THE FEASIBILITY OF MINING IN THE VALDEZ CREEK MINING DISTRICT, ALASKA

By Michael D. Balen

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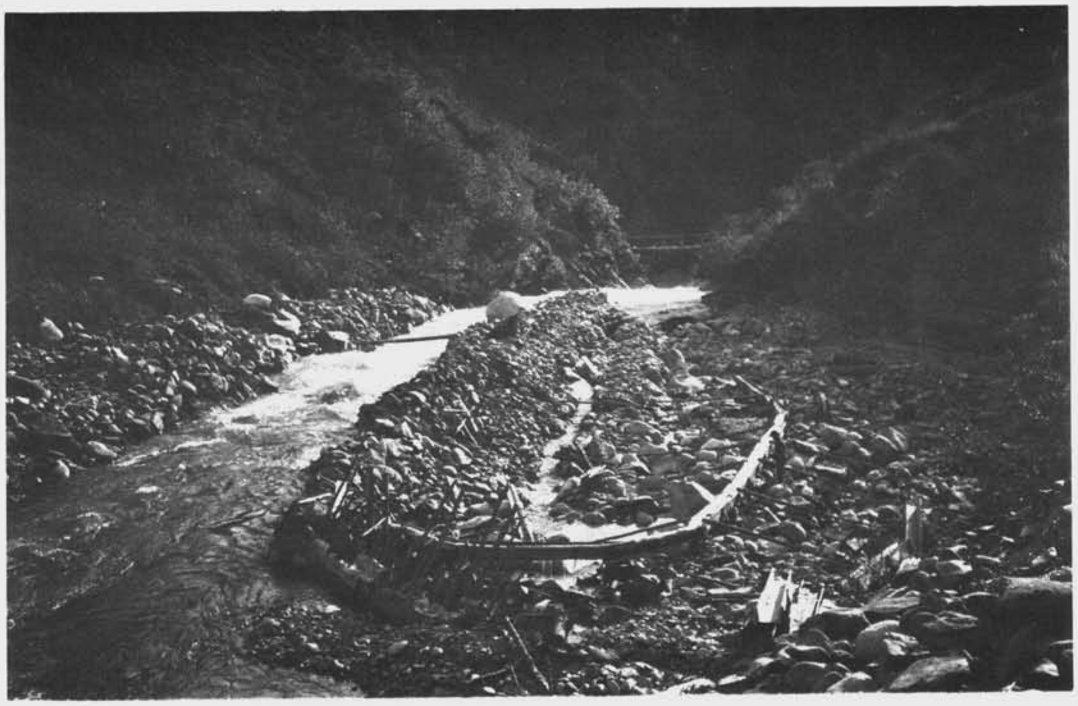

Cover photograph: Mining on Busch Creek, 1988.

Photo at left-top; Mining on Valdez Creek, circa 1915.
Courtesy of U.S. Geological Survey.

Photo at left-bottom; Mining on Valdez Creek, circa 1915.
Courtesy of Anchorage Museum of Art and History.

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

°	degrees
%	percent
$	dollars
DCFROR	discounted cash flow rate of return
CIS	capital investment schedule
BCY	bank cubic yards
BCYD	bank cubic yards per day
F	Fahrenheit
ft	feet, foot
ft^3	cubic feet
m	meter(s)
m^3	cubic meters
mi^2	square miles
mt	metric tons
mtpd	metric tons per day
RMV	recoverable metal value
ROR	rate of return
st	short tons
stpd	short tons per day

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by Michael D. Balen[1]

ABSTRACT

This Bureau of Mines open file report is one in a series of reports written about the Valdez Creek Mining District (VCMD) as a result of the continuing Bureau of Mines mining district evaluation program. This report presents the results of order-of-magnitude mining feasibility studies. The mining feasibility studies were conducted for mineral deposit models that were based on real and hypothetical deposits that occur in the VCMD. A total of 66 mine models were developed for application to the mineral deposit models. The goal of the feasibility study was to determine the monetary value per unit of minable ore that would cause the simulated cash flow for each of 66 mine models to achieve certain pre-defined rates of return for the invested capital.

INTRODUCTION

During the years 1987 through 1989, the Bureau of Mines (Bureau) and the Alaska Division of Geological and Geophysical Surveys (ADGGS) conducted mining and geological field investigations in the 5.7 million-acre Valdez Creek Mining District (VCMD) as part of the Bureau's continuing mining district evaluation program. The objectives of the VCMD investigation were to; (1) evaluate the mineral resources of the VCMD, (2) perform theoretical mining feasibility studies designed for application to the various deposit types that occur in the VCMD, (3) study the application of modern beneficiation technologies on known deposits, and (4) perform a probabilistic mineral resource and economic assessment (ROCKVAL) of the mining district.

The Bureau has published eight reports as a result of the VCMD investigation. Open file reports OFR 43-88 (1)[2] and OFR 31-89 (2) were published by the Bureau following each of the first two years respectively, of VCMD field work. These reports detail the findings of each year's geological and geochemical field investigations. The data from the first through the third year of field investigations is consolidated in a third report (3). A detailed compilation of the VCMD field work data including available historical data for all mineral occurrences in the district is presented in a fourth report (4). The industrial mineral resources of the VCMD (5), and the occurrence of gold- and platinum-bearing conglomerates in the VCMD (6) were evaluated in two additional reports. A complete summary of the VCMD investigation is presented in the Executive Summary (7).

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[2]Underlined numbers in parentheses refer to items in the list of references at the end of this report.

This report presents results of order-of-magnitude mining feasibility investigations. Mining feasibility investigations were conducted for a set of mineral deposit models that are based on real and hypothetical deposits that occur in the VCMD. Sixty-six mine models were developed for application to the mineral deposit models. The goal of the feasibility study was to determine the monetary value per metric ton of minable ore that would cause the simulated cash flow of each of the mine models to achieve certain pre-defined rates of return for the invested capital.

LOCATION

Located in the south-central portion of Alaska, the VCMD is geographically defined by that portion of the Susitna River drainage basin upstream from the Talkeetna River confluence (fig. 1). Bounded on the north by the crest of the Alaska Range, on the west by the Mt. McKinley massif, on the south by the Talkeetna Mountain Range, and on the east by the Lake Louise Plateau (8), the VCMD encompasses a vast Alaskan landscape.

LAND STATUS

The VCMD is comprised of federal, state, and private land holdings. A generalized land status map is shown in figure 1. Current land status for specific areas can most accurately be determined by reviewing the Master Title Plats at the Bureau of Land Management (BLM). Federal lands fall under the administration of the BLM and the National Park Service (NPS); state lands are administered by the Department of Natural Resources (DNR), Division of Lands.

ACCESS

Portions of the VCMD are accessible from the Parks, Denali, and Glenn Highways, which are the major roads within the district. Poorly maintained mining roads and hunting trails provide limited access to some back-country areas for 4-wheel drive or off-road vehicles. The most practical method of access into the majority of the VCMD is by helicopter or small fixed-wing aircraft. Access by shallow draft boat is possible on some of the larger rivers such as the Susitna, Chulitna, and Maclaren Rivers. The Alaska Railroad provides access to the western portion of the district via the rail line that runs between Anchorage and Fairbanks.

PHYSIOGRAPHY

The physical geography of the VCMD encompasses a wide variety of features. Periglacial landforms predominate in areas below 3,000 ft. above mean sea level (MSL). Rugged mountains with elevations as high as 20,320 ft Mt. McKinley host the snow fields that inaugurate the decent of thick glaciers into "U" shaped valleys. Some glaciers such as the Ruth, stretch 30 miles from their highest cirques. Approximately 63% (5,598 mi^2) of the land surface within the VCMD is higher than 3,000 ft above MSL, and 6% (536 mi^2) lies higher than 6,000 ft above MSL.

Lower elevation valley bottoms are vegetated with cottonwood, birch and white spruce. With increasing altitude, the mixed forest gives way to white spruce and aspen forests. An undergrowth of willow, alder and sphagnum moss is ubiquitous below treeline. Wetlands are

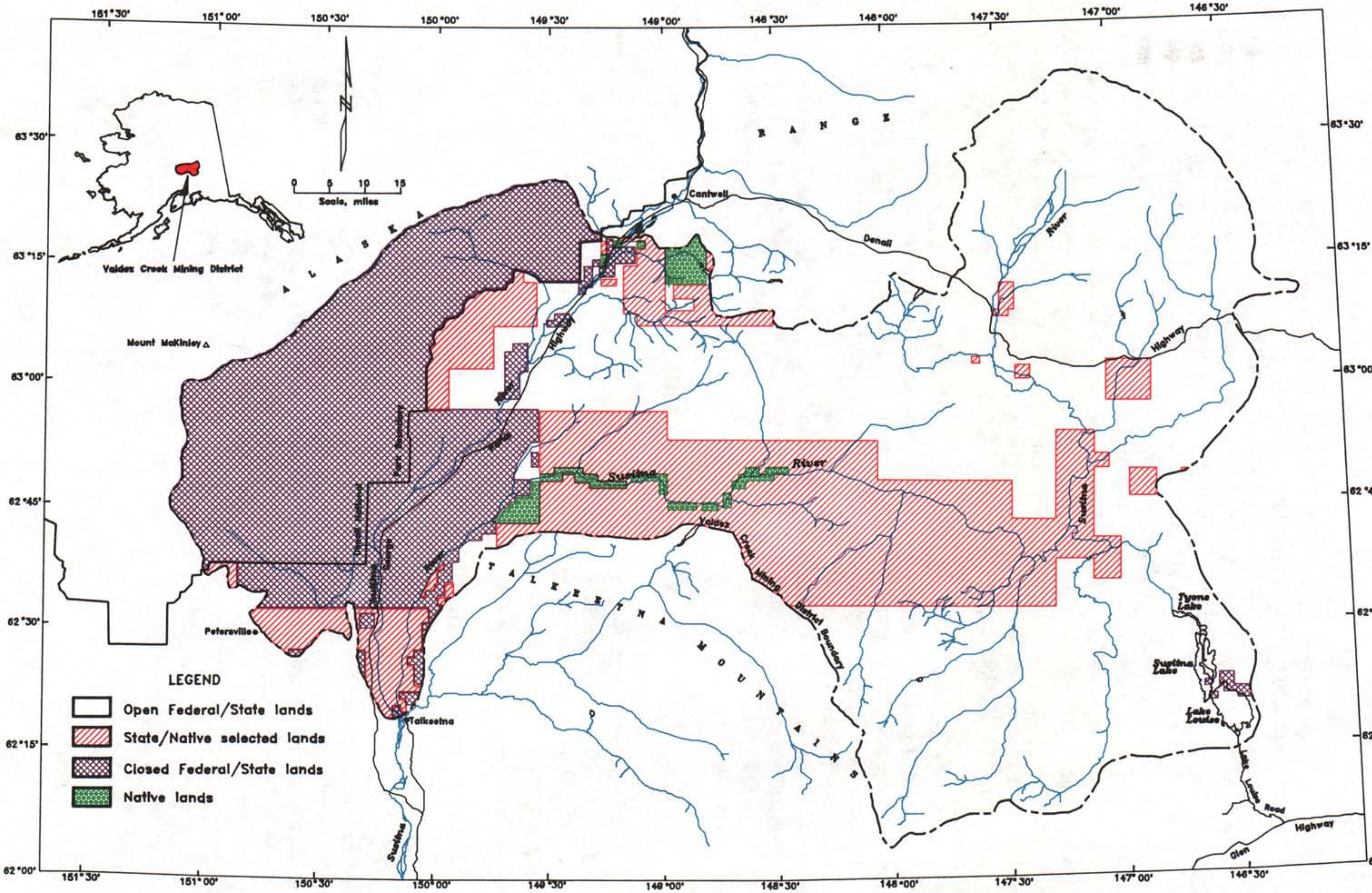

Figure 1. – Land status map of the Valdez Creek Mining District, Alaska

vegetated with sedge grasses, tamarack, and stunted black spruce. Treeline throughout the VCMD ranges from 2,500 to 3,000 feet above sea level.

Nearly all Alaskan species of wildlife can be found within the VCMD. Moose, caribou, brown and black bear are the most visible animals; they range throughout the region. Beaver, muskrat, geese, and ducks populate the wetlands in valley bottoms and lower elevations. Dall sheep inhabit the high peaks of the Talkeetna Mountains and the Alaska Range. Fox, wolf, porcupine, marten, mink, lynx, and wolverine are also VCMD residents, but are much less visible than the larger animals due to their reclusive nature.

Climatic conditions in the VCMD are influenced by warm ocean currents flowing in the Gulf of Alaska. Cool, rainy summers and cold, snowy winters are the norm throughout most of the district (9). Temperatures as low as -64°F and wind chill temperatures below -100°F have been recorded in the district. At the opposite end of the scale, summer time temperature extremes have exceeded +96°F. Snowfall in the VCMD has buried portions of the Chulitna River valley with over 21 feet of snow.

The VCMD is sparsely populated; most human residents live along the major highways. Talkeetna is the largest settlement near the VCMD and has a population of 269. Cantwell is the second largest population center near the VCMD with about 150 residents. The Valdez Creek Mining Company camp has a population of about 100 persons when the mine is in operation, and represents the largest settlement actually within the district. Other relatively significant population centers in the VCMD are located at Lake Louise, where less than 100 people live year-round, at Busch Creek where 3 to 10 miners work during the summer, and in the Valdez Creek drainage above the Valdez Creek Mine, where 5 to 20 people work placer and lode mines during the summer.

ACKNOWLEDGMENTS

The author thanks Denise Herzog, mining engineer, U.S. Bureau of Mines, Alaska Field Operations Center, Anchorage Branch, for assistance in preparing the section of this report entitled "Gold-Silver-Copper Breccia Pipe Deposit Model". This section is based on a mining feasibility study that was prepared for publication in Analysis of Balboa Bay, Beluga, Point Mackenzie, and Lost River as Port Sites for use by the Mineral Industry (10).

MINING FEASIBILITY STUDIES

Mining feasibility studies were conducted for deposits within the district at two levels of complexity. A generic order-of-magnitude study was conducted for mineral deposit models based on the undeveloped mineral occurrences, and on the geologically and geochemically inferred mineral occurrences that exist within the VCMD. Where it was logical to do so, several methods of mining technology (mine models) were applied to the deposit models to illustrate the effect that economy of scale would have on various types of mine and deposit model configurations. Order-of-magnitude mining feasibility investigations were conducted for metamorphic gold vein, copper-gold-silver skarn, plutonic related gold vein, basalt hosted copper, porphyry gold, and plutonic related tin deposits.

The presence of minimally developed, well studied, and currently sub-economic deposits in the district prompted a specific order-of-magnitude mining feasibility investigation for these types of deposits. Specific mining feasibility investigations were conducted for deposits modeled after the Golden Zone gold-sulfide breccia pipe, the Zackly copper-gold-silver skarn, the Valdez Creek deep placer gold deposit, and the Denali Copper basalt hosted copper deposit (fig. 2).

It is important to emphasize that the mining and milling scenarios as presented in this report are applied to generalized deposit models that are preliminary in nature and are accurate within $\pm$ 25%. Reference to actual deposits when discussing mining models is only for the purpose of analogy. The data presented here serve only as a guide toward understanding the potential for mineral development in the VCMD, and cannot be construed to represent all the factors that must be considered in a full scale mining feasibility analysis. A full scale mining feasibility investigation requires detailed evaluation of the vast number of variables embodied by the; 1) metallurgical, geometrical, and structural characteristics of the ore body, 2) metal markets, 3) availability of infrastructure, 4) sociopolitical climate, 5) environmental constraints, 6) corporate policy, and 7) profitability analysis. The order-of-magnitude nature of the mining feasibility studies in this report precludes all but the profitability analysis portion of a full scale mining feasibility study.

MINING FEASIBILITY PARAMETERS

The evaluation of the feasibility of mining each deposit model involved the resolution of numerous variables such as deposit tonnage, mining and milling methods, mining rate, mine life, and deposit access requirements. Deposit model tonnages were estimated by evaluating probabilistic distributions of tonnage and grade variability for analogous real deposits (11). In all cases, the estimated deposit model tonnages represent minable reserves.

Mine models were created by designing a mining and milling plan for each deposit model. Mine models were then evaluated by varying the mining plan to accommodate various deposit model tonnages. By evaluating the feasibility of mining each deposit model over a range of tonnages, a distribution of results was generated that showed the effect of the economy of scale. The deposit tonnage estimates were used to calculate the mining rate and the mine life for each deposit according to Taylor's Rule (12) where mine life (years) = $0.2(T)^{0.25}$, and mining rate (mtpd ore) = $(T^{0.75})/70$ (T = deposit size in metric tons). For the specific feasibility studies, the deposit tonnage was estimated based on current knowledge of the geology of the modeled deposit.

A variety of mine model types were used in this study and were selected in a way that provided a qualitative method to estimate the order-of-magnitude costs for most combinations of mining and milling techniques that might be applied to deposits in the VCMD. Table 1 itemizes these mining and milling techniques as applied to each deposit model.

