FEASIBILITY OF GOLD AND COPPER MINING IN THE CHUGACH NATIONAL FOREST, ALASKA

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FEASIBILITY OF ECONOMIC GOLD AND COPPER MINING IN THE CHUGACH NATIONAL FOREST, ALASKA

By Gary E. Sherman[1/] and Uldis Jansons[2/]

ABSTRACT

Preliminary economic mining feasibility studies of gold and copper deposits were conducted by the Bureau of Mines in 1982 to estimate mining costs in the Chugach National Forest, Alaska. Lode gold, placer gold, open pit copper, and underground copper mines were modeled.

Cost data for the lode and placer gold mines were based on actual operating costs, when available. Cost estimates for the copper mines were obtained using the Bureau of Mines Cost Estimating System and may fall within ± 25 pct of the actual costs.

Underground gold mining appears economically feasible for a deposit having reserves of 100,000 tons containing greater than 0.5 oz/ton over a 4-ft mining width. A gold price of $456/oz is required for the operation to break-even.

Placer gold mining operations of 100, 500, and 1,000 yd^3/day were modeled. At a gold price of $400/oz these operations would break-even at grades of 0.03, 0.012, and 0.009 oz gold/yd^3, respectively.

An 11,000 ton/day open-pit copper mine appears to be economically borderline at metal prices of $.70/lb copper, $0.37/lb zinc, $400/oz gold, and $10/oz silver. A 1,650 ton/day underground copper mine modeled would require a copper price of $0.75/lb and zinc price of $1.96/lb to be economic.

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INTRODUCTION

The Bureau of Mines (Bureau) recently completed a four year (1979-1983), intergency RARE II (P.L. 94-588) mineral appraisal of the Chugach National Forest (CNF) in southcentral Alaska (figure 1). The study area encompasses approximately 4.76 million acres and includes federal, state, and private lands (figure 2).

Considerable placer and lode gold mining took place sporadically in this area from 1895 until about 1942. After World War II economic conditions, small size of deposits, and metal prices militated against a restart of any siginificant lode gold mining industry. Small scale placer gold mining has continued in portions of the Kenai Peninsula to the present time. Major copper mining activity in the area began in 1897 with the discovery of the Beatson Mine on Latouche Island and continued until 1930.

PAST PRODUCTION

The majority of the primary gold produced from the CNF came from the placer districts near Turnagain Arm; principally Crow Creek, Resurrection Creek, and Canyon Creek. Placer gold production between 1895 and 1981 is estimated to be 125,000 oz (1)[1/]. The lode gold mines of the area generally were small and produced less than 5,000 oz of gold. The two exceptions to this are the Cliff Mine at Port Valdez and the Granite Mine at Port Wells which produced 51,267 and 24,940 oz gold, respectively. The Beatson Mine on Latouche Island, the largest copper mine in the CNF, produced more than 5,000,000 tons of zinc and copper sulfide ores containing by-product gold and silver. Direct-shipping ores and concentrates

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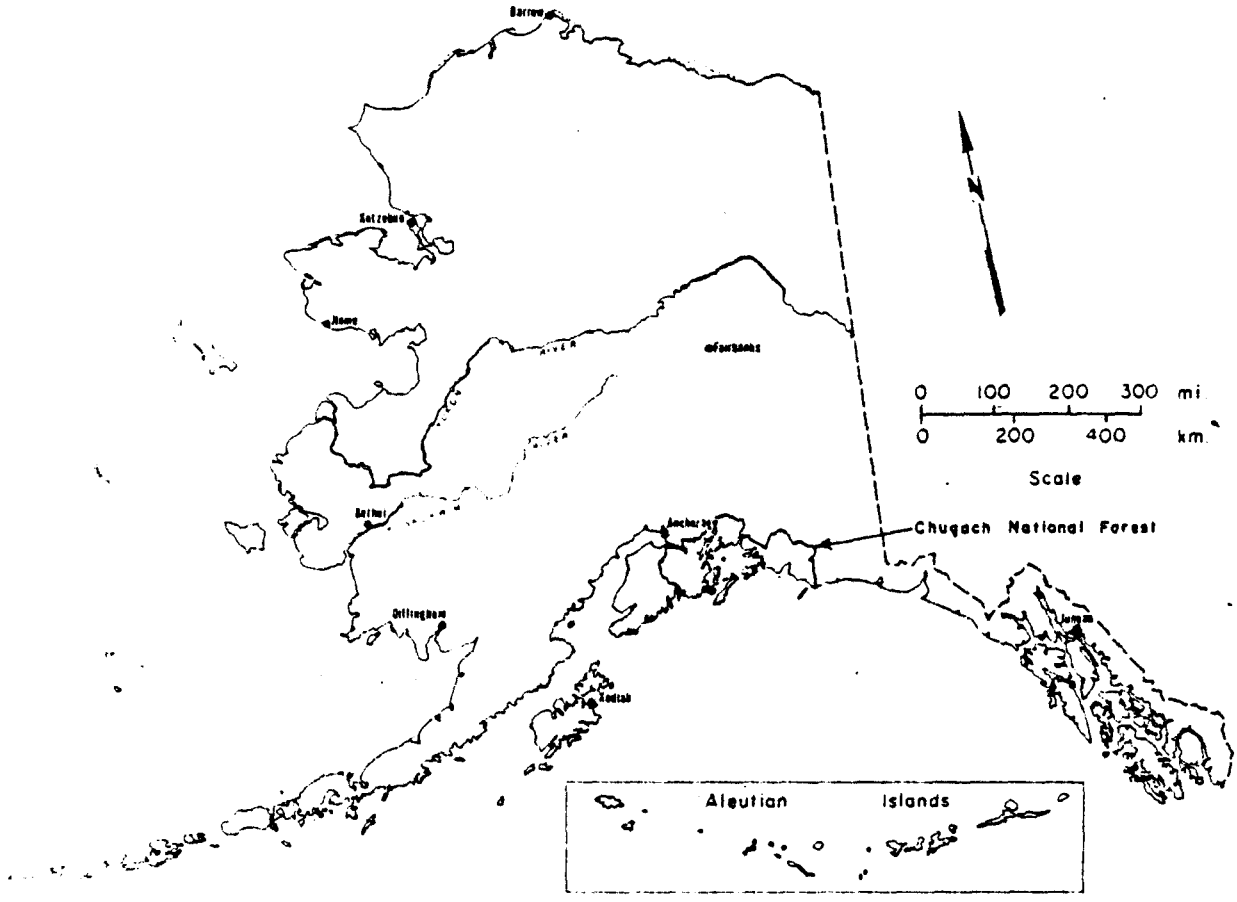
3/ Numbers in parentheses refer to references at the end of this report.



