

Mining in Northern British Columbia

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The history of the settlement of the province is tied to patterns of exploration and mine development. In Northern British Columbia the Cariboo goldfields provided the impetus for settlement of the region and the beginning for mining to extend into the western and northern regions in a series of minor gold rushes. The northern half of the province has a geological diverse mineral base that supports a wide variety of mining, and a gradual improvement of exploration and mining methods due to scientific knowledge and technology provided opportunities for lode gold and base metal mines to be developed. The success of mining is based on world ore prices and competitive markets that impact the economic viability of developing a mine. Mining faces increasing pressures in the northern half of the province due to other resource values, such as tourism or protected areas, that claim and compete for a similar land base.

Introduction

Mining exploration and development in northern British Columbia has historically been based first, on the search for gold, and later copper and other base metals. Mining provided the primary magnet to attract large numbers of people to remote areas, and stimulated the development of other resources and industries. H. A. Innis (1936, 177) speaking of the northwest of the province noted, "Placer gold acted as the most powerful conceivable force in mobilizing labour and capital for an attack on the difficult Pacific Coast Region. It capitalized in most direct fashion the strength of the pecuniary motive." The search for gold in the central and northern parts of the province was a primary factor in the development

of the colonial government, the transportation network, and the establishment of law and order.

The role of mining has changed dramatically over the last 140 years in British Columbia and continues to change with evolving technologies, competing land uses, global markets, and increasing government regulation. The northern half of the province, approximately from Williams Lake north, continues to be a focus for mining, but exploration and development techniques used today differ considerably from those used during the early placer days in the Cariboo. Increasing environmental concerns and the shrinking available land base have reduced the opportunities for mineral development. On the other hand, technical advances in exploration, mining, and milling techniques have provided new opportunities to develop previously uneconomical deposits.

This paper will provide an overview of the geology and history of mining development in the northern half of British Columbia with a focus on mineral exploration for lode deposits that developed into successful mining operations. The geology and terrain will be described with respect to physical classification and bedrock characteristics; additional descriptive overviews are provided for producing properties and those with potential reserves.

Physical Geology

British Columbia is dominated by a northwest-trending physiographic feature called the Canadian Cordillera which forms Canada's western mountain ranges that lie between the Pacific Ocean and the interior plains of the prairie provinces. It is composed of five plate tectonic divisions that are called, from east to west, the Foreland, Intermontane, Omineca, Insular and Coast belts. The five belts are bounded by major structural breaks (faults) that deeply penetrate the earth's crust.

The Foreland belt is composed of sedimentary rocks that were derived from the erosion of ancient North America and laid down during three main depositional cycles (beginning approximately 1,200 million years ago), the youngest of which occurred during Mississippian–Devonian time (about 350 million years ago). Two of the other four belts, Intermontane and Insular, each are a collage of geologically distinct terranes (with segments of similar geology), that originated as chains of volcanic islands or segments of ocean floor thousands of kilometres west and south of their present locations. These terranes collided with, or were accreted to, the western

edge of ancestral North America beginning in middle Jurassic time, about 170 million years ago.

Two metamorphic and igneous rock complexes, the Omineca and Coast belts, developed on the margins of the superterranes following accretion. They are composed of Mesozoic igneous and metamorphic rocks that were well established and in the process of being uplifted and exposed by Late Cretaceous time. During the Eocene, granitic magmatism was widespread in the Omineca and Coast belts. Continued uplift has exposed large amounts of this younger granitic material.

The sedimentary rocks that comprise the Foreland belt were compressed (i.e., folded, faulted, and displaced eastward and upward forming the Rocky Mountains) during the accretion of two major, amalgamated superterranes that comprise the Intermontane and Insular belts. The northeast corner of the province (Northeastern Plateau) was not affected by this Cordilleran deformation. Some of the smaller terranes that comprise the two superterranes originated far to the south of their present locations before being transported westward and northward, over a span of tens of millions of years, by plate tectonic processes (convergence at subduction zones along the continental west coast and right-lateral transcurrent faulting). It is estimated that during the accretion of terranes more than 10,000 km of ocean floor was consumed at subduction zones along the western margin of the continent. The rocks of these "exotic" terranes contain scientific information, in the form of fossil assemblages and paleomagnetic signatures, that are not consistent with the climate and setting off the west coast of the North American craton at the time of their formation. However, not all terranes originated from exotic localities and some have travelled relatively little.

The Omineca belt is composed of high grade metamorphic and granitic rocks. These are exposed in the Cariboo mountains in the central part of the province, and Omineca and Cassiar mountains in the northern half.