The overhand mining method as applied in this feasibility study is a variation of cut-and-fill mining practices. The mining method incorporates ore chutes, man-ways and haulage-ways in a system of mining that develops a block of ore by driving two-compartment raises every 31-62 m (100-200 ft) along the strike of an ore body. After the raises are completed, a slot is cut along the bottom of the ore block between two raises to initiate the cut-and-fill process. Ore

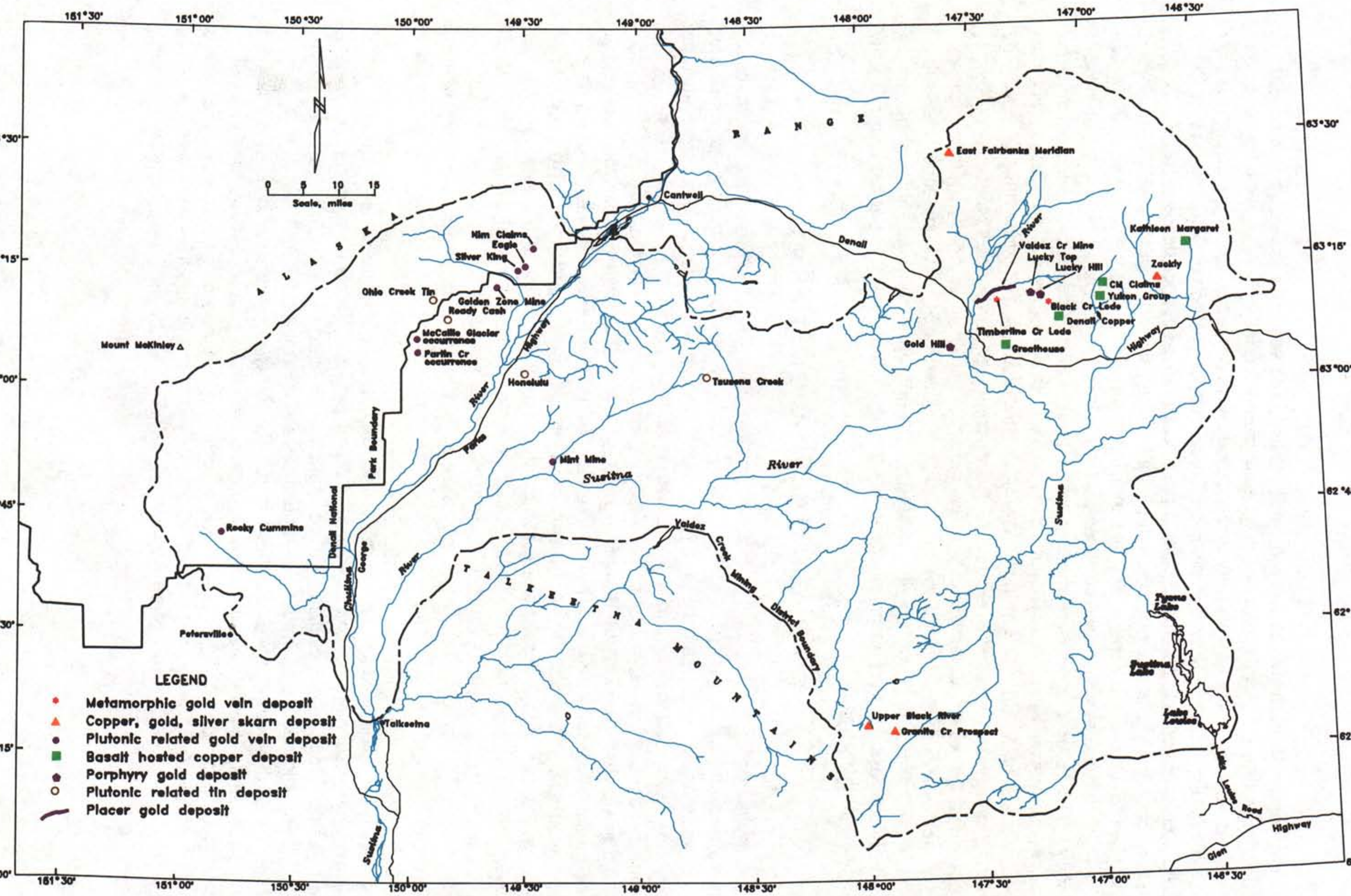

Figure 2. – Mineral deposits used as guides for developing mineral deposit models.

TABLE 1. - Mineral deposit and mine model descriptions.

ORDER-OF-MAGNITUDE MINE MODELS

Deposit type	Deposit size (mt)	Mine model (extraction method)	Mining rate (mtpd)	Mine life (years)	Mill type
Metamorphic gold vein	175,000	Overhand	125	4.1	Gravity
Metamorphic gold vein	350,000	Overhand	210	4.9	Gravity
Metamorphic gold vein	500,000	Overhand	275	5.4	Gravity
Metamorphic gold vein	750,000	Cut-and-fill	365	5.9	Gravity
Metamorphic gold vein	1,000,000	Cut-and-fill	500	6.5	Gravity
Metamorphic gold vein	1,500,000	Cut-and-fill	615	7.0	Gravity
Metamorphic gold vein	2,000,000	Cut-and-fill	760	7.5	Gravity
Metamorphic gold vein	5,000,000	Cut-and-fill	1,515	9.5	Gravity
Metamorphic gold vein	10,000,000	Cut-and-fill	2,550	11.3	Gravity
Cu, Au, Ag skarn	175,000	Overhand	125	4.1	Flotation
Cu, Au, Ag skarn	350,000	Overhand	210	4.9	Flotation
Cu, Au, Ag skarn	500,000	Overhand	275	5.4	Flotation
Cu, Au, Ag skarn	750,000	Cut-and-fill	365	5.9	Flotation
Cu, Au, Ag skarn	1,000,000	Cut-and-fill	500	6.5	Flotation
Cu, Au, Ag skarn	1,500,000	Cut-and-fill	615	7.0	Flotation
Cu, Au, Ag skarn	2,000,000	Cut-and-fill	760	7.5	Flotation
Cu, Au, Ag skarn	5,000,000	Cut-and-fill	1,515	9.5	Flotation
Cu, Au, Ag skarn	10,000,000	Cut-and-fill	2,550	11.3	Flotation
Plutonic related Au vein	175,000	Shrinkage	100	5.0	CIP
Plutonic related Au vein	350,000	Shrinkage	100	10.0	CIP
Plutonic related Au vein	500,000	Shrinkage	275	5.4	CIP
Plutonic related Au vein	750,000	Overhand	365	5.9	CIP
Plutonic related Au vein	1,000,000	Overhand	500	6.5	CIP
Plutonic related Au vein	1,500,000	Longhole-sublevel	615	7.0	CIP
Plutonic related Au vein	2,000,000	Longhole-sublevel	760	7.5	CIP
Basalt hosted copper	2,000,000	Longhole-sublevel	760	7.5	Flotation
Basalt hosted copper	5,000,000	Longhole-sublevel	1,515	9.5	Flotation
Basalt hosted copper	10,000,000	Longhole-sublevel	2,550	11.3	Flotation
Basalt hosted copper	15,000,000	Longhole-sublevel	3,445	12.4	Flotation
Porphyry gold	2,000,000	Open pit	760	7.5	CIP
Porphyry gold	5,000,000	Open pit	1,515	9.5	CIP
Porphyry gold	10,000,000	Open pit	2,550	11.3	CIP
Plutonic related tin	1,000,000	Open pit	500	6.5	Gravity
Plutonic related tin	1,500,000	Open pit	615	7.0	Gravity
Plutonic related tin	2,000,000	Open pit	760	7.5	Gravity
Plutonic related tin	5,000,000	Open pit	1,515	9.5	Gravity
Plutonic related tin	10,000,000	Open pit	2,550	11.3	Gravity

TABLE 1.--Continued - Mineral deposit and mine model descriptions.

SPECIFIC MINE MODELS					
Deposit type	Deposit size (mt)	Mine model (extraction method)	Mining rate (mtpd)	Mine life (years)	Mill type
Au, Ag, Cu breccia pipe	4,100,000	Open pit / cut-and-fill	733	14.4	Flotation/CIP
Cu, Au, Ag skarn	1,623,000	Longhole-sublevel	454	11.0	Flotation/CIP
Basalt hosted copper	5,100,000	Vertical crater retreat	1,000	15	Flotation
Basalt hosted copper	5,100,000	Vertical crater retreat	2,000	8	Flotation
Basalt hosted copper	5,100,000	Vertical crater retreat	3,000	6	Flotation
Deep placer gold	1,700,000 BCY	Open pit	1,000 BCYD	5	Gravity
Deep placer gold	3,400,000 BCY	Open pit	2,000 BCYD	5	Gravity
Deep placer gold	5,100,000 BCY	Open pit	3,000 BCYD	5	Gravity

is removed from the stope in horizontal slices that are blasted from the back. Sand back-fill is added to keep the floor of the workings at a convenient working distance below the back. Drilling is accomplished with jackleg drills and slushers are used to remove broken material from stopes to the ore chutes. This mining method is differentiated from cut-and-fill as described below, by lower production rates.

Cut-and-fill mining practices as applied to the deposit models in this feasibility study incorporate a series of bald-headed sublevel haulage-ways equipped with ore chutes and draw points that are used for extracting broken ore from stopes. Two-compartment raises provide access to the stopes, and storage for broken ore. Stopes are mined by blasting a horizontal cut from the back of the ore body. Ore is blasted down onto the floor of the stope, and is moved to ore chutes with slushers or load-haul-dump (LHD) vehicles (depending on production rate). Once the broken ore is removed, sand backfill is added to the stope to bring the floor up to a convenient elevation below the back in preparation for the next cut.

Shrinkage mining is similar in many respects to cut-and-fill mining. The major difference is related to the method employed to support the ribs of the stope, and in the methodology used for ore extraction. Stopes are developed by driving a series of finger raises off the haulage level drift. The finger raises are eventually belled out to form draw points for broken ore. Access raises are driven from the haulage level to define the longitudinal boundaries of the stope, and to provide access to the stope for workers and equipment. Mining occurs by blasting horizontal cuts from the back of the ore body. Ore is drawn from the stope as necessary to maintain a level working floor in the stope that is an adequate elevation below the back for drilling the next horizontal cut. The drill-blast cycle is continued until the entire stope has been mined.

Longhole-sublevel mining requires a large ore body or wide vein, strong host rocks, and good parting between the ore and the host rocks to minimize wall rock contamination during excavation. Stopes are developed by driving sublevels in ore at approximately 31 m (100 ft) vertical intervals. An opening raise is driven at one end of the stope to create air space for subsequent blasting, and a man-way raise is driven at the other end of the stope for worker and equipment access. Holes are drilled between sublevels and ore is blasted initially into the opening raise, and subsequently into the opening created by the previous round. The working face retreats to the man-way raise leaving pillars as necessary. Ore is drawn into main haulage-ways through draw points located at regular intervals along the bottom of the stope.

The sublevel caving technique of ore extraction is most effective in a thick, strong ore body, however, the method can be adapted for weak ore bodies. An ore body is developed for production by driving footwall haulage-ways at 9-11 m (30-35 ft) vertical intervals. Cross-cuts are driven into the ore body from the haulage-ways to the hanging wall of the ore body. A slot raise is driven along the hanging wall from the end of each cross-cut to provide an initial opening for blasting. Ore is drilled and blasted starting at the hanging wall, and allowed to cave into the cross-cuts. Mining progresses (retreats) towards the haulage-way (footwall) at the micro scale, and downward at the macro scale.

Open pit mining is most effective when applied to a large, near surface deposit. The method incorporates standard earthmoving equipment to excavate large volumes of material in such a manner that a pit is developed as a result of the extraction of ore and associated waste material.

All the mine models developed for this study have several features in common. Escalation factors were applied to the calculated costs to inflate dollars from the 1984 base to December 1989 values, unless otherwise noted. Additionally, Alaska escalation factors were applied to inflate costs to reflect the added expense of operating in remote locations in south-central Alaska. The Alaska escalation factors were derived in a previous Bureau publication (13), and represent the escalation of costs for Alaska that were applicable at that time. It must be noted that the Alaska escalation factors have probably changed, and application of new and more accurate up-to-date figures to this study would change the results. Electric power for all model mining operations is supplied by diesel generators. Each mining feasibility model operates 2 shifts per day and 350 days per year unless otherwise noted, for the life of the mine. All mining models include a camp facility of sufficient size to house and feed the entire mine and mill crew.

Recoverable Metal Value

Several sources of information were used to estimate the capital and operating costs associated with each mine model (14-20). The estimated costs for each mine model and a capital investment schedule (CIS) outlining the timing for capital investment for each mine model are presented in appendix A. The CIS's were the basis for the cash flow analysis procedure used to evaluate the economics of each mine model. The cash flow analysis procedure uses the CIS for each mine model to solve for two unknowns, namely the discounted cash flow rate of return on investment (DCFROR) and an independent variable, the recoverable metal value (RMV). The RMV is the gross monetary value of the metal recovered from the mineral deposit, less smelter royalty, less shipping costs for concentrate or doré. The cash flow analysis procedure evaluates the cash flow equation for a mine model through an iterative process that varies the RMV between assigned limits, solving in increments for the DCFROR. This procedure generates the distribution of RMV versus DCFROR as a function of the time value of money. The RMV was used in this study to eliminate the affect of changeable metal prices, ore grades, and mill recoveries in the cash flow analysis of a mining scenario. This can be done because of the independent nature of the RMV variable due to the iterative method by which the RMV is calculated. An RMV that produces a solution to a cash flow equation that equals a DCFROR of 0.0% was considered a break-even RMV. This value of RMV caused the mine model to recover all costs, and achieve zero profit upon exhaustion of the deposit. A mine model was considered to be economic if the cash flow analysis yielded a 15% DCFROR.

ANALYSIS OF ORDER-OF-MAGNITUDE MINE MODELS

Metamorphic Gold Vein Deposit Model

The metamorphic gold vein deposit models are based on geologic information available for mineralized veins that occur in metamorphic rocks in the VCMD. Examples of known occurrences upon which the deposit models are based are the Black Creek Lode and the Timberline Creek Lode (fig. 2).

The mine models designed for application to the metamorphic gold vein deposit model assume a nearly vertical, fairly competent ore body of relatively consistent width. The deposit model is further characterized by the type of access that is planned in each applicable mine model. Adit entry mine models assume that the ore body is exposed at the surface, and that there is sufficient back to warrant an adit entry. Shaft entry mine models assume that the top of the ore body is 35 meters below the shaft collar. Overall geometry of the ore body is assumed to be tabular with depth equal to length.

A total of 6 overhand mine models and 12 cut-and-fill mine models were developed for application to this deposit model. Table 1 lists the basic mine model description. Each applicable mine model in Table 1 was evaluated as either an adit entry mine or a shaft entry mine. In each model, the associated mill uses vibrating tables to concentrate the ore. All costs generated for each mine model are listed in appendix A.

Adit and shaft entry overhand mine models incorporate stopers and jackleg drills for production. Jackleg drills are also used for drift development. Slushers are used to move ore from the stopes to ore chutes, and LHD's are used to move ore from the chutes to ore storage locations. Shaft entry overhand mine models access the deposit through one production shaft. Shaft entry models also incorporate one combination ventilation-escapeway raise. Hydraulic sand is used to back-fill the stopes in each overhand mine model.

Adit and shaft entry cut-and-fill mine models incorporate jackleg drills and stopers for production development. Small jumbo drills are used for drift development. Slushers are used to move ore from the stopes to ore chutes, and LHD's are used to move ore from the chutes to ore storage locations. Shaft entry cut-and-fill mine models access the deposit through one production shaft. Shaft entry models also incorporate one combination ventilation-escapeway raise. Hydraulic sand is used to back-fill the stopes in each cut-and-fill mine model.

Table 2 lists a summary of the RMV vs. DCFROR cash flow analysis results. Figures 3, 4, and 5 graphically present the results of the cash flow analysis for the metamorphic gold vein deposit mine models. The RMV's required to achieve a 15% DCFROR range from a high of $533.50/mt for a shaft entry 125 mtpd mine, to a low of $148.00/mt for an adit entry 2,550 mtpd mine.

TABLE 2. - Summary of cash flow analysis results for mine models applied to metamorphic gold vein deposit models.

Deposit type	Deposit size (mt)	Mine type (extraction method)	Mining rate (mtpd)	RMV ($/mt)			
				Adit entry		Shaft entry	
				0% ROR	15% ROR	0% ROR	15% ROR
Metamorphic gold vein	175,000	Overhand	125	$359.00	$515.00	$380.00	$533.50
Metamorphic gold vein	350,000	Overhand	210	$288.00	$400.00	$305.00	$422.50
Metamorphic gold vein	500,000	Overhand	275	$241.00	$329.00	$255.00	$347.50
Metamorphic gold vein	750,000	Cut-and-fill	365	$241.00	$395.00	$280.00	$505.00
Metamorphic gold vein	1,000,000	Cut-and-fill	500	$196.00	$315.00	$209.00	$346.00
Metamorphic gold vein	1,500,000	Cut-and-fill	615	$170.00	$273.00	$180.00	$296.50
Metamorphic gold vein	2,000,000	Cut-and-fill	760	$156.00	$250.00	$166.00	$269.00
Metamorphic gold vein	5,000,000	Cut-and-fill	1515	$112.00	$185.00	$117.00	$197.50
Metamorphic gold vein	10,000,000	Cut-and-fill	2550	$89.00	$148.00	$93.00	$157.50

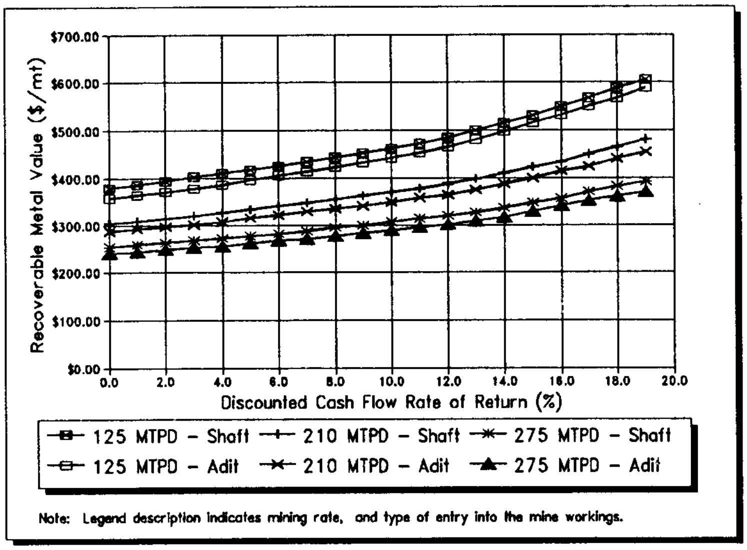

FIGURE 3. - RMV vs. DCFROR for a metamorphic gold vein deposit; 125, 210, and 275 mtpd, adit and shaft entry, overhand stope mine models.

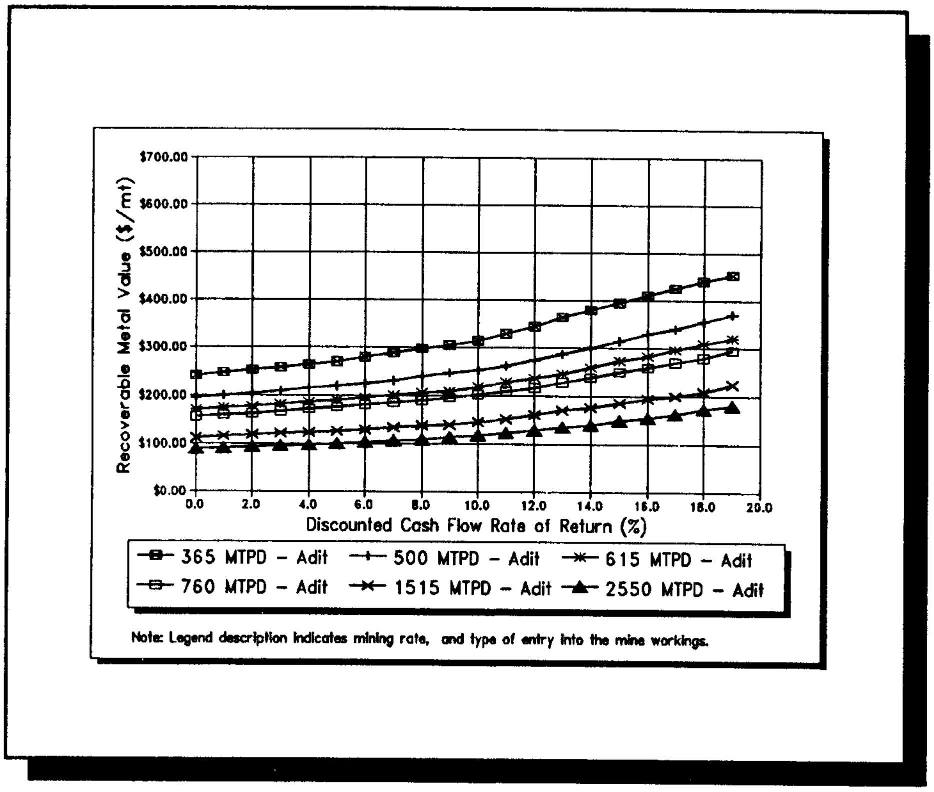

FIGURE 4. - RMV vs. DCFROR for a metamorphic gold vein deposit; 365, 500, 615, 760, 1,515, and 2,550 mtpd, adit entry, cut-and-fill stope mine models.

