British Columbia's Mineral Sector:

Prospects for the 1990s

Province of British Columbia
Ministry of Energy, Mines and
Petroleum Resources

Prospects for the 1990s

Hon. Anne Edwards, Minister
B.C. Ministry of Energy, Mines
and Petroleum Resources

British Columbia has a long history of mining. Coal, copper and other minerals have always and will continue to play a very important role in the economic, social and community development of our province.

As we move further into the decade of the 1990s the government of British Columbia will ensure a healthy climate for exploration and improve our overall competitiveness in the global economy.

There is strong potential for development in our mineral sector covering a wide array of commodities and related processing activities. This booklet just begins to describe the potential.

I hope you will take a look!

Province of British Columbia
Ministry of Energy, Mines and
Petroleum Resources

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British Columbia

An Overview of British Columbia

Mining is one of the cornerstones of British Columbia's economy from both a historical and a current perspective. Beginning some 150 years ago, with the coal mines of Vancouver Island and the placer gold camps of the Cariboo, British Columbia has become one of the world's great mining regions and its industry is internationally recognized for its expertise in mineral exploration and mine development. With our abundant mineral resources and skilled industry, mining is set for continued development in the years ahead.

The Industry Today

Today, British Columbia produces and exports over $2.5 billion (all figures are in Canadian dollars) worth of copper, coal, gold, zinc, molybdenum, silver, lead, and a growing variety of industrial minerals and structural materials.

Six mines produce metallurgical coal in southeastern and northeastern British Columbia; and two produce thermal coal, one in the southeast and the other on Vancouver Island.

There are nine base metal mines, including five large open-pit operations, and six precious metal mines at various locations throughout the province. Together they provide well-paid employment for approximately 20 000 men and women, and an additional 25 000 to 30 000 indirect jobs in the supply, service and support fields. This highly sophisticated and efficient industry competes successfully in world markets. The complex geological history of our province, similar to that of other countries along the North and South American Cordillera, has provided British Columbia with a rich and varied mineral endowment. In addition we enjoy access to an ample supply of relatively low-cost power, good transportation systems and other physical infrastructure, and a strategic location well positioned to serve fast-growing Pacific Rim markets.

People employed in British Columbia's mineral industry—mine and mill workers, engineers and geoscientists, managers and technical experts in many fields—are highly skilled and productive and are in demand throughout the world. Vancouver has become a major financial centre strongly oriented toward international trade in natural resources. It is also an important source of capital for mineral exploration and development, both within the province and internationally. British Columbia has become

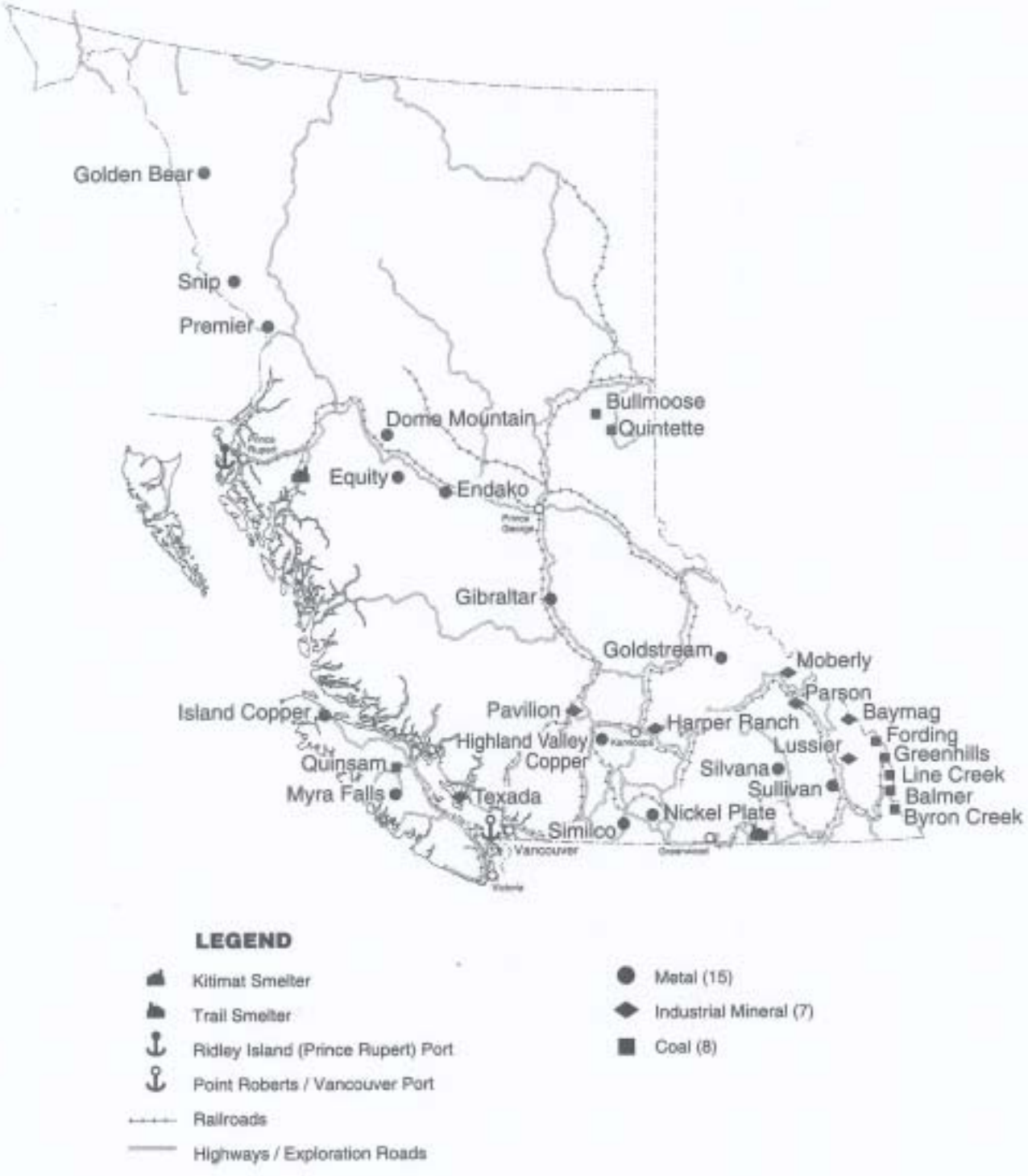


Figure 1
Operating Mines in British Columbia in 1992

internationally recognized as a centre of excellence in mining and related fields such as metallurgy, environmental engineering, mine safety and the geosciences.

Opportunities

Significant investment opportunities exist in British Columbia's mineral sector. In the mineral exploration and development field our abundant and diverse mineral resources hold opportunity for new, significant discoveries or development of known deposits that would be profitable in highly competitive world markets. Deposits that are at the advanced stage of exploration or are awaiting development, having received approval in the province's Mine Development Assessment Process, are identified on the accompanying illustrations.

Other strategic opportunities include the pursuit of innovative technologies in mineral exploration, mining, mineral processing and smelting, and the development of new markets and products particularly in the fields of structural materials, industrial and "high-technology" minerals.

Development Highlights
Current Targets and Opportunities

The discovery of new mineral deposits that will be the mines of tomorrow is essential for a healthy mining industry. Mineral exploration is big business in British Columbia but, as in other countries, is also cyclical.

A significant portion of the risk capital required for this industry comes from foreign, private and corporate sources. The balance is provided by the Vancouver Stock Exchange and profitable domestic mining operations. In the last decade annual mineral exploration expenditures have ranged from $75 to $225 million and total approximately $1.5 billion.

Several important new base and precious metal deposits were discovered. As a result of these discoveries, 20 new mines were commissioned during this period and many new projects passed through or recently entered the Mine Development Assessment Process.

