by Birkeland established significantly larger exploration targets than previously known. Birkeland also discovered a new gold showing southwest of the Main showing that yielded 3.48 g/t gold from a pyritic, chloritic diorite outcrop.

David Bridge discovered gold-bearing fault breccia with tetrahedrite and chalcopyrite near Prince George.

Linda Caron discovered a silicified zone in altered intrusive rocks that yielded 61 g/t silver and high base metals values. The new **Holy** showing is located in the Arrow Lakes region.

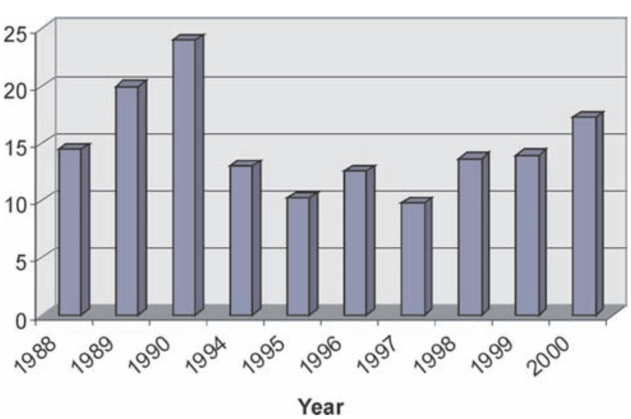

Figure 2. Claim units staked by grantee.

Warner Gruenwald discovered several new pegmatite-related Au-W-Cu-Bi skarn occurrences northeast of Shuswap Lake in 1999 and staked the **GQ** claims. His 2000 program was successful in locating numerous additional float and narrow bedrock showings. One float sample yielded 3.5 g/t gold.

Dave Haughton discovered a new magmatic nickel-copper showing in 1999 near Harrison Lake while prospecting with a PAP grant. The **Jason** claims were subsequently staked over the area, which was underlain by previously unidentified outcrops of ultramafic rock and hornblendite. Polished sections showed net texture sulphide consisting of pyrrhotite, pyrite, chalcopyrite and exsolved pentlandite. Maximum values obtained from float and outcrop include 0.22% nickel, 0.20% copper and 0.14% chromium. In 2000, Haughton used geophysics to further define targets with massive sulphide potential. Anomalous values in platinum and palladium were obtained from rock samples in 2000. An option was pending in early 2002.

John Hope staked the **Malachite** claims in the Dease Lake area to cover an east-west structure in granodiorite that assayed 1.9 per cent copper over 0.3 metres. The **Sphinx** claims were staked on Pyramid Mountain to cover pyritic mafic volcanics near diorite that yielded 0.066 per cent copper and 1.8 g/t gold. The **Northwest** claims were staked when Hope located rock assaying 271 ppb (Pt plus Pd) in brecciated Stuhini mafic volcanics. This rock was located as a result of a follow-up to a Pt-Pd silt anomaly obtained in his1999 PAP program.

John Kemp found several new showings and 8 new mag/VLF anomalies on his new **Snowshoe** claims near Greenwood. One mineralized quartz vein yielded 2.64 g/t gold, 693.8 g/t silver, 25.8% lead and 13.4% zinc over narrow widths. A rusty shattered zone, about 1.5 metres in width yielded grades of up to 5.85 g/t gold, 96.6 g/t silver, 4.78% lead, 1.57% zinc and 2.92% arsenic.

Cleve Lowry discovered a few small vein occurrences with Cu-Pb-Zn sulphides in the Adams Lake area and staked the **Plateau** and **Anomaly** claims.

Brian Malahoff identified a copper-in-soil geochemical anomaly on his **Malachite** claims in the Merritt area. The anomaly appears to be related to a north-trending fault.

Murray McClaren discovered a new potential gabbroid-associated sulphide deposit near Harrison Lake. McClaren staked the **Sable** claims to cover the ground. A sample of sulphidic quartz amphibolite schist yielded 0.19% copper, 0.31% nickel, 293 ppm cobalt, 319 ppm chromium, and 80 ppb palladium.

Anton Nijhuis discovered and evaluated a number of occurrences of marble, dimension limestone and flaggy sandstone on Vancouver Island. Nijhuis staked the **Oys** and **Boo** claims to cover his prospects.

