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MINE/MILL OPERATION

The Baker Mine operation

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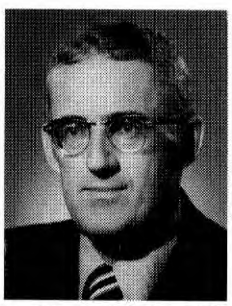
ABSTRACT

This paper reviews the complete cycle of a small mining operation in a remote section of northern British Columbia, including discovery, exploration, development and production. The discovery of high-grade epithermal gold-silver mineralization occurred in 1969 following a regional geochemical reconnaissance program designed to search for porphyry copper mineralization in the Cassiar-Omineca Mountains. Exploration and development from 1971 to 1979 included geological, geochemical and geophysical surveys; trenching, almost 30 000 feet of surface and underground drilling in about 100 holes and cross-cutting, drifting and raising on the principal gold-silver-bearing vein. This led to the delineation of 100 000 tons at an estimated grade of 0.9 oz gold per ton and 18 oz silver per ton to an average depth of 120 feet below surface.

A production decision in early 1980 led to the establishment of a 100-ton per day mining operation employing about 50 personnel with all supporting infrastructure transported to the site by a Hercules aircraft. The operation was subsequently supported by its own Twin Otter aircraft with periodic Hercules campaigns supplying major items including fuel.

The mining operation included both open-pit and cut-and-fill methods. The milling operation employed conventional cyanide-leach process with cyanide destruction initially by alkali chlorination and subsequently by the Inco SO_2/Air process.

The fly-in operation, initially structured on a 21-day-in and 7-day-out basis was modified to a 14-day-in and 7-day-out basis with no loss in efficiency and with a significant increase in employee satisfaction. The operation, which earned the B.C. Small Mines Safety Award in two consecutive years in its



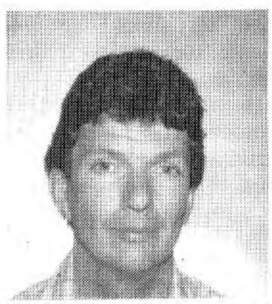
D.A. Barr

David A. Barr obtained a B.A.Sc. degree in mining geology from the University of Toronto in 1950. He has been involved in all aspects of mineral exploration and development in Canada, and has examined various mineral prospects and mining districts in the U.S.A., Mexico, Ireland, Zambia, and the Republic of South Africa. His career includes 22 years with Kennco Explorations (Canada) Limited and affiliated companies with positions ranging from exploration geologist to vice-president. As vice-president and general manager of Du Pont of Canada Exploration Limited he organized and directed the company's activities during its 11-year life. He was responsible for over-all management of the Baker Mine operation including its early exploration and development and more recently he has acted as property administrator on behalf of Du Pont. Currently a Vancouver consultant, he is also vice-president and general manager of Consoldiated CSA Minerals Inc.

Mr. Barr is an author or co-author of eleven previous papers on mineral industry related topics including three previous CIM publications.

He is a Member of CIM, GAC, SEG, and the Association of Professional Engineers of British Columbia and the executive committee of the B.C. & Yukon Chamber of Mines.

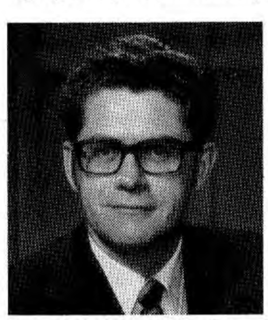
Keywords: Mine operation, Mill operation, Open-pit mining, Cut-and-fill method, Exploration, Mine development, Geology, Capital costs, Baker Mine.



T.J. Drown

Thomas Drown graduated from The University of British Columbia with a B.Sc. (Honours) geology degree in 1973. He has been employed by several major mining companies since 1973, including Du Pont of Canada Exploration Limited, Duval International Corporation and Kennco Explorations Western Limited. While with Du Pont of Canada Exploration Limited he was closely involved in the exploration, development and mining at Du Pont's Baker Mine.

Since 1983 he has worked for several Vancouver-based junior mining exploration companies involved in the development of smaller high-grade precious metal prospects in British Columbia.



T.W. Law

Terrence Law holds a B.Sc. degree in chemical engineering from the University of Alberta. He served for ten years with the military, including his university years and from 1963 to 1966 was an officer/instructor at Central Officer School, (R.C.A.F.) in Centralia, Ontario. He joined Du Pont of Canada Inc. at their St. Clair River Site in 1966. He has held several positions with this company in areas of design, maintenance, production and manufacturing in various locations, and from 1981 to 1984 was

BAKER MINE

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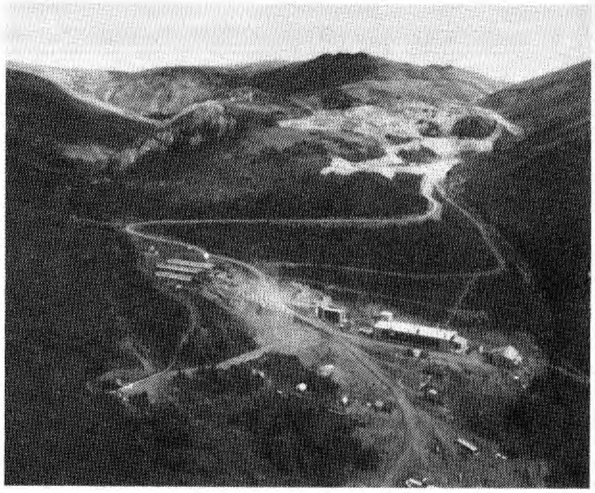


Photo 1. Baker Mine looking north across camp complex, crusher, mill and shop buildings to mine area.