One small gold mine, Dome Mountain, was commissioned in 1992, and two major projects received government approval—the Mt. Polley copper-gold project of Imperial Metals Corporation, and the Stronsay lead-zinc-silver project of Curragh Resources Ltd. These projects, and others at the development or advanced exploration stage, are important examples of precious and base metal deposits that are most actively sought the world over: copper and copper-gold porphyry deposits, volcanogenic massive sulphide (Kuroko type) deposits, sedimentary-exhalative lead-zinc-silver deposits, and mesothermal auriferous veins. In addition there are numerous deposits in the province at less advanced stages of exploration.

Opportunities

The exploration and development sector offer investment opportunities at all levels, from grass-roots exploration to mine and mill construction, the development of new technology for mineral exploration, and the establishment or expansion of transportation and other physical infrastructure vital to this industry.

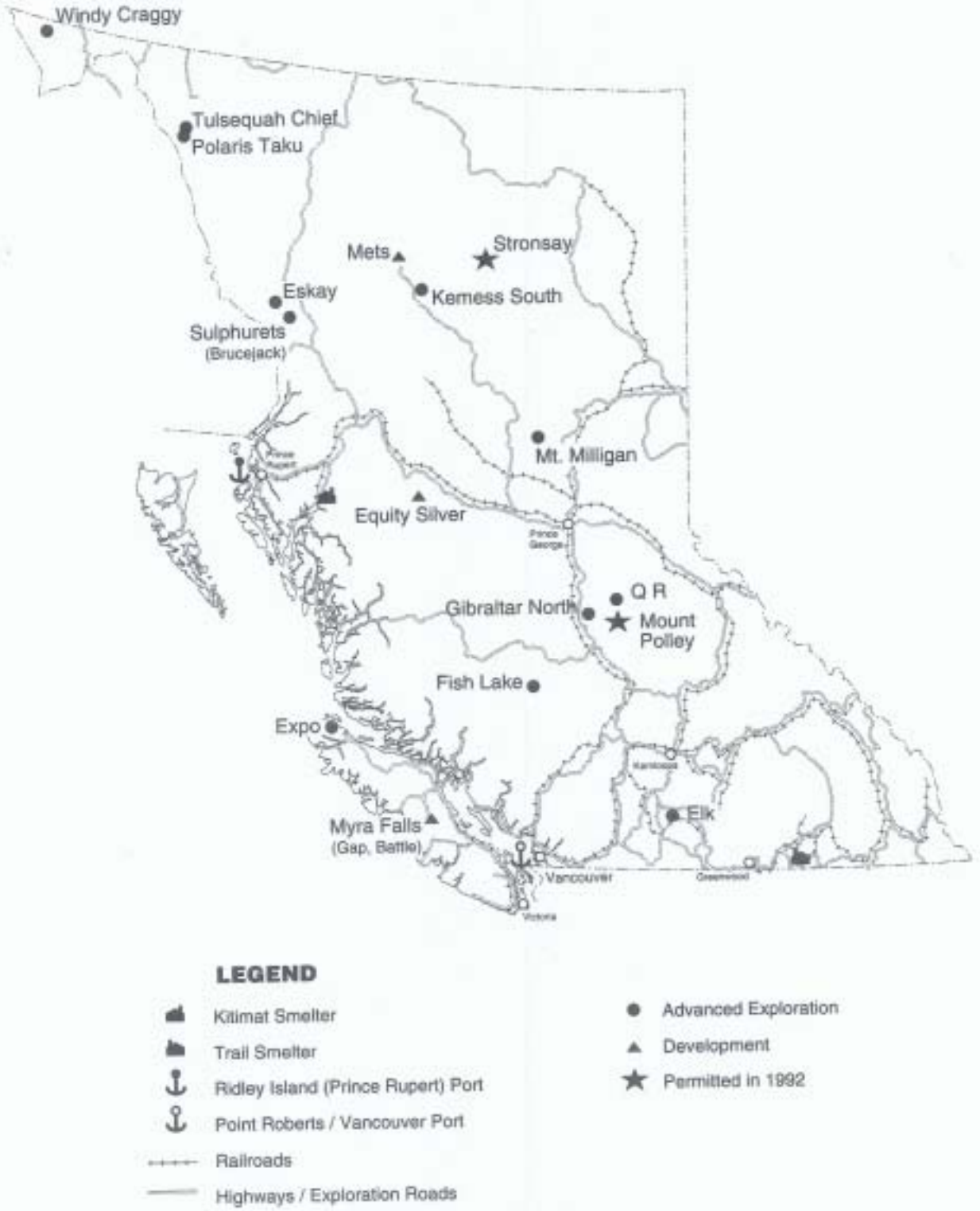


Figure 2
Advanced Exploration / Development Highlights

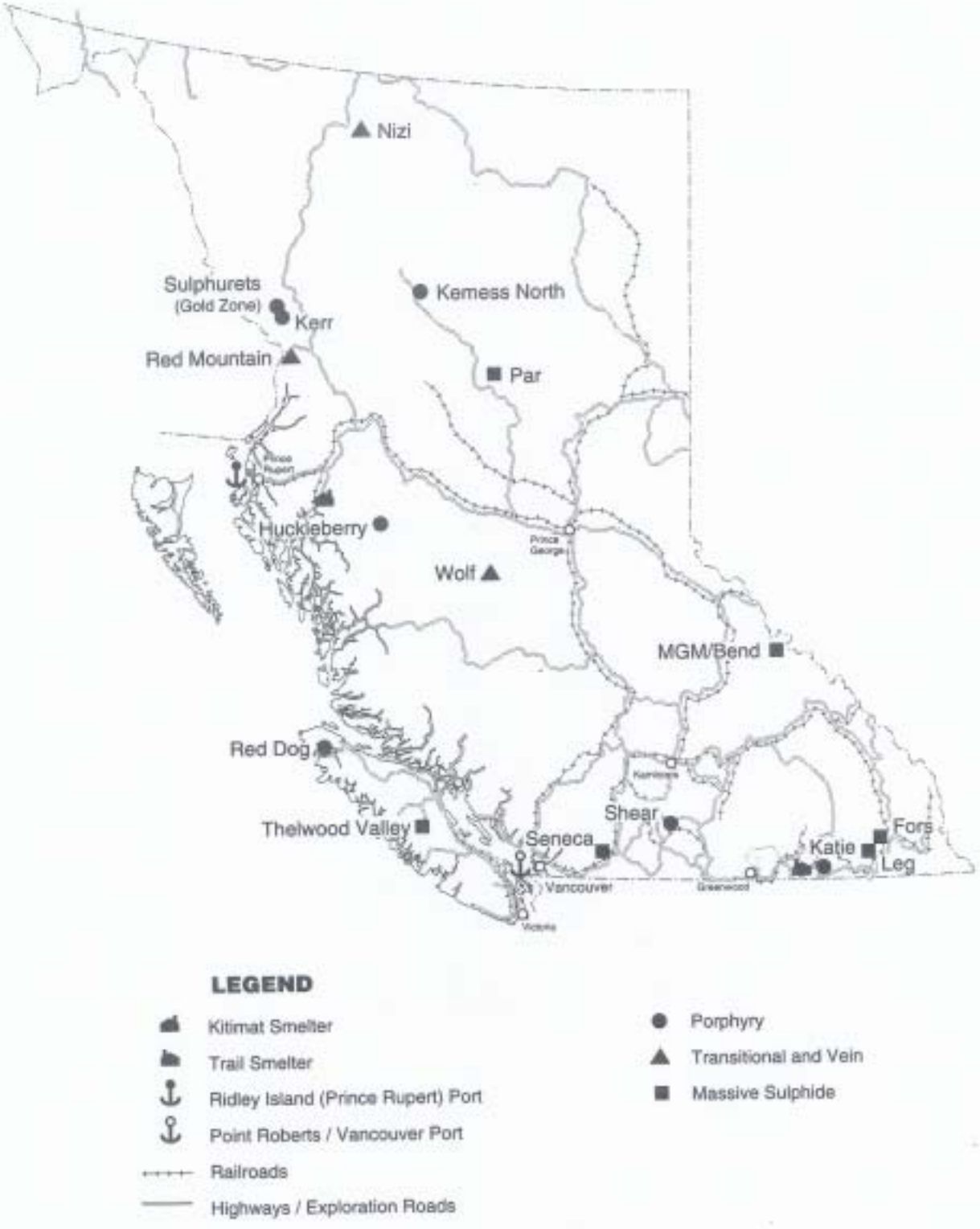


Figure 3
Exploration Highlight Projects

Geologic Setting and Mineral Opportunities

Canada is centred by ancient rocks of the Canadian Shield. The Shield is partly overlain by the Interior Platform and flanked to the east and west by mountain belts. British Columbia is within the Cordilleran belt, which makes up the western margin of North America from Alaska to Mexico.