Gary Polischuk was able to define five new target areas where gold is indicated on his **Dave** claims near Lillooet. One channel sample yielded 3.28 g/t gold over 1.5 metres. A very prominent swarm of 10-100 cm wide, sheeted quartz veins occur in altered diorite at the **Payday** zone. Visible gold was discovered in the **Cavalier** zone during the 2000 work, and is associated with arsenopyrite and galena in narrow quartz veins. Most of the other occurrences also have arsenopyrite, pyrite and traces of chalcopyrite in quartz and altered diorite.

Frank Renaudat discovered pyritic massive sulphides in volcanic rock near Greenwood and staked the **Storm** claims. On sample assay 0.135% copper, 0.15% lead and 0.64% zinc.

Mikkel Schau discovered a new gold occurrence on northern Vancouver Island and staked the **Flan** claim. Samples from a narrow quartz vein in a gabbro sill yielded up to 61 g/t gold.

Lorne Warren discovered a high-grade porphyry/magmatic copper showing on his **Bor** claims, just east of Tchentlo Lake in northern BC. Chloritically altered and brecciated diorite hosts coarse-grained chalcopyrite, pyrite and magnetite in fractures and as centimetre-scale patches.

Paul Watt located an area of attractive pyroxenite southwest of Little Fort and staked the **Mirrorball** claims to cover this potential dimension/decorative stone. A “US sale” was reported and a bulk sample permit was to applied for. Watt also discovered gold-bearing quartz-chalcopyrite float on his **Spide**r claims.

PROPERTIES OPTIONED

Alley

The Alley claims were staked by **Adam Travis** in early 2001 to cover an alkalic porphyry property in the Allendale Lake area east of Okanagan Falls and subsequently optioned to **Santoy Resources Ltd**. Unusual syenite-related PGM mineralization was the focus of a small exploration program by Santoy in 2001. The alkalic Allendale Lake stock is approximately 2.5 kilometres in diameter and includes megacrystic syenite porphyry and shonkinite phases. A grab sample of a malachite stained mafic rock (the **Spoon** showing) assayed 0.31% copper, 0.93 g/t palladium, 0.19 g/t platinum and 0.70 g/t gold.

Bell

A high-grade volcanogenic massive sulphide discovery by Shawn Turford was made near Kitkiata Lake toward the southern end of the Ecstall VMS belt, south of Prince Rupert. The property was briefly optioned to **Doublestar Resources Ltd.** in May of 2001. The company was attracted by the high precious metals component, particularly silver, occurring within the copper-lead-zinc mineralization. One sample yielded a best assay of 0.710% copper, 7.16% lead, 19.24% zinc, 368.9 g/t silver and 2.40 g/t gold.

Broken Hill

Three sulphide occurrences discovered near Avola by Leo Lindinger are presumed to be from the same exhalative horizon. They occur over a distance of five kilometres. The **Vista** showing sample assayed 24.3 per cent zinc, 4.89 per cent lead and 62.74 grams per tonne silver. The **Navan** showing, located approximately 1.5 kilometres southeast of the Vista showing, yielded a sample that assayed 23.6 per cent zinc, 4.05 per cent lead and 16.22 grams per tonne silver. The **Mike** showing, located approximately five kilometres to the south-southeast of the Vista occurrence, consists of a number of angular float boulders with mineralization visually similar to the Vista and Navan. Collectively known as the Broken Hill property, these occurrences were optioned in late 2000 to **Cassidy Gold Corp.** Following a small program of gravity, soil and geological surveys, Cassidy drilled the main showings in January 2001. Despite the presence of numerous outcrops of thin (20-40 centimetre wide) flat-lying, massive sulphide, Cassidy’s best drill hole hit only 2.52% zinc over 3.9 metres, with an estimated true width of 2.2 metres. Cassidy returned the claims to Lindinger in late 2001.

Fox

In 1999, with PAP funding, **Dave Ridley** discovered the **Fox** molybdenum-tungsten property just east of 100 Mile House. He was able to further advance this promising skarn property in 2000 with a second grant and subsequently optioned the property to **Starcore Resources Ltd.** in July 2001. The prospect is located about 25 kilometres east of the former producing Boss Mountain molybdenum mine. Mineralization has been traced over a strike length of more than two kilometres; it is hosted by Paleozoic metasedimentary rocks near the contact with the Cretaceous Deception stock. Starcore reported that scheelite (up to 0.69% tungsten) and molybdenite (up to 4.9% molybdenum in grab samples) appear to occur in separate areas. Garnet, diopside, vesuvianite, quartz and calcite have been identified in the skarn. Soil and rock geochemistry has also identified local anomalous Au and Zn values on the property. Starcore has agreed to spend $240,000 on the property over three years.