31-month operating history, emphasized safety and process hazard awareness. Wildlife studies in the environmentally sensitive mine area also showed that industry and wildlife can co-exist in harmony.

Most importantly, the paper compares the feasibility assumptions with actual operating experience.

History

The Baker Mine (Photo 1) formerly known as the Chappelle property is located at an elevation of about 5500 feet in a sub-Alpine environment at the western margin of the Omineca Mountains about 170 miles north of Smithers, British Columbia (Fig. 1). The earliest recorded prospecting activity in the area was associated with placer gold mining in the 1930s on the Toodoggone River about five miles north of the mine. Lead-zinc mineralization in skarn, which lies about one mile southwest of Vein A, was also discovered, staked and explored by Cominco during this early period.

In 1968, Kennco Explorations (Western) Limited carried out geochemical reconnaissance surveys in the search for porphyry copper deposits in the general area, and as a result, staked the original Chappelle block of claims (Barr, 1978). Stream-sediment sampling in the area proved to be the most direct indicator of gold-silver mineralization of potential interest. It led to the discovery of seven auriferous quartz veins on the Chappelle property, of which only Vein A has been of economic interest to date.

During follow-up of a molybdenum-silver soil anomaly at the present property in 1969, quartz float aroused the curiosity of Gordon Davies, a Kennco prospector. One fragment assayed 2.5 oz Au/ton and 65 oz Ag/ton. During 1970 - 1972, the balance of the Chappelle claims were staked and soil sampling, hydraulic trenching and rock chip sampling delineated a 10-foot wide mineralized quartz vein (Vein A) grading 1.0 oz/Au ton and 18 oz/Ag ton over a strike length of about 750 ft. Two X-ray diamond drill holes indicated persistence of high-grade mineralization to a depth of at least 65 ft. In 1973, Kennco decided that the property should be dealt to outside parties and an agreement was entered into with Conwest Exploration Ltd.

During that year, Conwest built a 2800-foot airstrip at Black Lake and a five-mile access road to the property (Fig. 1). A 500 ft adit was driven to intersect Vein A, and 150 ft of drifting and some underground diamond drilling was completed. The results of the program were not sufficiently encouraging and Conwest terminated its option at the end of 1973.

Early in 1974, Du Pont of Canada Exploration Limited optioned the property and over the next five years completed over 28 500 feet of diamond drilling in 96 holes. In addition, an underground development program resulted in 300 feet of crosscuts and 1200 ft of drifts and raises.

The chronological development of the Baker Mine ore reserve over an eight-year period commencing in 1971 is shown in Figure 2 on a series of longitudinal sections. By 1975 the reserve was estimated at 71 966 tons grading 0.98 oz gold per ton and 18.43 oz silver per ton based on eight drill holes lying between surface and a drift on the 5420 ft level which essentially bottomed the reserve. Further drilling and underground work supported more closely defined reserve calculations in 1977 and 1979 which formed the basis for feasibility studies completed in those years.

During the period 1969 - 1979, total costs of exploration and development were \$3.3 million of which Du Pont's costs totalled \$2.2 million. Attempts to increase mineable reserves during the mining operation (1981-1983) involved about 14 000 ft of surface and underground drilling in 65 holes. Unfortunately, these efforts were unsuccessful, and the mine was placed on a care and maintenance basis after exhausting its ore reserves on December 1, 1983, 31 months after the start of production.

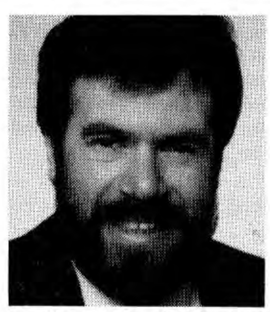
Feasibility

The original feasibility study completed in 1977 provided conceptual and preliminary designs for all aspects of the mine, mill, support facilities and attendant services required to bring the mine into production. The capital and operating costs estimates were considered to be accurate to within $\pm 15\%$. The

manager of mining operations, Du Pont Canada Explorations Ltd. in Vancouver.

G.A. McCreary

G.A. (Gord) McCreary holds a B.Sc. in mining engineering and an M.B.A. from Queen's University. During the past 12 years, he has worked in many aspects of the mining industry including mine operations, bulk explosives technical sales/contract administration, advanced exploration/development mineral evaluation and mining industry analysis. Upon Du Pont's withdrawal from its mineral venture he formed Minnovation Consulting Inc. and consulted in the area of computerized mineral evaluations. He has recently joined Alfred Bunting & Co. Limited in Toronto as a mining analyst to complement existing mining research capabilities for institutional clients.



W.W. Muir

W.W. Muir was born and educated in British Columbia and graduated in chemical and metallurgical technology from B.S. Institute of Technology in 1970.

From 1971 to 1980 he worked at Cyprus Anvil Mining Corporation progressing from technician to plant metallurgist. In 1981 he joined Du Pont of Canada Exploration Ltd., Baker Mine operations where he was involved with mill start-up and assumed mill superintendent's role in late 1981. In June 1984 he joined Giant Yellowknife Mines Limited, Salmita Division as mill superintendent, and in September 1984 he was appointed operations superintendent.

Mr. Muir is a Member of CIM and Society of Engineering Technologists of B.C.