The eastern part of the Cordillera, comprising the Foreland and Omineca Belts, is a deformed and broken, fold and thrust belt that consists dominantly of sedimentary rocks eroded from North America. The western part consists of a series of volcanic terranes accreted as a result of interactions of the Pacific and North American tectonic plates; the accretion of each new terrane extended the edge of the continent westward.

The complex geological processes that formed the Cordillera are reflected in the distribution of its mineral resources. Belts of distinctive rocks, each with a characteristic suite of mineral deposits, run northwest-southeast through British Columbia, approximately parallel to both the ancestral continental margin and the present coastline. As a result, the character of the province's mineral resources varies most markedly west to east. The dominantly volcanic terranes to the west contain deposits of copper, iron, gold, silver and molybdenum, while the sedimentary rocks to the east are rich in lead, zinc and silver. For the same reason, most of the oil, natural gas and industrial mineral resources, formed by various sedimentary processes, are located along the eastern margin of the Cordillera.

The most important metallic mineral deposit types include:

- zinc and copper bearing massive sulphides,
- sedimentary-exhalative lead-zinc-silver deposits,
- copper-molybdenum and copper-gold porphyry deposits,
- mesothermal gold veins,
- epithermal gold-silver veins, and
- base and precious metal skarns.

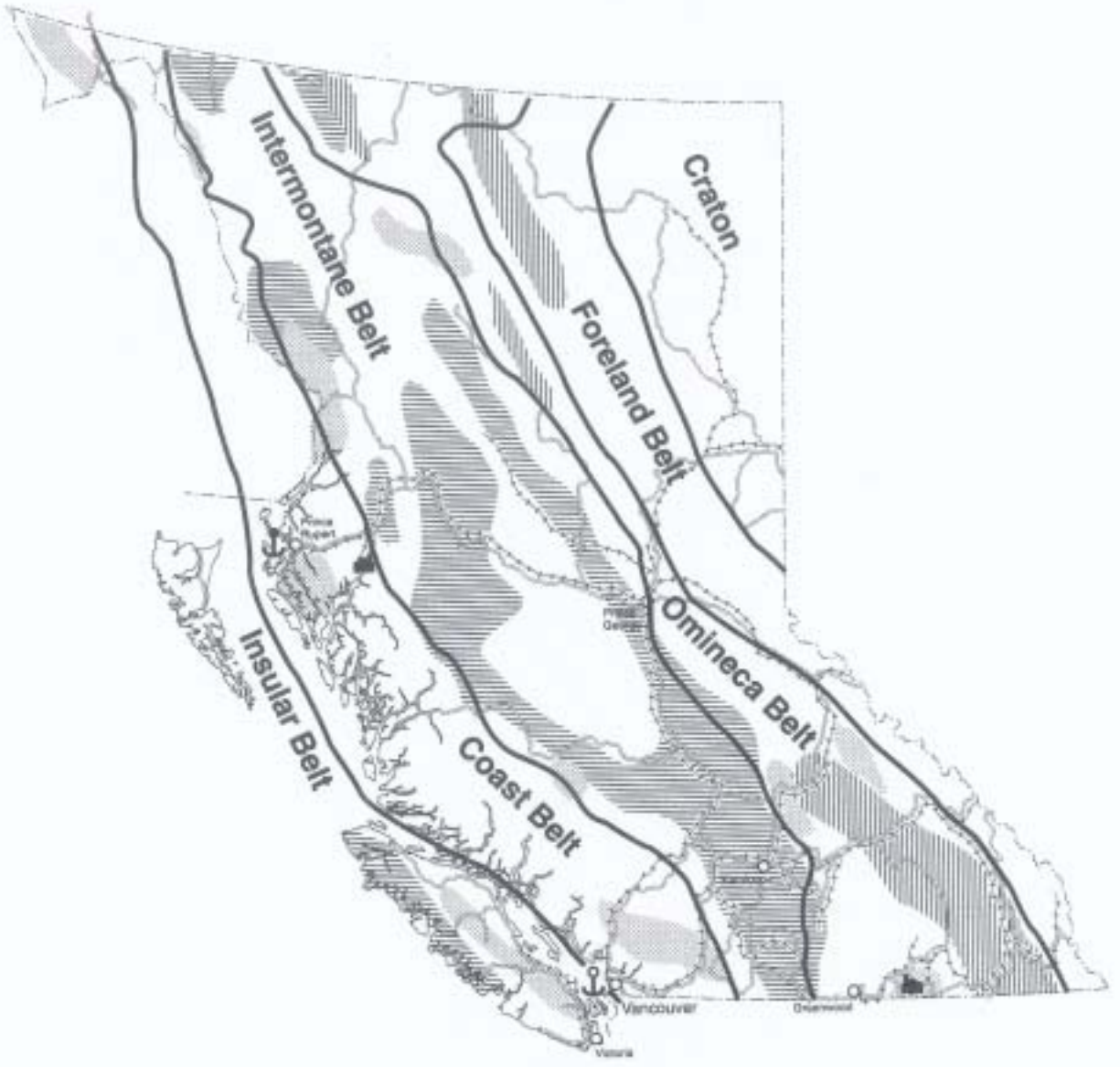


Figure 4
Tectonic Belts and Prospective Areas

Mineral Deposits of the Ancient Continental Margin

The Foreland and Omineca Belts consist largely of material deposited in extensional settings during three main episodes of rifting that created a thick wedge of sediments along the western edge of the North American craton. The initial event, some 1200 million years ago, in middle Proterozoic time, produced clastic sediment and carbonate sequences many kilometres thick. Clastic rocks of this succession host the famous and prolific Sullivan lead-zinc-silver sediment-hosted exhalative (sedex) deposit in southeastern British Columbia.

Some 500 million years later, in late Proterozoic time, a second series of rifting events occurred along the length of the Cordillera. Evidence of volcanic activity, basic flows and dikes, is widespread in the sediments related to this protracted episode in earth history. Extensive deposits of cherty iron formation in the McKenzie Mountains of the Yukon Territory were formed at this time.

A major metallogenic episode accompanied the third period of rifting, deformation and volcanism along the continental margin, in mid-Devonian to early Mississippian time. It produced sedex barite-lead-zinc-silver deposits in the Selwyn Basin and the Kechika Trough. One, the Stronsay deposit in northern British Columbia, recently received approval for mine development. Platformal carbonate rocks of similar age host Mississippi Valley-type lead-zinc deposits in the northern Rocky Mountains.

Mineral Deposits of Accreted Terranes

Younger rocks of the Intermontane, Coast and Insular Belts host polymetallic massive sulphide deposits of the Kuroko type, massive cupriferous pyrite deposits analogous with those found on the island of Cyprus, and copper-zinc deposits classified as Besshi type that have made significant contributions to British Columbia's production of copper, zinc and silver. Porphyry copper-molybdenum and copper-gold deposits are associated with subvolcanic felsic intrusions, particularly in the Intermontane and Insular Belts. Production from these deposits has underpinned the province's copper industry for the last two decades. Significant iron, copper and gold production has been obtained from skarns formed during arc construction, and modest amounts of nickel and copper have been recovered from orebodies within more mafic intrusions.