Peg

This beryl crystal occurrence near Kimberly was staked by **Peter Klewchuk** and optioned to **Chapleau Resources Ltd**. for its potential as a beryllium-rubidium-Rare-Earth-Element-tantalum-niobium prospect. The Peg is a large granitic pegmatite body containing abundant (3 to 5 per cent by volume) beryl crystals in surface outcrops. Four diamond drill holes (totaling 98.7 metres) drilled on the Peg revealed the continuity of this gently dipping pegmatite body along strike for over 60 metres and down dip for over 421 metres. The thickness was found to vary from 5 to 21 metres, increasing to the southwest and down dip. Highlights of the drilling include up to 6 metres grading 1133 grams per tonne BeO, including 1 metre grading 2908 grams per tonne BeO, and up to 4 metres grading 66 grams per tonne Ta2O5. The pegmatite body remains open along strike and down dip. Subsequent to the drill program, the property was returned to the vendors, Supergroup Holdings Inc., who are now seeking a new joint venture partner for the property.

Silver Lynx

This is a new volcanogenic massive sulphide occurrence discovered by **Bruce Doyle** in 2000 just southwest of Nelson. Mineralization consists of sphalerite, galena, chalcopyrite and pyrrhotite (silver-lead-zinc-copper) located near the contact between felsic volcanic rocks and black argillaceous sediments, possibly as part of an exhalative horizon. Doyle completed a soil geochemical program in 2000 with results delineating highly anomalous polymetalic values over 800 metres long, open on both ends, and up to 300 meters wide with an average width of 125 metres. An individual selected grab sample from road cut materials assayed 24.59% zinc, 22.35% lead, 0.21% copper and 556.4 grams per tonne silver. The Silver Lynx was optioned to **Cassidy Gold Corp**. in November 2000 who plan to spend $350,000 over four years. Four diamond-drill holes totaling 643 metres as well as geophysical and geochemical surveys were completed by December 2001. The trend of the mineralized rocks was tested over a strike length of 265 metres. Two distinct horizons with disseminated to semi-massive sphalerite, galena, chalcopyrite, and arsenopyrite were encountered in 3 of the holes, as well as widely distributed sphalerite stringers; the fourth hole encountered a thick mafic intrusive. Assays graded up to 6.87% zinc, 1.13% lead, and 42.5 g/t silver over 0.6 metre. The company is planning a follow-up program in 2002.

ACTIVE PROPERTIES DEVELOPED THROUGH PREVIOUS PAP GRANTS

The following are the known properties picked up or worked by companies during 2000-2001 because of work done by PAP grantees under previous programs dating from 1988 to 1999. The actual amount of exploration activity flowing from PAP sponsored discoveries is likely to be far greater than that captured below. Table 3 provides a listing of these active properties and a partial listing of other presently non-active PAP-related properties that were optioned to companies for further work.

Bizar/Goldstrike

Located near Blue River, the Bizar prospect is a gold-bismuth-copper prospect discovered by **Leo Lindinger** during the execution of his 1998 PAP program. Quartz-sulphide veins cut micaceous quartzite and mica schist. A chip sample across a 20-centimetre wide vein yielded 56 g/t gold, 0.5% bismuth and 0.34% copper, along with anomalous silver, cobalt, molybdenum, nickel, selenium, tellurium and tungsten**. Cassidy Gold Corp.** optioned the Bizar claims in 1998 and renamed the property **Goldstrike**. Cassidy drilled five short holes in late 1999, intersecting several narrow veins with anomalous gold values. The best was 6 g/t over 20 centimetres. The company reported $46,762 in expenditures in 1999. A total of $500,000 was to be spent by the end of the fourth year. The property was returned to Lindinger who did some work on it in 2001.