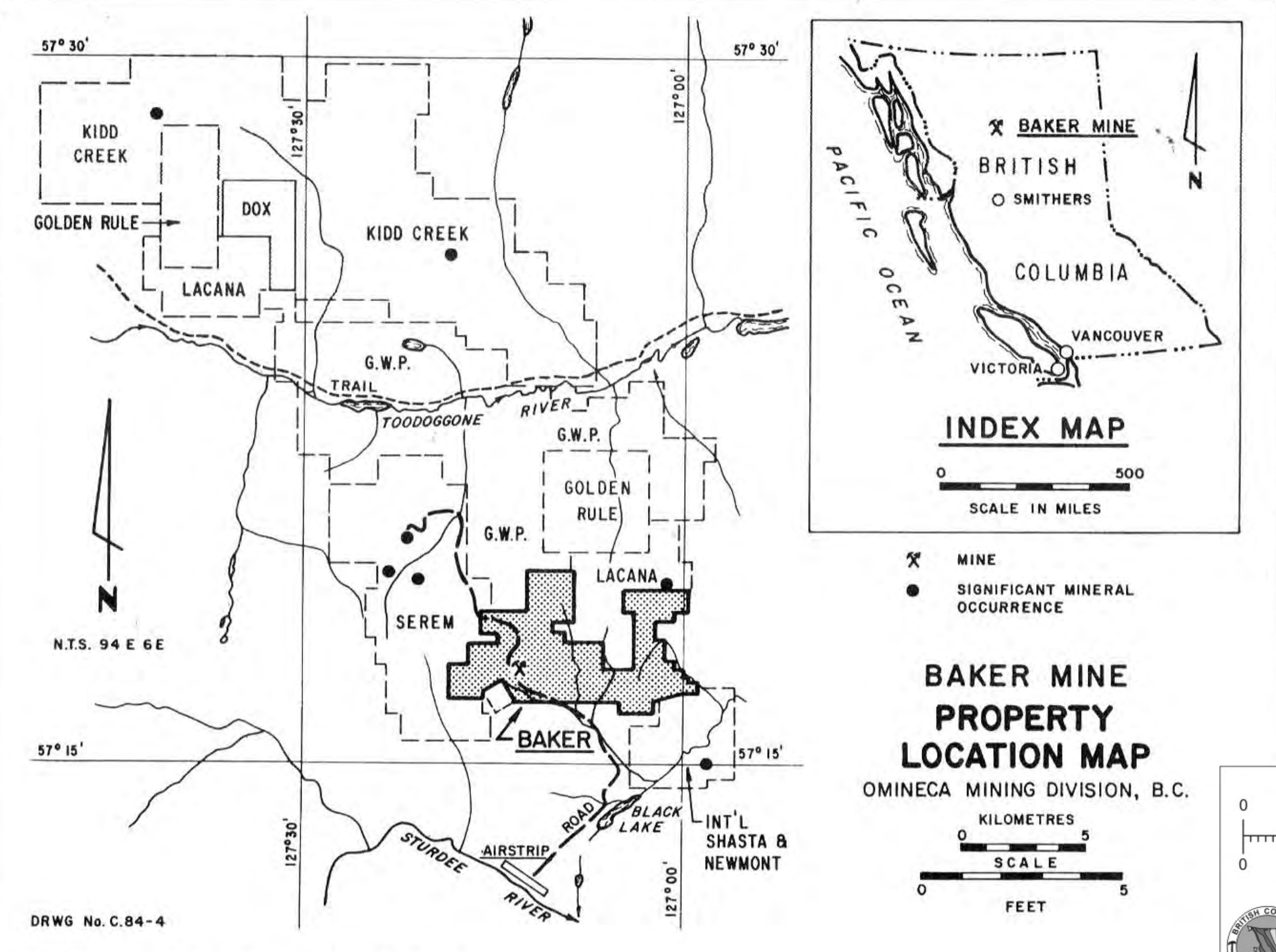
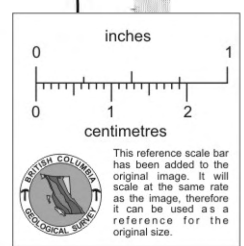


FIGURE 1. Baker Mine property location map.



study included the following principal considerations:

- Review of geology and ore reserves.
- Development of mining method and facilities required.
- Review of metallurgical test work, development of process flowsheets and preparation of a conceptual mill design.
- Review of requirements and preliminary design of auxiliary facilities including power supply, water supply, and accommodation.
- Review of environmental and social economic considerations.
- Development of capital and operating cost estimates and project schedules.
- Development of cash flows and profitability for the project.

Although the results of the study were considered viable by Kilborn Engineering (B.C.) Ltd., the engineering consultant retained by Du Pont, the DCF after tax rates of return which ranged up to 23% were not considered sufficiently attractive to Du Pont at the time.

During 1978 and 1979, more work was carried out with the object of increasing and better defining the reserve.

The 1979 feasibility update, completed by Kilborn, provided for an all air transportation system, revisions of the plant flow sheet, modifications to the mining method, increased selling

J. Paxton

Jim Paxton, P.Eng. (B.C.), graduated from the University of Saskatchewan with a B.A. degree in geology in 1953. Following graduation he worked on several exploration projects, spending three years as a geologist at Gunnar Mine and two years as senior mine geologist at the Pickle Crow gold mine in Ontario. From 1964 to 1975 he was employed as a senior geologist by Granby Mining Corporation, mainly at its Phoenix copper mine in southern British Columbia. From 1976 to 1980 he worked as a senior mine geologist for Kerr Addison Mines Ltd. on the Grum Joint Venture and at the Cenex uranium mine near Uranium City, Saskatchewan. In 1980 he was employed as site geologist at the Baker Mine in northern British Columbia. Since 1983 he has been president of his consulting firm, Petralith Services Ltd.