Early Cretaceous mesothermal gold deposits have been mined along the length of the North American Cordillera, from Cassiar in northern British Columbia, to Bralorne in the south of the province and to the Mother Lode district in northern California. Although not directly related to island arc volcanism, all occur in fragments of deep oceanic crust thrust upwards onto the continental margin during terrane accretion.

Copper

In recent years copper has vied with coal as the most important mineral commodity mined in British Columbia, in terms of dollar value. The value of annual production reached $900 million in 1992, 36 percent of the total for all the province's mineral products. British Columbia accounted for 43 percent of Canadian copper output in 1991, and 3.8 percent of western world production in 1990. All production is exported as concentrate, principally to smelters in Japan (80 percent), Spain (8 percent) and the Philippines (8 percent).

Copper has long been a mainstay of the province's metal mining industry. The earliest production was from skarn and massive sulphide deposits. The first production from porphyry copper deposits was from the Bethlehem mine in the Highland Valley southwest of Kamloops in 1962. The Highland Valley became the province's leading copper-producing district with the opening of the Lornex mine in 1972 and its position has never been challenged.

Following a decade of vigorous and successful exploration and new mine development in the 1960s and 1970s, open-pit mining of porphyry copper deposits now accounts for almost 90 percent of British Columbia's copper production. In terms of milling capacity, the Highland Valley mine is now second only to Chuquicamata in Chile among copper producers in free market economies, accounting for 177 500 tonnes of copper in 1991 or approximately 2.5 percent of western world production. Total copper production from the Highland Valley deposits is approaching 2.3 million tonnes with significant byproduct molybdenum, gold and silver. Ore reserves in the Highland Valley are currently estimated at 750 million tonnes containing 3 million tonnes of copper. Other current porphyry copper producers are the Island Copper mine on Vancouver Island (58 000 tonnes per year); the Gibraltar mine near Williams Lake (28 000 tonnes per year) and the Similco operation at Copper

Company Name	Project Name	Commodity	Estimated Tonnes (000s)	Estimated Grade
Porphyry deposits				
Taseko Mines Ltd.	Fish Lake	Cu, Au	1 080 000	0.23% Cu, 0.41 g/t Au
El Condor Resources Ltd.	Kemess South	Cu, Au	207 000	0.23% Cu, 0.64 g/t Au
St Philips Resources Inc.				
Jordex Resources Inc.	Expo/Hushamu	Cu, Au, Mo	173 260	0.25% Cu, 0.31 g/t Au, 0.01% Mo
Imperial Metals Corp.	Mount Polley	Cu, Au	49 000	0.38% Cu, 0.55 g/t Au
Gibraltar Mines Ltd.	Gibraltar North	Cu	50 000+	0.4% Cu
CMP Resources Ltd.	Q R	Au	1 200	5.2 g/t Au
Placer Dome Inc.	Mount Milligan	Cu, Au	284 000	0.2% Cu, 0.58 g/t Au
Massive Sulphide deposits				
Westmin Resources Ltd.	Battle Zone/ Myra Falls	Cu, Pb, Zn, Ag, Au	3 018	2.9% Cu, 0.4% Pb, 14.0% Zn, 24.0 g/t Ag, 1.0 g/t Au
Geddes Resources Ltd.	Windy Craggy	Cu, Au, Ag, Co	297 440	1.38% Cu, 0.2 g/t Au, 3.83 g/t Ag, 0.069% Co
Curragh Resources Ltd	Stronsay	Pb, Zn, Ag	22 080	2.8% Pb, 9.4% Zn, 60 g/t Ag
Homestake Canada Ltd.	Eskay Creek 21B	Au, Ag	1 190	59.41 g/t Au, 2659.3 g/t Ag
Redfern Resources Ltd.	Tulsequah Chief	Cu, Pb, Zn, Au, Ag	7 800	1.6% Cu, 1.18% Pb, 6.47% Zn, 2.74 g/t Au, 109.72 g/t Ag
Transitional & Vein deposits				
Equity Silver Mines Ltd.	North Waterline Zone	Cu, Au, Ag	750	0.68% Cu, 209 g/t Ag 4.18 g/t Au
Cheni Gold Mines Ltd.	Mets	Au	53.5	11.62 g/t Au
Golden Rule Resources Ltd.				
Manson Creek Resources Ltd.				
Canarc Resources Corp.	Polaris-Taku	Au	2 590	14.74 g/t Au
Suntac Minerals Corp.				
Newhawk Gold Mines Ltd.	Brucejack Lake	Au, Ag	749.3	15.43 g/t Au, 647.2 g/t Ag
Granduc Gold Mines Ltd.	(Bruceside)		(West Zone)	
Fairfield Minerals Ltd.	Elk	Au	308.4	22.18 g/t Au, 24.68 g/t Ag

Table A
Advanced Exploration / Development Projects

Company Name	Project Name	Commodity	Estimated Tonnes (000s)	Estimated Grade
Porphyry deposits				
Placer Dome Inc.	Kerr	Cu, Au	126 000	0.62% Cu, 0.274 g/t Au
Placer Dome Inc.	Sulphurets Gold (Sulphside)	Au, Cu	18 000	0.35% Cu, 0.823 g/t Au
New Canamin Res. Ltd.	Huckleberry	Cu, Au	78 000	0.401% Cu, 0.025% MoS2
El Condor Res. Ltd.	Kemess North	Cu, Au	116 109	0.19% Cu, 0.377 g/t Au
Placer Dome Inc.	Shear	Cu, Au	n/a	n/a
Yellowack Res. Ltd.	Katie	Cu, Au	n/a	n/a
Crew Natural Res. Ltd.	Red Dog	Cu, Au, Mo	25 000	0.35% Cu, 0.44g/t Au, 0.006% Mo
Massive Sulphide deposits				
Cominco Ltd.	Par	Pb, Zn, Ag, Ba	n/a	n/a
Teck Explorations Ltd. Cominco Ltd.	MGM/Bend	Zn, Pb, Ag	n/a	n/a
Kokanee Explorations Ltd., Chapleau Res. Ltd., Barkhor Res. Inc.	Fors	Ag, Pb, Zn	n/a	n/a
Kokanee Explorations Ltd., Legion Res. Ltd.	Leg	Zn, Ag, Ba	n/a	n/a
Minnova Inc. International Curator Res. Ltd.	Seneca	Zn, Cu, Au, Ag	533	0.91% Cu, 0.22% Pb, 7.06% Zn, 68.8 g/t Ag, 1.44 g/t Au
Westmin Resources Ltd.	Thelwood Valley (Myra Falls)	Cu, Pb, Zn, Ag, Au	n/a	n/a
Transitional & Vein deposits				
Lac Minerals Ltd.	Red Mountain (Marc Zone)	Au	840	12.68 g/t Au
Gold Fields Canadian Mining Ltd.	Nizi	Au, Ag	n/a	n/a
Minnova Inc.	Wolf	Au	n/a	n/a

Table B
Exploration Highlight Projects

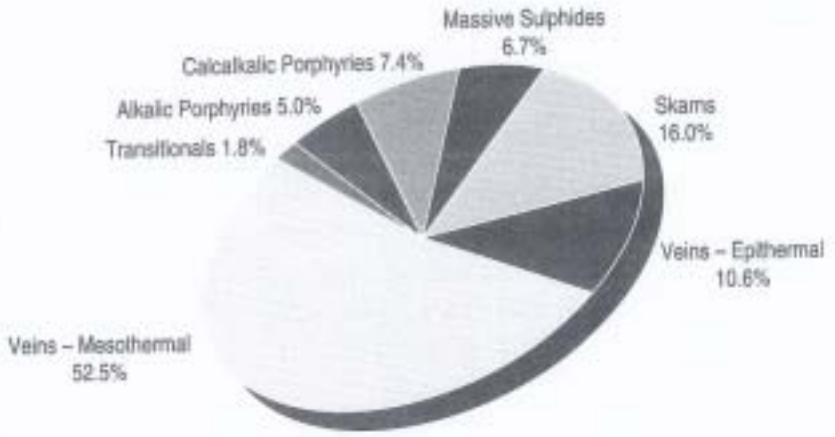
Mountain (14 500 tonnes per year). Significant undeveloped porphyry copper-molybdenum and copper-gold deposits have been recently discovered. Their principal characteristics are summarized in Table A.