FICURE 1. - Chugach National Forest, Alaska

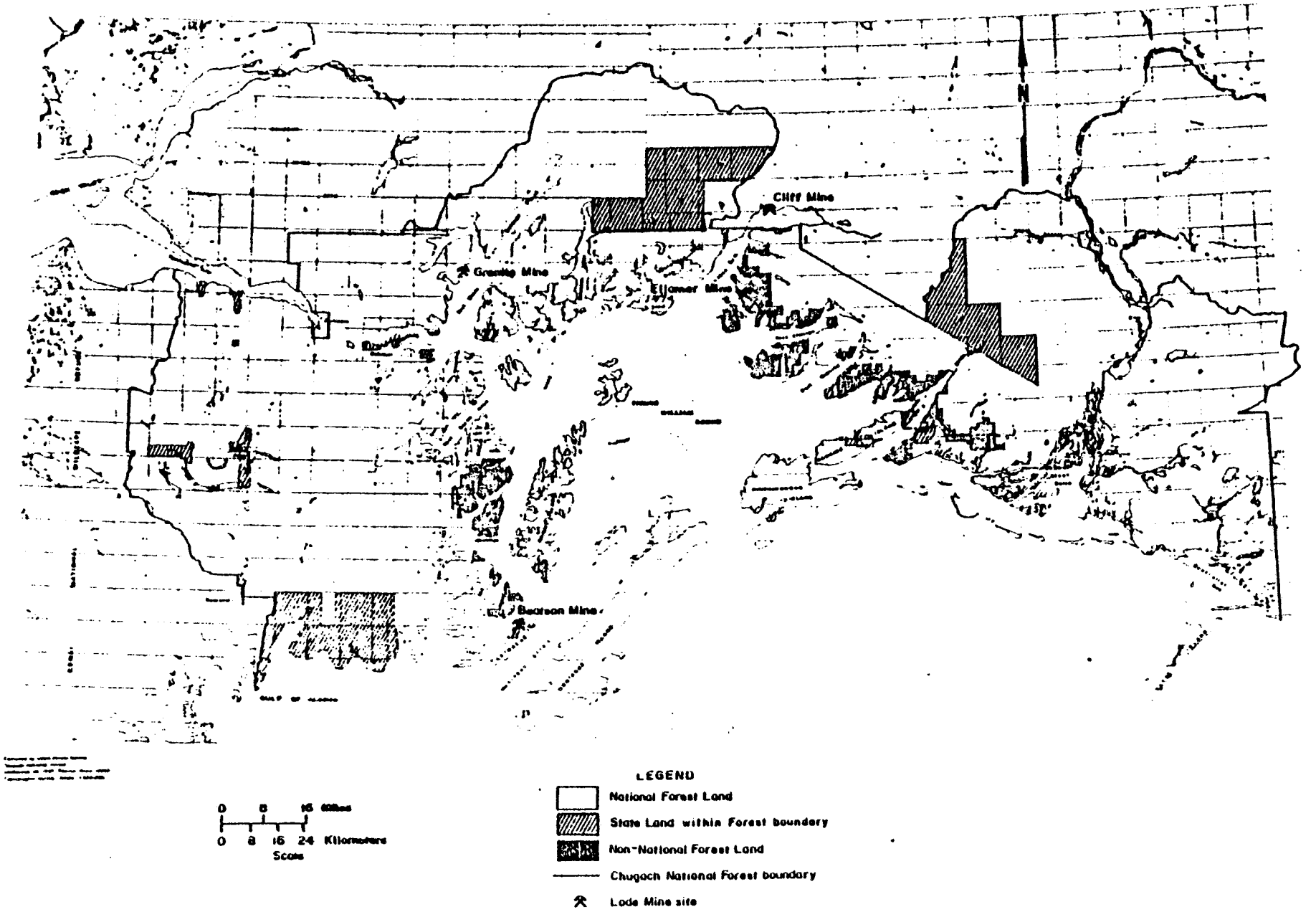


FIGURE 2. - Land status and location of lode mines, Chugach National Forest, Alaska.

were smelted at Tacoma, Washington. The Ellamar Mine, the second leading copper producer in the CNF shipped 301,580 tons of gold, silver, and copper-bearing sulfide ores. Twenty-two other operations shipped some copper during this time period but the Beatson Mine accounted for about 80 pct of the total production. Production data for the major mines are shown on table 1.

TABLE 1. - Major metal producing mines in and near the Chugach National Forest, Alaska.

Mine	Principal Commodity	Production			
		Gold (oz)	Silver (oz)	Copper (lbs)	tons ore
Cliff	Gold	51,267	8,047	-----	20,695
Granite	Gold	24,940	2,492	-----	31,919
Beatson	Copper	100,000 1/	1,229,059	170,000,000	5,000,000
Ellamar	Copper	51,305	191,615	15,761,337	301,580

1/ No production figures available. Total gold production is estimated using an average grade of 0.02 oz/ton, with more than 5 million tons of ore produced.