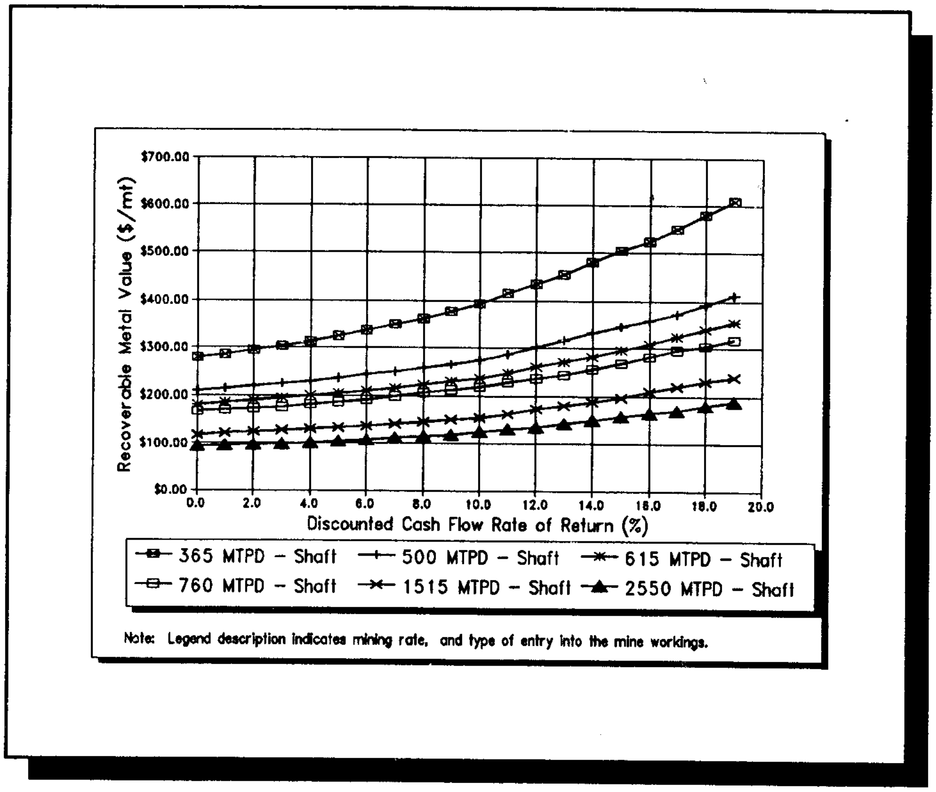

FIGURE 5. - RMV vs. DCFROR for a metamorphic gold vein deposit; 365, 500, 615, 760, 1,515, and 2,550 mtpd, shaft entry, cut-and-fill stope mine models.

Copper-Gold-Silver Skarn Deposit Model

The copper-gold-silver skarn deposit models are based on the geologic information available for mineralized skarns that occur in the VCMD. Examples of known occurrences upon which the deposit models are based are the Zackly prospect, the Nim Claims, Upper Black River prospect, Granite Creek prospect, and East Fairbanks Meridian prospect (fig 2).

The mine models designed for application to the copper-gold-silver skarn deposit model assume a steeply dipping, marginally competent ore body of relatively consistent width. The deposit model is further characterized by the type of access that is planned in each applicable mine model. Adit entry mine models assume that the ore body is exposed at the surface, and that there is sufficient back to warrant an adit entry. Shaft entry mine models assume that the top of the ore body is 35 meters below the shaft collar. Overall geometry of the ore body is assumed to be tabular with depth equal to length.

A total of 6 overhand mine models and 12 cut-and-fill mine models were developed for application to this deposit model. Table 1 lists the basic mine model description. Each applicable mine model in the table was evaluated as either an adit entry mine or a shaft entry mine. In each model, the associated mill uses one product flotation technology to produce an ore concentrate. Ore concentrates are shipped to a smelter for refining. All costs generated for each mine model are listed in appendix A.

Adit and shaft entry overhand mine models incorporate stopers and jackleg drills for production. Jackleg drills are also used for drift development. Slushers are used to move ore from the stopes to ore chutes, and LHD's are used to move ore from the chutes to ore storage locations. Shaft entry overhand mine models access the deposit through one production shaft. Shaft entry models also incorporate one combination ventilation-escapeway raise. Hydraulic sand is used to back-fill the stopes in each overhand mine model.

Adit and shaft entry cut-and-fill mine models incorporate jackleg drills and stopers for production development. Small jumbo drills are used for drift development. Slushers are used to move ore from the stopes to ore chutes, and LHD's are used to move ore from the chutes to ore storage locations. Shaft entry cut-and-fill mine models access the deposit through one production shaft. Shaft entry models also incorporate one combination ventilation-escapeway raise. Hydraulic sand is used to back-fill the stopes in each cut-and-fill mine model.

Figures 6, 7, and 8 graphically present the results of the cash flow analysis for the copper, gold, silver skarn deposit mine models. Table 3 summarizes the results of the RMV vs. DCFROR cash flow analysis for the mine models. The RMV's required to achieve a 15% DCFROR range from a high of $568.50/mt for a shaft entry 125 mtpd mine, to a low of $157.50/mt for an adit entry 2,550 mtpd mine.

Plutonic Related Gold Vein Deposit Model

The plutonic related gold vein deposit models (vein deposit) are based on the geology of mineralized veins that occur in several locations in the VCMD such as the Golden Zone, the Partin Creek occurrence, the Rocky Cummins Claims, the Silver King occurrence, the Mint Mine, the MacCallie Glacier occurrence, and the Eagle prospect (fig 2).

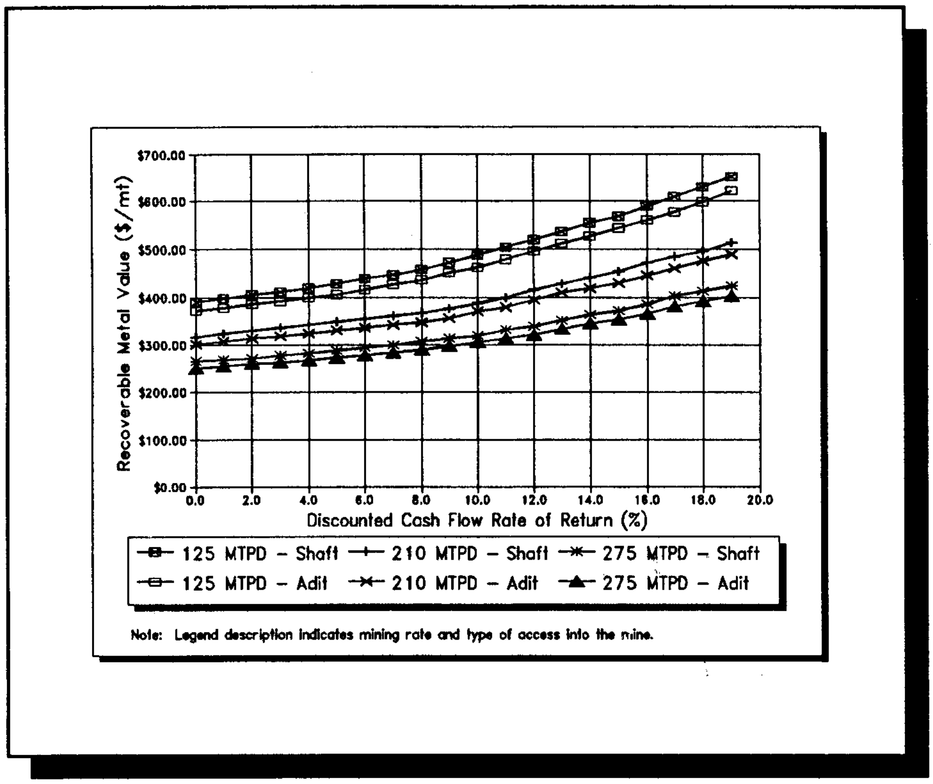

FIGURE 6. - RMV vs. DCFROR for a copper-gold-silver skarn deposit; 125, 210, and 275 mtpd, adit and shaft entry, overhand stope mine models.

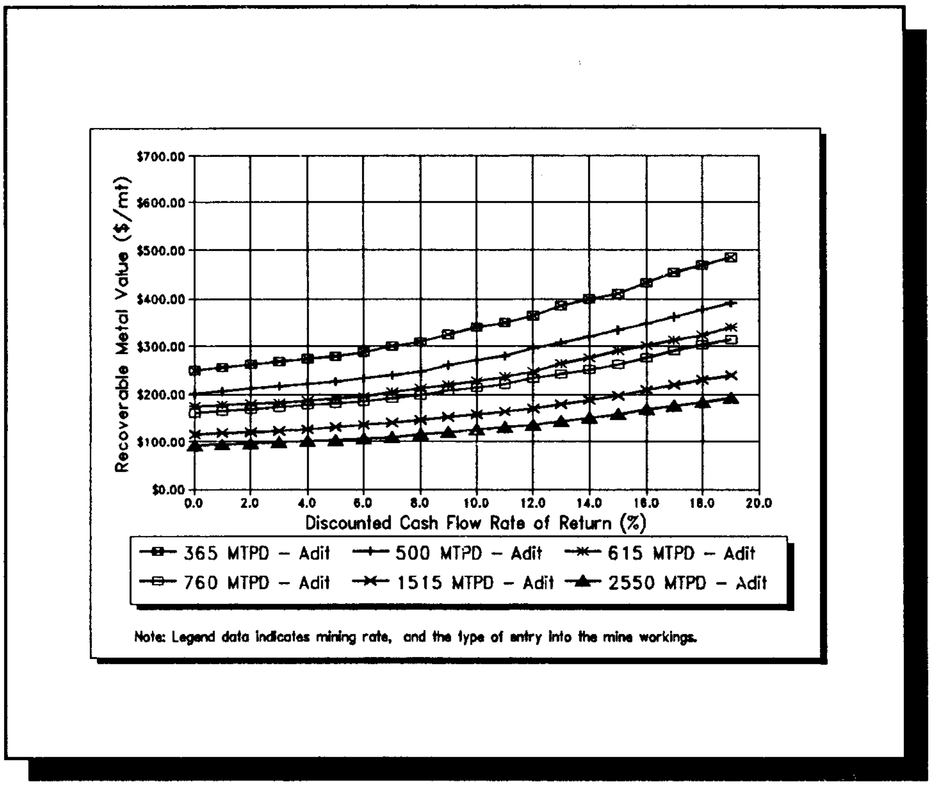

FIGURE 7. - RMV vs. DCFROR for a copper-gold-silver skarn deposit; 365, 500, 615, 760, 1,515, and 2,550 mtpd, adit entry, cut-and-fill stope mine models.

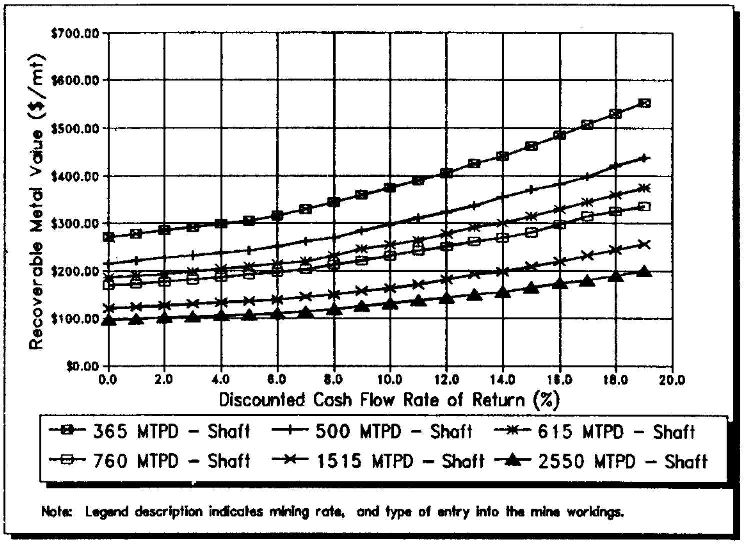

FIGURE 8. - RMV vs. DCFROR for a copper-gold-silver skarn deposit; 365, 500, 615, 760, 1,515, and 2,550 mtpd, shaft entry, cut-and-fill stope mine models.

TABLE 3. - Summary of cash flow analysis results for mine models applied to copper-gold-silver skarn deposit models.

Deposit type	Deposit size (mt)	Mine type (extraction method)	Mining rate (mtpd)	RMV ($/mt) Adit entry 0% ROR	RMV ($/mt) Adit entry 15% ROR	RMV ($/mt) Shaft entry 0% ROR	RMV ($/mt) Shaft entry 15% ROR
Cu, Au, Ag skarn	175,000	Overhand	125	$372.00	$544.50	$391.00	$568.50
Cu, Au, Ag skarn	350,000	Overhand	210	$302.00	$430.00	$318.00	$456.50
Cu, Au, Ag skarn	500,000	Overhand	275	$251.00	$354.00	$265.00	$372.00
Cu, Au, Ag skarn	750,000	Cut-and-fill	365	$250.00	$410.00	$271.00	$472.50
Cu, Au, Ag skarn	1,000,000	Cut-and-fill	500	$202.00	$334.00	$216.00	$371.00
Cu, Au, Ag skarn	1,500,000	Cut-and-fill	615	$175.00	$291.00	$186.00	$315.00
Cu, Au, Ag skarn	2,000,000	Cut-and-fill	760	$161.00	$263.00	$170.00	$281.00
Cu, Au, Ag skarn	5,000,000	Cut-and-fill	1515	$115.00	$197.00	$121.00	$213.00
Cu, Au, Ag skarn	10,000,000	Cut-and-fill	2550	$92.00	$157.50	$96.00	$166.00

The mine models designed for application to the plutonic related gold vein deposit model assume a steeply dipping, competent ore body of consistent width. For all mine models, the deposit model geometry is tabular and there is a 31 m (100 ft) thick zone extending downward from the surface that is low grade and will not be mined. The tonnage factor has been estimated at 0.3527 m^3/mt (11.3 ft^3/st).

A total of 3 shrinkage, 4 overhand, and 4 longhole-sublevel mine models were developed for application to this deposit model. Table 1 lists the basic mine model description. Applicable overhand and longhole mine models in the table were evaluated as either an adit entry or a shaft entry mine. The shrinkage mine models were evaluated as shaft entry mine models only. In each model, the associated mill uses a carbon-in-pulp (CIP) technology with Merrill-Crowe precipitation to process ore. All costs generated for each mine model are listed in appendix A.

Shaft entry shrinkage mine models incorporate the use of jackleg drills and LHD's for drift development; and stopers, jackleg drills, jumbo mounted drifters and LHD's for stope development and production. Shaft entry shrinkage mine models access the deposit through one production shaft. Shaft entry models also incorporate one combination ventilation-escapeway raise. Hydraulic sand is used to back-fill the stopes in each shrinkage mine model.

Adit and shaft entry overhand mine models incorporate stopers and jackleg drills for production. Jackleg drills are also used for drift development. Slushers are used to move ore from the stopes to ore chutes, and LHD's are used to move ore from the chutes to ore storage locations. Shaft entry overhand mine models access the deposit through one production shaft. Shaft entry models also incorporate one combination ventilation-escapeway raise. Hydraulic sand is used to back-fill the stopes in each overhand mine model.

Adit and shaft entry cut-and-fill mine models incorporate jackleg drills and stopers for production development. Small jumbo drills are used for drift development. Slushers are used to move ore from the stopes to ore chutes, and LHD's are used to move ore from the chutes to ore storage locations. Shaft entry cut-and-fill mine models access the deposit through one production shaft. Shaft entry models also incorporate one combination ventilation-escapeway raise. Hydraulic sand is used to back-fill the stopes in each cut-and-fill mine model.

Adit and shaft entry longhole-sublevel mine models incorporate jumbo and down-the-hole drills for production development and production. Small jumbo drills are used for drift development. LHD's are used to move ore from the stopes to ore chutes and storage locations. Shaft entry longhole-sublevel mine models access the deposit through one production shaft. Shaft entry models also incorporate one combination ventilation-escapeway raise.

Figures 9, 10, and 11 show the cash flow analysis results for the shrinkage, overhand, and longhole-sublevel mine models respectively, that were applied to the plutonic related gold vein deposit model. Table 4 lists a summary of the RMV vs. DCFROR cash flow analysis results for the plutonic related gold vein mine models. The RMV's required to achieve a 15% DCFROR range from a high of $430.00/mt for a shaft entry 100 mtpd shrinkage mine, to $174.00/mt for an adit entry 760 mtpd longhole-sublevel mine.

Basalt Hosted Copper Deposit Model

The basalt hosted copper deposit model is based on the geology of mineralized occurrences in the VCMD such as the Denali Copper prospect, the Kathleen Margaret prospect, the CM Claims, the Greathouse prospect, and the Yukon Group prospect (fig 2).

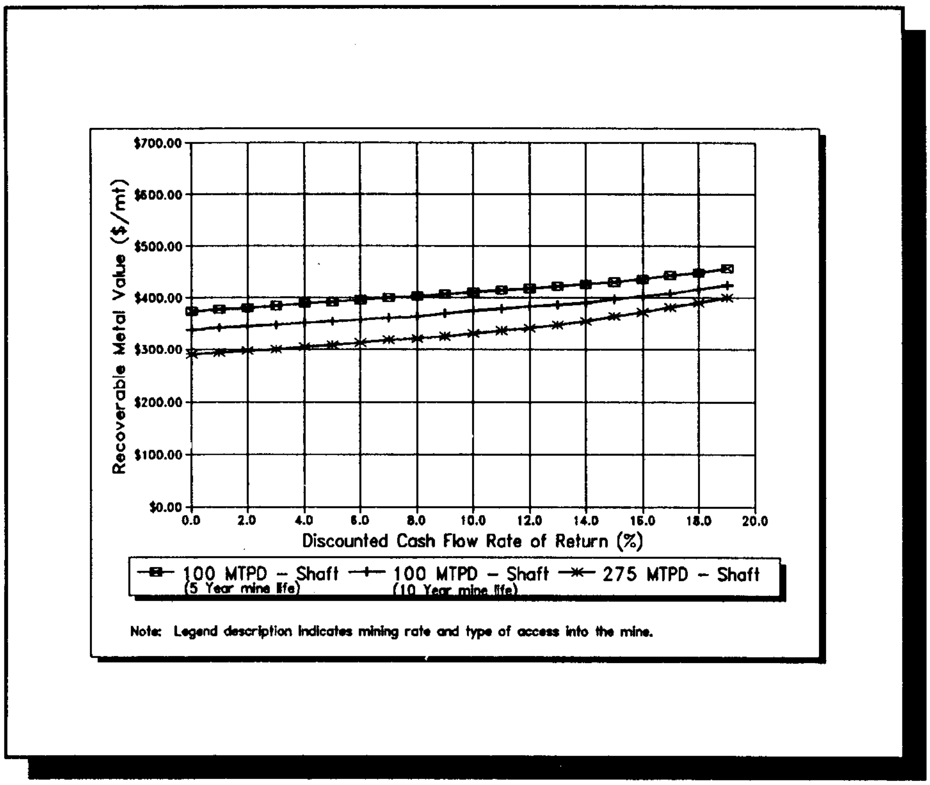

FIGURE 9. - RMV vs. DCFROR for a plutonic related gold vein deposit; 100 and 275 mtpd, shaft entry, shrinkage stope mine models.