Carbonado

The Carbonado claim was staked by **Dave Javorsky** to cover the **Jack** alkaline diatreme near Golden. Javorsky was able option the property in early 2000 to **Icefield Diamond Mines**. In 1983, treatment of seven bulk samples from an upper breccia portion of the diatreme produced

TABLE 2
OPTION AGREEMENTS RESULTING FROM YEAR 2000 PROGRAMS

P#	Grantee	Optionee	Amount	Property
46	Bruce Doyle	Cassidy Gold Corp.	$350,000 over 3 years	Silver Lynx
59	Peter Klewchuk	Chapleau Resources Ltd.	$200,000 over 2 years	Peg
62	Leo Lindinger	Cassidy Gold Corp	$300,000 over 3 years	Broken Hill
65	Dave Ridley	Starcore Resources Ltd.	$240,000 over 3 years	Fox
103	Adam Travis	Santoy Resources Ltd	undisclosed	Alley
21	Sean Turford	Doublestar Resources	undisclosed	Bell
		TOTAL	**>$1,000,000**	

pyrope garnets, ilmenites and chromites. More significantly, one 29.5-kilogram bulk sample of sandy marl from the diatreme breccia was reported to have produced an excellent quality octahedral microdiamond weighing 0.00037320 carats. Further sampling and analysis and diamond drilling in 1985 and 1986 failed to confirm the presence of macro or microdiamonds. Icefield spent approximately $100,000 on the property in 2000. More work was planned for 2001.

Mark

Dave Javorsky staked the Mark 2000 and Mark 2001 claims to cover the Mark alkaline diatreme near Golden and was later able to option the property to **Kootenay Diamond Mines** in early 2000. In 1983, a 30-kilogram portion of a 160-kilogram bulk sample of the diatreme produced one ilmenite and thirteen chromites and one 0.00015820-carat microdiamond fragment. Further examination, sampling, processing and analysis in 1986, 1988 and 1990 has identified ilmenite, chromite and garnet but failed to reveal or substantiate the presence of macro or microdiamonds. However, scanning electron microscope (SEM) studies identified corundum - several blue sapphires were present in the fused concentrates of three samples of diatreme material. Kootenay spent $46,000 on the property in 2000. Some sampling work was done in 2001.

Demers (Crazy Fox)

Robert Bourdon located an interesting 10-kilometre long, linear Zn-Cu-Cd-As-Sb-Ba-Hg anomaly in till and soil. This discovery was a follow-up of high geochemical values from a Geological Survey Branch till survey northwest of Little Fort. Bourdon and partner Lloyd Addie staked the Demers claims to cover the prospect. They spent about $14,000 on the property before optioning it in the summer of 2000 to Inmet Mining Corporation. Inmet spent $17,600 dollars on a geophysical program in early 2001 but dropped the option later in the year. Cassidy Gold Corp picked up the property and drilled one hole. More work is planned.

Dominion Creek

Allan Raven's 1998 prospecting grant provided funding that was instrumental in acquiring the additional data necessary to promote the property and finally option it in 2000 to **Gold City Industries Ltd.** The Dominion Creek property, northeast of Wells, hosts a series of auriferous quartz-sulphide vein, stringer and replacement zones. Mineralization is lithologically and structurally controlled and occurs within argillaceous limestone of the upper Isaac Formation. A bulk sample comprised of material from the 2B and 3B veins totaled 1180 tonnes and averaged 14.1 g/t Au. In 2000, Gold City carried out a regional prospecting, mapping and stream sediment sampling program followed by a 17 hole, 1100-metre drill program on the South Zone discovery. Expenditures by Gold City in 2000 totaled $220,000. No work was done in 2001.

Hardy Island

Prospecting for dimension stone in 1998 led **Helgi Sigurgeirson** to the waters near Jervis Inlet where he restaked the Hardy Island quarry on Hardy Island (last worked in the 1920s). This quarry was originally one of the Jervis Inlet Granite quarries, a group of quarries which supplied most of the granite for numerous historic buildings in the province erected during the early part of the century. Landmarks of note using stone from the Hardy Island quarry include the breakwater at Ogden Point (Victoria) and the Lions at the old courthouse in Vancouver. Sigurgeirson applied for and received a quarry permit in 1999. Approximately 1600 tonnes of blocks were shipped from the quarry in 1999, and a further 2500 tonnes is expected to be shipped in 2000, much of which will be exported to the United States. Most of the blocks are processed into split facing, but some is used for custom sizes such as coping. Hardy Island Granite Quarries Ltd. has also recently supplied the stone for work on the Lions Gate Bridge. Though there are subtle differences between the stones from the quarries on Nelson, Kelly, Fox and Hardy islands, all are light grey, medium grained, biotite hornblende granodiorite. The stone at Hardy Island has excellent splitting qualities and well developed jointing.