ECONOMIC MINING FEASIBILITY STUDIES

Economic feasibility studies for four mining operations used the discounted cash flow method(2) to determine DCFROI.4/ When possible, characteristics such as grade, shape, size of ore body, and extent of reserves have been modeled using available CNF mining records. The mine models include lode and placer gold, open-pit, and underground copper mining scenarios.

Capital and operating costs and parameters were compiled by two methods. Actual operating costs from companies and manufacturers specifications were utilized for the lode and placer gold studies. The capital and

4/ Discounted cash flow return on investment.

operating costs for the copper mines were compiled using the computerized version of the "Capital and Operating Cost Estimating System Handbook"(3). The Bureau of Mines MINSIM[5/] program was used to calculate yearly cash flows, rate of return, and present value for each mining operation.

ACKNOWLEDGMENTS

R. D. Carnes, Bureau of Mines, AFOC, Juneau, compiled the capital and operating costs for the copper mines through use of a computerized version of the cost estimating system (3). Mine operating costs, ore recoveries, and other data were provided by various mining companies historically associated with the operations in the area. Wayne Murton, Silverado Mines Ltd. provided valuable criticisms and suggestions for the lode gold mine model.

LODE GOLD MINING FEASIBILITY

Gold-bearing quartz lode deposits are widespread in the region and include those associated with granitic plutons and felsic dikes, and those with no apparent association to igneous rocks.

Vein widths are highly variable but average less than 2 ft for most deposits. For example, in the Granite Mine the vein reportedly ranged from 1.5 to 8 ft wide but averaged about 2 ft (4). Factors affecting mining costs of the gold deposits include narrow veins, steep dips, relatively simple mineralogy, variable but high grade, erratic distribution of free gold, structural offset, and pinching-out of veins along structures.

5/ Mine Simulation computer program.

ASSUMPTIONS

The hypothetical ore body used for this study was a steeply-dipping 2 ft wide quartz vein. An estimated 70 pct of the free-milling gold was recovered by simple gravity separation techniques. Access to the mine workings was via an adit and all mine entries and stopes were 4 ft wide. The mine model had reserves of 50,000 tons of gold ore, but due to the 4 ft mining width, 100,000 tons of material were extracted. Operating 330 days/year at 100 tons/day gave the mine a life of about 3 years.

Cut-and-fill mining with a minor amount of hand sorting, where practical, would be employed. Mill tailings were used for back fill. Historically, however, more economical open stope mining methods were used when ground support was not a problem.

COST DATA AND RESULTS

Most mine-related costs were estimated or based on factual data wherever possible. Used equipment costs were utilized in many cases. Pre-production costs and capital expenditures were $3,630,700. The major expenditures are summarized on table 2; costs are itemized in appendix A.

TABLE 2. - Summary of capital and operating costs for a hypothetical 100 ton/day lode gold mine, Chugach National Forest, Alaska.

	Item	$ Amount
Capital:	Exploration	$ 230,000
	Acquisition	33,000
	Development	890,300
	Surface plant	429,200
	Underground plant	173,200
	Mill plant	750,000
	Support facilities	1,125,000
	Total	$ 3,630,700
Operation:	Mine & mill (per ton of ore)	$113.06

The gold price required for zero and 25 pct DCFROI was calculated for ore grades from 0.125 to 2 oz/ton using the Bureau of Mines MINSIM program. The results are shown on table 3 and plotted on figure 3. A cash-flow analysis for the hypothetical lode gold mine in which the grade is 0.5 oz/ton and the gold price $500/oz indicates a possible 11.3 pct DCFROI (table 4).

TABLE 3. - Ore grades and gold prices required for zero and 25 pct DCFROI for a hypothetical 100 ton/day lode gold mine, Chugach National Forest, Alaska.

Grade 1/ (oz/ton)	Gold price ($/oz) 0 pct DCFROI	Gold price ($/oz) 25 pct DCFROI
0.125	1,796.94	2,233.48
0.25	901.25	1,119.52
0.5	456.02	565.79
0.75	305.28	378.32
1.0	230.13	284.86
1.5	155.42	191.94
2.0	118.01	145.41

1/ Grade over 4-ft mining width.