R.L. Roscoe

Mr. Roscoe was born in Sudbury, Ontario, and grew up in Noranda, Quebec. He obtained a B.Sc. in mining engineering plus post-graduate geology at Queen's University. Mr. Roscoe had early engineering experience at Anglo-Rouyn Mines near Noranda and many years in supervisory positions for Boyles Bros. Drilling Company, including branch manager at Boyle's Noranda and Moncton locations, and assistant general manager for Boyle's Western Operations. Since 1967 he has supervised exploration and mining projects. Mr. Roscoe was mine manager at Du Pont's Baker Mine from construction through production and is currently mine manager at Blackdome Mining Corporation's producing mine near Clinton, British Columbia.

Mr. Roscoe is a Life Member of CIM.

price for precious metals and a 25% increase to the ore reserve.

The project was determined to be financially viable under nine separate cash flow projections using various gold and silver prices, capital and operating costs and increased ore reserves. DCF after tax rates of return calculated by the consulting firm ranged between 45% and 65%.

The financial projections were further modified by Du Pont to allow for higher capital costs and lower revenues. Resulting DCF after tax rates of return with the sensitivities considered, ranged from a low of 15% based on 30% less revenue to a high of 35% with 20% more revenue than the base case. A compelling factor for approving the project was the indicated pay-back period ranging from 15 to 21 months, depending on the sensitivities considered. Of these, the defined reserve provided an operating period 2.2 times the pay-back period, which was consistent with a 2x minimum rule-of-thumb rate used by some evaluators.

Capital Costs

The Baker Mine project was approved in February 1980 at an authorized capital cost of \$12.5 million ±20%. The actual costs compared to original project were \$14.4 million, or

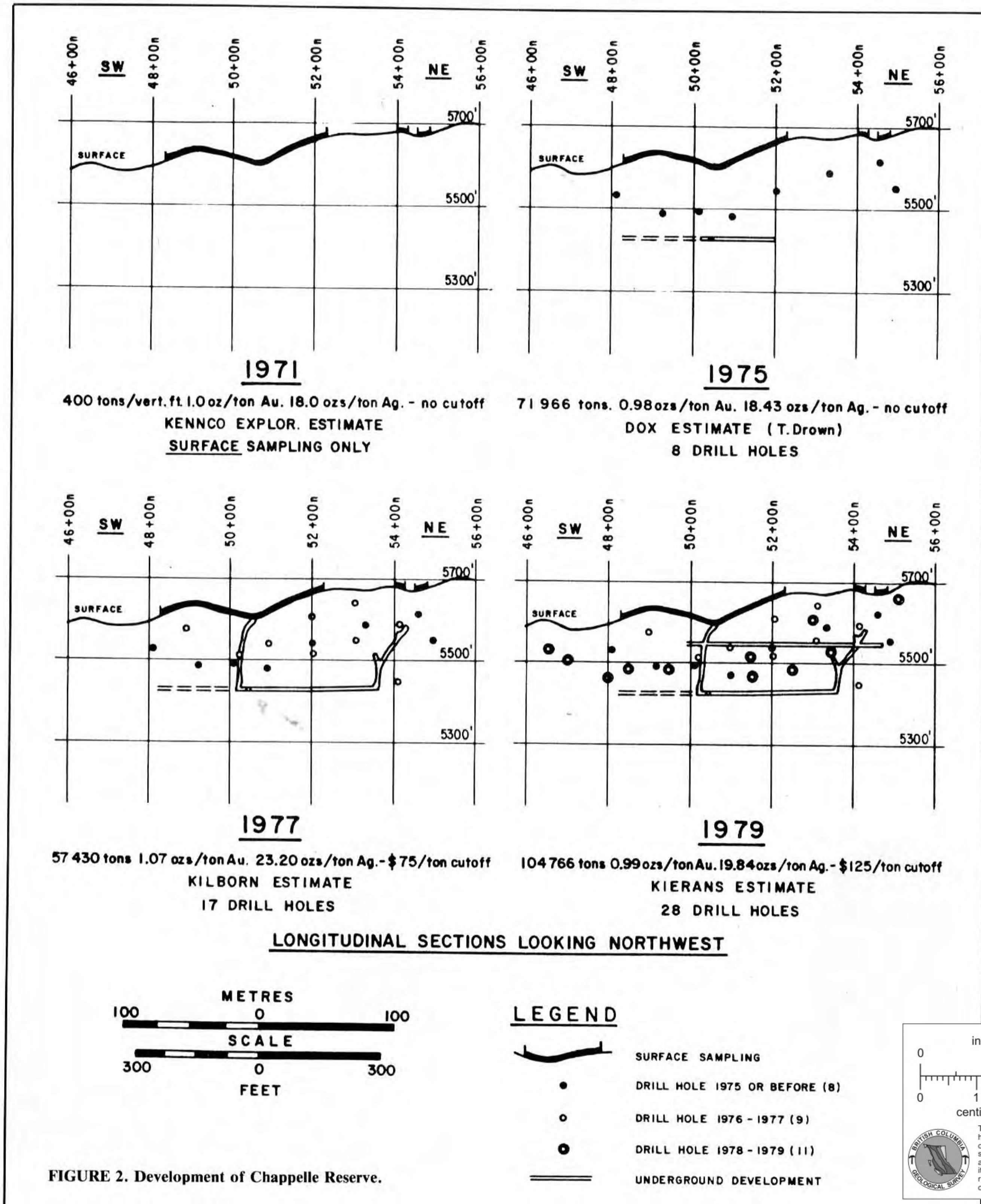


FIGURE 2. Development of Chappelle Reserve.

15.2% overrun. The principal causes of the overrun were higher than estimated costs for the construction of the process plant and for air transportation.