The balance of British Columbia's copper production is from skarns and volcanogenic massive sulphide deposits. All produce other metals as byproducts or coproducts, including gold, silver, lead, zinc and iron. Only two deposits of this type, the Westmin operations at Myra Falls on Vancouver Island and the Goldstream mine near Revelstoke, are currently in production but important properties are being explored or awaiting development. Most notable among these are the Tulsequah Chief deposit where significant new reserves of polymetallic ore have been delineated, and the huge Windy Craggy deposit, estimated to contain over four million tonnes of copper, almost 60 000 kilograms of gold and significant amounts of cobalt. Volcanogenic deposits of the Kuroko type, of which Tulsequah Chief and Myra Falls are examples, are favoured exploration targets. Exploration for these deposits is challenging, but British Columbia offers excellent potential for new discoveries.

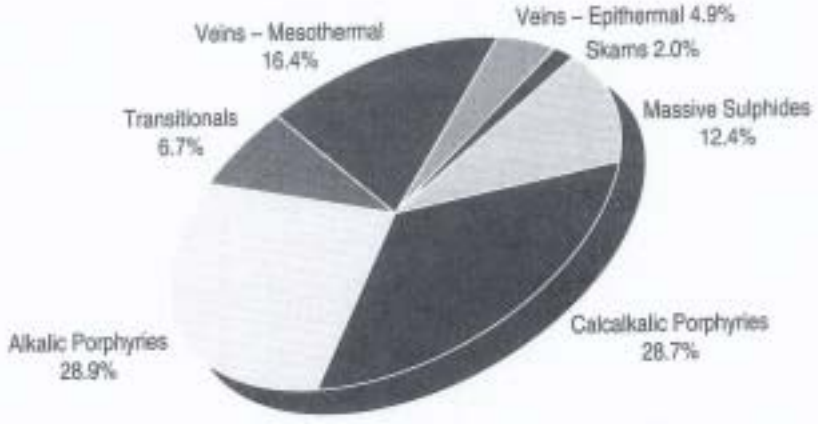
Other deposit types have made relatively small contributions to British Columbia's copper production. Copper, together with chromium, cobalt, gold, platinum and palladium, was an important byproduct of magmatic nickel orebodies worked at the Giant Mascot mine near Hope, on the Fraser River. Byproduct copper is also produced from subvolcanic and epithermal vein deposits mined primarily for their precious metal content; examples include the Equity Silver and Silbak Premier mines. Sediment-hosted copper deposits have never been mined in British Columbia but significant potential is known to exist, most notably the Sustut deposit in the northcentral part of the province with geological reserves estimated at 50 million tonnes with a grade of 1.25 percent copper.

Gold

Since 1971 annual gold output has increased steadily, reaching 17 385 kilograms in 1991. Initially this production increase was underpinned by byproduct gold from newly developed porphyry copper mines. Another major reason was the dramatic increase in the gold price during the 1970s that stimulated a massive renewal of interest and resulted in the discovery of new vein deposits. It is estimated that more



B.C. Lode Gold Production (1890-1990)
by Deposit Type
Total Production 683.4 Tonnes



1991 B.C. Lode Gold Reserves
by Deposit Type
Total Reserves 1813 Tonnes

Figure 5
Lode Gold Production and Reserves

than $1 billion has been spent on gold exploration in the province since 1985, adding substantially to known geological reserves.

The precious metal potential of undeveloped porphyry deposits is well illustrated by past production records. To date, byproduct gold production from British Columbia porphyry deposits exceeds 85 tonnes. Of this, almost 90 percent has been recovered from five deposits.

The Expo and Red Dog porphyry deposits, both within trucking distance of the Island Copper concentrator, together contain over 70 tonnes of gold. Other undeveloped porphyry copper-gold deposits with contained gold estimated in excess of 100 tonnes include Fish Lake (437 tonnes), South Kemess (148 tonnes) and Mount Milligan (134 tonnes). The much smaller, but slightly higher grade Mount Polley deposit in the Cariboo district, with reserves containing 28 tonnes of gold, has been permitted and is moving toward production.

Notwithstanding the large potential for gold reserves in porphyry copper deposits, nearly 80 percent of gold production in British Columbia has been won from three other types of deposits: mesothermal veins; epithermal deposits; and skarns.

Mesothermal Veins: This deposit type has accounted for more than half of the province's historical gold production. Recent developments include the opening of the Golden Bear mine in 1989 and the Snip mine in 1991, both in remote mountainous areas of northwestern British Columbia. The Snip mine, operated by Cominco Ltd., provides an excellent example of how a small but efficient high-grade operation can be profitable, even in the most isolated of areas.

Epithermal Deposits: The Premier mine in the Stewart camp produced more than 61 tonnes of gold from high-grade epithermal ores during the period 1918-1976. The mine was reopened in 1989 as an open-pit operation working low-grade ore. The Lawyers mine in the Toodoggone district has produced 5.4 tonnes of gold and 108.9 tonnes of silver while operating from 1989 to 1992. The Blackdome mine in the Chilcotin district, although small is among the province's most successful recent mining developments. With a start-up reserve of only 184 000 tonnes of ore, this mine produced 7 tonnes of gold and 24 tonnes of silver during its short operating life from 1986 to 1990.

A poorly understood class of deposits transitional between porphyries and epithermal veins, is also a potentially important source of both gold and silver. The best known example in British Columbia is the Equity mine near Houston in the central part of the province. Opened in 1981, the mine has produced more than 15 tonnes of gold and 2000 tonnes of silver as well as significant amounts of copper. Research in progress suggests there is excellent potential for the discovery of similar deposits elsewhere in the province, notably on northern Vancouver island.

Gold Skarns: These account for 16 percent of past gold production in the province but most were derived from two districts, Hedley and Greenwood. Since 1904, when the Nickel Plate Mine first opened at Hedley, more than 65 tonnes of gold have been recovered. The mines in the Greenwood district, worked primarily for their copper content, have yielded over 35 tonnes gold.

Volcanogenic Massive Sulphides: Gold production from volcanogenic massive sulphide deposits accounts for less than 10 percent of historic production, but this proportion may soon increase. The 25 million tonnes of polymetallic massive sulphide ore at Westmin's Myra Falls mines are estimated to contain 47.5 tonnes of gold. Recent reserve estimates for Kuroko-type deposits at the Tulsequah Chief mine are 7.8 million tonnes with an average grade of 1.6 percent copper and 2.7 grams per tonne gold. The discovery of high-grade deposits at Eskay Creek northwest of Stewart in 1988 may well push the Iskut district into the ranks of the top producers. Reserves in the 21B deposit alone contain 70 tonnes of gold. The huge Windy Craggy massive sulphide deposit contains close to 60 tonnes of gold (Table A).

Lead, Zinc and Silver

Canada is the world's largest producer and exporter of zinc and the third largest producer of lead, ranking behind the United States and Australia. Both metals are commonly produced together, with considerable byproduct silver. Recent Canadian production totals over 1.1 million tonnes of zinc, 240 000 tonnes of lead and 1240 tonnes of silver annually. Approximately 10 percent of the zinc, 25 percent of the lead and 40 percent of the silver were mined in British Columbia.