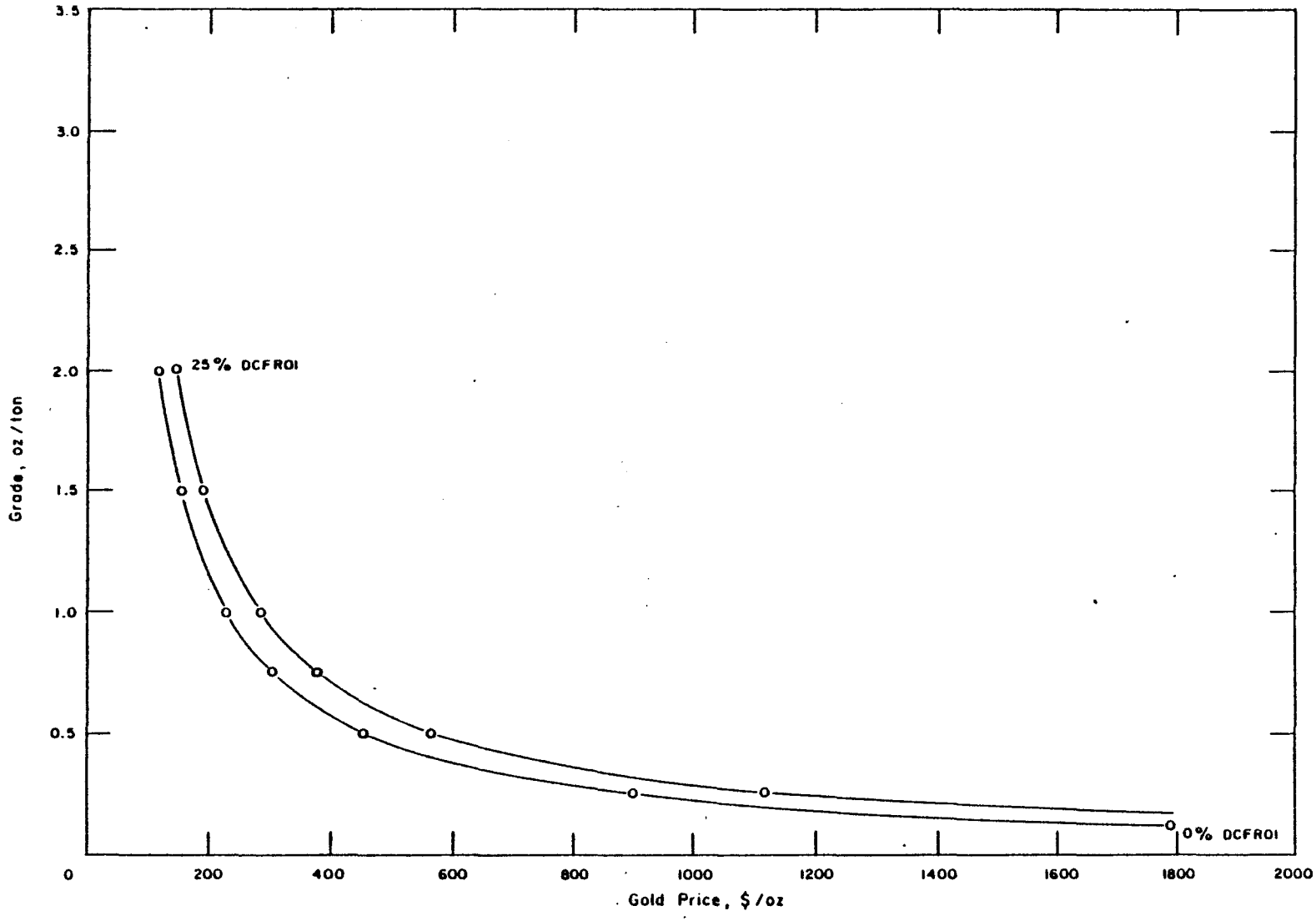


FIGURE 3. - Grade versus gold price, lode gold mine Chugach National Forest, Alaska.

TABLE 4. - Cash flow analysis for a hypothetical 100tpd lode gold mine, Chugach National Forest, Alaska, based on a grade of 0.5 oz/ton with a 4 ft stope width, and a gold price of $500/oz.

Year	-1	0	1	2	3
Capital Expenditures	(148,000) [1]	(3,482,700)	(1,243,900) [2]		
Gross Sales			5,761,306 [3]	5,761,306	5,761,306
Smelting Costs			(64,024)	(64,024)	(64,024)
Operating Costs			(3,730,748)	(3,730,748)	(3,730,748)
Depreciation			(504,073)	(401,097)	(319,256)
Depletion			(731,230)	(782,718)	(823,639)
Taxable Income			731,231	782,719	823,639
Mining License Tax			0	0	0
Taxable State Income			731,231	782,719	823,639
State Income Tax			(68,736)	(73,575)	(77,422)
Taxable Federal Income			662,495	709,144	746,217
Federal Income Tax			(285,497)	(306,956)	(324,010)
Income After Taxes			376,998	402,188	422,207
Cash Flow:					
Income After Taxes			376,998	402,188	422,207
Depreciation			504,073	401,097	319,256
Depletion			731,230	782,718	823,638
Net Cash Flow	(148,000)	(3,482,700)	368,400	1,586,003	2,809,001 [4]
Cumulative Present Value @ 11.32% DCFROI	(132,950)	(2,943,360)	(2,676,305)	(1,643,517)	(334)

1/ Parentheses indicate negative value.
2/ Working Capital.
3/ Numbers may not be reproducible due to computer rounding.
4/ Includes working capital.

Capital costs were not financed in this model. Financing would increase the price of gold required for DCFROI's less than 10 pct. For DCFROI's above 10 pct, the tax advantage of the loan interest payments takes effect and slightly lowers the price of gold required for a given rate of return. For example, when captial costs are financed the price of gold required to give a 25 pct DCFROI is 7 pct lower than when costs are not financed. For this model a minimum grade of about 0.5 oz/ton over the 4 ft mining width is required to mine the deposit profitably at a rate of 100 tons/day.

PLACER GOLD MINING FEASIBILITY

Alluvial, bench, eluvial, and glacial placer gold deposits have been identified in the CNF (1). Historically, most of the placer mining operations have processed primarily alluvial and bench deposits from creeks that have yielded gold sporadically for decades.

Prior to the use of mechanized equipment, most mining was done by ground sluicing, shoveling into boxes, and hydraulicking. Equipment in use today commonly includes trommels, shaking screens, and simple sluice boxes fed by bulldozer, backhoe, or front end loader.

ASSUMPTIONS

Four sizes of placer gold mines with different mining rates were modeled. The types of operations with rate of production, reserves, mine life, and expected recovery are listed on table 5. All mines were assumed to operate 10 hours/day, 100 days/year. All operations were equipped with a grizzly, trommel, spray bars, and double sluice boxes which received the classified material.

TABLE 5. - Placer gold mine models in the Chugach National Forest, Alaska.