The Intermontane belt, or superterrane, consists of the Stikine, Quesnel, Slide Mountain, and Cache Creek terranes. The former two are volcanic island terranes, or island arcs, and the latter two are segments of oceanic crust. Intermontane belt rocks are generally expressed as low rolling hills in areas of heavy glaciation, such as in the Nechako, Fraser, and Stikine Plateaus, but further north they form the rugged ranges of the Skeena Mountains. In the north, the Coast belt is comprised of metamorphic and granitic rocks exposed in the Coast Mountains.

The Insular superterrane is made up of the Wrangellia and Alexander terranes, which were welded together prior to their accretion with North America, approximately 100 million years ago (middle Cretaceous). These rocks are exposed in the extremely rugged St. Elias Mountains that occur in northwest BC and straddle the Yukon and Alaska borders. Since that time a number of smaller terranes have joined the continent, including the Pacific Rim, and Crescent terranes on Vancouver Island and the Yakutat terrane on the Alaskan panhandle.

The term *Overlap Assemblage* has been given to rocks that formed in post accretionary time (Souther, 1984). They include the Cenozoic (8.7 to 0.8 million years old) Anahim volcanic belt, an easterly trending chain of eroded shield volcanoes (these are spectacular) that extends from Bella Coola to Nazko in the central interior, and voluminous Eocene (50 million year old) and younger volcanic flows that cover much of the Nechako Plateau.

Mineral Development

Early exploration consisted of prospectors using simple panning techniques to test creeks for placer gold. This type of prospecting or exploration occurred independently of any substantial knowledge of surrounding geology. In the earliest period of prospecting, before any geological survey had been carried out, the search for gold was very much hit and miss. The technique was simple—every inch of the province which was suspected of holding gold was scrutinized, every creek panned, and gold was thus found through serendipity rather than science. Subsequent development of lode gold deposits occurred primarily in the vicinity of known placer areas. However, geological base maps became a valuable tool as prospectors and geologists began to understand the spatial association between geology and the processes that formed mineral deposits. For example, disseminated or porphyry copper deposits are found commonly with certain types of granitic rocks called monzonites or quartz monzonites. As Guilbert and Park (1986, 23) note,

Close relationships such as these strengthened the deduction that a genetic relationship exists between igneous rocks and many ores. The arrangement of minerals in zones around igneous centres likewise suggested that ore-bearing fluids spread from in channels that tapped deep-seated sources. As the fluids rose through the rocks, they deposited their minerals in favourable structural and stratigraphic environments.

The structural geology of an area and the location of ore bearing minerals have an important correlation that guides the search for valuable deposits. Thus, as the province was more or less systematically mapped by federal and/or provincial geologists, the regional mapping projects identified significant structures such as folds or faults that could contain valuable ores. The maps formed the basis for regional reconnaissance work that has been carried out by prospectors and mining companies for decades.

Many mineral deposits in northern BC are related to the plate tectonic processes that formed much of the province. Mineral rich areas occur in volcanic island arc terranes, such as Stikinia or Quesnelia, and have a long axis that is parallel to the major north-west structural grain of the province. These areas have been identified by early prospecting and further refined by mapping. Such belts of rock have been mapped in more detail where warranted and details such as structures (faults, fractures, and joints that provide permeability in rock and create openings for hydrothermal or magmatic fluids to pass through and deposit the metals that they carry in solution), host rock types and the nature of contacts between different rock bodies, and alteration systematics have been recorded.

Where prospecting has located a mineral occurrence, systematic bedrock mapping, geochemical sampling, and geophysical surveying follow. If warranted, trenching and drilling would then proceed to assess the potential of the deposit. In areas with little bedrock exposure, regional scale geochemical and geophysical surveys have been used to identify anomalies where more detailed follow-up work is required.

The history and development of mining in the province is a story of technological change, accumulation and spread of scientific knowledge, and a developing transportation network that facilitated access to remote areas. Each of these hurdles had a direct impact on the development of northern British Columbia, not only for mining, but also for the eventual settlement of many northern communities.

The search for gold provides a good example of the technological changes that have accompanied mining practices over the last 140 years with respect to technology. Barr (1980) divides the gold production in the Canadian Cordillera according to three types of deposits that define distinct periods in the search for gold: placer gold (1858–1917), lode gold (1918–1967), and base metal (1967–present). Each of these periods reflects a distinct advance in technology, both in the ability to find and mine the gold.