Subsequent capital requirements approved in the first year of operation totalling $2.8 million included the purchase of a Twin Otter aircraft to provide more reliable transportation than would have been possible by charter aircraft. It was necessary to construct a hangar at Smithers to provide for adequate inspection and maintenance. With start-up costs added, the total capital cost of the operation, excluding prior exploration and development was $18.6 million, or 49% higher than originally envisaged by the feasibility study (Table 1).

The original physical completion target date for production was January 1, 1981. Essential work required for production was completed in April 1981, with official production recorded as May 1, 1981.

Development

The paramount item to be addressed in the development of the Baker Mine was the determination of the most cost-effective method of access to such a remote location. The small, high-grade nature of the deposit supported a decision to proceed with a totally aircraft-supported operation following the government's decision not to proceed with extension of the Omineca road into the Baker Mine area. During 1979 - 1980, a 5330 ft gravel Sturdee Valley airstrip was constructed by Du Pont and the British Columbia Ministry of Energy, Mines and Petroleum Resources and was equipped with radio, beacon, lighting facilities and a weather observer. The construction period required 213 flights with a PWA C-130 Hercules aircraft in order to transport 4000 tons of heavy equipment, camp/mill components, fuel and supplies. In addition, over 250 return flights with a company-based Navajo Chieftain were required for personnel and small freight transportation.

In late 1980, Du Pont purchased a Twin Otter aircraft that was used almost exclusively for support of the Baker Mine operations while logging 1325 return flights to Sturdee Valley, during which 1645 tons of freight and personnel were carried. The aircraft was based out of a modern company-owned hangar in Smithers and was operated and maintained by a 5-man crew contracted from Innotech Aviation.

Heavy freight and diesel fuel requirements were marshalled in Smithers and transported to Sturdee Valley via Hercules aircraft in 30 to 35 flight campaigns every three to four months throughout the life of the operation. This required an additional 274 flights during which 5739 tons of freight and fuel were transported. Delivered price to Sturdee Valley in 1983 was 15 cents per pound or $1.76/ton mile. The impact of this cost is reflected in the landed cost of diesel fuel which was purchased in Smithers at a discounted price of 35.7 cents per litre but was costed to the operation at 63.7 cents per litre, or 78% higher than the original purchase price.

In order to bring the mine into production, over 25 permits were required, concerned most notably with the environment, water pollution control and the mining plan. Fortunately, as early as 1976, Du Pont had initiated an environmental baseline study primarily concerned with water quality. In addition, environmental/reclamation and wildlife studies were started during the pre-production period, with special emphasis on a large herd of Osborne caribou nearby. These monitoring programs, completed by a consultant and conducted over a two-year operating life, showed that wildlife and industry can live in harmony.

Because the mine is located in a sub-alpine environment at the head of a creek system in an area of moderate precipitation, a particular concern during development of the project was an adequate water supply for potable purposes and mill requirements. The water system that evolved included both a 5500 ft Sclaircore polyethylene water line to a cirque at the head of the creek system and a small dam on the creek near the camp.

The construction phase of the Baker Mine presented many challenges typical of remote mine developments. Within 400 days of the production decision, the first dore bar was poured at Baker Mine after airlifting over ten million pounds of freight, and transporting over 1300 passengers between Smithers and the Sturdee airstrip.

TABLE 1.

Investment	Assumed	Actual
	(Dollars in thousands)	
Fixed assets		
— Original Project	11,600	13,766
— Aircraft	—	1,790
— Hangar	—	525
— Drum Filter	—	180
— Minor Projects		324
	11,600	16,585
Pre-Production		
— Original Project	900	691
— Start-up Costs	—	1,356
	900	2,047
	12,500	18,632
Prior Exploration and Development	2,259	2,259

Mining Operations

The mining operation has involved both an open-pit and an underground mine. During 1980, ore for initial mill feed was developed by the contractor (Dillingham) in a small open-pit using an airtrac drill, a front-end loader, a dozer and two trucks. The steeply dipping ore vein, which varies from 5 to 20 ft in width, tends to be very strong but is cut by numerous cross joints and faults (Fig. 3). However, the wall rock is relatively incompetent and as a result, the segregation of ore and waste was initially recognized as a significant problem during open pit mining and continued to be a problem underground. The weak wall rock and complex faulting indicated

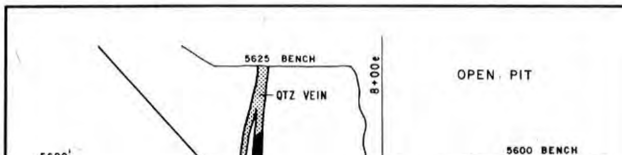


FIGURE 3. Section 51+00n looking northeast.

that shrinkage stoping was not feasible. Therefore, all underground mining was by cut and fill using upholes in good ground and breasting in less competent areas. Fill consisted of waste rock from the open pit mining operation. Fasloc resin rock bolts and timbering were used for stability as required.

The Baker Mine was a trackless operation with a single 2 yd^3 Scooptram capable of handling the daily output of 100 tons of ore. Mine access was based on two adits at elevations of 5538 ft and 5420 ft. Initial underground mine development included raises between the two main levels and between the upper level and surface for ventilation, escapeways and fill. Ventilation and heating of mine air were provided by a fan and oil-fired heater, as required. Compressed air was supplied by two 750 cfm compressors and mine water was collected from old diamond drill holes and pumped throughout the mine.