Type[1/]	Ore (yd^3/day) Processed	Reserves (yd3)	Life of mine (years)	Anticipated Recovery (pct)
1	100	50,000	5	80
2	500	250,000	5	80
3	500	250,000	5	70
4	1000	300,000	3	80

1/ Type of operation: 1) D4-size dozer and 930 wheeled loader[2/]
2) D6-size dozer and 966 wheeled loader
3) D8-size dozer
4) D8-size dozer and 980 wheeled loader

2/ Reference to a product name does not imply endorsement by the Bureau of Mines.

COST DATA AND RESULTS

100 yd3/day Placer Mine

The 100 yd^3/day placer model had reserves of 50,000 yd^3, a life of 5 years, and an anticipated gold recovery of 80 pct. The pre-production, working capital, and operating costs for the project are $219,190 (table 6). Costs for this operation are itemized in appendix B.

TABLE 6. - Pre-production, capital, and operating costs for a 100 yd^3/day placer gold mine, Chugach National Forest, Alaska

Item	Amount ($)
Exploration	5,000
Development	4,600
Equipment	104,800
Annual operating costs	69,860
Working capital 1/	34,930
Total	219,190

1/ 50 pct of operating cost.

The relationship of the discounted cash flow rate of return of this operation to the grade of material mined and the price of gold is shown in figure 4. At $400/oz a break-even (zero DCFROI) grade of 0.03 oz gold/yd^3 is indicated. Gravels with an in-place grade of 0.04 oz gold/yd^3 at $400/oz will yield approximately a 25 pct DCFROI. A cash flow analysis (table 7) of an operation with an in-place grade of 0.035 oz/yd^3 indicates a possible 14.6 pct DCFROI at a gold price of $400/oz.

500 yd3/day Placer Mine

The 500 yd^3/day placer mine was projected to have reserves of 250,000 yd^3, a 5 year life, and a varying degree of gold recovery depending on which of two mining methods were used. The first method used a D6-size bulldozer and a 966C-size front-end loader to feed the trommel, and recovered 80 pct of the gold. The second case used a D8-size bulldozer to feed the trommel directly and recovered 70 pct of the gold.

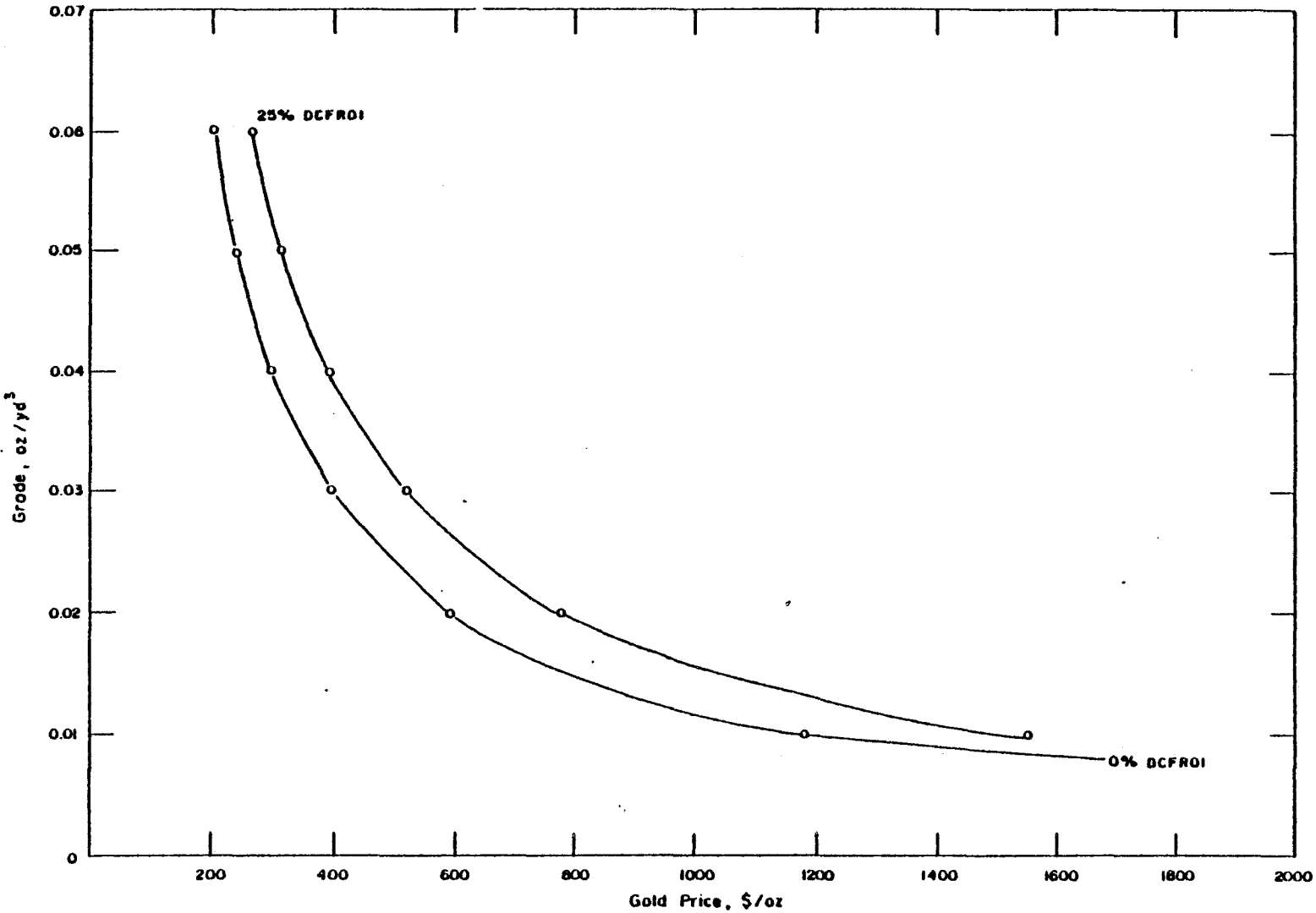


FIGURE 4. - Grade, gold price, and rate of return relationship, 100 yd^3/day placer mine, [redacted]

TABLE 7. - Cash flow analysis of a 100 yd^3/day placer mine, Chugach National Forest, Alaska. Gravels have a grade of 0.035 oz/yd^3 and plant recovery is 80 pct. Price of gold is set at $400/oz.