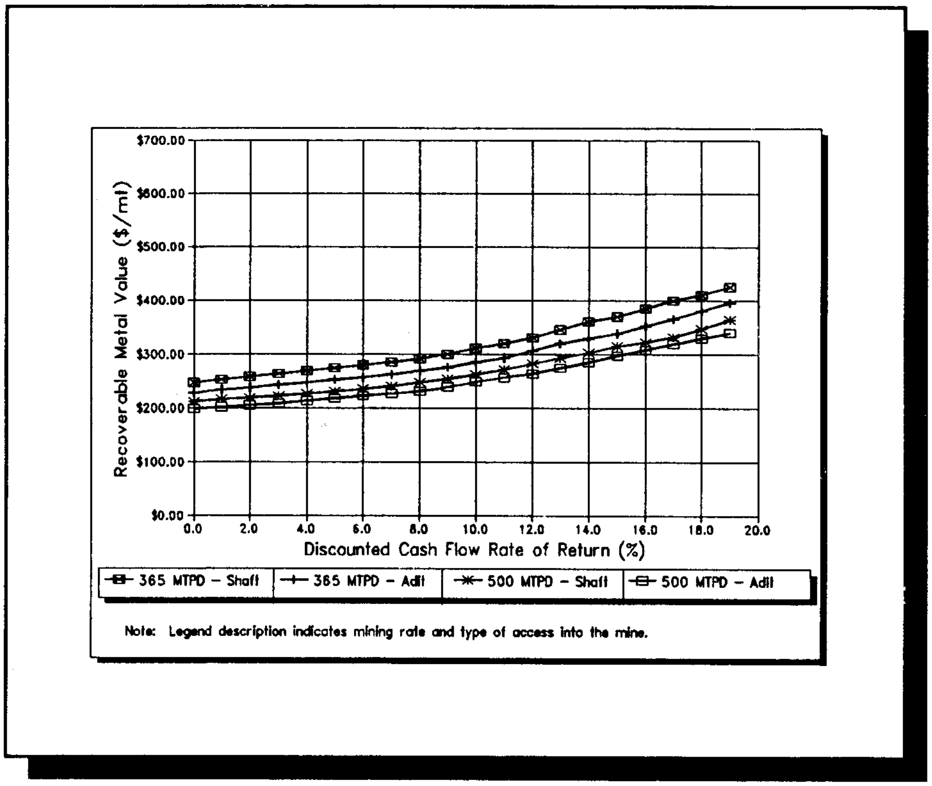

FIGURE 10. - RMV vs. DCFROR for a plutonic related gold vein deposit; 365 and 500 mtpd, adit and shaft entry, overhand stope mine models.

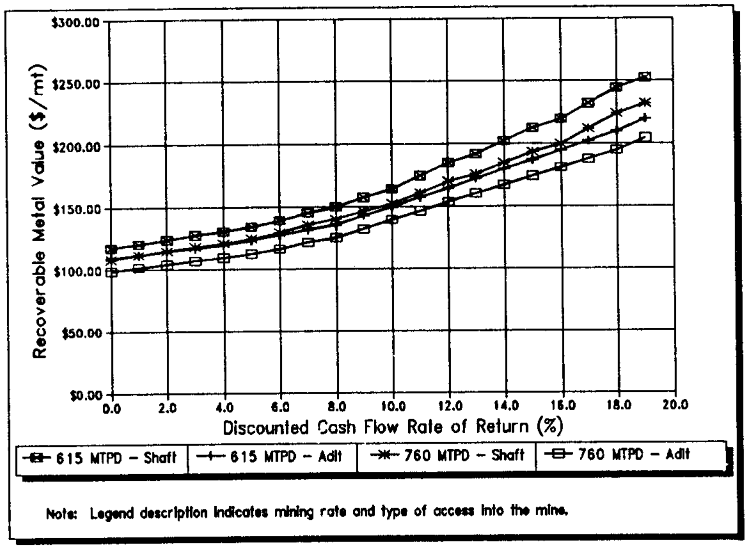

FIGURE 11. - RMV vs. DCFROR for a plutonic related gold vein deposit; 615 and 760 mtpd, adit and shaft entry, sublevel-longhole stope mine models.

TABLE 4. - Summary of cash flow analysis results for mine models applied to plutonic related gold vein deposit models.

Deposit type	Deposit size (mt)	Mine type (extraction method)	Mining rate (mtpd)	RMV ($/mt)			
				Adit entry		Shaft entry	
				0% ROR	15% ROR	0% ROR	15% ROR
Plutonic related Au vein	175,000	Shrinkage	100	n/a	n/a	$373.00	$430.00
Plutonic related Au vein	350,000	Shrinkage	100	n/a	n/a	$337.00	$396.00
Plutonic related Au vein	500,000	Shrinkage	275	n/a	n/a	$290.00	$360.00
Plutonic related Au vein	750,000	Overhand	365	$228.00	$338.00	$246.00	$370.00
Plutonic related Au vein	1,000,000	Overhand	500	$198.00	$296.00	$211.00	$314.00
Plutonic related Au vein	1,500,000	Longhole-sublevel	615	$109.00	$187.50	$117.00	$213.00
Plutonic related Au vein	2,000,000	Longhole-sublevel	760	$99.00	$174.00	$108.00	$194.00

The mine models designed for application to the basalt hosted copper deposit model assume a steeply dipping, competent ore body of variable width. The deposit model is further characterized by the type of access that is planned in each applicable mine model. Adit entry mine models assume that the ore body is exposed at the surface, and that there is sufficient back to warrant an adit entry. Shaft entry mine models assume that the top of the ore body is 35 meters below the shaft collar. Overall geometry of the ore body is assumed to be tabular.

A total of 8 longhole-sublevel mine models were developed for application to this deposit model. Table 1 lists the basic mine model descriptions. Each applicable mine model in the table was evaluated as either an adit entry mine or a shaft entry mine. In each model, the associated mill uses one product flotation technology to produce an ore concentrate. Ore concentrates are shipped to a smelter for refining. All costs generated for each mine model are listed in appendix A.

Adit and shaft entry longhole-sublevel mine models incorporate jumbo and down-the-hole drills for production development and production. Small jumbo drills are used for drift development. LHD's are used to move ore from the stopes to ore chutes and storage locations. Shaft entry longhole-sublevel mine models access the deposit through one production shaft. Shaft entry models also incorporate one combination ventilation-escapeway raise.

Figures 12 and 13 show the cash flow analysis results for the longhole-sublevel mine models that were applied to the basalt hosted copper deposit model. Table 5 lists a summary of the RMV vs. DCFROR cash flow analysis results for the basalt hosted copper deposit models. The RMV's required to achieve a 15% DCFROR range from a high of \$188.00/mt for a shaft entry 760 mtpd mine, to a low of \$106.00/mt for an adit entry 3,445 mtpd mine.

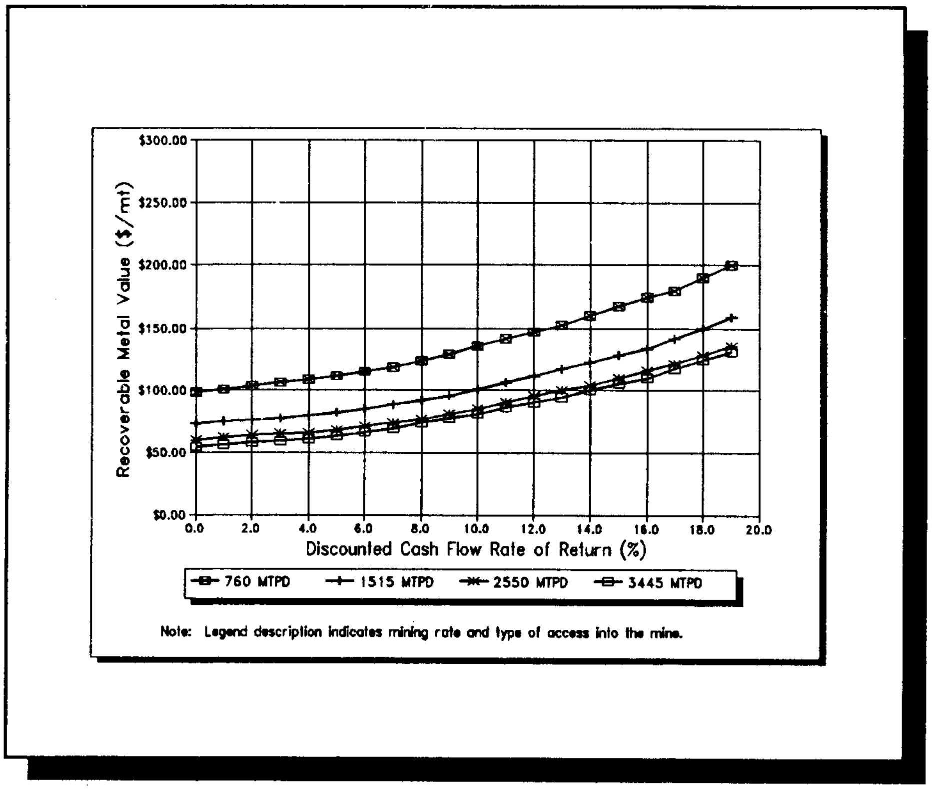

FIGURE 12. - RMV vs. DCFROR for a basalt hosted copper deposit; 760, 1,515, 2,550, and 3,445 mtpd, adit entry, sublevel-longhole stope mine models.

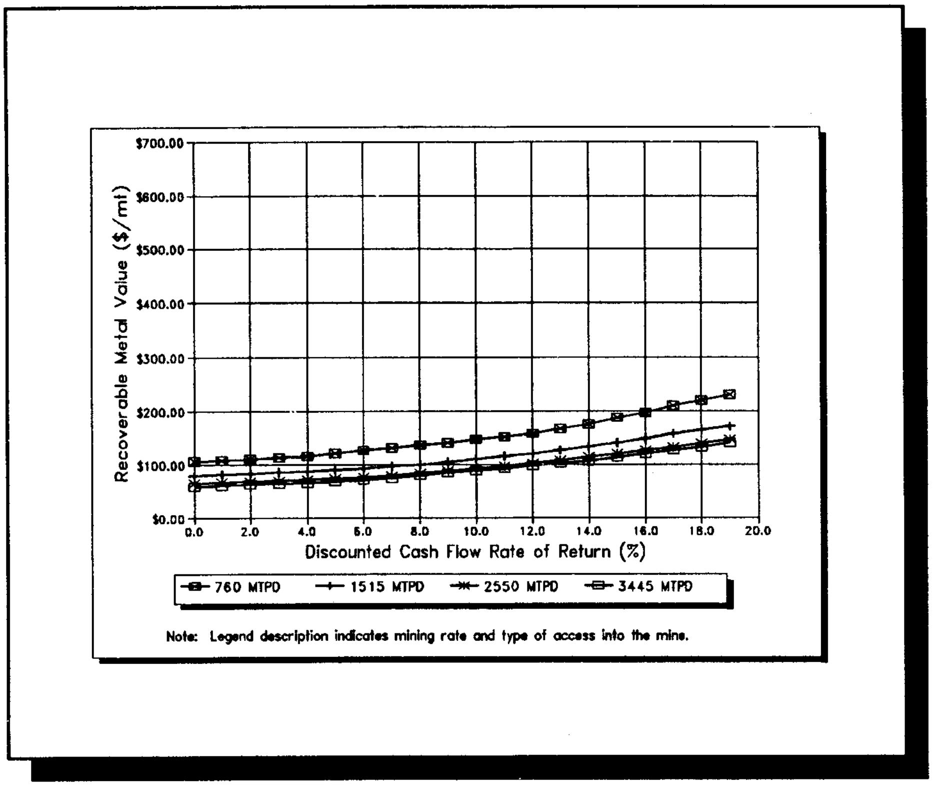

FIGURE 13. - RMV vs. DCFROR for a basalt hosted copper deposit; 760, 1,515, 2,550, and 3,445 mtpd, shaft entry, sublevel-longhole stope mine models.

TABLE 5. - Summary of cash flow analysis results for mine models applied to basalt hosted copper deposit models.

Deposit type	Deposit size (mt)	Mine type (extraction method)	Mining rate (mtpd)	RMV ($/mt)			
				Adit entry		Shaft entry	
				0% ROR	15% ROR	0% ROR	15% ROR
Basalt hosted copper	2,000,000	Longhole-sublevel	760	$98.00	$169.00	$106.00	$188.00
Basalt hosted copper	5,000,000	Longhole-sublevel	1,515	$73.00	$128.00	$79.00	$140.00
Basalt hosted copper	10,000,000	Longhole-sublevel	2,250	$60.00	$110.00	$65.00	$120.00
Basalt hosted copper	15,000,000	Longhole-sublevel	3,445	$55.00	$106.00	$59.00	$113.25

Porphyry Gold Deposit Model

The porphyry gold deposit model is based on the geology of mineralized occurrences in the VCMD such as the Gold Hill, the Lucky Hill, and the Lucky Top prospects (fig 2).

The mine models designed for application to the porphyry gold deposit model assume that the deposit is located near the surface and the structural characteristics of the ore body are such that open pit mining methods are applicable. Ore body geometry is modeled after a horizontal disk where the thickness is equal to half the horizontal radius.

A total of 3 open pit mine models were developed for application to this deposit model. Table 1 lists the basic mine model descriptions. In each mine model, the associated mill uses CIP technology with Merrill-Crowe precipitation to process the ore. All costs generated for each mine model are listed in appendix A.

Open pit mine models incorporate the use of rubber-tired front-end loaders, trucks, and percussion drills. Pit slopes are designed at 45 degrees. The stripping ratio is estimated at 1:1.

Figure 14 graphically presents the cash flow analysis results for the open pit mine models. Table 6 lists a summary of the RMV vs. DCFROR cash flow analysis results for the open pit mine models that were applied to the porphyry gold deposit model. The RMV's required to achieve a 15% DCFROR range from a high of $155.50/mt for a 760 mtpd open pit mining operation, to $94.00/mt for a 2,250 mtpd open pit mining operation.

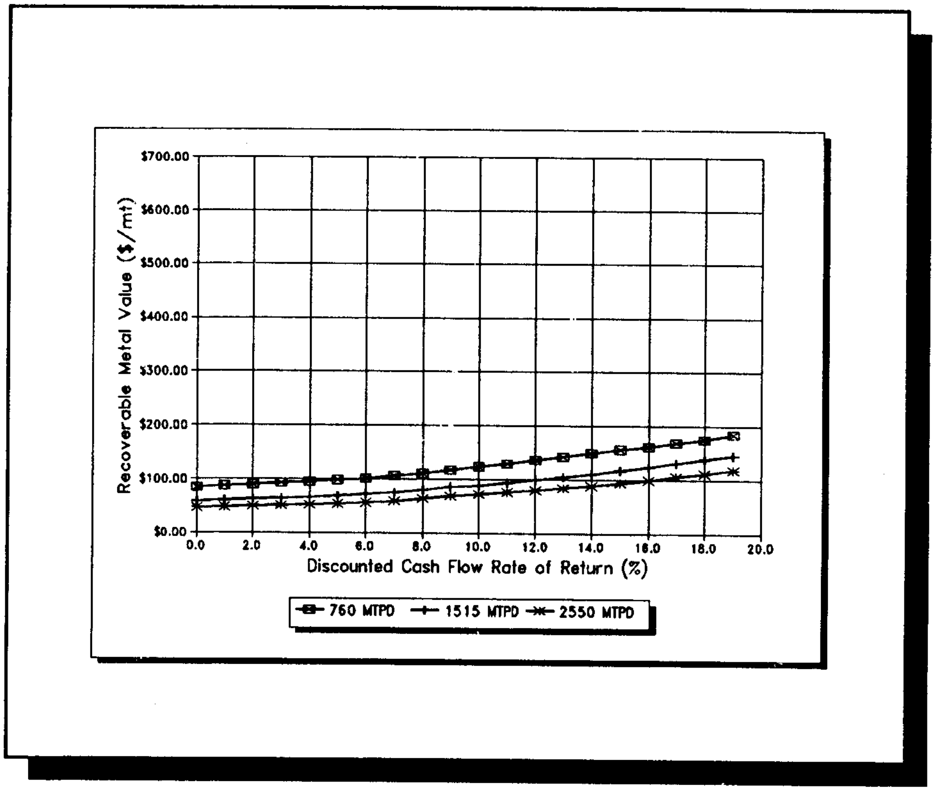

FIGURE 14. - RMV vs. DCFROR for a porphyry gold deposit; 760, 1,515, and 2,550 mtpd open-pit mine models.

TABLE 6. - Summary of cash flow analysis results for mine models applied to porphyry gold deposit models.

Deposit type	Deposit size (mt)	Mine type (extraction method)	Mining rate (mtpd)	RMV ($/mt)	
				0% ROR	15% ROR
Porphyry gold	2,000,000	Open pit	760	$85.00	$155.50
Porphyry gold	5,000,000	Open pit	1,515	$59.00	$117.00
Porphyry gold	10,000,000	Open pit	2,550	$46.00	$94.00

Plutonic Related Tin Deposit Model

The plutonic related tin deposit model is based on the geology of mineralized occurrences in the VCMD such as the Honolulu prospect, the Tsusena Creek prospect, the Ohio Creek prospect, and the Ready Cash prospect (fig 2).

The mine models designed for application to the plutonic related tin deposit model assume that the deposit is located near the surface, and that the structural characteristics of the ore body are such that open pit mining methods are applicable. Ore body geometry is modeled after a horizontal disk where the thickness is equal to half the horizontal radius.

A total of 5 open pit mine models were developed for application to this deposit model. Table 1 lists the basic mine model descriptions. In each model, the associated mill uses a gravity mill to process the ore and produce a concentrate. Concentrates are shipped to a smelter for refining. All costs generated for each mine model are listed in appendix A.

Open pit mine models incorporate the use of rubber-tired front-end loaders, trucks, and percussion drills. Overall pit slope angles are specified at 45 degrees.

Table 7 lists a summary of the RMV vs. DCFROR cash flow analysis results for the plutonic related tin mine models. The RMV's required to achieve a 15% DCFROR range from a high of $153.50/mt for a 500 mtpd open pit mine, to a low of $71.00/mt for a 2,250 mtpd open pit mine. Figure 15 graphically presents the cash flow analysis results for the open pit mine models that were applied to the plutonic related tin deposit model.