The main cross faults were used as the boundaries of the stopes since the strike slip component of the offset can be up to 30 ft and because sudden changes in vein width are often associated with the main faults. In areas where stopes were carried across major cross faults, caving lead to high dilution from wall rock. Ground stability problems in stopes near surface resulted in the need to take a small 50-foot thick crown pillar from surface using the Du Pont Sequential Blasting System of non-electric delay decking. De-coupled charges for pre-shear and cushion blasting were used to control overbreak and hence minimize dilution. The final strip ratio in this part of the operation was about 6:1.

Vein A is part of a fault-controlled quartz vein system composed of several northeast-striking veins which dip 80 degrees southeast to about 70 degrees northwest.

Figure 4 shows actual geologic plans of various superimposed lifts, each 8 feet above the other, in a portion of the mine and illustrates the structural complexities and internal dilution which contributed to the over-all high dilution.

A typical cross section through the Vein A area looking northeasterly (Fig. 3) illustrates the degree of fault offset which amounted to 150 feet locally. Of interest is a parallel vein in the hangingwall, which averaged less than one foot in width, but because of its high grade (2 oz gold per ton and 30 oz silver per ton), was mined economically across an average mining width of 5 feet.

The ore values occur as shoots within the vein that generally plunge at a low-angle. The combination of these low-angle ore shoots with fault offsets made it very difficult to mine the ore and waste portions of the vein separately.

Gold in Vein A is mostly associated with fine-grained electrum while the predominant silver mineral is acanthite. Experience has shown that the best grades generally occur along the hangingwall of the vein and the recognition of chalcopyrite and sphalerite in the ore is a reliable indication of high-grade mineralization.

An additional contributing factor to high dilution is the fact that miners, and even the mine geologist had difficulty in predicting grades based on visual inspection. These problems lead to detailed sampling of stope backs, the use of percussion test holes and detailed stockpile sampling. In fact, the grade control program evolved to the point that a "laydown pad" was established whereby each 15-ton truck load was sampled. Assays were turned around in twenty-four hours to allow stope backs and stockpiles to be designated as ore, sub-ore, or waste depending on the prevailing metal price/operating cost impact on cut-off grade.

Milling Operation

The milling operation at Baker Mine which is described in a CIM paper by Muir (1984), came on-stream in April 1981. The initial period of operation was plagued with throughput bottlenecks, as the single-stage dewatering section, utilizing a belt filter could not adequately process the finely-ground ore. Conversion to a two-stage dewatering process with the addition of a drum filter in the third quarter of 1981 followed by process development, concentrating on grinding and gold/silver dissolution, increased throughput to design levels by the fourth quarter of 1981. Recoveries above 94% for gold and 87% for silver were demonstrated in the mill when mill feed calculated heads reached design levels. The milling operation operated very steadily through 1982 and 1983 with very good mechanical utility. In addition, the belt-filter capacity and efficiency was increased significantly in 1983 with the installation of a specially designed needle felt cloth. The tailings cyanide destruction system was converted from alkaline chlorination to the Inco SO_2/air process in 1983 with a significant improvement in safety, cost and performance.

Safety

Safety of personnel should always be given the highest priority in any operation, particularly in a remote one such as Baker Mine, which relied totally on air-support for transporting personnel.

In 1982 and 1983, Baker Mine was awarded the British Columbia Small Mines Safety Award presented annually by the West Kootenay Mine Safety Association to the safest small mining operation in British Columbia.

In 1983, the mine recorded one lost-work-day case of four days duration. The steady improvement in safety performance is reflected by safety statistics. Accident frequency in 1983 was 2.55 injuries per 200 000 exposure hours compared with 6.94 injuries per 200 000 exposure hours in 1982. Severity was 10.21 days per 200 000 exposure hours, compared with 32.98 days per 200 000 exposure hours in 1982. The latest statistics are based on 78 364 hours of exposure in an 11-month operating period in 1983. In addition, the Baker operation recorded an accident-free air operation service provided by Innotech over the total mine life of three years.

Environment

As previously discussed, it has been shown that a mining operation like Baker can co-exist with nature. Most importantly, in its remote wilderness area, Baker Mine has shown to be ideally located to minimize the impact on water quality and wildlife. Like safety, environment is a "must" management priority, rating equally as important as production. Operating experience has emphasized the importance of thorough "environmental design" at the feasibility stage and of thorough measurement and testing through construction and start-up. Baker Mine operated through the period in gold mining history where the technology of tailings treatment has finally met the needs of the environment. There is no question that the involvement of experienced site management personnel in the feasibility and construction phases of any new mining operation will help identify and deflect any potential environmental problems.

Personnel/Productivity

At the peak of operation, the complement on site was 47, made up of 44 company and 3 contract personnel. Two company and 5 contract personnel at Smithers provided purchasing, receiving and flight operations coverage.

The initial rotation allowed for a 21-day-in and 7-day-out schedule but was modified in 1982 to a 14-day-in and 7-day-out basis, primarily at the suggestion of employees. Efficiency was not affected, productivity was improved by approximately 12% and employee satisfaction solidified.

Recreation on the site centred around a satellite receiving dish that brought in four TV channels and one radio station. A VCR complimented the system that is distributed throughout the bunkhouse to each individual room.

Over-all, an excellent working and living climate was developed at Baker Mine through the close relationships maintained among all personnel.