The first miners to rush after the rich placer deposits of the Cariboo required little equipment or training. Placer deposits were first worked by miners equipped with basic gold pans and an endurance for cold water and hard work. The use of the rocker box and more complex sluice operations followed, where the sand and gravel deposits were dumped into the box, washed and rocked across a series of baffles which trapped the alluvial gold dust and nuggets. This type of operation required two or more miners and was labour intensive. As the alluvial deposits became depleted, placer mining operations gradually became more complex in order to extract a higher percentage of gold, and as a result, the need for water and the scale of the operations increased. Sluice flumes and the access to water became more elaborate with new improved technologies such as iron pumps, hydraulic monitors, and dredges. Increased access to the goldfields and the interior of the province provided the opportunity to use larger and more technically advanced equipment to search for placer gold.

As the goldfields' placer deposits were depleted, intensive methods of hard-rock mining followed that required capital-intensive investment, more technologically advanced equipment and mining expertise. Hard-rock mining initially was conducted by hand drilling for most of the nineteenth century. One man held a chisel-shaped drill and rotated the bit, while another wielded a heavy sledge-hammer to drive the drill into rock. Mining in British Columbia adopted the compressed air drills in the late 1890s, which were initially developed for railroad tunnelling. With the advent of this technology, and a means to keep the drill bits cool, lode deposits became easier to mine and new opportunities were developed for hardrock mining.

With the gradual depletion of reserves at lode gold mines and an increase in the development of base metal mines, significant gold was produced at mines whose primary commodities were copper. Porphyry copper deposits became economically feasible to mine in the mid-1960s as the mining and milling methods improved. In addition, the exploration methods also played a major role in the location of valuable deposits. For example, the use of helicopters to reach remote areas and service base camps has given exploration geologists a much more efficient means to conduct fieldwork. Drilling methods also improved to delineate selected deposits. As Newell et al. (1995, 7) reflect,

The development of the wireline diamond-drill in the mid-Sixties made sampling and delineation a great deal easier, once a discovery was made. Again using the Galore Creek example, fourteen

machines were employed to complete 17,570 m of exploratory drilling in 1965; in the 1991 season, 13,685 m of drilling were completed using an average of three machines. The productivity of a drilling machine increased more than fivefold...

Thus, improvements in exploration and mining technology continue to influence how metals are discovered and mined.

Although technology is used to make mining operations more efficient, the world price of metal is also an important factor in the mining industry simply because it governs the selling price and thus the feasibility of developing a deposit. Again, gold provides a good example of the world price trends that can affect mineral development. Schroeter et al (1989, 19-20) link the development of primary hard-rock or lode-gold camps in British Columbia to three major cycles in the world price of gold over the past one hundred years:

The obvious conclusion to be drawn from this historical analysis is that British Columbia's gold mining industry has only prospered when the gold price has been rising faster than the rate of inflation in Canada (or remained fixed at a time of deflation). It is a matter of historical observation that virtually all new production has been brought on stream within a few years either side of the peaks of three major price cycles, each separated by intervals of 38 years.

Similar observations can be made for most minerals that are subject to world price fluctuations, and the health of the mining industry in the province is strongly influenced by world trends.

The History of Mining

Mining has played a central role in the historical development of the province of British Columbia. It was one of the single driving factors in the growth of the colony and influenced the formation and settlement of the province. Until approximately 1880, gold produced the greatest wealth and employed the largest number of people in the province (Taylor, 1978). It is interesting to note that it was mining events in the central and northwestern parts of the province that played the most pivotal roles in the establishment of British Columbia as a province.

Mineral deposits were first developed in the province by indigenous First Nations people that used metals to make tools and ceremonial implements. Copper was mined by the northwest coast cultures for ceremonial shields, termed "coppers", and for decora-

tive and artistic purposes. Whether the copper was hammered or smelted remains a debate, however, there are oral traditions that outline the smelting procedures for copper using charcoal (McDonald, pers. com.). In addition, argillite was mined in this area for carving and decorative purposes.

First Nations people also played an important role in the first discoveries of placer gold throughout the province. The value of gold to the white man was soon realized by the local inhabitants, and many First Nations people actively sought nuggets for trading purposes or reported sightings of gold in isolated areas. This sparked the beginning of several gold rushes throughout the province.