Jasper

The Jasper property comprises 3 showings and there are three styles of sulphide mineralization present: massive, fracture-filling and, disseminated. The property is located between Caycuse Creek and Jasper Creek, 7 kilometres northeast of the north end of Nitinat Lake on Vancouver Island. Hudson Bay Mining and Smelting staked and conducted geological mapping, soil and rock geochemistry and an induced polarization (IP) geophysical survey in 1970 and 1971. Further work on the property was completed by various concerns in the early and mid 1980s. **Arne Birkeland** relocated the property in 1994 with the aid of a Prospectors Assistance grant. Geological mapping and sampling consisting of 39 rocks, 40 silts and 133 soils was carried out in 1994 with further geological and geochemical surveys following in 1995. Birkeland optioned the property to Consolidated Taywin Resources Inc. (later renamed **Inspiration Mining Corporation**) in 1995 and from December 1995 to June 1996, a work program was carried out consisting of 84 soil samples, a 1.2 kilometre IP survey, a 3 kilometre VLF and Horizontal Loop survey and a 2.1 kilometre ground magnetics survey. In 1998, Inspiration's exploration program consisted of rock chip sampling of showings and mineralized float. The 2000 exploration program extended the 1998 grid 650 metres northward and geochemical sampling continued. An estimate of expenditures since 1994, based on Assessment Reports, is approximately $126,000. Preliminary work was done on the property in 2001 in advance of a planned $500,000 exploration program.

Lottie Lake

Located just north of the town of Wells, the Lottie Lake property consists of two originally separate properties within the Antler Formation that were both discovered and/or worked by PAP grantee **Martin Peter.** The **Bow** property was created in 1997 when Martin Peter staked two areas of copper±zinc±gold±silver float . Samples of massive fine-grained pyrite with faint bands of chalcopyrite, yielded up to 7% copper, 1% zinc, 4 g/t gold and 7 g/t silver. **Eureka Resources Inc.** optioned Peter's Bow and Tow claims in December 1997 and identified two prominent airborne EM conductors in 1998. Estimates of expenditures in 1998 were $140,000. In 1998, funded by another PAP grant Peter staked the nearby Lottie claims to cover another new discovery of massive sulphide float. Boulders of mineralized chert and altered volcanic rock were found to occur over a distance of about 75 metres. A sample from one boulder assayed 24.3% copper, 0.4 gram per tonne gold, 19.6 grams per tonne silver, 0.06% cobalt, 0.12% molybdenum, 0.02% lead and 0.04% zinc. The Lottie was optioned to Eureka Resources Inc. early in 1999 who then spent about $70,000. Both the Bow and Lottie properties were subsequently optioned to **Hudson Bay Mining and Smelting** in May 2000 and this group of 850 contiguous claims became known as the Lottie Lake property. In the five-month 2000 field season, Hudson Bay spent approximately $650,000 and conducted property wide stream and moss matt geochemical and sampling programs; as well as extensive till fabric studies and till geochemical sampling. The eastern one-third of the property was flown with Hudson Bay's proprietary Spectrem airborne geophysical system. A total of 81.5 kilometres of line was cut in grids covering nine targets selected from new and past geochemical and geophysical anomalies. Max-min ground electromagnetic surveys were conducted on all grids and the anomalies were confirmed. This was followed by 709.4 metres of drilling in six holes. Four holes were drilled to test the Lottie target in the area of high-grade float previously discovered in 1998 by Eureka, one hole tested an older Dighem anomaly, and one hole tested a Spectrem anomaly. The Lottie holes intersected volcanic rocks with intercalated chert and graphitic siltstone, and Hudson Bay concluded that the graphitic units satisfactorily explain the geophysical responses. No source was found for the high-grade copper boulders seen in past trenches. Eureka announced in January 2001 that Hudson Bay was dropping its option. Eureka subsequently announced its plans to spend $100,000 in 2001 in order to investigate a considerable number of geophysical and geochemical anomalies located in 2000 and in previous programs. Unspecified work was done by Eureka in 2001.