TABLE 7. - Summary of cash flow analysis results for mine models applied to plutonic related tin deposit models.

Deposit type	Deposit size (mt)	Mine type (extraction method)	Mining rate (mtpd)	RMV ($/mt)	
				0% ROR	15% ROR
Plutonic related tin	1,000,000	Open pit	500	$89.00	$153.50
Plutonic related tin	1,500,000	Open pit	615	$76.00	$130.00
Plutonic related tin	2,000,000	Open pit	760	$69.00	$120.00
Plutonic related tin	5,000,000	Open pit	1,515	$48.00	$88.50
Plutonic related tin	10,000,000	Open pit	2,550	$38.00	$71.00

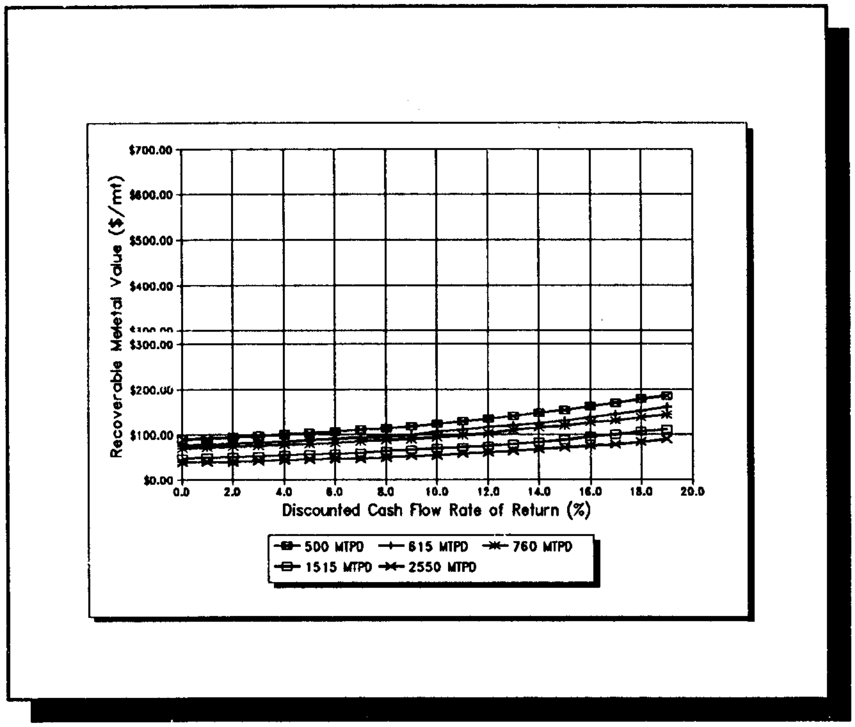

FIGURE 15. - RMV vs. DCFROR for a plutonic related tin deposit; 500, 615, 760, 1,515, and 2,550 mtpd, open-pit mine models.

ANALYSIS OF SPECIFIC MINE MODELS

Gold-Silver-Copper Breccia Pipe Deposit Model

The gold-silver-copper breccia pipe deposit model (breccia pipe model) is based on current geologic knowledge of the Golden Zone deposit (20), located near the headwaters of the Chulitna River (fig 2). The deposit tonnage for the purposes of the breccia pipe deposit model is 4,100,000 st of ore.

The mine model designed for application to the breccia pipe model assumes that the deposit geometry is analogous to a vertically oriented cylinder. Approximate dimensions of the cylinder are 91 m (300 ft) diameter by 457 m (1,500 ft) depth. The mining plan calls for open-pit mining during the first two years of mine operation. Ore and waste will be drilled using rotary drills. Front-end loaders and 20-ton (18 mt) rock trucks will transport ore and waste to proper storage locations. Ore will be produced at 733 mtpd (808 stpd). The stripping ratio is 3.66:1, which will result in the mining of 3,417 mtpd (3,767 stpd) of ore and waste combined. There will be no overburden to remove from the deposit. Total pit depth will be 58 m (190 ft).

In the third year of mine production, the ore will be extracted by the underground cut-and-fill method. Underground workings will consist of a concrete-lined hoisting shaft of 497 m (1500 ft) in depth, a main haulage adit 31 m (102 ft) in length and stretching from the surface at the 107 m (350 ft) level to the shaft at the 128 m (420 ft) level. The total length of the underground workings will total 5,396 m (17,000 ft) when the mine is fully developed. This figure includes the lengths of the main shaft and adit as well as those of the drifts, raises, and ore shoots necessary for cut-and-fill production.

The ore will be transported to the hoisting shaft via LHD vehicles at a rate of 733 mtpd (808 stpd). Once the ore has been transported to the surface, it will be loaded onto 20-ton (18 mt) ore trucks and hauled to the mill site. Fill needed in the mine will come from waste generated from the open-pit stage as well as from partially de-watered mill tailings.

The ore grade distribution in the deposit is such that there are two types of ore. High grade ore will be sent through a flotation/vat-leach circuit, and low grade ore will be routed to heap-leach pads. Both types of ore will be crushed to minus 0.25 inch (0.64 cm). After crushing, high grade ore will pass through a cone grinder which will reduce the ore to -325 mesh at the rate of 251 mtpd (277 stpd).

Ore will pass from the grinding circuit to a jig where free gold will be recovered, and then to a flotation circuit which will float the copper bearing ore. Tailings from the flotation circuit will be vat leached in a carbon-in-leach (CIL) circuit. The pregnant solution from the CIL circuit will be electrolytically refined to recover gold and silver. Tailings from the milling process will be thickened and placed in a double lined impoundment near the mill site.

Low grade ore will be crushed, agglomerated, and stacked on impermeable leaching pads. Cyanide solution will be applied to the ore on the leach pad during the months of June through October.

Pregnant solution from the heap leach process will be passed into the CIL circuit and electrolytically refined. Barren cyanide solution will be recharged and reapplied to the ore remaining on the heap-leach pad.

Flotation concentrates and doré produced in the milling process will be shipped to a smelter in Japan at a rate of 449 st (407 mt) per year.

The mine and mill are assumed to operate 350 days per year, three shifts per day. The total mine life is 14.38 years.

Costs for this model are estimated in July 1989 dollars, and have been escalated to reflect costs as would be experienced in the VCMD, Alaska. Operating costs are listed in Table 8. Capital costs for this model are listed in Table 9. Concentrates will be shipped at a rate of $60.00/mt ($54.43/st).

The cash flow analysis for this mine model relies on a CIS which details the timing of capital investment for development of the mine and mill facilities. Table 10 itemizes the costs as they were applied to the cash flow model.

TABLE 8. - Operating costs ($/mt) for the gold-silver-copper breccia pipe deposit mine model.

Mine (open pit)	Mine (underground)	Mill (vat)	Mill (heap)
$42.87	$79.92	$19.56	$17.29

TABLE 9. - Capital costs for mine models applied to the gold-silver-copper breccia pipe deposit model.

Capital cost item	Cost ($)
Exploration/Acquisition	4,281,476
Mine permitting	2,500,000
Development (open-pit)	10,069,732
Development (underground)	8,012,284
Mine equipment (open-pit)	4,392,894
Mine equipment (underground)	2,644,142
Mine plant (open-pit)	5,516,000
Mine plant (underground)	2,681,336
Infrastructure	4,417,314
Restoration	1,724,098
Working capital (open-pit)	3,959,025
Working capital (underground)	7,936,155
Mine TOTAL	**58,134,456**
Mill plant (vat)	11,059,268
Mill plant (heap)	11,950,314
Working capital (mill)	3,403,429
Mill TOTAL	**26,413,011**
TOTAL CAPITAL COST	**84,547,467**

TABLE 10. - Capital investment schedule for development of the mine and mill facilities, breccia pipe deposit model.

Item	Cost ($)	Year(s) of expenditure
Summary of surface mine capital costs		
Acquisition	2,500,000	1
Exploration	781,476	2-3
Permitting	2,500,000	2-3
Development	10,069,732	4-5
Mine plant	5,516,000	4-5
Mine equipment	4,392,894	4-5
Infrastructure	4,417,314	4-5
Restoration	1,724,098	20
Working capital	3,959,025	5
TOTAL	**35,860,539**	
Summary of underground mine capital costs		
Exploration	1,000,000	2-3
Development	8,012,284	6-7
Mine plant	2,681,336	6-7
Mine equipment	2,644,142	6-7
Working capital	7,936,155	8
TOTAL	**22,273,917**	

TABLE 10.--Continued - Capital investment schedule for development of the mine and mill facilities, breccia pipe deposit model.

Item	Cost ($)	Year(s) of expenditure
Summary of vat leach mill capital costs		
Mill plant	11,059,268	4-5
Working capital	1,806,559	6
TOTAL	**12,865,827**	
Summary of heap leach mill capital costs		
Mill plant	11,950,314	4-5
Working capital	1,596,870	6
TOTAL	**13,547,184**	

Cash Flow Analysis for the Gold-Silver-Copper Breccia Pipe Deposit Mine Model

Figure 16 graphically shows the results of the cash flow analysis for the mining scenario applied to the breccia pipe deposit model. The cash flow model results in a zero percent DCFROR (break even) when the RMV equals $202.00/mt of ore, and 15% DCFROR when the RMV equals $260.00/mt of ore.

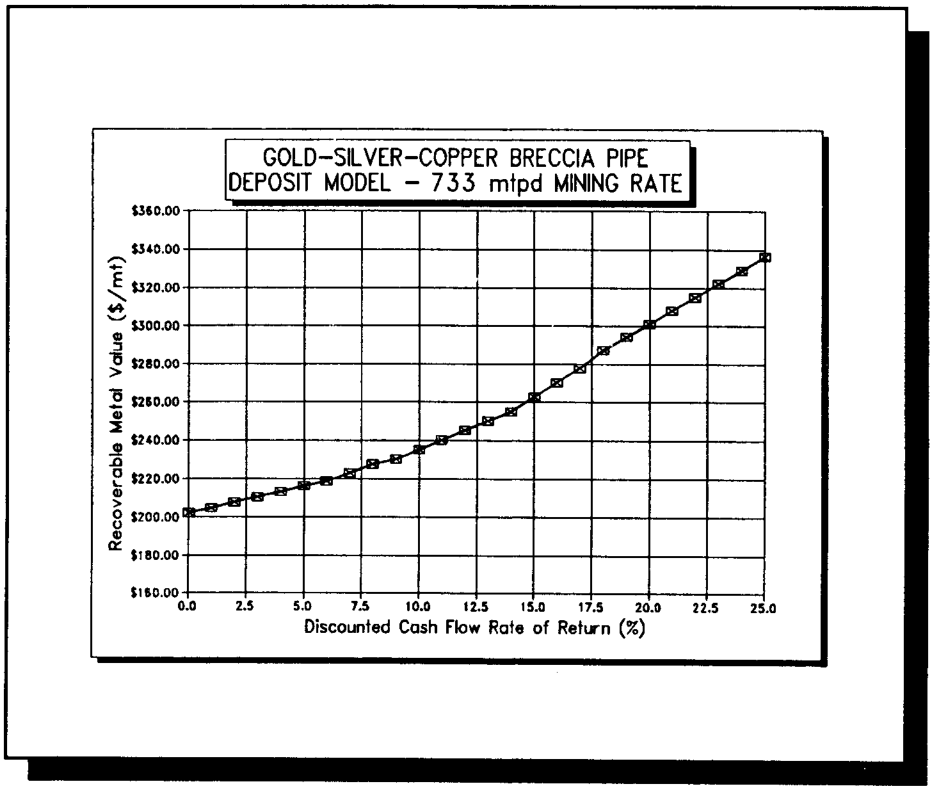

FIGURE 16. - Cash flow analysis results for the breccia pipe deposit mine model.

Copper-Gold-Silver Skarn Deposit Model

The copper-gold-silver skarn deposit model is based on current geologic knowledge of the Zackly deposit, located in the Clearwater Mountains near the Maclaren Glacier (21) (fig 2). The deposit size for the purposes of this copper-gold-silver skarn deposit model is 1,623,000 mt of ore. The deposit model geometry is tabular, with a strike length of 726 m (2,381 ft), a depth of 298 m (977 ft), and an average mining width of 2.6 m (8.53 ft). The tonnage factor has been estimated at 0.3434 m^3/mt (11 ft^3/st). Ore will be produced from the deposit at a rate of 454 mtpd (500 stpd), 325 days per year, for a total of 11 years. The ore body will be accessed by a series of adits and declines collared at locations along the valley wall in such a way that production levels are created every 92 m (300 ft) vertically. A total of 4 production levels will need to be developed to allow access to the ore body. The ore body is assumed to be competent enough to allow bulk mining by the longhole-sublevel method. Ore will be mined from mining blocks 61 m (200 ft) long by 92 m (300 ft) high. LHD vehicles will remove broken ore from the stopes at draw points. Ore drawn from stopes accessed by declines will be transferred to an underground crushing station located on the lowest level via an ore pass. Crushed ore will be transported to the surface stockpile location via conveyors. Ore mined from levels accessed by adits will be removed from stope draw points and transported to the surface by LHD vehicles. Ore feed to the mill will be accomplished by surface conveyors.

Development of the ore body will commence with construction of the 297 m (975 ft) level decline, and development of the 23 m (75 ft) and the 114 m (375 ft) level adits. Full capacity ore production will begin within three months of completion of the adit portal on the 23 m (75 ft) level. Upon completion of the 297 m (975 ft) haulage level, the underground crushing station will be installed and the ore pass raise will be driven to the 114 m (375 ft) level. Mining will continue on the 23 m (75 ft) and the 114 m (375 ft) levels until the ore reserve is exhausted. Development of stopes on the 206 m (675 ft) and the 297 m (975 ft) levels will begin so that start-up of production will be synchronized with the completion of mining on the 23 m (75 ft) and the 114 m (375 ft) levels.

Ore processing involves crushing and grinding the ore to 80% -325 mesh. After grinding, the ore will pass across a jig where free gold will be recovered. Ore will proceed from the jig to a flotation circuit which will float the copper ore. Tailings from the flotation circuit will be leached in a CIP circuit. The pregnant solution from the CIP circuit will be electrolytically refined to recover gold and silver. Tailings from the milling process will be thickened and placed in a double lined impoundment near the mill site.

Flotation concentrates and doré produced in the milling process will be shipped to smelter in Japan at a rate of 12,145 st (11,018 mt) per year. The cost for concentrate shipping has been estimated at $110.00/mt ($100.00/st).

Costs for this model are estimated in July 1989 dollars, and have been escalated to reflect costs as would be experienced in the VCMD, Alaska. Operating costs for this model are listed in table 11. Capital costs are listed in table 12.

TABLE 11. - Operating costs ($/mt) for the copper-gold-silver skarn deposit mine model.

Infrastructure	Mine	Mill	Ore Concentrate Shipping	Total
$15.92	$41.88	$41.19	$7.47	$106.40

TABLE 12. - Capital costs for the copper-gold-silver skarn deposit mine model.

Capital cost item - mine	Cost ($)
Exploration/Acquisition	3,055,080
Mine permitting	2,000,000
Development	4,789,497
Mine equipment	5,054,532
Mine plant	8,131,061
Infrastructure	8,486,346
Working capital	1,098,109
Mine TOTAL	**32,614,625**
Capital cost item - mill	**Cost ($)**
Mill plant	20,152,880
Working capital	1,121,957
Mill TOTAL	**21,274,837**
TOTAL CAPITAL COST	**53,889,462**

Cash Flow Analysis for the Copper-Gold-Silver Skarn Deposit Mine Model

The cash flow analysis for this mine model relies on a CIS which details the timing of capital investment for development of the mine and mill facilities. Table 13 itemizes the costs as they were applied to the cash flow model.

TABLE 13. - Capital investment schedule for development of the mine and mill facilities, copper-gold-silver skarn deposit model.

Item	Total cost ($)	Year(s) of expenditure
Summary of mine capital costs		
Acquisition	1,055,080	1
Exploration	2,000,000	1-6
Permitting	2,000,000	3-6
Development, mine plant, mine equipment	17,975,090	3-6
Infrastructure	8,486,346	3-6
Working capital	1,098,109	6
TOTAL	32,614,625	
Summary of mill capital costs		
Mill plant	20,152,880	4-5
Working capital	1,121,957	6
TOTAL	21,274,837	
Summary of operating costs		
Mine operating cost	$65.27/mt	7-18
Mill operating cost	$41.19/mt	7-18

Figure 17 graphically shows the results of the cash flow analysis for the mining scenario applied to the copper-gold-silver skarn deposit model. The cash flow model results in a zero percent DCFROR (break even) when the RMV equals $160.00/mt of ore, and 15% DCFROR when the RMV equals $250.00/mt of ore.

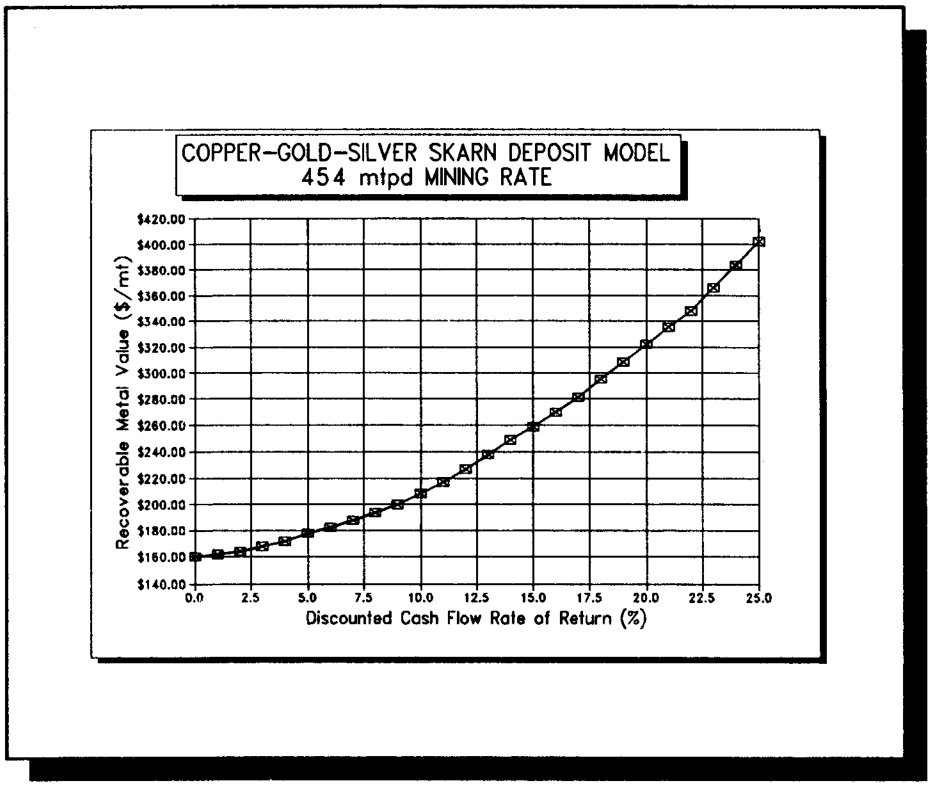

FIGURE 17. - Cash flow analysis results for the copper-gold-silver skarn deposit mine model.