The Placer Gold Rushes in the North

The first mining operation in the province was located in northwestern British Columbia on Moresby Island of the Queen Charlotte Islands. News of the discovery of gold was first reported in 1850, and verified when a nugget was used in trade in 1851 by a First Nations woman at the Hudson's Bay post at Fort Simpson. This sparked the first gold rush in the province in 1852 to the Queen Charlotte Islands (Haida Gwaii), but very little gold was found. However, this event was primarily significant because it forced the new crown colony to assert its sovereignty with respect to mining law. As Taylor (1978, 16) has observed,

The mini-rush to the Queen Charlottes petered out, but it proved to be of historical importance....It set precedents that proved invaluable when invoked by Governor Douglas in the greater rushes that were to occur on the Fraser and Thompson rivers. It was on the Queen Charlottes that James Douglas in his capacity as governor asserted the traditional rights of the Crown to all discoveries of precious metals. He also took the first steps toward government regulation of miners and mining, an approach that was to have far-reaching results in the mining districts of the Fraser and Cariboo.

A system of mineral tenure was established and miners' licenses were required, with fees payable to Victoria. With the subsequent gold rushes in the mid-1850s on the lower Fraser and Thompson, Governor Douglas issued a proclamation in 1857 extending sovereignty over the mainland on all gold mining by setting up a licensing system. Douglas' actions were prompted by concern over the future of British sovereignty in the region, for the majority of min-

ers that came to the area were American veterans of the California goldrush of 1849. As a result of his proclamation British control over the mainland became well established as the gold fields developed.

The Cariboo gold rush was one of the most colourful mining events to take place in central British Columbia. This was one of many gold rushes that gradually moved north as the transportation links improved and more miners flocked to already depleted gold fields, only to move on to other potential gold fields. From the lower Fraser and Thompson rivers, miners moved north into the Quesnel area by the summer of 1859, where a thousand miners were working the surrounding rivers and gravel bars. The following year, subsequent to the rich finds in the Barkerville area, over 3,000 miners and prospectors were working in the Cariboo area (Taylor, 1978). The rich strikes at Williams and Lightning Creeks are well documented, as well as characters such as Billy Barker and Cariboo Cameron. With the news of the gold rush travelling worldwide, Barkerville expanded to a small city of 10,000 people in 1865 and briefly became the largest western city north of San Francisco.

The rich placer gold deposits did not last long and were largely worked out by 1876, with only 27 small companies working the deposits (compared to 169 companies in 1862). However, the volume of placer gold discovered in the Cariboo was significant in the provincial context, where approximately 50 per cent of all placer gold produced in British Columbia came from this short gold rush (Barr, 1980).

Although the rich shallow deposits were depleted relatively quickly, gold mining continued in the Cariboo. The smaller companies were gradually replaced by larger placer operations that applied hydraulic mining methods to the alluvial benches in the late 1880s and continued into the late 1940s. Much of the gold was taken from high-volume low-grade placer deposits by the use of miles of elaborately constructed flumes and large hydraulic nozzles to wash down the gravel from the hillsides. The Cariboo Hydraulic Mining Company had one of the largest placer operations in the world at the turn of the century, located at Bullion. As with the dredging operations in the Klondike, the hydraulic mining companies required heavy capital backing and were controlled by large companies such as the Guggenheim Exploration Company of New York.

The Cariboo gold rush had a major impact on the interior of the province through the large number of people that were attracted to the gold, either to find it or to offer services to the mining industry.

Many people that failed as miners turned to ranching and farming in the Cariboo.

After the depletion of the gold fields in 1865, the rush continued north. Three primary gold rushes followed the Cariboo bonanza in northern British Columbia prior to the Klondike strikes in 1896. The first rush occurred in the Omineca–Peace region in 1869–1872. The search for another rich placer deposit similar to the Cariboo pushed prospectors into the northeastern part of the province. However,

Although a few of the diggings proved profitable, most of the miners became discouraged and left... Their greatest number in the Omineca was about 600 in 1872. When good reports of mining in the Cassiar reached the camps in 1873 the crowd dwindled (Taylor, 1978, 56-57).

The second rush to the Cassiar district (the name applied at the time to the Liard basin area) proved to be more profitable. The Cassiar gold rush occurred in 1874–75 following Angus McCulloch and Henry Thibert's discovery in 1873, with hundreds of miners pouring in from Victoria, the Cariboo, and the Omineca. Miners located rich finds along McDame, Dease, and Thibert creeks. The exodus from the goldfields began in 1878 (with approximately 1,500 miners working that year) as the deposits were worked out, although the area continued to produce substantial amounts of gold until 1895 (Mandy, 1936).