McNeil Creek

The McNeil Creek property is located 18 kilometres southwest of Cranbrook**. Frank O'Grady** explored the area in 1995 and 1996 after being funded by a PAP grant in each of those years. Underlain by Moyie intrusive rock and Middle Aldridge sediments, O'Grady's Phantom, Mar and Cubby claims represent a Sullivan-type massive sulphide target. In 1996, O'Grady optioned his claims to **Sedex Mining Corp**. In 1998, Sedex drilled a hole to a point just below the Lower-Middle Aldridge contact, encountering minor sulphides. Sedex subsequently optioned the property in 1999 to **Webb Bay Resources Ltd**, later re-named **National Gold Corp**. which has committed to spend $1,000,000 over four years. National Gold Corp. drilled a 2000-foot hole on their McNeil Creek Group of claims (some of which are not part of the O'Grady option). While no work was done in 2001, National Gold continues to hold the property.

McPhee

Bruce Doyle discovered several gold-bearing quartz veins east of Castlegar in 1999 and staked the McPhee claims. The property hosts gold-bearing veins in weakly altered, fractured granitic rocks. A chip sample from one vein assayed 202 grams per tonne gold and 127 grams per tonne silver over 0.3 metres. Visible gold can be seen in several locations along this steeply dipping vein. Other gold-bearing veins have been located more than 50 metres from the discovery site. **Cassidy Gold Corp**. optioned the property in December 1999 and agreed to make staged cash payments totaling $100,000, issue 200,000 common shares, and spend at least $500,000 in exploration and development work on the property over a period of four years. Borehole numbers 4 and 5 of a 600-meter, 5-hole drill program conducted during August/October 2000 tested the down dip extension of these veins. Drill hole number 4 found that the entire vein set was faulted off. Although more work had been planned by Cassidy in 2001, the property was returned to Doyle with no additional work done.

Red Mountain

Prospector **Charles Kowall** discovered significant gold-silver mineralization on Willoughby Creek east of Stewart while prospecting under a PAP grant received in 1988. Kowall was able to option the property to **Bond International Gold Inc.** who spent several hundred thousand dollars on the property. The Company subsequently made further significant discoveries on nearby Red Mountain. **North American Metals**, which is 89%-owned by **Wheaton River Minerals**, acquired the property in 1999 from **Royal Oak Mines.** Wheaton River spent some time reexamining the core in 2001. The property was then optioned to **Seabridge Resources** in the spring of 2002. Close to $10,000,000 has been spent on the Red Mountain property since Kowall's initial find at Willoughby Creek.

GRANTS FOR TRAINING COURSES

Grants were issued to the following groups at the beginning of the fiscal year to assist them in the delivery of prospector training courses:

BC & Yukon Chamber of Mines	$5,000
BC Museum of Mining	$5,000
Smithers Exploration Group	$5,000
Omineca Mining Group	$5,000
Chamber of Mines of Eastern BC	$5,000
Kamloops Exploration Group	$5,000
Boundary Mining Association	$5,000
East Kootenay Chamber of Mines	$5,000