Basalt Hosted Copper Deposit Model

The basalt hosted copper deposit model that was evaluated in this section is based on current geologic knowledge of the Denali Copper deposit (22-23), located in the Clearwater Mountains near the head of Windy Creek (fig. 2). The geometry of the modeled deposit is assumed to be a tabular shaped body, dipping 60-70°, with an average thickness of 21 m (70 ft), a strike length of 244 m (800 ft), and a depth of 305 m (1,000 ft). The ore body volume is estimated to be 5.2 million m^3 (56 million ft^3), equivalent to approximately 5.1 million mt (5.6 million st) of ore with a tonnage factor of 0.3086 m^3/mt (10 ft^3/st). The feasibility of mining the ore body was investigated for mining rates of 907 mtpd (1,000 stpd), 1,815 mtpd (2,000 stpd), and 2,722 mtpd (3,000 stpd) (24). The mine life for the three mining scenarios are 15, 8, and 6 years respectively. The ore body will be accessed by a 991 m (3,250 ft) crosscut adit to the 305 m

(1,000 ft) level, a short upper level adit, and five levels connected by inclined workings. Three raises will be drilled; two for ore and waste passes and one for ventilation. The ore body is assumed to be competent enough to allow bulk mining by the vertical crater retreat (VCR) blast hole stoping method. Stopes will be backfilled with coarse mine tailings. Ore will be crushed underground and transported to live storage at the mill via conveyor. Initial grinding will reduce the ore to 100% -65 mesh. The -65 mesh material will pass to the mill and bulk flotation cells for primary concentration. Concentrates will be reground to 80% -325 mesh before selective flotation which will produce a 23% copper concentrate. Concentrates will be thickened, filtered, and dried before truck haulage to a rail load-out at Cantwell, Alaska. Unit trains will haul the concentrate to Seward, Alaska for shipping to Japan for smelting.

Cash Flow Analysis for the Basalt Hosted Copper Deposit Mine Model

Capital and operating costs are listed below in Tables 14 and 15, respectively. The data has been summarized from Hughes and Hawley (25). All costs have been adjusted to reflect higher costs for Alaska.

TABLE 14. - Capital costs for the basalt hosted copper deposit mine model.

Capital cost item	907 mtpd mine model	1,814 mtpd mine model	2,722 mtpd mine model
Mine	$13,625,245	$15,878,231	$17,759,617
Mill	$16,663,019	$23,951,471	$30,210,117
Miscellaneous	$515,110	$515,110	$515,110
TOTAL	$30,803,374	$40,344,812	$48,484,845

TABLE 15. - Operating costs for the basalt hosted copper deposit mine model.

Operating cost item	907 mtpd mine model ($/mt)	1,814 mtpd mine model ($/mt)	2,722 mtpd mine model ($/mt)
Mine	$15.18	$13.19	$12.53
Mill	$28.00	$21.07	$19.03
TOTAL	$43.18	$34.26	$31.56

Figure 18 graphically shows the results of the cash flow analysis for the mining scenarios applied to the basalt hosted copper deposit model. The cash flow model results in a zero percent DCFROR (break even) for the best case mine model (1,814 mtpd) when the RMV equals $55.36/mt of ore. The best case mine model achieved a 15% DCFROR when the RMV equals $64.70/mt of ore. Contrary to what logic may dictate, the larger production rate mine is not the best case mine model due to the definition of the deposit model. For a 2,722 mtpd (3,000 stpd) mine model, the function of the time value of money causes the model to economically perform poorly due to the limitation of minable reserves in the deposit model.

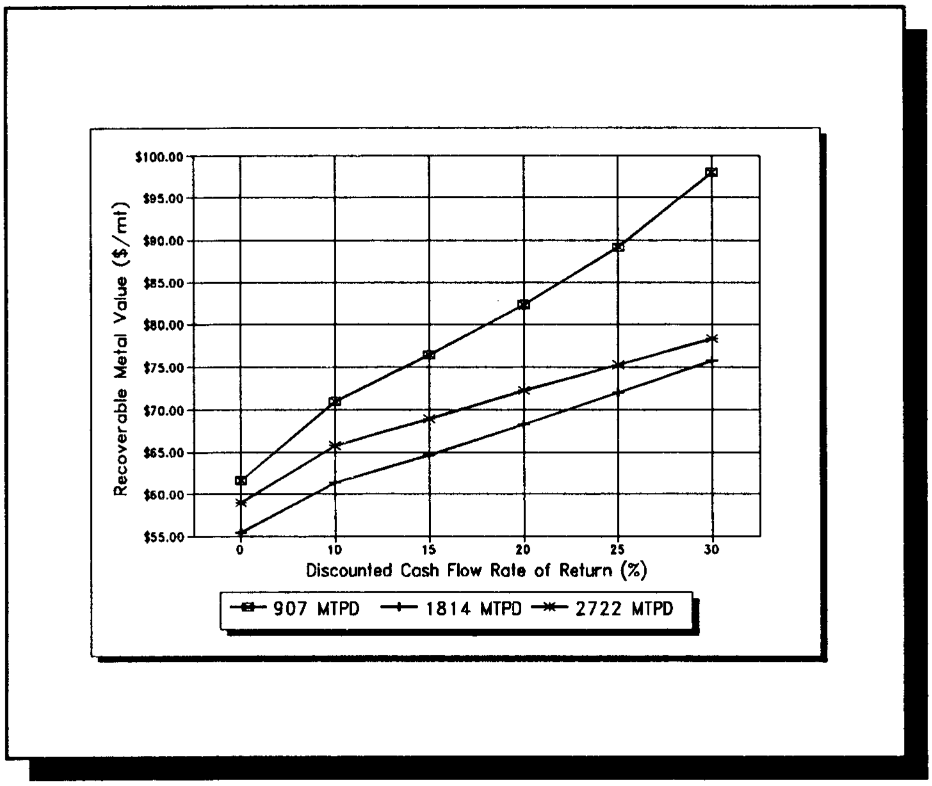

FIGURE 18. - Cash flow analysis results for the basalt hosted copper deposit mine model.

Deep Placer Gold Deposit Model

The deep placer gold deposit model that was evaluated in this section is based on current geologic knowledge of the Valdez Creek Mine placer gold deposit located on Valdez Creek in the Clearwater Mountains, Alaska (fig. 2). The geometry of the deposit model is assumed to be a horizontally oriented, tabular shaped body. The ore body is buried beneath an average of 61 m (200 ft) of overburden. Ore body dimensions average 4.6 m (15 ft) thick, 30.5 m (100 ft) wide, and of variable length, depending on the mining rate of the mine model. Mine life is assumed to be 5 years minimum for the deep placer gold deposit mine models. The swell factor for excavated material is estimated at 35%. The stripping ratio is estimated at 42:1. The ore body is composed of fluvially deposited, well sorted gravel with boulders up to 1.2 m (4 ft) in diameter. Gold is disseminated throughout the ore body, and extends an average of 0.6 m (2 ft) into the fractured bedrock. Overburden consists of unfrozen glacial till and glacially derived fluvial and lacustrian sediments.

The mining plan is based on open pit, side cast excavation techniques. Pit walls are designed for a 45° maximum slope. Mining occurs 340 days per year, for an average of 18 hours per day. Overburden will be blasted, and then loaded onto rear-dump trucks with loaders for haulage to storage areas. Average one-way overburden haul distances are 915 m (3,000 ft) over an average gradient of 8%. Ore will be extracted by hydraulic excavators, and transported to the washing plant in rear-dump trucks. Average one-way ore haul distances will be 3,049 m (10,000 ft) over an average gradient of 6%. Ore will be dumped from the haul trucks directly into the mill feed hopper 50% of the time, and 50% of the mill feed requirements will be supplied from a stock pile by a loader. The washing plant consists of a feed hopper, vibrating screens, conveyor system, multi-channel sluice box, jigs, and a table concentrator.

The mine model was evaluated for economic performance at production rates of 1,000 bank cubic yards per day (BCYD), 2,000 BCYD, and 3,000 BCYD. Mine and mill equipment requirements are appropriately scaled for each variation in production rate of the mine model.

Cash Flow Analysis for the Deep Placer Gold Deposit Mine Model

Figure 19 graphically shows the results of the cash flow analysis for the mining scenarios applied to the deep placer gold deposit model. The cash flow model results in a zero percent DCFROR (break even) for the best case mine model (3,000 BCYD) when the RMV equals $90.09 per bank cubic yard (BCY) of ore. The best case mine model achieved a 20% DCFROR when the RMV equals $102.60/BCY of ore.

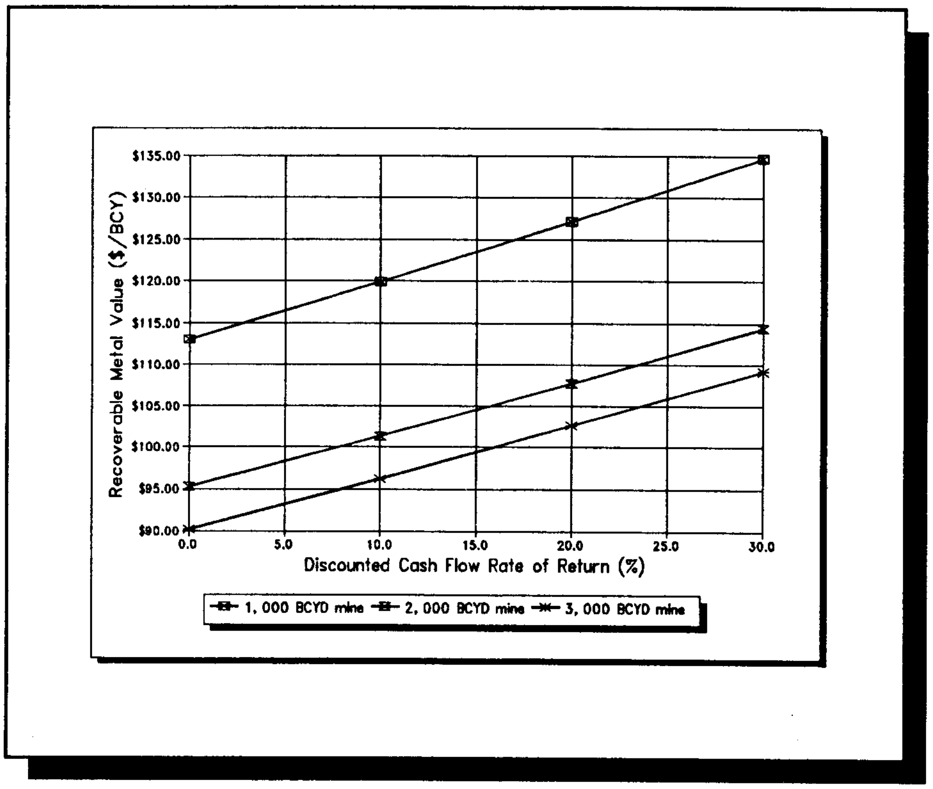

FIGURE 19. - Cash flow analysis results for the deep placer gold deposit mine model.

Capital and operating costs are listed below in tables 16 and 17, respectively. The data has been summarized from WGM (26). All figures have been adjusted upward to reflect higher costs for Alaska, and have been inflated to May, 1990 dollars.

TABLE 16. - Capital costs for the deep placer gold deposit mine model.

Capital cost item		Mine model		
		1,000 BCYD	2,000 BCYD	3,000 BCYD
Exploration:	panning	$3,000	$5,000	$7,000
	general reconnaissance	$40,000	$60,000	$80,000
	camp costs	$8,000	$16,000	$24,000
	seismic surveying	$9,000	$18,000	$27,000
	rotary drilling	$227,000	$452,000	$679,000
Development:	access roads	$162,000	$162,000	$162,000
	clearing	$349,000	$638,000	$888,000
Overburden removal:	air track drills	$118,000	$237,000	$237,000
	bulldozers	$461,000	$530,000	$1,060,000
	front-end loaders	$3,292,000	$6,583,000	$598,000
	hydraulic shovel	$0	$0	$6,213,000
	rear-dump trucks	$8,933,000	$17,865,000	$26,798,000
	service vehicles	$458,000	$498,000	$642,000
Pre-production costs:	drill and blast	$3,672,000	$7,344,000	$9,364,000
	bulldozers	$1,604,000	$2,062,000	$2,427,000
	front-end loaders	$1,672,000	$2,749,000	$500,000
	rear-dump trucks	$5,276,000	$8,249,000	$10,146,000
	hydraulic shovel	$0	$0	$10,459,000
Mine equipment:	backhoes	$252,000	$352,000	$552,000
	bulldozers	$125,000	$217,000	$303,000
	front-end loaders	$94,000	$173,000	$275,000
	rear-dump trucks	$263,000	$579,000	$1,038,000
Processing equipment:	conveyors	$29,000	$34,000	$40,000
	feed hoppers	$6,000	$7,000	$10,000
	jig concentrators	$7,000	$7,000	$7,000
	sluices	$6,000	$6,000	$8,000
	table concentrators	$11,000	$17,000	$17,000
	vibrating screens	$51,000	$78,000	$109,000
Reclamation - $1,000/acre		$450,000	$845,000	$1,250,000
Supplemental:	buildings	$224,000	$333,000	$425,000
	housing	$1,420,000	$2,700,000	$4,027,000
	generators	$790,000	$1,200,000	$1,532,000
	pumps	$37,000	$58,000	$74,000
	settling ponds	$8,000	$16,000	$23,000
TOTAL		$30,057,875	$55,093,196	$80,002,845

TABLE 17. - Operating costs for the deep placer gold deposit mine model.

Operating cost item	1,000 BCYD mine model ($/BCY)	2,000 BCYD mine model ($/BCY)	3,000 BCYD mine model ($/BCY)
Exploration	$0.70	$0.70	$0.70
Overburden removal	$35.95	$30.01	$32.17
Mining	$2.75	$1.87	$1.42
Processing	$0.42	$0.36	$0.27
Supplemental	$62.78	$52.44	$46.29
TOTAL	$102.61	$85.38	$80.85

SUMMARY

This investigation evaluated 8 deposit models and resulted in the creation of 66 individual mine models. Capital and operating costs were calculated for all 66 mine models. From the cost data for each mine model, a CIS was developed to show the timing of capital investment into the mining model. A cash flow analysis was performed for the CIS data for each mine model, and the DCFROR versus RMV distribution was evaluated. The result of the cash flow analysis is a graphical representation of the economic performance of the mine model, expressed in terms of expected DCFROR. All of the results are estimated to be within an order-of-magnitude of real costs.

The cash flow analysis for each mine model covered a range of RMV's that caused the DCFROR result of the cash flow analysis to exceed the arbitrary 15% DCFROR economic threshold. The 15% DCFROR threshold was chosen to represent the level of return on investment that would be considered an acceptable minimum for economic viability of a mine model. In many cases, the RMV required for economic viability of a mine model was unrealistically high, and the mine model(s) associated with high RMV('s) was uneconomic at the order-of-magnitude scale used in this investigation. Conversely, several mine models had cash flow results in a reasonable and realistic range. The results of the mining feasibility analysis of these mine models could be used in a preliminary manner to evaluate the mining potential of real mineral deposits that are similar to the deposit models.

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APPENDIX A - Capital and operating costs for VCMD mine models.

TABLE A-1. - Capital and operating costs for a 125 mtpd shaft entry, overhand stope, metamorphic gold vein mine, with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$687,000	$687,000	-4	-4
Exploration	$1,123,000	$225,000	-5	-1
Infrastructure	$11,590,000	$3,863,000	-3	-1
Mine	$8,595,000	$2,865,000	-3	-1
Mill	$4,230,000	$1,410,000	-3	-1
Working capital	$1,434,000	$1,434,000	0	0
TOTAL	$27,659,000	n/a	n/a	n/a
Mine operating cost	$161.87/mt	$7,082,000	0	4.1
Mill operating cost	$39.34/mt	$1,721,000	0	4.1

TABLE A-2. - Capital and operating costs for a 210 mtpd shaft entry, overhand stope, metamorphic gold vein mine, with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$782,000	$782,000	-4	-4
Exploration	$1,387,000	$277,000	-5	-1
Infrastructure	$15,444,000	$5,148,000	-3	-1
Mine	$10,697,000	$3,566,000	-3	-1
Mill	$5,723,000	$1,908,000	-3	-1
Working capital	$2,081,000	$2,081,000	0	0
TOTAL	$36,114,000	n/a	n/a	n/a
Mine operating cost	$135.64/mt	$9,970,000	0	4.9
Mill operating cost	$29.54/mt	$2,171,000	0	4.9

TABLE A-3. - Capital and operating costs for a 275 mtpd shaft entry, overhand stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$855,000	$855,000	-4	-4
Exploration	$1,589,000	$318,000	-5	-1
Infrastructure	$17,935,000	$5,979,000	-3	-1
Mine	$12,006,000	$4,002,000	-3	-1
Mill	$6,770,000	$2,257,000	-3	-1
Working capital	$2,540,000	$2,540,000	0	0
TOTAL	$41,695,000	n/a	n/a	n/a
Mine operating cost	$128.32/mt	$12,351,000	0	5.4
Mill operating cost	$25.62/mt	$2,466,000	0	5.4

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-4. - Capital and operating costs for a 365 mtpd shaft entry, cut-and-fill stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$955,000	$955,000	-5	-5
Exploration	$1,868,000	$311,000	-6	-1
Infrastructure	$20,989,000	$5,247,000	-4	-1
Mine	$44,854,000	$11,213,000	-4	-1
Mill	$8,154,000	$2,038,000	-4	-1
Working capital	$2,692,000	$2,692,000	0	0
TOTAL	$79,512,000	n/a	n/a	n/a
Mine operating cost	$100.73/mt	$12,868,000	0	5.9
Mill operating cost	$22.18/mt	$2,833,000	0	5.9

TABLE A-5. - Capital and operating costs for a 500 mtpd shaft entry, cut-and-fill stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,107,000	$1,107,000	-5	-5
Exploration	$2,287,000	$381,000	-6	-1
Infrastructure	$25,004,000	$6,251,000	-4	-1
Mine	$50,106,000	$12,527,000	-4	-1
Mill	$10,159,000	$2,540,000	-4	-1
Working capital	$2,291,000	$2,291,000	0	0
TOTAL	$90,954,000	n/a	n/a	n/a
Mine operating cost	$90.68/mt	$15,869,000	0	6.5
Mill operating cost	$19.03/mt	$3,330,000	0	6.5

TABLE A-6. - Capital and operating costs for a 615 mtpd shaft entry, cut-and-fill stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,235,000	$1,235,000	-5	-5
Exploration	$2,644,000	$441,000	-6	-1
Infrastructure	$28,059,000	$7,015,000	-4	-1
Mine	$53,999,000	$13,500,000	-4	-1
Mill	$11,846,000	$2,961,000	-4	-1
Working capital	$3,763,000	$3,763,000	0	0
TOTAL	$101,546,000	n/a	n/a	n/a
Mine operating cost	$84.70/mt	$18,232,000	0	7.0
Mill operating cost	$17.27/mt	$3,717,000	0	7.0