Although the Baker production decision did not rely on development of additional reserves in order to increase the original three-year life of the operation, it was hoped that additional exploration would achieve this objective. Unfor-

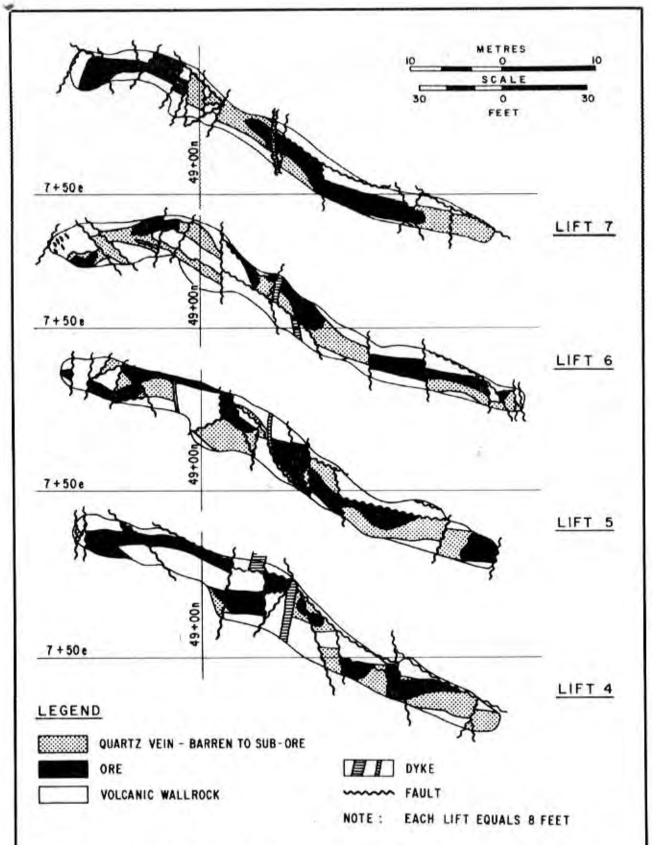


FIGURE 4. 546 stope composite plans.

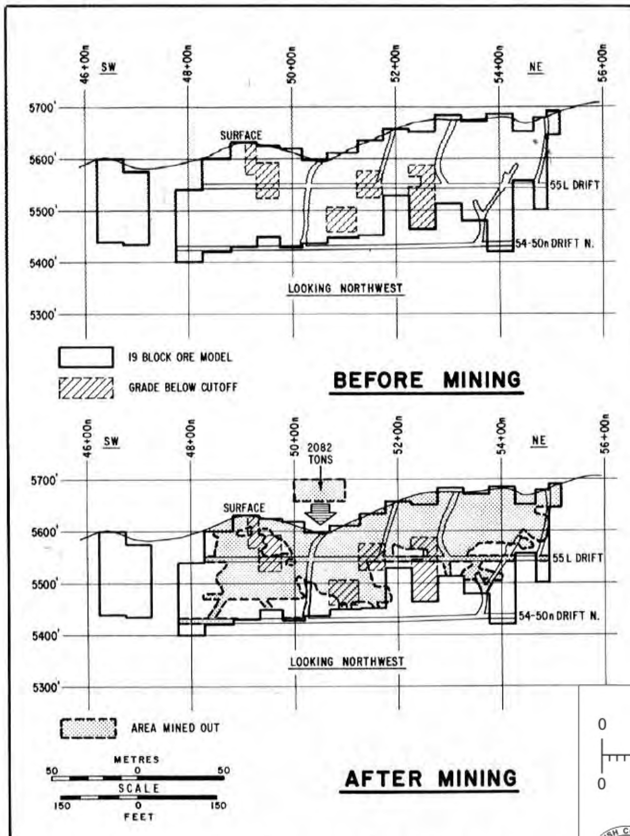
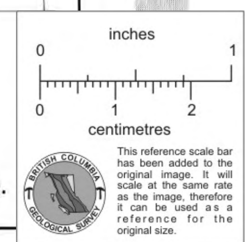


FIGURE 5. Baker Mine before mining and after mining.



tunately, this did not occur. Thus, as a result of the reduction of the original reserves due to dilution and cost, Baker Mine was forced to cease operations in November 1983.

Other mining companies in the area have had some encouragement, although insufficient reserves have yet been delineated for production decisions. The Baker Mine infrastructure, if it can be used by others in the nearby area, would significantly reduce the risk factor in a new development because of the lower capital cost, and the reduced construction and run-in periods involved.

Economic Viability

In summarizing the principal factors which affected the economic viability of the Baker Mine operation, the most significant were: tonnage dilution; value content; and operating costs.

Tonnage Dilution

Two separate economic studies which influenced the production decision considered that the geologic reserve would be diluted by 10% to 20% with waste material containing no gold or silver values, to produce the mineable reserve. In practice, ore dilution averaged about 65%, because of the extensive faulting and for other reasons previously discussed.

In the first two years of the operation, the average mill grades were above the cut-off of 0.3 gold equivalent. By 1983 as operations moved to lower grade portions of the mine, it became necessary to employ a full-time mine technologist on grade control. Although the program contributed positively to cash margin in 1983, it also resulted in removal of part of the original reserve.

Value Content

The longitudinal section in the upper part of Figure 5 shows the pre-production reserve model which was based on taking vertical sections through the orebody along the plane of drill-hole intersections and projecting the data within the plane and from section to section. Another reserve calculation by Kilborn was based partly on polygonal ore blocks centred on drill holes within a longitudinal projection of the deposit. In addition, the data from surface assays were projected downward to meet polygonal ore block boundaries.

The Baker Mine production decision ore reserve was based on 114 sub-blocks contained within 19 principal blocks all of which were within 200 feet of surface (Fig. 5). An extremely detailed surface sampling program of the vein provided avarage gold and silver contents which were essentially duplicated by later drilling results (Fig. 2). Over 60% of the ore blocks contained reference intercepts of plus 0.8 oz gold/ton with high silver values, i.e. in the range of 20 to 1 silver to gold ratios. For these reasons, no cut factor was applied to the assays when calculating the mineable reserve.