North of the Cassiar, in the Atlin region, placer gold was discovered by prospectors on their way to the Klondike in 1898. As with other discoveries, in a short period almost 3,000 people had arrived to mine the alluvial gold. Gradually the placer deposits were worked out and large companies with hydraulic mining and dredges took the place of the small miner.

Lode Gold

The rush north eventually resulted in the depletion of the placer deposits (with the available technology) in British Columbia, and the miners crossed the province's northern boundary to mine the last of the great placer deposits of the Rocky Mountain chain in the Klondike (Baker and Morrison, 1999). Following the depletion of placer deposits, the search for gold focused on bedrock or lode deposits. Many areas that had supported rich placer deposits also bore evidence of gold in the bedrock. Economic accumulations of gold are primarily found in five different types of lode mineral

deposits: massive sulphide, porphyry, transitional (porphyry related), skarn, and vein (Schroeter et al., 1989).

The first appreciable lode gold production was developed in the northwest at Engineer mine on Lake Tagish near Atlin, which commenced operations in 1913, and closed soon after. In 1917, the Belmont Surf Inlet mine opened on Princess Royal Island (130 km south of Prince Rupert) and operated until 1926. It reopened in 1936 and operated for another seven years and in total, produced close to 400,000 ounces of gold. One of the most significant gold developments in the northwest occurred in 1918 near Stewart at the head of the Portland Canal, with the discovery of "bonanza ore" (high grade) in the Premier mine. The Premier mine worked continuously from 1918 to 1953 and intermittently until 1967; over this period the mine produced 1.8 million ounces of gold and 41 million ounces of silver (Barr, 1980). The mine was reopened in 1989 and closed early in 1996, although exploration drilling continues at the mine site in an attempt to prove additional reserves. Total gold production for Premier exceeded two million ounces.

Gold was also produced from several other deposits in the "Stewart Camp". The Scottie Gold mine produced 105,000 ounces from 1981–1985 and Granduc mine rendered over 65,000 ounces from its copper rich deposit from 1971–1983. Polaris–Taku, a former gold mine on the banks of the Tulsequah River, produced 230,000 ounces of gold between 1938 and 1951. Following mine closure, the mill was leased by The Consolidated Mining and Smelting company and used to concentrate ore produced from the Tulsequah Chief and Big Bull deposits located across the river.

In the Cariboo, the two primary lode gold mines were located near Wells and Barkerville. The first mine to be established was the Cariboo Gold Quartz mine in 1933, soon followed by Island Mountain mines in 1934. The two companies were consolidated in 1954, and operations continued until 1959 for Cariboo Gold Quartz and 1967 at Island Mountain. Approximately 1.2 million ounces of gold were produced between the two mines (Barr, 1980).

Recent Developments

In the Iskut River area, the Johnnie Mountain mine produced over 92,000 ounces of gold between 1988 and 1993. The Snip mine, up to the end of 1996, has produced over 790,000 ounces of gold since it began operating in 1991.

In the Toadoggone region, approximately 200 km north of Smithers and east of the Spatzizi Plateau, several small mines, Baker, Lawyers and Shasta, collectively produced over 235,000

ounces of gold between 1980 and 2001. Farther to the northwest in the Tatsamenie Lake area, the Golden Bear mine operated from 1989 to 2001 and produced 337,323 ounces of gold and 5.5 million ounces of silver from both underground and open pit ore zones.

British Columbia's most recent gold mines are QR, located in the Cariboo 70 km southeast of Quesnel, and Eskay Creek, located approximately 85 km north-northeast of Stewart between the Unuk and Iskut rivers. QR opened in mid-1995 and closed by the spring of 1998, producing approximately 128,000 ounces of gold. Eskay Creek, an exceedingly rich sulphide mine, opened in January 1995 and is the fifth richest silver deposit in the world and one of the highest grade gold and silver mines. Eskay employs approximately 235 workers and produces 550 tonnes per day, of which approximately one-half is direct-shipping ore because of its high grade. At the end of 2001 this mine has produced 1.9 million ounces of gold and 89.8 million ounces of silver; existing reserves could carry the mine for another 10 years of operation.

Base Metals

The development of copper deposits in the northern half of the province follows a similar pattern to that of gold. Copper was extracted using state of the art mining technology and sold at world market prices. The first copper deposits to be mined in British Columbia were high grade (volcanogenic) massive sulphide deposits comprised of metal-rich layers formed on or near the sea floor. The average grade of these deposits commonly exceeded 1% copper, but some were rich in other base metals, such as zinc and lead, as well as precious metals such as gold and silver. It was their "polymetallic" character that made them attractive and profitable mining operations.