Though no longer the largest lead-zinc producer in the world, a position it held for many years, the Sullivan mine continues to dominate production of lead and zinc in British Columbia, and it has recently accounted for almost 85 percent of the zinc and 95 percent of the lead mined in the province. Concentrates are smelted and refined at the metallurgical complex in Trail, which also receives feed from mines in adjacent Washington State, State of Alaska and elsewhere in Canada.

The Sullivan orebody belongs to the class of sediment-hosted exhalative (sedex) deposits that are prolific producers of lead and zinc the world over. Other sedex deposits are known in British Columbia. One of them, the Stronsay orebody located in the Kechika Trough in northern British Columbia, is currently being developed for production. Reserves are estimated at 22 million tonnes containing 2.1 million tonnes of zinc, 616 000 tonnes of lead and over 1325 tonnes of silver. The development of the Stronsay deposit will provide needed infrastructure and rekindle exploration in the entire Kechika Trough. The balance of British Columbia's zinc production is largely derived from the H-W and Lynx volcanogenic massive sulphide orebodies at Westmin Resources' Myra Falls mine on Vancouver Island. Recent production is about 25 000 tonnes of zinc concentrate annually, together with significant amounts of copper, gold and silver. The recent discovery of the Gap and Battle orebodies with reserves of approximately four million tonnes of high-grade ore will contribute to a long and prosperous life for this operation.

Other lead and zinc production is obtained from volcanogenic deposits, and as coproducts from mining high-grade silver veins. Following its reopening in 1991, the Goldstream mine near Revelstoke initially produced only copper concentrates from its volcanogenic massive sulphide orebody, but zinc concentrate production resumed in 1992.

Besides the Stronsay deposit there are significant resources in undeveloped volcanogenic massive sulphide deposits such as the Tulsequah Chief (estimated 500 000 tonnes zinc and 90 000 tonnes lead) and several other less-explored deposits. The future of lead, zinc and silver production in British Columbia is highly promising.

Molybdenum and Tungsten

Molybdenum and tungsten occur associated with granitic rocks but are rarely both recovered from a single deposit. Canada ranks third in the world in molybdenum production, after the United States and Chile, and virtually all of Canada's production is mined in British Columbia. Tungsten has been mined in the province but there is no current production.

Molybdenum

Approximately 9200 tonnes of molybdenum was mined in British Columbia in 1992, down from 10 800 tonnes the previous year, and the metal is a major source of export earnings. In 1990, for example, 83 percent of the production was exported, with Japan (39 percent) and Western Europe (18 percent) the major destinations. Between 1950 and 1992, more than 320 000 tonnes of molybdenum has been mined in the province, with a value of $2.75 billion. Production peaked in 1977 at 15 520 tonnes and has since fluctuated between 6000 and 14 000 tonnes annually.

Large-scale and continuous production of molybdenum did not begin until the 1960s. Most of the porphyry copper deposits discovered in the 1960s contained significant amounts of molybdenum and their development transformed the molybdenum mining industry in the province. Three of the four currently operating open-pit porphyry copper mines, Island Copper, Gibraltar and Highland Valley Copper, produce significant amounts of byproduct molybdenum. The Endako porphyry molybdenum mine, the only currently operating primary producer of molybdenum in the province, now accounts for more than 70 percent of production.

The potential for new mine production of molybdenum in British Columbia is excellent. Several porphyry deposits containing molybdenum as their principal commodity remain undeveloped in addition to a number of undeveloped porphyry copper deposits which also contain significant molybdenum

Tungsten

The province has a short history of tungsten mining. A total of 9200 tonnes of tungsten concentrate was produced, mostly from high-grade skarn deposits in southern British Columbia that were worked intermittently between 1944

and 1972. Large areas of the province are prospective for similar deposits and more than 50 tungsten skarn occurrences are known.

Although the province is not currently producing tungsten, two of the world's largest tungsten-bearing skarns, the Cantung and Mactung deposits, with combined reserves of 36 million tonnes of tungsten ore, are located in the MacKenzie Mountains in the Yukon and Northwest Territories. The geological setting of these deposits can be traced south to poorly explored areas of British Columbia, offering significant potential for major discoveries.

Coal

Coal rivals copper as British Columbia's most important mineral product. Production in 1992 was over 15 million tonnes of metallurgical coal, valued at $645.6 million, and 2.5 million tonnes of thermal coal, valued at $75.2 million, for a total minehead value of $720.8 million, representing a little over half of Canada's total coal production. Almost all British Columbia's production was exported through two ocean terminals, at Robert's Bank near Vancouver in the south and Ridley Island at Prince Rupert on the north coast. Together, these two ocean ports can handle 38 million tonnes of coal exports annually and have storage capacity for 4.4 million tonnes.

All three of the non-crystalline tectonic belts in British Columbia contain significant coal deposits, but the *Rocky Mountain* coalfields in the Foreland Belt along the eastern edge of the Cordillera are by far the most important in terms of production. Coal reserves in the province total 2.15 billion tonnes of metallurgical coal and 880 million tonnes of thermal coal. In addition, 14.35 billion tonnes of metallurgical coal and 5.13 billion tonnes of thermal coal are classified as resources of potential economic interest in the near to medium term.

Rocky Mountain Coalfields

The *Flathead, Crowsnest* and *Elk Valley* coalfields extend northwards through the East Kootenay district from the Montana border. They are the most important in the province, having produced well over 100 million tonnes of metallurgical coal and about 10 million tonnes of thermal coal since 1898. The rank of Kootenay coals varies from low to high-volatile A bituminous.