Year	0	1	2	3	4	5
Capital Expenditures	(114,400) 1/	(34,930) 2/				
Gross Sales	0	112,000	112,000	112,000	112,000	112,000
Smelting costs		(1,540)	(1,540)	(1,540)	(1,540)	(1,540)
Operating Costs		(69,860)	(69,860)	(69,860)	(69,860)	(69,860)
Depreciation		(19,643)	(15,960)	(12,967)	(10,536)	(8,560)
Depletion		(10,478)	(12,320)	(13,816)	(15,032)	(16,020)
Taxable Income		10,479	12,320	13,817	15,032	16,020
Mining License Tax		0	0	0	0	0
Taxable State Income		10,479	12,320	13,817	15,032	16,020
State Income Tax		(109)	(146)	(176)	(200)	(220)
Taxable Federal Income		10,370	12 ,174	13,641	14,832	15,800
Federal Income Tax		(2,281)	(2,678)	(3,000)	(3,262)	(3,475)
Income After Taxes		8,089	9,496	10,641	11,570	12,325
Cash Flow						
Income After Taxes		8,089	9,49 6	10,641	11,570	12,325
Depreciation		19,643	15,960	12,967	10,536	8,560
Depletion		10,478	12,320	13,816	15,032	16,020
Net Cash Flow	(114,400)	3,280	37,776	37,424	37,138	71,835 3/
Cumulative Present Value @ 14.62% DCFROI	(114,400)	(111,538)	(82,785)	(57,932)	(36,415)	(105)

1/ Parentheses indicate negative value.
2/ Working capital.
3/ Includes working capital.

Bulldozer-Loader Operation

The pre-production, capital, and operating costs for the bulldozer and loader operation are $425,200 (table 8). Costs for all phases of this operation are itemized in appendix B.

TABLE 8. - Pre-production, capital, and operating costs for a 500 yd^3/day placer mine using a dozer and front-end loader, Chugach National Forest, Alaska.

Item	Amount ($)
Exploration	19,600
Development	7,000
Equipment	213,300
Operating Costs	123,500
Working Capital 1/	61,800
Total	$425,200

1/ 50 pct of operating cost.

A discounted cash flow analysis was performed for this mining model to show the relationship between the DCFROI, gold price, and the gold content per cubic yard. The results of the analysis are shown graphically on figure 5. At a gold price of $400/oz the break-even grade is approximately 0.011 oz gold/yd^3. A cash flow analysis of the operation, given an in-place grade of 0.0125 oz/yd^3 and a gold price of $400/oz, indicates a possible 10.2 pct DCFROI (table 9).

Bulldozer Operation

The pre-production, capital, and operating costs for the 500 yd^3/day operation using a D8-size dozer to feed the plant are $338,300 (table 10). Costs for this operation are itemized in appendix B.