In 1901 the Hidden Creek copper deposits were discovered on the west shore of Observatory Inlet, 175 km north of Prince Rupert and were eventually developed into the Hidden Creek mine and the town of Anyox. Anyox was one of the first industrial towns to be constructed in the province by the mining industry. The construction of the town and mine began in 1912, with production beginning in 1914. Granby Consolidated Mining Company developed a considerable infrastructure to support the mine, with an established port, hospital, hotel, and three churches. The Anyox plant consisted of a smelter, concentrator, coke plant, power houses, dam, and an electric railway. The operation of the mine and

smelter lasted for 21 years, and in the summer of 1935 operations were halted and the plants were sold and dismantled.

Several small volcanogenic massive sulphide (VMS) deposits were mined in northern BC during the time that Anyox was in operation. They include Outsider and Torbrit, although the latter was primarily a zinc-silver producer. Mining of Big Missouri, a precious metal rich massive sulphide deposit which fed the Premier Mill, took place in the late 1930s and early 1940s.

The Tasu iron-copper skarn deposit, located on the south side of Tasu Sound, Moresby Island, was mined intermittently from 1914 to 1917. It was mined at a much larger scale by Wesfrob Mines Ltd during a 15-year span beginning in 1969. Iron and copper concentrates were produced by magnetic separation and flotation, respectively.

Important base metal mines in the north that were developed later include Tulsequah Chief and Granduc. The zinc-rich Tulsequah Chief and Big Bull VMS deposits, located on the east side of the Tulsequah River, 95 km south of Atlin, were mined from 1951 to 1957. Recent exploration at Tulsequah Chief by Redfern Resources has identified a mineable reserve of 7.9 million tonnes of copper-zinc-lead-silver-gold ore. The Granduc copper mine, located at the head of the Leduc River amongst the glaciers 40 km north-northwest of Stewart, operated during two periods, from 1971–1978 and 1980–1984. Access to the mine was by an 18 km tunnel that passed beneath the Leduc Glacier from the concentrator and camp site at Tide Lake.

As the local deposits were depleted, the development of high-grade copper was shifted to other parts of the world until “Spud” Huestis and the Bethlehem Copper Corporation (south of Kamloops) demonstrated that porphyry deposits lacking a supergene enrichment blanket could be mined profitably (Newell et al., 1995). This resulted in a resurgence of copper mining in the province with the development of 13 different porphyry deposits over the last 30 years. Porphyry deposits have been the source of most of the copper and molybdenum and more than 40% of the gold produced in the province (McMillan et al., 1991). Porphyry deposits, mined by large-scale open pit methods, have been the backbone of metal mining in the north, and the province, for the last 25 years. It is the gold-enriched variety of these deposits that is driving exploration in much of the province today.

The first significant copper deposit developed in northern British Columbia was Granisle, on the shore of Babine Lake. The Granby Mining Corporation started operations in 1966 and mining

continued until mid-1982. The Bell copper mine, also located near Babine Lake, was put into production by Noranda Mines Limited in 1972. This gold-rich copper porphyry deposit operated until 1991, but was shut down for more than two years during the early 1980s. The mine produced 303,277 tonnes of copper (over 650 million pounds) and 12,794 kg of gold (over 400,000 ounces) over its 18-year life. The Bell and Granisle porphyry deposits are two of many that occur in the Babine Lake area, and exploration continues to locate new reserves.

The Gibraltar copper mine, located approximately 50 km north of Williams Lake, was brought into production by Placer Development Ltd. in 1972. Mining was stopped in 1983, but milling of ore stockpiles continued throughout the year. Mine operations were cut back and suspended entirely in 1993, but resumed late in 1994 and continued until December 1998. Gibraltar is the only mine in BC that produced cathode copper. This pure (market ready) product is recovered by circulating a solvent through oxide ore and waste rock dumps and collecting the copper-laden (pregnant) solution in tanks where the copper is plated out on to stainless steel electrodes. Gibraltar produced 876,712 tonnes of copper, 9,036 tonnes of molybdenum, plus minor amounts of gold and silver.

The Equity Silver copper-silver-gold mine, 35 km south of Houston, opened in 1981 and operated for 14 years during which it was the province's largest silver producer. Mining of this transitional deposit took place from three open pits and one underground development. Reclamation of the site is complete and long-term mitigation measures have been implemented.