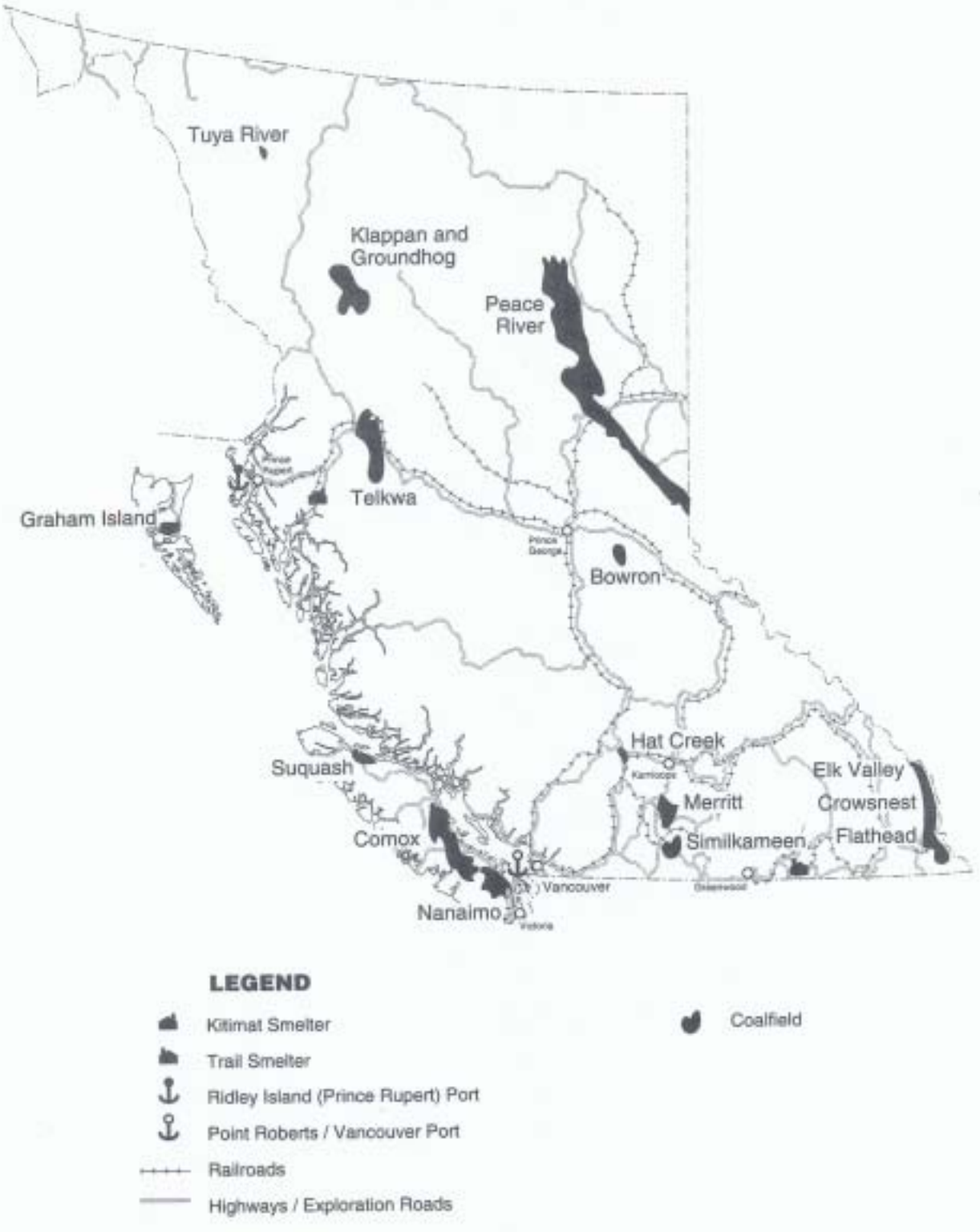


Figure 6
Coalfields in British Columbia

Five surface mines in these coalfields produce a range of coking, semi-coking and thermal coal products: Elkview Coal Corporation (Teck Corp.) Balmer mine and Corbin Creek Resources Ltd. Byron Creek mine, the latter producing principally from one seam; Fording Coal Ltd.'s Greenhills and Fording River operations and the Line Creek mine of Minalta Coal Ltd., the latter two mines producing from several seams.

The *Peace River* coalfield, in the northeast part of the province, produced about 100 000 tonnes of medium-volatile bituminous coal from small mines between 1908 and 1960. Coal rank varies from low to high-volatile bituminous with good coking qualities.

In response to rising world demand for metallurgical coal, the entire coalfield was subjected to intensive exploration in the 1970s and two large open-pit mines, Quintette and Bullmoose, were subsequently developed. Both are now operated by Teck Corporation and produce mainly metallurgical coal. Significant undeveloped deposits include Burnt River and Sukunka.

Insular Coalfields

The *Comox* and *Nanaimo* coalfields on Vancouver Island played a prominent role in the early development of the province. More than 50 million tonnes of high-volatile A and B bituminous coal was mined from the Douglas, Newcastle and Wellington seams in the *Nanaimo* coalfield during a 100-year period ending in 1953. The *Comox* coalfield produced 18.6 million tonnes of coal between 1888 and 1953 and is currently the only producing coalfield west of the Rocky Mountains. The Quinsam mine began producing thermal coal for export in 1988, and since then it has steadily increased its output to 650 000 tonnes in 1992. Potential for future growth is good, given the favourable location of this mine.

There has been no significant production from the other Insular Belt coalfields. The Suquash mine on northern Vancouver Island was the first mine to be developed in the province but produced only about 23 000 tonnes of high-volatile B and C bituminous coal. The Upper Cretaceous Suquash coal basin covers an area of about 100 square kilometres but the coal is of poor quality due to its high ash content. Both Tertiary lignites and Mesozoic anthracites and

bituminous coals are known on Graham Island in the Queen Charlotte Islands, but have not been extensively explored.

Intermontane Coalfields

Mesozoic and Tertiary successor basins in the Intermontane Belt contain a number of coal deposits. The largest, in the *Klappan-Groundhog* coalfield in the north, and the *Hat Creek* coalfield in the south, are undeveloped. There has been modest production from the *Telkwa, Merritt* and *Similkameen* coalfields.

The *Klappan-Groundhog* coalfield covers approximately 2300 square kilometres between the Klappan and Skeena rivers in northern British Columbia. The coal measures are 300 to 500 metres thick and contain up to 16 seams of low-volatile bituminous coal to anthracite, some locally reaching 5 metres in thickness. Gently dipping parts provide potential sites for surface mining. The *Hat Creek* coalfield comprises two deposits each containing four distinct zones of Tertiary coal, 200 to 430 metres thick and ranging in rank from lignite to sub-bituminous A. Only a third of the coal-bearing sequence is considered to be waste rock and the field contains approximately 5 billion tonnes of coal.

The *Similkameen* coalfield, comprising the Princeton and Tulameen Tertiary coal basins, produced 4.1 million tonnes of coal before 1961. Four seams of mainly high-volatile bituminous B coal in the Tulameen basin, with a maximum aggregate thickness of about 27 metres, were worked in three underground mines and two small surface mines. The nearby Princeton basin covers an area of 120 square kilometres, but all production has been from the central area. Four principal coal zones, with an aggregate thickness of about 70 metres, contain a number of seams with coal ranks varying from lignite to high-volatile B bituminous. The *Merritt* coalfield, not far to the north, produced 23 million tonnes of predominantly high-volatile B bituminous coal from 1906 to 1963, mostly from underground mines.

In the central part of the province, intermittent production from the *Telkwa* coalfield in the Lower Cretaceous Skeena Group totalled 433 000 tonnes between 1918 and 1970, mostly for local use. The coal measures, containing as many as ten seams with individual seams up to 5 metres thick, locally exceed 400 metres in thickness and have been extensively explored in recent years. The coal varies in rank from high-volatile bituminous to meta-anthracite and sites suit-

able for surface mining are available in areas of gentle dips. This coalfield is stratigically located very close to a major railway and only 390 kilometres from the port of Prince Rupert. The little-explored *Bowron River* coalfield, southeast of Prince George, contains three coal zones with an aggregate thickness of 8.5 metres, within a sequence of Tertiary coal measures. The coal measures cover an area of 50 square kilometres and the coal is predominantly of high-volatile B bituminous rank.

Coalbed Methane Potential

The total resource of coalbed methane in British Columbia is estimated to be between 3000 and 5000 billion cubic metres. Major resources exist in the southeast and northeast where natural gas pipelines already exist. Vancouver Island, soon to be integrated into the natural gas distribution network, has a resource of between 5 and 20 billion cubic metres. Other smaller basins, such as Telkwa, have resources close to existing markets. Opportunities for investment in this new energy field will abound in the next few years.

Industrial Minerals

Industrial minerals are a significant component of British Columbia's mineral production. Products such as limestone, silica and gypsum, are processed locally and utilized in local and regional markets. Other commodities, such as sulphur, magnesia and clay, have international markets. Significant growth potential exists in this sector with investment opportunities in many different fields such as **dimension stone, refractory minerals, peat** and **high unit value synthetic products.**

Limestone

For over one hundred years British Columbia has been the main source of limestone for the Pacific Northwest. Two production centres on Texada Island in the Strait of Georgia ship between 4 and 5 million tonnes of limestone annually to lime and cement producers along the Pacific Coast from northern California to Alaska. The value of cement, lime and limestone produced in British Columbia exceeds $150 million annually.

Major, untapped limestone resources are located on the west coast of Vancouver Island in the Holberg Inlet and

Quatsino Sound area. Many potential limestone resources are known in the interior and the Marble Canyon limestone belt, near Lillooet, has been developed and produces about one million tonnes of chemical lime annually.

White limestone for extender and filler applications is produced from two sources on the coast, and one in the interior, at a rate of some 100 000 tonnes a year with a significant potential for growth.

Sulphur

About 500 000 tonnes of sulphur, valued at $55 million, is produced annually as a byproduct to processing natural gas and lead-zinc sulphides. There is further potential for ultra-sour natural gas pools and potential Frasch sulphur deposits.