Experience has shown that apart from tonnage dilution, the calculated head values for mill feed determined from solution values and dore bullion measured in the mill, represent only 71% of the gold and silver ounces predicted in the deposit in the ore reserve calculations. When the tonnage dilution and value content experience was applied to some of the lower grade ore blocks, the probability of producing mill feed from these blocks, above the economic cut-off was considered remote, and accordingly, they were removed from the reserve. The by-passed blocks as shown in the lower part of Figure 5 accounted for 40% of the original reserve tonnage and 34% of the assumed value content.

Mill feed cut-off at Baker Mine ranged from about 0.30 to 0.45 oz/t gold equivalent, depending on gold and silver prices considered.

Costs

The average operating cost during the 31-month operating life of the project was $214/ton. Operating efficiency reduced operating costs in each operating year, the lowest being the $205/ton achieved in 1983. On a constant dollar basis (1980$), as shown in Table 2, the over-all average operating costs at

FIGURE 6. Gold and silver prices, 1977-1983.

$182/ton milled are about 46% higher than predicted at the feasibility stage. Contributing factors to the much higher operating costs than forecast, included higher costs for reagents, especially the calcium hypochlorite required in the mill cyanide destruction process and for diesel fuel as a result of spiralling Canadian crude oil prices. The feasibility study did not provide adequate coverage for the mine organization to meet its requirements for reliability and safety. Du Pont also decided to purchase its own Twin Otter aircraft rather than rely on charters.

The impact of the higher operating costs was compounded by the assumption in the feasibility that over the life of Baker Mine, the precious metal prices would increase to offset inflation. This did not happen. In fact, the combined average gold/silver prices over the life of Baker are just about equal to the feasibility values at US$350/oz gold and $11.50/oz silver. The average annual inflation over the same period was 10%, and is reflected by an increase in the CPI of over 30% between 1980 - 1983.

As shown in Figure 6, the Baker Mine project was approved at a period of record high gold and silver prices. The start-up coincided with a dramatic period of decreasing metal prices at the beginning of the worst recession in fifty years. Notwithstanding the above, the average gold price in 1981 and 1982 exceeded the assumed project price, although the average silver price was significantly below the silver price assumed for the project.

In retrospect, an ore reserve 3 to 4 times that of the payout period assumed in the base-case feasibility study would appear warranted, in situations such as Baker Mine, rather than the rule-of-thumb of two times used by many evaluators.

TABLE 2. Assumptions in appropriation request compared with actual operating results

		Total 3 years 1981 1983 incl. Assumed (36 mos)	Actual (31 mos)
General Data			
Milling Rate: tpd		100.0	100.7
Metal grade (diluted):	Gold oz/t	0.9	0.49
	Silver oz/t	19.0	10.3
Metal Recovered:	Gold ozs	88 000	37 606
	Silver oz/t	1 798 000	742 117
Operating Cost(1) Cdn $/ton		100.78	214.36
(Adjusted for refining)		124.58	742.36
Operating Costs: 1980$(2)/ton milled			
Mining		34.71	33.44
Exploration		Ø	6.76
Milling		22.53	40.80
Power		6.16	25.10
Refining		19.82	9.42
General Expense		29.43	29.36
Administration		11.95	37.56
		124.60	182.44

(1) Feasibility assumed production of precipitate with $19.80/ton ore allowed for smelting and refining, i.e. 20% of over-all operating cost. Refining cost reduced to $11.75 or 5.5% by minor capital cost addition for refining facility on site to dore bar production.
(2) Using CPI relationships 1980 - 1983.

When comparing the operating cost performance of Baker Mine, it is well to remember that the "remoteness" component of operating cost is significant. At Baker Mine, above 25% of the $200/ton operating cost was directly related to remoteness.

Finally, we believe that if the Toodoggone gold-silver district has a future, which appears very likely, then the Baker property and its well situated infrastructure should be a key component in the development of other deposits in the area.

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BHRA's Hydrotransport 10 Conference

BHRA, the Fluid Engineering Centre will hold its tenth international conference on the Hydraulic Transport of Solids in Pipes in Innsbruck, Austria, from **October 29-31, 1986.** This meeting is co-sponsored by U.K. Institution of Chemical Engineers.

Today, hydrotransport is acknowledged as a viable alternative to conventional forms of transport for many mining products and particulate materials. Greater efficiency and reliability are now the aims of users, equipment suppliers and researchers. For example, polyurethane linings for steel pipes are expensive to manufacture and install, exhibiting difficulties with the alignment of joints welded on site and therefore poor reliability in some cases. Kawasaki Steel of Japan will describe a new type of polyurethane lining which can be installed at room temperature and does not require thermosetting. Joints can be lined and welded easily on site.

An overview of the benefits of the hydraulic transport of coal will be presented by Dr. Peter Wood of IEA Coal Research, who lists a number of problems, such as the optimization of dewatering procedures for fine coals, which must still be tackled.

Other contributions will cover: coal/water slurries; coarse coal and waste systems; pumps and dredging; the theory and practice of fluid mechanics; operational experience in the chemical industry; slurry pipelines; instrumentation; rheology; and three-phase systems. The conference will provide an opportunity for users, manufacturers and practical researchers and designers to exchange experiences, and to discuss the current methods and future markets for slurry pipelining.

Immediately before the conference, BHRA is organizing an intensive short course on slurry pipelining. For further details of the conference and the short course, please contact: The Conference Organizer (Hydro 10), BHRA, The Fluid Engineering Centre, Cranfield, Bedford MK43 0AJ, England; Tel. 0234-750422; Telex 825059. CIM