Several major copper producers are coming on stream in Chile and will affect the price of the metal. The world demand for copper has not increased and additional mines will affect the supply and demand ratio, possibly driving down the price of copper. This, in turn, may affect the feasibility of maintaining production in British Columbia. Many other deposits, such as Galore Creek and Schaft Creek which have not been mined because of their remote locations and current economic conditions, represent vast resources of the red metal which can be exploited in the future.

The first large molybdenum producer in the province was located at Endako, 160 km west of Prince George. The mine was put into production in 1965 by Placer Development Limited and is still in operation today, though mining was suspended from 1982 to 1986 because of poor world molybdenum prices. The mine currently processes 28,000 tonnes of ore per day, and a small drilling program was conducted in December, 2001.

Kitsault, another open pit molybdenum mine, is located near tidewater at the head of Alice Arm, approximately 140 km north-east of Prince Rupert. The mine, no longer in operation, was put into production by Kennco Explorations Ltd., and operated from 1968 to 1972. Kennco sold the mine in 1973 and Amax of Canada Ltd., after a detailed feasibility study, brought the mine back into production in 1981. However, weak metal prices undermined the original economic evaluation of the deposit and the operation closed late in 1982.

Mercury mining was developed with Pinchi Lake and Bralorne Takla mines during the Second World War. The Pinchi Lake Mercury mine is located on the north shore on Pinchi Lake approximately 25 kilometers from Fort St. James. It was discovered in 1937 by J. Gray of the Geological Survey of Canada and optioned to Cominco. The mine opened in 1940, with peak production in 1943, and due to the falling price of mercury the mine closed in 1944. The mine re-opened in 1968 and operated until 1975, when again the price of mercury dropped and the mine closed. The Bralorne Takla mine followed a similar pattern. It is located 37 kilometers north-east of Talkla Landing and was first located by Bralorne Mines in 1942. Mining ceased in 1944 after nine months of operation.

Recent Developments

The three newest mines in North-Central BC were put into production in late 1997 and early 1998: Mount Polley gold-copper development, 56 kilometres northeast of Williams Lake, the Kemess South gold-copper operation, approximately 300 kilometres northwest of Mackenzie, and the Huckleberry copper development, 86 kilometres south of Houston. In full operation, the three mines directly employed approximately 700 full-time staff and created an estimated 1,500 indirect jobs.

Mount Polley mine opened in September of 1997 and employed approximately 180 full-time staff. The Mount Polley deposit consists of three zones called Cariboo, Bell, and Springer that, once mined, will form one interconnected open pit. The first recorded exploration, on what was then the Cariboo Bell property, took place in 1964. The 82 million tonne mineable ore reserve contains over 1.1 million ounces of gold and more than 540 million pounds of copper. Mount Polley was a victim of falling world copper and gold prices and was placed on temporary closure in October 2001. Since start up, the mine has produced 370,700 ounces of gold and 133.9 million pounds of copper.

Kemess South, a 200 million tonne deposit that contains 4.1 million ounces of gold and 900 million pounds of copper, opened in the spring of 1998. The 50,000 tonne per day operation produces approximate 250,000–275,000 ounces of gold and 60–70 million pounds of copper per year. The Kemess South property was first explored in 1983 and, by the end of 1991, a deposit in excess of 200 million tonnes had been outlined by diamond drilling. The Kemess South deposit is not exposed at the surface; this blind discovery was made by drill testing geochemical and geophysical anomalies. Prospectors were originally attracted to the region because of the prominent, rust coloured ridges that occur immediately to the north, and in part, make up the Kemess North deposit.

Construction of the Huckleberry copper mine south of Houston began on June 1995 and was completed in September 1997 at a cost of \$141.5 million. The Huckleberry mineral resource, some 90 million tonnes averaging 0.513% copper and 0.014% gold, is contained in two closely spaced deposits, the Main and East zones. The Main zone was discovered in 1962, but mining commenced from the larger and higher grade East zone, which was not discovered until 1993. A work force of approximately 200 people was required to build the Huckleberry project and presently the mill processes approximately 7 million tonnes of ore annually. In 2001, 36,398 tonnes of copper, 888 tonnes of molybdenum, 330 kg of gold, and 9052 kg of silver were mined.

Coal

Coal has played an important role in the development of the province. As early as 1848, coal was being mined at the north end of Vancouver Island, and the increasing demand for coal led to the development of large mines around Nanaimo for almost a century. Primary producing coal fields in British Columbia are located on Vancouver Island, in the southeast Kootenays, and in the southern Peace River District. The deposits developed in the northeastern part of the province have been a relatively new venture compared to the southern half.