Magnesite

British Columbia has a number of major deposits of magnesite. The dolomite hosted Baymag magnesite mine in the Rocky Mountains, open since 1979, has produced almost 200 thousand tonnes annually valued at $3.5 million. Magnesite is processed into high purity caustic and fused magnesia that have worldwide markets. Other, undeveloped stratabound magnesite resources are known in the southeastern part of the province.

Silica

Approximately 100 000 tonnes of glass and metal-grade silicon, worth over $2 million has been produced from two locations in southeastern British Columbia since 1980. The productive horizon is a massive quartzite unit that occurs over a length of 100 kilometres. A similar undeveloped unit is known in the northeast.

Clay Products

About 40 000 tonnes of refractory products valued at $5 million are manufactured annually near Vancouver. This operation uses raw materials mostly of local origin and manufactures high alumina and lightweight insulation refractory bricks. Standard refractory bricks are sold mostly locally in the Pacific Northwest area while the insulation product is marketed worldwide.

Diatomaceous clay-based industrial and domestic absorbents valued at $400 000 annually are also produced in the province and exported to markets in central and western Canada.

Gypsum

The British Columbia gypsum industry, concentrated in the southeast of the province since the 1950s, supplies cement and wallboard manufacturers in both Alberta and British Columbia. A number of undeveloped gypsum deposits ensure this $3 million business will be able to maintain current annual production of 500 000 tonnes well into the future.

Other Industrial Minerals

British Columbia produces small quantities of jade and rhodonite as semiprecious stones from several locations in central and northern parts of the province. Barite for drilling mud, as well as filler applications, is shipped from the southeastern part of the province. Recently, several companies started dimension stone production and processing; eight varieties of granite and three of marble are quarried in the Lower Mainland area and on Vancouver Island.

Industrial mineral development and exploration opportunities are too numerous to describe in detail. Abrasive garnet from placer and hardrock deposits can be produced in the central part of the province. Tertiary basins have potential for deposits of residual kaolin and vermiculite. Extensive deposits of peat are known from the northern coast and northeastern areas of the province. Major asbestos deposits are known in the northwest.

Phosphates in southeastern British Columbia have significant values of yttrium and other rare earth elements. In the northern Rocky Mountains there are significant occurrences of niobium and other rare earth elements.

Mineral Processing Opportunities

There are numerous mineral processing facilities in British Columbia. Zinc and lead concentrates are smelted in the Cominco metallurgical complex in Trail, with the recovery of significant quantities of silver and other byproduct metals. The sulphuric acid produced in the smelting and

refining process is used in the manufacture of phosphate fertilizers. In Kitimat, on the northern coast, imported bauxite is smelted and refined to produce aluminum. The Endako mine has a molybdenum roaster producing molybdic trioxide and there are two small, precious metal refineries in the Lower Mainland area in the south of the province.

There are many opportunities in the processing of industrial minerals to produce value-added products for export and to replace imports to the province. British Columbia's ample supply of low-cost electricity and natural gas provides a competitive edge in the production of energy-intensive products, such as refractory bricks and fused magnesia currently shipped around the world. The provincial government encourages value-added initiatives by industry, particularly concerning the utilization of industrial minerals. Examples of specific opportunities include the production and processing of refractories and the manufacture of synthetic minerals.

Refractory minerals such as magnesite, olivine, kyanite group aluminosilicates, graphite, silica and refractory clays are widespread in the province. Processing into specialized products that can withstand very high temperatures consumes large quantities of electricity, which British Columbia can supply at very competitive rates.

Demand for synthetic minerals such as aluminum oxide, silicon carbide, mullite and spinel is increasing. British Columbia can provide both a source of raw materials and an appropriate site for manufacturing. Cultured quartz crystals, silicon metal, ferrosilicon, magnesium metal and titanium dioxide are other examples of high-energy products that could be produced using locally available raw materials.

Geoscience Information

The Ministry of Energy, Mines and Petroleum Resources, Geological Survey Branch is dedicated to collecting and disseminating high quality geoscience information to the mining industry, government and the public. As part of this mandate the Geological Survey Branch provides the following services and information:

Mineral Exploration Information

In British Columbia, Assessment Reports documenting mineral exploration programs are submitted by the mining industry to maintain mineral tenure. About 22 500 reports,

submitted since 1946, are available for viewing as originals or on microfiche. These reports are also catalogued in ARIS, a computerized index.

MINERAL DEPOSITS INVENTORY

MINFILE is a computerized mineral inventory system containing geological and economic information on 11 000 metallic mineral, industrial mineral and coal occurrences in British Columbia. The system is a "desktop prospecting" tool used for planning mineral exploration programs, investments, resource management, policy planning, land use planning, teaching and research. MINFILE is recognized locally, nationally and internationally as an exceptional geoscience information system.

MINERAL DEPOSITS RESEARCH LIBRARY

Property File is a library of research material on the mineral occurrences documented in the Minfile database. The material in Property File consists of: news clippings, field notes, company documents, historical information, geology, geochemistry, geophysics, drilling data, claim maps, sketches of workings and photographs. Most of these are unique documents, and are extremely valuable to researchers. This library is available for public viewing and copying.

COAL

The Geological Survey Branch maintains a large library of coal Assessment Reports, available for public viewing and copying, that date from 1900. These have been submitted by exploration companies in compliance with the Coal Act. Partial libraries are located in district offices.

Exploration data from the assessment reports have been summarized and stored in a computer information system called COALFILE, which provides a quick and efficient method for accessing the large volume of data.

GEOLOGY

District Geologists are located in five offices around the province and provide close liaison with the mining and exploration industry. They also provide information for regional land use planning initiatives. The District Geologists offer training, advice and information to the mining industry, government and the public. The main

office of the Geological Survey Branch, located in Victoria, provides the services of staff geologists who have expertise in a wide variety of areas.

Mineral Potential

The Mineral Potential project prepares 1:250 000-scale interpretive mineral potential map. This program ensures that the best possible assessment of the known and unknown mineral resources of British Columbia is available for land use, planning and resource development.

These maps present an evaluation of the mineral potential of the various areas based on recent geological mapping, an integration of geochemical and geophysical data and current knowledge of economic geology.

Geochemistry

The Regional Geochemical Survey database consists of: high quality multi-element analytical data, field observations, lithological data and site locations for stream sediment and water samples collected from approximately 33 000 sites across British Columbia.

Thirty-three, 1:250 000-scale map sheets have been sampled at an average density of one site every 13 square kilometres. Many new mineral prospects have been discovered, old ones have been re-evaluated and a number of areas previously thought to have little mineral potential have been investigated as a result of these surveys.

Information from the database is readily available and is useful for exploration work, regional metallogenic studies, geological interpretations and projections, land use decisions and environmental studies.

Geological Mapping

The province carries out systematic 1:50 000-scale mapping and releases the data annually as Open File maps for sale to the public. When field projects are complete, final interpretations are released as Geoscience Maps at 1:50 000-scale, and reports are published. Numerous publications, both reports and maps, are available on a wide variety of geoscience topics.

Information Services

For further information on British Columbia's mineral resources, please enquire with:

Ministry of Energy, Mines and Petroleum Resources
Parliament Buildings
Victoria, B.C.
Canada
V8V 1X4

Attention: Assistant Deputy Minister,
Mineral Resources Division
Tel: (604) 387-6242
Fax: (604) 356-0080

British Columbia Trade Development Corporation
Suite 730–999 Canada Place
Vancouver, B.C.
Canada
V6C 3E1

Attention: Vice President, Trade Operations
Tel: (604) 844-1900
Fax: (604) 660-2457

Ministry of Energy, Mines and Petroleum Resources
Mineral Resources Division
Geological Survey Branch Information Circular 1993–6