TABLE 3
PAP ASSOCIATED PROPERTIES SINCE 1996

Property	Prospector	Grant Year	Ownership and Work	Expenditures to Date	Planned Expenditures
Alley	Adam Travis	2000	Santoy Resources Ltd. did some work in 2001.	unknown	undisclosed
Allin	John Kemp	1996	Worked 1996-1998 by Hudson Bay Mining.	$370,000	nil
Ample-Goldmax	Dave Javorsky Gary Polischuk	1995	Inactive since Gold Ore Res. work of 1999.	$850,000	nil
Babs	Ralph Keefe	1995	1996 work by Pacific Sentinel Gold Ltd.	$360,000	nil
Bizar/Goldstrike	Leo Lindinger	1998	Cassidy Gold Corp. Worked in 1999 and 2000. Returned to vendor.	$47,000	nil
Broken Hill	Leo Lindinger	2000	Cassidy Gold Corp.	$220,000	nil
Carbonado	Dave Javorsky	1999	Operated by Icefield Diamond Mines in 2000.	$100,000	undisclosed
Cam-Gloria	Camille Berube	1997	Inactive since Teck Corp. work of 1999.	$100,000	nil
Demers	Bob Bourdon	1999	Operated by Inmet Mining Corp. in 2000. Option picked up by Cassidy Gold Corp in 2001.	$72,000	undisclosed
Dominion Creek	Allan Raven	1998	Worked in 2000 by Gold City Industries.	$220,000	undisclosed
Findlay Creek	Tim Termuende	1995	Worked from 1996 to 1999.	$2,000,000	nil
Fox	Dave Ridley	1999 2000	Optioned in 2001 to Starcore Resources Ltd.		$240,000
Hen/Ledge	Dave Ridley	1997	Mandaly Resources Corp. Optioned 1998, worked 1999 and 2000. Dropped in 2001.	$130,000	nil
Jasper	Arne Birkeland	1994 1995	Work by Inspiration Mining Corp. 1996, 1998 and 2000.	$126,000	$500,000
Joe	John Kemp	1996	Inactive since Pender Gold Corp option of 1996.	$83,000	nil
Ladybug	Leo Lindinger	1996	Worked in 1998 and 1999 by Cross Lake Minerals Ltd.	$102,000	unknown
Lottie Lake	Martin Peter	1997 1998	Operated by Hudson Bay Mining and Smeltin in 1998, 1999 and 2000. Option reverted to Eureka Resources in 2001.	$930,000	unknown
Mark	Dave Javorsky	1999	Operated by Kootenay Diamond Mines in 2000.	$46,000	undisclosed
McNeil Creek	Frank O'Grady	1995 1996	1998 work by Sedex Mining Corp. Optioned by National Gold Corp. in 1999.	$85,000	$1,000,000
McPhee	Bruce Doyle	1999	Cassidy Gold Corp in 2000. Option dropped in 2001.	$55,000	nil
Peg	Peter Klewchuk	2000	Chapleau Resources Ltd. Option later dropped.	$40,000	nil
Quill	Allan St. James	1998	Worked in 1999 by Petra Res.	$120,000	nil
Red Mountain	Charles Kowall	1988	Wheaton River Minerals.	>$200,000*	undisclosed
Silver Lynx	Bruce Doyle	2000	Cassidy Gold Corp.	$100,000	$250,000
Zymo	Robin Day	1996 1997 1998	Worked in 1999 by Freeport Copper Company.	$200,000	nil
TOTAL				**$6,356,000**	**$1,990,000**

** 10 million dollars spent on follow-up program on Red Mountain*

CONCLUSIONS

The year 2000 program produced immediate benefits for the province including options and claim staking. Program funded prospectors were able to option 6 recently discovered mineral occurrences to mining companies for further exploration that has the potential to generate at least $1,000,000 worth of exploration activity over the next few years. The grants played a critical role in allowing these prospectors to find and then develop their discoveries to a level that excited corporate interest.

A number of other new mineral occurrences were discovered by grantees in 2000 that will see further exploration over the coming years, and in all likelihood lead to more company investment. As well, work done by grantees in previous program years continues to generate corporate exploration investment in the province. Some of these PAP-related properties that were discovered after 1995 have since generated a minimum of 6.35 million dollars worth of activity with a further $2 million planned (Table 3).

The overall performance of the active grantees in 2000 was excellent. The average number of prospecting days per grantee was 43. While this is the lowest total number of prospecting days to occur in five years, the lower value was to be expected with this year's lowering of the required minimum number of prospecting days to 21 days from the previous 30 days. In 2002, a total of 898 claim units were staked by the 52 active grantees. What is surprising is that there was an actual 24% increase in the number of claim units staked per grantee over last year even with the fewer total prospecting days (Table 1). This continues a trend of increased claim staking that started in the mid 90s (Figure 2) and may be an indication of a more buoyant exploration community.

The final report evaluations were high with 35 (67%) of the active grantees scoring 8 out of 10 or higher and only 4 (7.7%) scoring 5 or lower. The average score was 8.2.

The decline in the number of option deals made by BC's prospectors in the late 1990s (Table 1) is an indication of the difficult times that BC's prospectors have had to endure. Many good prospectors have been sustained through these difficult times with the help of the grant program and a number of new mineral prospects have been discovered with the aid of PAP grubstakes. Some of these, as previously documented, have been optioned to exploration companies, whose subsequent work and financial investment has helped sustain BC's important mining industry.

It was announced on January 16, 2002 that the Prospector Assistance program would not be funded in the future. The program was cancelled after a government wide review of all subsidy programs.

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