Coal-bearing sedimentary rock formations form a continuous belt along the eastern side of the Rocky Mountains from south of the international border to about latitude 56 degrees north. Coal also occurs in the Bowser Basin, a broad region in north-central BC and near the town of Smithers. Sedimentary rocks and coal measures in the Northeast Coalfield are generally highly folded. However, early exploration for coal took place within this belt of

rocks where the strata has a low, uniform dip (i.e., on the Sukunka and Quintette properties). Other significant, but as yet, undeveloped deposits occur on the Carbon Creek, Mount Spieker, Monkman, and Saxon properties.

The coal deposits of the Peace River District are presently the primary deposits being mined in the northern half of the province. Other undeveloped sources include the Tuya River coalfield, the Klappan and Groundhog coalfields, the Telkwa coalfield, the Graham Island coalfield, and the Bowron River coalfield. The development of the Peace River coal had an initial short lifespan in the Hudson's Hope area:

Although first reported in 1879, the coal deposits of the Peace River were not exploited until shortly after the construction of the Alaska Highway in 1944. By 1950, three small mines were operating, and in that year approximately 12 thousand tonnes of coal were produced. No sooner had this infant coal-mining industry become established, however, when oil and natural gas were discovered in major amounts in the Northeast region. From this time on the industry declined rapidly and the total production from the mines did not exceed 65 thousand tonnes (British Columbia, 1986, 4).

Coal mining in this area did not revive until the creation of an export market in Japan for metallurgical coal.

In the early 1980s, two large open pit mines were developed south of Chetwynd in the Sukunka Valley to supply metallurgical coal to the Japanese market. The northeast coal block was developed with the creation of a town, Tumbler Ridge, and a rail link. Bullmoose and Quintette mines were developed into large operating open pits that supplied approximately 20% of the metallurgical coal mined in British Columbia. Coal occurs in one of two formations, both Cretaceous in age. The Gething Formation contains coal seams of mineable thickness, but the Gates formation (100 million years old) contains all the reserves at the Bullmoose and Quintette mines. Both open pit operations produced high quality metallurgical coking coal that was exported to Japan. Since opening in 1984, the Quintette and Bullmoose coal mines collectively have produced between five and six million tonnes of clean metallurgical coal each year. In 2000, Quintette mine was shut down due to dropping coal prices. By 2001, Bullmoose mine was the only operating mine in the region, producing approximately 2.1 million tonnes of clean metallurgical coal that year. The mine is scheduled to shut down in the first quarter of 2003.

Despite these shut-downs, there was a tenfold increase in exploration spending, to approximately \$1.25 million on metallurgical and thermal coal projects in the Peace River coalfields in 2001 compared to 2000. Five major coal projects have been developed over the last two years in the Peace River area: Burnt River, West Brazion, EB, Perry Creek and Willow Creek. The Willow Creek property has developed and shipped 36,000 tonnes over late 2000 and 2001.

This increase in development is a result of the turn-around in world coal markets that has coincided with a re-assessment of the coalbed methane potential of the northeast due to increasing natural gas prices. The changes in world prices are due to a variety of factors that include the increasing prices of world metallurgical coal, the ongoing restructuring and consolidation of the coal mining sector, increasing energy demands for coal-fired generators, and changes in coal bed methane technologies

Conclusion

The development of most of the mines in the northern half of the province has occurred in "undeveloped areas," removed from other competing resource uses. The history of mining has been the advancement of the northern frontier. This is changing rapidly. Other activities or resource values that can be affected by mining, such as wildlife or tourism, are contesting the rights to mine in certain areas. The Tatsenshini land use conflict on the northwest coast provides a good example of conflicting land uses where the right to mine is challenged by other resource values such as habitat conservation and protected areas.

In addition, the present land use planning process is also forcing mining to identify reserves at an early stage in order to plan for potential future mining. For example, Land and Resource Management Plans (LRMPs) have been completed province-wide and are allocating available crown land for uses such as forestry and protected areas. With increasing resource use pressures in the north, First Nations land claims, and the development of the land base for a myriad of resource values, it is becoming more difficult today to simply develop a mine where the best mineral deposits occur.

The future of mining will continue to depend on exploration, technology, and individuals who are willing to gamble on the wealth of potential deposits. World mineral prices and mining costs in other countries will always affect the viability of develop-

ing deposits in the North. However, mining in northern British Columbia faces the additional challenge of developing deposits in a changing landscape of competing values and complex resource uses.

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