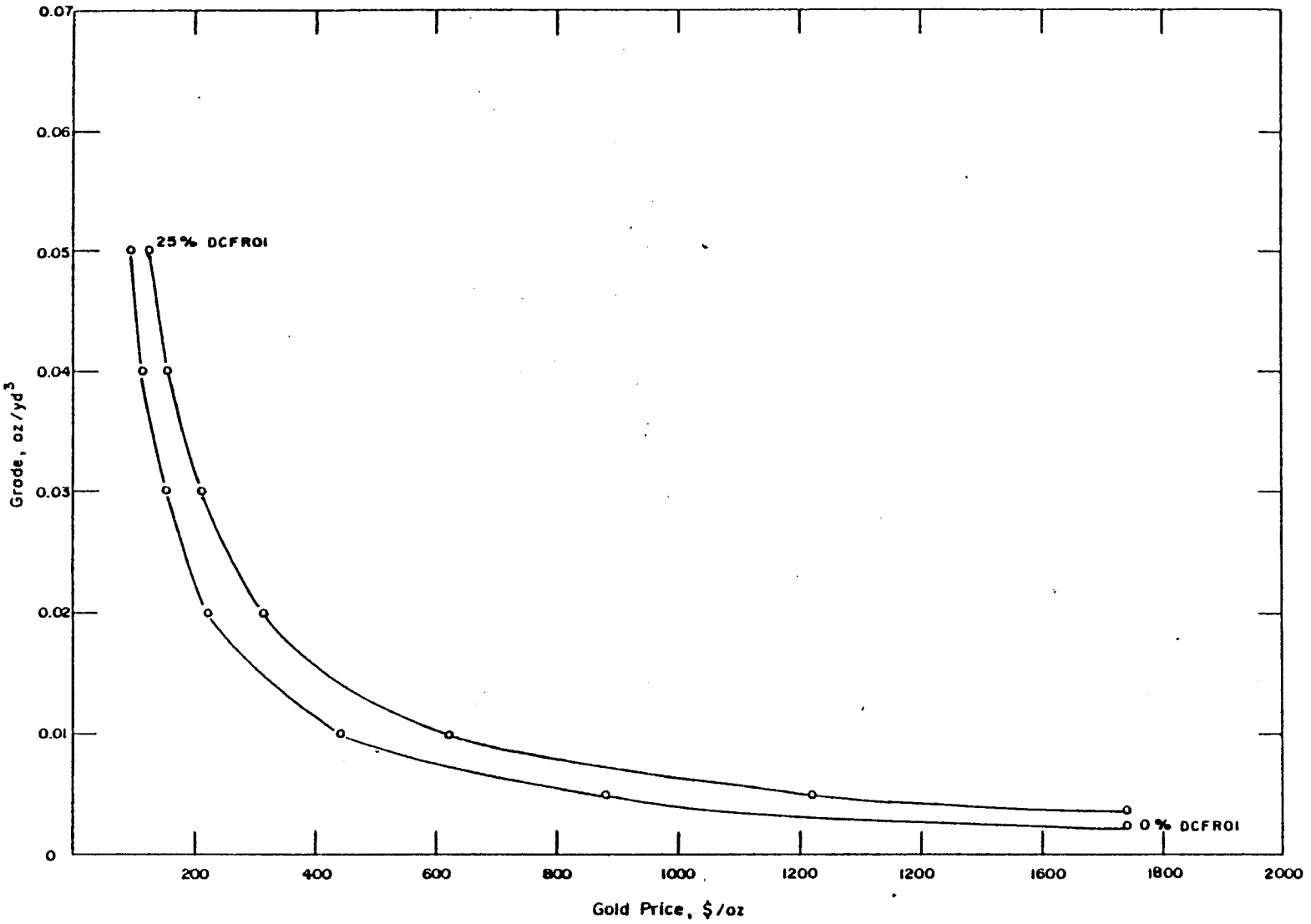


FIGURE 5. - Grade, gold price, and rate of return relationship, 500 yd^3/day bulldozer and loader placer mine, Chugach National Forest, Alaska.

TABLE 9. - Cash flow analysis of a 500 yd^3/day bulldozer and loader placer mine, Chugach National Forest, Alaska. Gravels have a grade of 0.0125 oz/yd^3 and plant recovery is 80 pct. Gold price is set at $400/oz.

Year	0	1	2	3	4	5
Capital Expenditures	(239,900) [1/]	(61,800) [2/]				
Gross Sales		200,000	200,000	200,000	200,000	200,000
Smelting Costs		(2,750)	(2,750)	(2,750)	(2,750)	(2,750)
Operating Costs		(123,500)	(123,500)	(123,500)	(123,500)	(123,500)
Depreciation		(39,998)	(32,498)	(26,405)	(21,454)	(17,431)
Depletion		(16,876)	(20,626)	(23,672)	(26,148)	(28,159)
Taxable Income		16,876	20,626	23,673	26,148	28,160
Mining License Tax		0	0	0	0	0
Taxable State Income		16,876	20,626	23,673	26,148	28,160
State Income Tax		(237)	(318)	(410)	(484)	(544)
Taxable Federal Income		16,639	20,308	23,263	25,664	27,616
Federal Income Tax		(3,660)	(4,467)	(5,117)	(5,818)	(6,754)
Income After Taxes		12,979	15,841	18,146	19,846	20,862
Cash Flow						
Income After Taxes		12,979	15,841	18,146	19,846	20,862
Depreciation		39,998	32,498	26,405	21,454	17,431
Depletion		16,876	20,626	23,672	26,148	28,159
Net Cash Flow	(239,900)	8,053	68,965	68,223	67,448	128,252 [3]
Cumulative Present Value @ 10.2% DCFROI	(239,900)	(232,592)	(175,803)	(124,825)	(79,090)	(176)

1/ Parentheses indicates negative value.
2/ Working Capital.
3/ Includes working capital.

TABLE 10. - Pre-production, capital, and operating cost data for a 500 yd^3/day placer mine using a D8-size bulldozer to feed the plant, Chugach National Forest, Alaska

Item	Amount($)
Exploration	19,600
Development	7,000
Equipment	139,200
Operating Costs	115,000
Working Capital 1/	57,500
Total	$338,300

1/ 50 pct of operating cost.

The relationship of grade, DCFROI, and price of gold for this operation is shown on figure 6. With a gold price of $400/oz the break-even grade was approximately 0.0114 oz/yd^3. The use of only a bulldozer lowers the capital and operating costs, but also lowers the rate of gold recovery (70 pct) which results in a break-even grade similar to the dozer and loader operation. A cash flow analysis with a grade of 0.015 oz/yd^3 and a gold price of $400/oz indicates a possible 29 pct DCFROI (table 11).

1000 yd3/day Placer Mine

The hypothetical 1000 yd^3/day placer operation used a D8-size bulldozer and 980-size front-end loader to feed a trommel. Ore reserves consisting of 300,000 yd^3 gave the mine a life of 3 years. The pre-production, capital, and operating costs for this mine are approximately $556,900 (table 12). Costs for this operation are itemized in appendix B.