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-7. - Capital and operating costs for a 760 mtpd shaft entry, cut-and-fill stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,398,000	$1,398,000	-5	-5
Exploration	$3,094,000	$516,000	-6	-1
Infrastructure	$31,572,000	$7,893,000	-4	-1
Mine	$58,382,000	$14,596,000	-4	-1
Mill	$13,980,000	$3,495,000	-4	-1
Working capital	$4,320,000	$4,320,000	0	0
TOTAL	$112,746,000	n/a	n/a	n/a
Mine operating cost	$79.05/mt	$21,027,000	0	7.5
Mill operating cost	$15.70/mt	$ 4,176,000	0	7.5

TABLE A-8. - Capital and operating costs for a 1515 mtpd shaft entry, cut-and-fill stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$2,243,000	$2,243,000	-6	-6
Exploration	$5,438,000	$777,000	-7	-1
Infrastructure	$46,403,000	$9,281,000	-5	-1
Mine	$76,050,000	$15,210,000	-5	-1
Mill	$25,894,000	$5,179,000	-5	-1
Working capital	$6,842,000	$6,842,000	0	0
TOTAL	$162,870,000	n/a	n/a	n/a
Mine operating cost	$63.48/mt	$33,660,000	0	9.5
Mill operating cost	$11.80/mt	$6,257,000	0	9.5

TABLE A-9. - Capital and operating costs for a 2550 mtpd shaft entry, cut-and-fill stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$3,403,000	$3,403,000	-6	-6
Exploration	$8,650,000	$1,236,000	-7	-1
Infrastructure	$62,090,000	$12,418,000	-5	-1
Mine	$93,702,000	$18,740,000	-5	-1
Mill	$45,590,000	$9,118,000	-5	-1
Working capital	$9,773,000	$9,773,000	0	0
TOTAL	$223,208,000	n/a	n/a	n/a
Mine operating cost	$54.11/mt	$48,293,000	0	11.3
Mill operating cost	$9.77/mt	$8,720,000	0	11.3

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-10. - Capital and operating costs for a 125 mtpd adit entry, overhand stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$687,000	$687,000	-4	-4
Exploration	$1,123,000	$225,000	-5	-1
Infrastructure	$11,590,000	$3,863,000	-3	-1
Mine	$7,250,000	$2,417,000	-3	-1
Mill	$4,230,000	$1,410,000	-3	-1
Working capital	$1,359,000	$1,359,000	0	0
TOTAL	$26,239,000	n/a	n/a	n/a
Mine operating cost	$141.86/mt	$6,206,000	0	4.1
Mill operating cost	$39.34/mt	$1,721,000	0	4.1

TABLE A-11. - Capital and operating costs for a 210 mtpd adit entry, overhand stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$782,000	$782,000	-4	-4
Exploration	$1,387,000	$277,000	-5	-1
Infrastructure	$15,443,000	$5,148,000	-3	-1
Mine	$9,075,000	$3,025,000	-3	-1
Mill	$5,723,000	$1,908,000	-3	-1
Working capital	$1,956,000	$1,956,000	0	0
TOTAL	$34,366,000	n/a	n/a	n/a
Mine operating cost	$125.70/mt	$9,239,000	0	4.9
Mill operating cost	$29.54/mt	$2,171,000	0	4.9

TABLE A-12. - Capital and operating costs for a 275 mtpd adit entry, overhand stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$855,000	$855,000	-4	-4
Exploration	$1,589,000	$318,000	-5	-1
Infrastructure	$17,935,000	$5,978,000	-3	-1
Mine	$10,210,000	$3,403,000	-3	-1
Mill	$6,770,000	$2,257,000	-3	-1
Working capital	$2,376,000	$2,376,000	0	0
TOTAL	$39,735,000	n/a	n/a	n/a
Mine operating cost	$118.39/mt	$11,395,000	0	5.4
Mill operating cost	$25.62/mt	$2,466,000	0	5.4

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-13. - Capital and operating costs for a 365 mtpd adit entry, cut-and-fill stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$955,000	$955,000	-5	-5
Exploration	$1,868,000	$311,000	-6	-1
Infrastructure	$20,989,000	$5,247,000	-4	-1
Mine	$33,734,000	$8,433,000	-4	-1
Mill	$8,154,000	$2,038,000	-4	-1
Working capital	$2,638,000	$2,638,000	0	0
TOTAL	$68,338,000	n/a	n/a	n/a
Mine operating cost	$98.26/mt	$12,553,000	0	5.9
Mill operating cost	$22.18/mt	$2,833,000	0	5.9

TABLE A-14. - Capital and operating costs for a 500 mtpd adit entry, cut-and-fill stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,107,000	$1,107,000	-5	-5
Exploration	$2,287,000	$381,000	-6	-1
Infrastructure	$25,004,000	$6,251,000	-4	-1
Mine	$38,812,000	$9,703,000	-4	-1
Mill	$10,159,000	$2,540,000	-4	-1
Working capital	$3,216,000	$3,216,000	0	0
TOTAL	$80,585,000	n/a	n/a	n/a
Mine operating cost	$88.19/mt	$15,433,000	0	6.5
Mill operating cost	$19.03/mt	$3,330,000	0	6.5

TABLE A-15. - Capital and operating costs for a 615 mtpd adit entry, cut-and-fill stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,235,000	$1,235,000	-5	-5
Exploration	$2,644,000	$441,000	-6	-1
Infrastructure	$28,059,000	$7,015,000	-4	-1
Mine	$42,574,000	$10,644,000	-4	-1
Mill	$11,846,000	$2,961,000	-4	-1
Working capital	$3,670,000	$3,670,000	0	0
TOTAL	$90,028,000	n/a	n/a	n/a
Mine operating cost	$82.18/mt	$17,689,000	0	7.0
Mill operating cost	$17.27/mt	$3,717,000	0	7.0

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-16. - Capital and operating costs for a 760 mtpd adit entry, cut-and-fill stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,398,000	$1,398,000	-5	-5
Exploration	$3,094,000	$516,000	-6	-1
Infrastructure	$31,572,000	$7,893,000	-4	-1
Mine	$46,809,000	$11,702,000	-4	-1
Mill	$13,980,000	$3,495,000	-4	-1
Working capital	$4,204,000	$4,204,000	0	0
TOTAL	**$101,057,000**	n/a	n/a	n/a
Mine operating cost	$76.49/mt	$20,346,000	0	7.5
Mill operating cost	$15.70/mt	$4,176,000	0	7.5

TABLE A-17. - Capital and operating costs for a 1515 mtpd adit entry, cut-and-fill stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$2,243,000	$2,243,000	-6	-6
Exploration	$5,438,000	$777,000	-7	-1
Infrastructure	$46,403,000	$9,281,000	-5	-1
Mine	$63,868,000	$12,774,000	-5	-1
Mill	$25,894,000	$5,179,000	-5	-1
Working capital	$6,600,000	$6,600,000	0	0
TOTAL	**$150,446,000**	n/a	n/a	n/a
Mine operating cost	$60.81/mt	$32,245,000	0	9.5
Mill operating cost	$11.80/mt	$6,257,000	0	9.5

TABLE A-18. - Capital and operating costs for a 2550 mtpd adit entry, cut-and-fill stope, metamorphic gold vein mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$3,403,000	$3,403,000	-6	-6
Exploration	$8,650,000	$1,236,000	-7	-1
Infrastructure	$62,090,000	$12,418,000	-5	-1
Mine	$80,901,000	$16,180,000	-5	-1
Mill	$45,590,000	$9,118,000	-5	-1
Working capital	$9,347,000	$9,347,000	0	0
TOTAL	**$209,981,000**	n/a	n/a	n/a
Mine operating cost	$51.32/mt	$45,893,000	0	11.3
Mill operating cost	$9.77/mt	$8,720,000	0	11.3

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-19. - Capital and operating costs for a 125 mtpd shaft entry, overhand stope, copper-gold-silver skarn mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$687,000	$687,000	-4	-4
Exploration	$1,123,000	$225,000	-5	-1
Infrastructure	$11,590,000	$3,863,000	-3	-1
Mine	$8,595,000	$2,865,000	-3	-1
Mill	$5,064,000	$1,688,000	-3	-1
Working capital	$1,538,000	$1,538,000	0	0
TOTAL	**$28,597,000**	n/a	n/a	n/a
Mine operating cost	$157.87/mt	$6,907,000	0	4.1
Mill operating cost	$53.16/mt	$2,326,000	0	4.1

TABLE A-20. - Capital and operating costs for a 210 mtpd shaft entry, overhand stope, copper-gold-silver skarn mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$782,000	$782,000	-4	-4
Exploration	$1,387,000	$277,000	-6	-1
Infrastructure	$15,444,000	$5,148,000	-3	-1
Mine	$10,697,000	$3,566,000	-3	-1
Mill	$6,499,000	$2,166,000	-3	-1
Working capital	$2,187,000	$2,187,000	0	0
TOTAL	**$36,996,000**	n/a	n/a	n/a
Mine operating cost	$141.64/mt	$10,411,000	0	4.9
Mill operating cost	$37.93/mt	$2,788,000	0	4.9

TABLE A-21. - Capital and operating costs for a 275 mtpd shaft entry, overhand stope, copper-gold-silver skarn mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$855,000	$855,000	-4	-4
Exploration	$1,589,000	$318,000	-5	-1
Infrastructure	$17,935,000	$5,978,000	-3	-1
Mine	$12,006,000	$4,002,000	-3	-1
Mill	$7,509,000	$2,503,000	-3	-1
Working capital	$2,650,000	$2,650,000	0	0
TOTAL	**$42,544,000**	n/a	n/a	n/a
Mine operating cost	$134.32/mt	$12,928,000	0	5.4
Mill operating cost	$32.26/mt	$3,105,000	0	5.4

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-22. - Capital and operating costs for a 356 mtpd shaft entry, cut-and-fill stope, copper-gold-silver skarn mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$955,000	$955,000	-5	-5
Exploration	$1,868,000	$311,000	-6	-1
Infrastructure	$20,989,000	$5,247,000	-4	-1
Mine	$44,854,000	$11,213,000	-4	-1
Mill	$8,848,000	$2,212,000	-4	-1
Working capital	$2,808,000	$2,808,000	0	0
TOTAL	$80,322,000	n/a	n/a	n/a
Mine operating cost	$106.73/mt	$13,635,000	0	5.9
Mill operating cost	$27.50/mt	$3,513,000	0	5.9

TABLE A-23. - Capital and operating costs for a 500 mtpd shaft entry, cut-and-fill stope, copper-gold-silver skarn mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,107,000	$1,107,000	-5	-5
Exploration	$2,287,000	$381,000	-6	-1
Infrastructure	$25,004,000	$6,251,000	-4	-1
Mine	$50,106,000	$12,527,000	-4	-1
Mill	$10,790,000	$2,697,000	-4	-1
Working capital	$3,418,000	$3,418,000	0	0
TOTAL	$92,712,000	n/a	n/a	n/a
Mine operating cost	$96.68/mt	$16,919,000	0	6.5
Mill operating cost	$23.25/mt	$4,069,000	0	6.5

TABLE A-24. - Capital and operating costs for a 615 mtpd shaft entry, cut-and-fill stope, copper-gold-silver skarn mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,235,000	$1,235,000	-5	-5
Exploration	$2,644,000	$441,000	-6	-1
Infrastructure	$28,059,000	$7,015,000	-4	-1
Mine	$53,999,000	$13,500,000	-4	-1
Mill	$12,424,000	$3,106,000	-4	-1
Working capital	$3,898,000	$3,898,000	0	0
TOTAL	$102,259,000	n/a	n/a	n/a
Mine operating cost	$90.70/mt	$19,523,000	0	7.0
Mill operating cost	$20.93/mt	$4,505,000	0	7.0

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-25. - Capital and operating costs for a 760 mtpd shaft entry, cut-and-fill stope, copper-gold-silver skarn mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,398,000	$1,398,000	-5	-5
Exploration	$3,094,000	$516,000	-6	-1
Infrastructure	$31,572,000	$7,893,000	-4	-1
Mine	$58,382,000	$14,596,000	-4	-1
Mill	$14,496,000	$3,624,000	-4	-1
Working capital	$4,467,000	$4,467,000	0	0
TOTAL	$113,409,000	n/a	n/a	n/a
Mine operating cost	$85.05/mt	$22,623,000	0	7.5
Mill operating cost	$18.90/mt	$5,027,000	0	7.5

TABLE A-26. - Capital and operating costs for a 1515 mtpd shaft entry, cut-and-fill stope, copper-gold-silver skarn mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$2,243,000	$2,243,000	-6	-6
Exploration	$5,438,000	$777,000	-7	-1
Infrastructure	$46,403,000	$9,281,000	-5	-1
Mine	$76,050,000	$15,210,000	-5	-1
Mill	$26,012,000	$5,202,000	-5	-1
Working capital	$7,045,000	$7,045,000	0	0
TOTAL	$163,191,000	n/a	n/a	n/a
Mine operating cost	$69.48/mt	$36,842,000	0	9.5
Mill operating cost	$14.03/mt	$7,439,000	0	9.5

TABLE A-27. - Capital and operating costs for a 2550 mtpd shaft entry, cut-and-fill stope, copper-gold-silver skarn mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$3,403,000	$3,403,000	-6	-6
Exploration	$8,650,000	$1,236,000	-7	-1
Infrastructure	$62,090,000	$12,418,000	-5	-1
Mine	$93,702,000	$18,740,000	-5	-1
Mill	$45,446,000	$9,089,000	-5	-1
Working capital	$10,054,000	$10,054,000	0	0
TOTAL	$223,345,000	n/a	n/a	n/a
Mine operating cost	$60.02/mt	$53,568,000	0	11.3
Mill operating cost	$11.60/mt	$10,353,000	0	11.3

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-28. - Capital and operating costs for a 125 mtpd adit entry, overhand stope mine, copper-gold-silver skarn with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$687,000	$687,000	-4	-4
Exploration	$1,123,000	$225,000	-5	-1
Infrastructure	$11,590,000	$3,863,000	-3	-1
Mine	$7,250,000	$2,417,000	-3	-1
Mill	$5,064,000	$1,688,000	-3	-1
Working capital	$1,463,000	$1,463,000	0	0
TOTAL	$27,177,000	n/a	n/a	n/a
Mine operating cost	$147.86/mt	$6,469,000	0	4.1
Mill operating cost	$53.16/mt	$2,354,000	0	4.1

TABLE A-29. - Capital and operating costs for a 210 mtpd adit entry, overhand stope mine, copper-gold-silver skarn with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$782,000	$782,000	-4	-4
Exploration	$1,387,000	$277,000	-5	-1
Infrastructure	$15,444,000	$5,148,000	-3	-1
Mine	$9,075,000	$3,025,000	-3	-1
Mill	$6,499,000	$2,166,000	-3	-1
Working capital	$2,062,000	$2,062,000	0	0
TOTAL	$35,249,000	n/a	n/a	n/a
Mine operating cost	$131.70/mt	$9,680,000	0	4.9
Mill operating cost	$37.93/mt	$2,788,000	0	4.9

TABLE A-30. - Capital and operating costs for a 275 mtpd adit entry, overhand stope mine, copper-gold-silver skarn with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$855,000	$855,000	-4	-4
Exploration	$1,589,000	$318,000	-5	-1
Infrastructure	$17,935,000	$5,978,000	-3	-1
Mine	$10,210,000	$3,403,000	-3	-1
Mill	$7,509,000	$2,503,000	-3	-1
Working capital	$2,486,000	$2,486,000	0	0
TOTAL	$40,584,000	n/a	n/a	n/a
Mine operating cost	$124.39/mt	$11,973,000	0	5.4
Mill operating cost	$32.26/mt	$3,105,000	0	5.4

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-31. - Capital and operating costs for a 365 mtpd adit entry, cut-and-fill stope, copper-gold-silver skarn mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$955,000	$955,000	-5	-5
Exploration	$1,868,000	$311,000	-6	-1
Infrastructure	$20,989,000	$5,247,000	-4	-1
Mine	$33,734,000	$8,433,000	-4	-1
Mill	$8,848,000	$2,212,000	-4	-1
Working capital	$2,754,000	$2,754,000	0	0
TOTAL	$69,148,000	n/a	n/a	n/a
Mine operating cost	$104.26/mt	$13,319,000	0	5.9
Mill operating cost	$27.50/mt	$3,513,000	0	5.9

TABLE A-32. - Capital and operating costs for a 500 mtpd adit entry, cut-and-fill stope, copper-gold-silver skarn mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,107,000	$1,107,000	-5	-5
Exploration	$2,287,000	$381,000	-6	-1
Infrastructure	$25,004,000	$6,251,000	-4	-1
Mine	$38,812,000	$9,703,000	-4	-1
Mill	$10,790,000	$2,697,000	-4	-1
Working capital	$3,343,000	$3,343,000	0	0
TOTAL	$81,343,000	n/a	n/a	n/a
Mine operating cost	$94.19/mt	$16,483,000	0	6.5
Mill operating cost	$23.25/mt	$4,069,000	0	6.5

TABLE A-33. - Capital and operating costs for a 615 mtpd adit entry, cut-and-fill stope, copper-gold-silver skarn mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,235,000	$1,235,000	-5	-5
Exploration	$2,644,000	$441,000	-6	-1
Infrastructure	$28,059,000	$7,015,000	-4	-1
Mine	$42,574,000	$10,644,000	-4	-1
Mill	$12,424,000	$3,106,000	-4	-1
Working capital	$3,805,000	$3,805,000	0	0
TOTAL	$90,741,000	n/a	n/a	n/a
Mine operating cost	$88.18/mt	$18,981,000	0	7.0
Mill operating cost	$20.93/mt	$4,505,000	0	7.0

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-34. - Capital and operating costs for a 760 mtpd adit entry, cut-and-fill stope, copper-gold-silver skarn mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,398,000	$1,399,000	-5	-5
Exploration	$3,094,000	$516,000	-6	-1
Infrastructure	$31,572,000	$7,893,000	-4	-1
Mine	$46,809,000	$11,702,000	-4	-1
Mill	$14,496,000	$3,624,000	-4	-1
Working capital	$4,350,000	$4,350,000	0	0
TOTAL	$101,719,000	n/a	n/a	n/a
Mine operating cost	$82.49/mt	$21,942,000	0	7.5
Mill operating cost	$18.90/mt	$5,027,000	0	7.5

TABLE A-35. - Capital and operating costs for a 1515 mtpd adit entry, cut-and-fill stope, copper-gold-silver skarn mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$2,243,000	$2,243,000	-6	-6
Exploration	$5,438,000	$777,000	-7	-1
Infrastructure	$46,403,000	$9,281,000	-5	-1
Mine	$63,868,000	$12,774,000	-5	-1
Mill	$26,012,000	$5,202,000	-5	-1
Working capital	$6,802,000	$6,802,000	0	0
TOTAL	$150,766,000	n/a	n/a	n/a
Mine operating cost	$66.81/mt	$35,426,000	0	9.5
Mill operating cost	$14.03/mt	$7,439,000	0	9.5

TABLE A-36. - Capital and operating costs for a 2550 mtpd adit entry, cut-and-fill stope, copper-gold-silver skarn mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$3,403,000	$3,403,000	-6	-6
Exploration	$8,650,000	$1,236,000	-7	-1
Infrastructure	$62,090,000	$12,418,000	-5	-1
Mine	$80,901,000	$16,180,000	-5	-1
Mill	$45,446,000	$9,089,000	-5	-1
Working capital	$9,628,000	$9,628,000	0	0
TOTAL	$210,118,000	n/a	n/a	n/a
Mine operating cost	$57.32/mt	$51,158,000	0	11.3
Mill operating cost	$11.60/mt	$10,353,000	0	11.3

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-37. - Capital and operating costs for a 100 mtpd shaft entry, shrinkage stope, plutonic related gold vein mine with a CIP mill and a 5 year mine life.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$687,000	$687,000	-4	-4
Exploration	$1,123,000	$225,000	-5	-1
Infrastructure	$3,954,000	$1,318,000	-3	-1
Mine	$7,576,000	$2,525,000	-3	-1
Mill	$4,520,000	$1,507,000	-3	-1
Working capital	$1,145,000	$1,145,000	0	0
TOTAL	$19,005,000	n/a	n/a	n/a
Mine operating cost	$203.80/mt	$7,133,000	0	5.0
Mill operating cost	$69.73/mt	$2,441,000	0	5.0

TABLE A-38. - Capital and operating costs for a 100 mtpd shaft entry, shrinkage stope, plutonic related gold vein mine with a CIP mill and a 10 year mine life.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$687,000	$687,000	-4	-4
Exploration	$1,123,000	$225,000	-5	-1
Infrastructure	$4,899,000	$1,633,000	-3	-1
Mine	$7,664,000	$2,555,000	-3	-1
Mill	$4,520,000	$1,507,000	-3	-1
Working capital	$1,158,000	$1,158,000	0	0
TOTAL	$20,051,000	n/a	n/a	n/a
Mine operating cost	$204.12/mt	$7,144,000	0	10.0
Mill operating cost	$69.73/mt	$2,441,000	0	10.0

TABLE A-39. - Capital and operating costs for a 275 mtpd shaft entry, shrinkage stope, plutonic related gold vein mine with a CIP mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$855,000	$855,000	-4	-4
Exploration	$1,589,000	$318,000	-5	-1
Infrastructure	$5,406,000	$1,802,000	-3	-1
Mine	$9,851,000	$3,284,000	-3	-1
Mill	$13,199,000	$4,400,000	-3	-1
Working capital	$2,772,000	$2,772,000	0	0
TOTAL	$33,672,000	n/a	n/a	n/a
Mine operating cost	$179.17/mt	$17,245,000	0	5.4
Mill operating cost	$41.77/mt	$4,020,000	0	5.4

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-40. - Capital and operating costs for a 365 mtpd shaft entry, overhand stope, plutonic related gold vein mine with a CIP mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$955,000	$955,000	-5	-5
Exploration	$1,868,000	$311,000	-6	-1
Infrastructure	$20,989,000	$5,247,000	-4	-1
Mine	$13,568,000	$3,392,000	-4	-1
Mill	$16,206,000	$4,051,000	-4	-1
Working capital	$3,452,000	$3,452,000	0	0
TOTAL	$57,038,000	n/a	n/a	n/a
Mine operating cost	$121.33/mt	$15,500,000	0	5.9
Mill operating cost	$36.28/mt	$4,635,000	0	5.9

TABLE A-41. - Capital and operating costs for a 500 mtpd shaft entry, overhand stope, plutonic related gold vein mine with a CIP mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,107,000	$1,107,000	-5	-5
Exploration	$2,287,000	$381,000	-6	-1
Infrastructure	$25,004,000	$6,251,000	-4	-1
Mine	$15,564,000	$3,891,000	-4	-1
Mill	$20,495,000	$5,124,000	-4	-1
Working capital	$4,368,000	$4,368,000	0	0
TOTAL	$68,825,000	n/a	n/a	n/a
Mine operating cost	$114.33/mt	$20,008,000	0	6.5
Mill operating cost	$31.25/mt	$5,469,000	0	6.5

TABLE A-42. - Capital and operating costs for a 615 mtpd shaft entry, sublevel-longhole stope, plutonic related gold vein mine with a CIP mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,235,000	$1,235,000	-5	-5
Exploration	$2,644,000	$441,000	-6	-1
Infrastructure	$22,710,000	$5,677,000	-4	-1
Mine	$23,154,000	$5,789,000	-4	-1
Mill	$24,024,000	$6,006,000	-4	-1
Working capital	$2,467,000	$2,467,000	0	0
TOTAL	$76,234,000	n/a	n/a	n/a
Mine operating cost	$38.40/mt	$8,266,000	0	7.0
Mill operating cost	$28.46/mt	$6,126,000	0	7.0

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-43. - Capital and operating costs for a 760 mtpd shaft entry, sublevel-longhole stope, plutonic related gold vein mine with a CIP mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,398,000	$1,398,000	-5	-5
Exploration	$3,094,000	$516,000	-6	-1
Infrastructure	$25,581,000	$6,395,000	-4	-1
Mine	$24,680,000	$6,170,000	-4	-1
Mill	$28,380,000	$7,095,000	-4	-1
Working capital	$2,851,000	$2,851,000	0	0
TOTAL	$85,984,000	n/a	n/a	n/a
Mine operating cost	$36.55/mt	$9,722,000	0	7.5
Mill operating cost	$25.96/mt	$6,905,000	0	7.5

TABLE A-44. - Capital and operating costs for a 365 mtpd adit entry, overhand stope mine, plutonic related gold vein with a CIP mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$955,000	$955,000	-5	-5
Exploration	$1,868,000	$311,000	-6	-1
Infrastructure	$20,989,000	$5,247,000	-4	-1
Mine	$11,564,000	$2,891,000	-4	-1
Mill	$13,209,000	$3,302,000	-4	-1
Working capital	$3,234,000	$3,234,000	0	0
TOTAL	$51,819,000	n/a	n/a	n/a
Mine operating cost	$111.40/mt	$14,231,000	0	5.9
Mill operating cost	$36.28/mt	$4,635,000	0	5.9

TABLE A-45. - Capital and operating costs for a 500 mtpd adit entry, overhand stope mine, plutonic related gold vein with a CIP mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,107,000	$1,107,000	-5	-5
Exploration	$2,287,000	$381,000	-6	-1
Infrastructure	$25,004,000	$6,251,000	-4	-1
Mine	$13,295,000	$3,324,000	-4	-1
Mill	$20,495,000	$5,124,000	-4	-1
Working capital	$4,069,000	$4,069,000	0	0
TOTAL	$66,257,000	n/a	n/a	n/a
Mine operating cost	$104.38/mt	$18,267,000	0	6.5
Mill operating cost	$31.25/mt	$5,469,000	0	6.5

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-46. - Capital and operating costs for a 615 mtpd adit entry, sublevel-longhole stope, plutonic related gold vein mine with a CIP mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,235,000	$1,235,000	-5	-5
Exploration	$2,644,000	$441,000	-6	-1
Infrastructure	$22,710,000	$5,677,000	-4	-1
Mine	$11,650,000	$2,912,000	-4	-1
Mill	$24,024,000	$6,006,000	-4	-1
Working capital	$2,374,000	$2,374,000	0	0
TOTAL	$64,637,000	n/a	n/a	n/a
Mine operating cost	$35.88/mt	$7,723,000	0	7.0
Mill operating cost	$28.46/mt	$6,126,000	0	7.0

TABLE A-47. - Capital and operating costs for a 760 mtpd adit entry, sublevel-longhole stope, plutonic related gold vein mine with a CIP mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,398,000	$1,398,000	-5	-5
Exploration	$3,094,000	$516,000	-6	-1
Infrastructure	$25,581,000	$6,395,000	-4	-1
Mine	$13,027,000	$3,257,000	-4	-1
Mill	$28,380,000	$7,095,000	-4	-1
Working capital	$2,734,000	$2,734,000	0	0
TOTAL	$74,214,000	n/a	n/a	n/a
Mine operating cost	$34.00/mt	$9,044,000	0	7.5
Mill operating cost	$25.96/mt	$6,905,000	0	7.5

TABLE A-48. - Capital and operating costs for a 760 mtpd shaft entry, longhole-sublevel stope, basalt hosted copper mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,907,000	$1,907,000	-5	-5
Exploration	$6,513,000	$1,085,000	-6	-1
Infrastructure	$25,581,000	$6,395,000	-4	-1
Mine	$24,680,000	$6,170,000	-4	-1
Mill	$14,496,000	$3,624,000	-4	-1
Working capital	$1,029,000	$1,029,000	0	0
TOTAL	$74,206,000	n/a	n/a	n/a
Mine operating cost	$43.55/mt	$11,584,000	0	7.5
Mill operating cost	$18.90/mt	$5,027,000	0	7.5

TABLE A-49. - Capital and operating costs for a 1515 mtpd shaft entry, longhole-sublevel stope, basalt hosted copper mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$2,244,000	$2,244,000	-6	-6
Exploration	$13,048,000	$1,864,000	-7	-1
Infrastructure	$37,722,000	$7,544,000	-5	-1
Mine	$31,038,000	$7,760,000	-4	-1
Mill	$26,112,000	$6,528,000	-4	-1
Working capital	$4,125,000	$4,125,000	0	0
TOTAL	$114,289,000	n/a	n/a	n/a
Mine operating cost	$38.35/mt	$20,335,000	0	9.5
Mill operating cost	$14.03/mt	$7,439,000	0	9.5

TABLE A-50. - Capital and operating costs for a 2550 mtpd shaft entry, longhole-sublevel stope, basalt hosted copper mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$2,706,000	$2,706,000	-6	-6
Exploration	$22,007,000	$3,144,000	-7	-1
Infrastructure	$50,592,000	$10,118,000	-5	-1
Mine	$37,660,000	$7,532,000	-5	-1
Mill	$45,446,000	$9,089,000	-5	-1
Working capital	$6,080,000	$6,080,000	0	0
TOTAL	$164,491,000	n/a	n/a	n/a
Mine operating cost	$35.14/mt	$31,362,000	0	11.3
Mill operating cost	$11.60/mt	$10,353,000	0	11.3

TABLE A-51. - Capital and operating costs for a 3445 mtpd shaft entry, longhole-sublevel stope, basalt hosted copper mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$3,105,000	$3,105,000	-7	-7
Exploration	$29,754,000	$3,719,000	-8	-1
Infrastructure	$59,952,000	$9,992,000	-6	-1
Mine	$42,420,000	$8,484,000	-5	-1
Mill	$65,867,000	$13,173,000	-5	-1
Working capital	$7,659,000	$7,659,000	0	0
TOTAL	$208,757,000	n/a	n/a	n/a
Mine operating cost	$33.52/mt	$40,417,000	0	12.4
Mill operating cost	$10.54/mt	$12,709,000	0	12.4

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-52. - Capital and operating costs for a 760 mtpd adit entry, longhole-sublevel stope, basalt hosted copper mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,907,000	$1,907,000	-5	-5
Exploration	$6,513,000	$1,085,000	-6	-1
Infrastructure	$25,581,000	$6,395,000	-4	-1
Mine	$13,027,000	$3,257,000	-4	-1
Mill	$14,496,000	$3,624,000	-4	-1
Working capital	$2,412,000	$2,412,000	0	0
TOTAL	$63,936,000	n/a	n/a	n/a
Mine operating cost	$41.00/mt	$10,906,000	0	7.5
Mill operating cost	$18.90/mt	$5,027,000	0	7.5

TABLE A-53. - Capital and operating costs for a 1515 mtpd adit entry, longhole-sublevel stope, basalt hosted copper mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$2,244,000	$2,244,000	-6	-6
Exploration	$13,048,000	$1,864,000	-7	-1
Infrastructure	$37,722,000	$7,544,000	-5	-1
Mine	$18,779,000	$4,695,000	-4	-1
Mill	$26,112,000	$6,528,000	-4	-1
Working capital	$3,882,000	$3,882,000	0	0
TOTAL	$101,787,000	n/a	n/a	n/a
Mine operating cost	$35.68/mt	$18,919,000	0	9.5
Mill operating cost	$14.03/mt	$7,439,000	0	9.5

TABLE A-54. - Capital and operating costs for a 2550 mtpd adit entry, longhole-sublevel stope, basalt hosted copper mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$2,706,000	$2,706,000	-6	-6
Exploration	$22,007,000	$3,144,000	-7	-1
Infrastructure	$50,592,000	$10,118,000	-5	-1
Mine	$24,784,000	$4,957,000	-5	-1
Mill	$45,446,000	$9,089,000	-5	-1
Working capital	$5,653,000	$5,653,000	0	0
TOTAL	$151,188,000	n/a	n/a	n/a
Mine operating cost	$32.35/mt	$28,872,000	0	11.3
Mill operating cost	$11.60/mt	$10,353,000	0	11.3

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-55. - Capital and operating costs for a 3445 mtpd adit entry, longhole-sublevel stope, basalt hosted copper mine with a one product flotation mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$3,105,000	$3,105,000	-7	-7
Exploration	$29,754,000	$3,719,000	-8	-1
Infrastructure	$59,952,000	$9,992,000	-6	-1
Mine	$29,107,000	$5,821,000	-5	-1
Mill	$65,867,000	$13,173,000	-5	-1
Working capital	$7,066,000	$7,066,000	0	0
TOTAL	$194,851,000	n/a	n/a	n/a
Mine operating cost	$30.65/mt	$36,956,000	0	12.4
Mill operating cost	$10.54/mt	$12,709,000	0	12.4

TABLE A-56. - Capital and operating costs for a 760 mtpd, open pit, porphyry gold mine with a CIP mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,920,000	$1,920,000	-4	-4
Exploration	$3,913,000	$783,000	-5	-1
Infrastructure	$20,632,000	$5,158,000	-4	-1
Mine	$13,341,000	$3,335,000	-4	-1
Mill	$28,380,000	$7,095,000	-4	-1
Working capital	$2,180,000	$2,180,000	0	0
TOTAL	$70,366,000	n/a	n/a	n/a
Mine operating cost	$21.84/mt	$5,809,000	0	7.5
Mill operating cost	$25.96/mt	$6,905,000	0	7.5

TABLE A-57. - Capital and operating costs for a 1515 mtpd, open pit, porphyry gold mine with a CIP mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$2,173,000	$2,173,000	-5	-5
Exploration	$4,731,000	$789,000	-6	-1
Infrastructure	$28,802,000	$5,760,000	-5	-1
Mine	$18,653,000	$3,731,000	-5	-1
Mill	$50,729,000	$10,146,000	-5	-1
Working capital	$3,322,000	$3,322,000	0	0
TOTAL	$108,410,000	n/a	n/a	n/a
Mine operating cost	$16.79/mt	$8,903,000	0	9.5
Mill operating cost	$19.76/mt	$10,478,000	0	9.5

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-58. - Capital and operating costs for a 2550 mtpd, open pit, porphyry gold mine with a CIP mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$2,518,000	$2,518,000	-5	-5
Exploration	$5,853,000	$976,000	-6	-1
Infrastructure	$37,088,000	$7,418,000	-5	-1
Mine	$24,086,000	$4,817,000	-5	-1
Mill	$83,038,000	$16,608,000	-5	-1
Working capital	$4,639,000	$4,639,000	0	0
TOTAL	**$157,222,000**	n/a	n/a	n/a
Mine operating cost	$13.80/mt	$12,317,000	0	11.3
Mill operating cost	$16.51/mt	$14,735,000	0	11.3

TABLE A-59. - Capital and operating costs for a 500 mtpd, open pit, plutonic related tin mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,834,000	$1,834,000	-4	-4
Exploration	$3,631,000	$726,000	-5	-1
Infrastructure	$16,865,000	$4,216,000	-4	-1
Mine	$10,915,000	$2,729,000	-4	-1
Mill	$10,159,000	$2,540,000	-4	-1
Working capital	$1,341,000	$1,341,000	0	0
TOTAL	**$44,745,000**	n/a	n/a	n/a
Mine operating cost	$29.68/mt	$5,194,000	0	6.5
Mill operating cost	$19.03/mt	$3,330,000	0	6.5

TABLE A-60. - Capital and operating costs for a 615 mtpd, open pit, plutonic related tin mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,872,000	$1,872,000	-4	-4
Exploration	$3,756,000	$751,000	-5	-1
Infrastructure	$18,630,000	$4,658,000	-4	-1
Mine	$12,046,000	$3,012,000	-4	-1
Mill	$11,846,000	$2,961,000	-4	-1
Working capital	$1,512,000	$1,512,000	0	0
TOTAL	**$49,662,000**	n/a	n/a	n/a
Mine operating cost	$27.71/mt	$5,965,000	0	7.0
Mill operating cost	$17.27/mt	$3,717,000	0	7.0

APPENDIX A - Capital and operating costs for VMCD mine models--Continued.

TABLE A-61. - Capital and operating costs for a 760 mtpd, open pit, plutonic related tin mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$1,920,000	$1,920,000	-4	-4
Exploration	$3,913,000	$783,000	-5	-1
Infrastructure	$20,632,000	$5,158,000	-4	-1
Mine	$13,341,000	$3,335,000	-4	-1
Mill	$13,980,000	$3,495,000	-4	-1
Working capital	$1,712,000	$1,712,000	0	0
TOTAL	$55,498,000	n/a	n/a	n/a
Mine operating cost	$25.84/mt	$6,873,000	0	7.5
Mill operating cost	$15.70/mt	$4,176,000	0	7.5

TABLE A-62. - Capital and operating costs for a 1515 mtpd, open pit, plutonic related tin mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$2,173,000	$2,173,000	-5	-5
Exploration	$4,731,000	$789,000	-6	-1
Infrastructure	$28,802,000	$5,760,000	-5	-1
Mine	$18,653,000	$3,731,000	-5	-1
Mill	$25,894,000	$5,179,000	-5	-1
Working capital	$2,599,000	$2,599,000	0	0
TOTAL	$82,852,000	n/a	n/a	n/a
Mine operating cost	$20.79/mt	$11,024,000	0	9.5
Mill operating cost	$11.80/mt	$6,357,000	0	9.5

TABLE A-63. - Capital and operating costs for a 2550 mtpd, open pit, plutonic related tin mine with a gravity mill.

Category	Total cost	Cost per year	Beginning year	Ending year
Acquisition	$2,518,000	$2,518,000	-5	-5
Exploration	$5,853,000	$976,000	-6	-1
Infrastructure	$37,088,000	$7,418,000	-5	-1
Mine	$24,086,000	$4,817,000	-5	-1
Mill	$45,590,000	$9,118,000	-5	-1
Working capital	$3,607,000	$3,607,000	0	0
TOTAL	$118,742,000	n/a	n/a	n/a
Mine operating cost	$17.80/mt	$24,606,000	0	11.3
Mill operating cost	$9.77/mt	$8,720,000	0	11.3