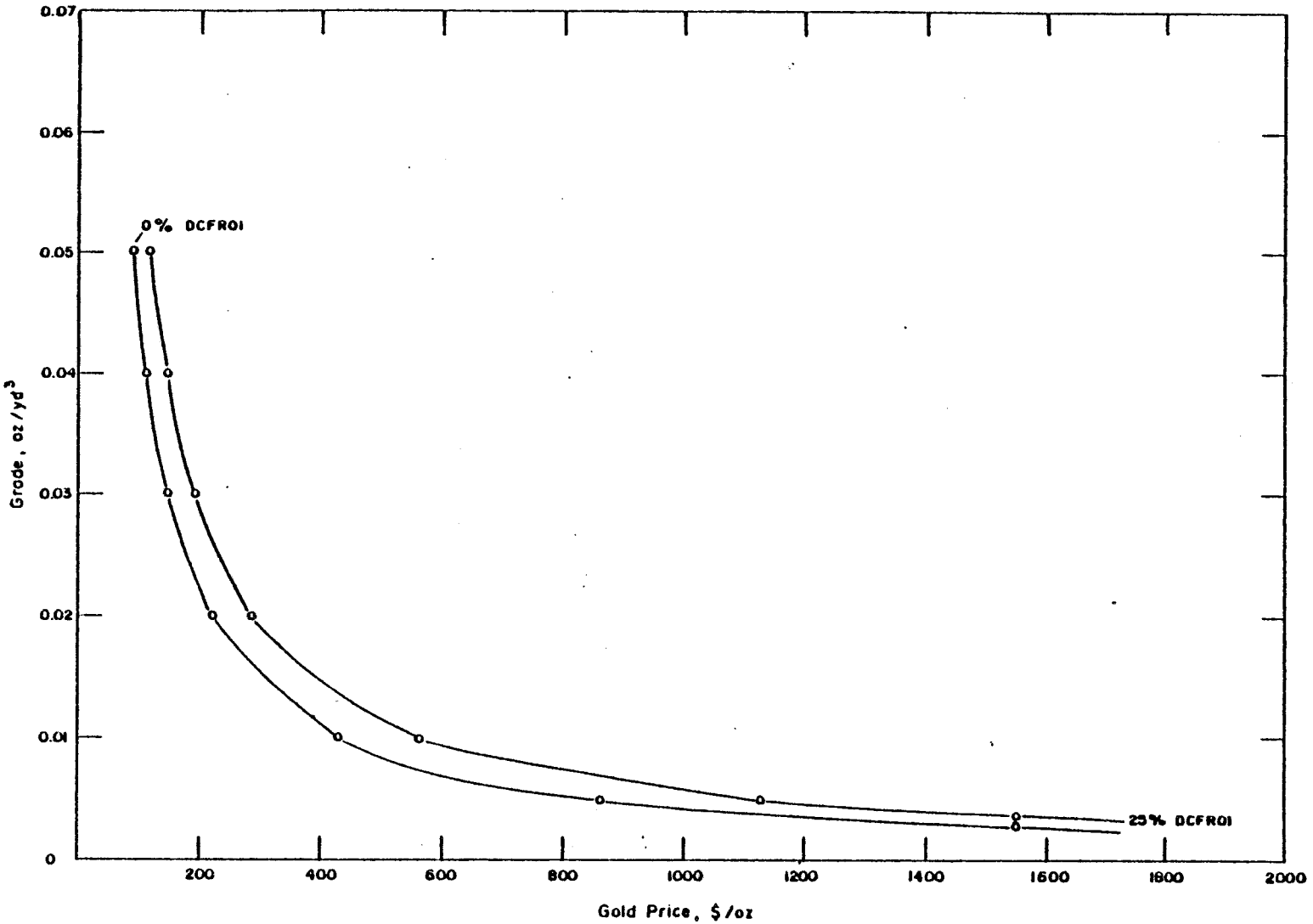


FIGURE 6. - Grade, gold price, and rate of return relationship, 500 yd^3/day bulldozer placer mine, Chugach National Forest, Alaska.

TABLE 11. - Cash flow analysis of a 500 yd^3/day (bulldozer only) placer mine, Chugach National Forest, Alaska. Gravels have a grade of 0.015 oz/yd^3 and plant recovery is 70 pct. Price of gold is $400/oz.

Year	0	1	2	3	4	5
Capital Expenditures	(165,800) 1/	(57,500) 2/				
Gross Sales		210,000	210,000	210,000	210,000	210,000
Smelting Costs		(2,887)	(2,887)	(2,887)	(2,887)	(2,887)
Operating Costs		(115,000)	(115,000)	(115,000)	(115,000)	(115,000)
Depreciation		(26,090)	(21,198)	(17,223)	(13,994)	(11,370)
Depletion		(31,066)	(31,066)	(31,066)	(31,066)	(31,066)
Taxble Income		34,957	39,849	43,824	47,053	49,677
Mining License Tax		0	0	0	0	(1,490)
Taxable State Income		34,957	39,849	43,824	47,053	48,187
State Income Tax		(798)	(993)	(1,191)	(1,352)	(1,409)
Taxable Federal Income		34,159	38,85	42,633	45,701	46,778
Federal Income Tax		(9,895)	(12,149)	(13,962)	(15,435)	(15,952)
Income After Taxes		24,264	26,707	28,671	30.266	30,826
Cash Flow						
Income After Taxes		24,264	26,707	28,671	30,266	30,826
Depreciation		26,090	21,198	17,223	13,994	11,370
Depletion		31,066	31,066	31,066	31,066	31,066
Net Cash Flow	(165,800)	23,920	78,971	76,960	75,326	130,762 3/
Cumulative Present Value @ 29.0% DCFROI	(165,800)	(147,257)	(99,802)	(63,951)	(36,750)	(146)

1/ Parentheses indicate negative value.
2/ Working Capital.
3/ Includes working capital.

TABLE 12. - Pre-production, capital, and operating cost data for a 1000 yd^3/day placer mine, Chugach National Forest, Alaska

Item	Amount ($)
Exploration	19,600
Development	13,800
Equipment	338,100
Operating Costs	123,625
Working Capital[1/]	61,813
Total	556,938

1/ 50 pct of operating cost.

For the 1000 yd^3/day operation the break-even grade at $400/oz gold is approximately 0.009 oz/yd^3 (figure 7). A cash flow analysis for the operation using an in-place grade of 0.0125 oz/yd^3 and a gold price of $400/oz indicates a possible 23.9 pct DCFROI (table 13).

DISCUSSION OF RESULTS

As in the majority of mining ventures, the greater the amount of ore produced, the lower the unit cost. This is true in the case of the hypothetical placer mines presented above. The grade required to obtain a break-even operation and a 25 pct DCFROI on the capital investment for each of the hypothetical operations is shown on table 14.

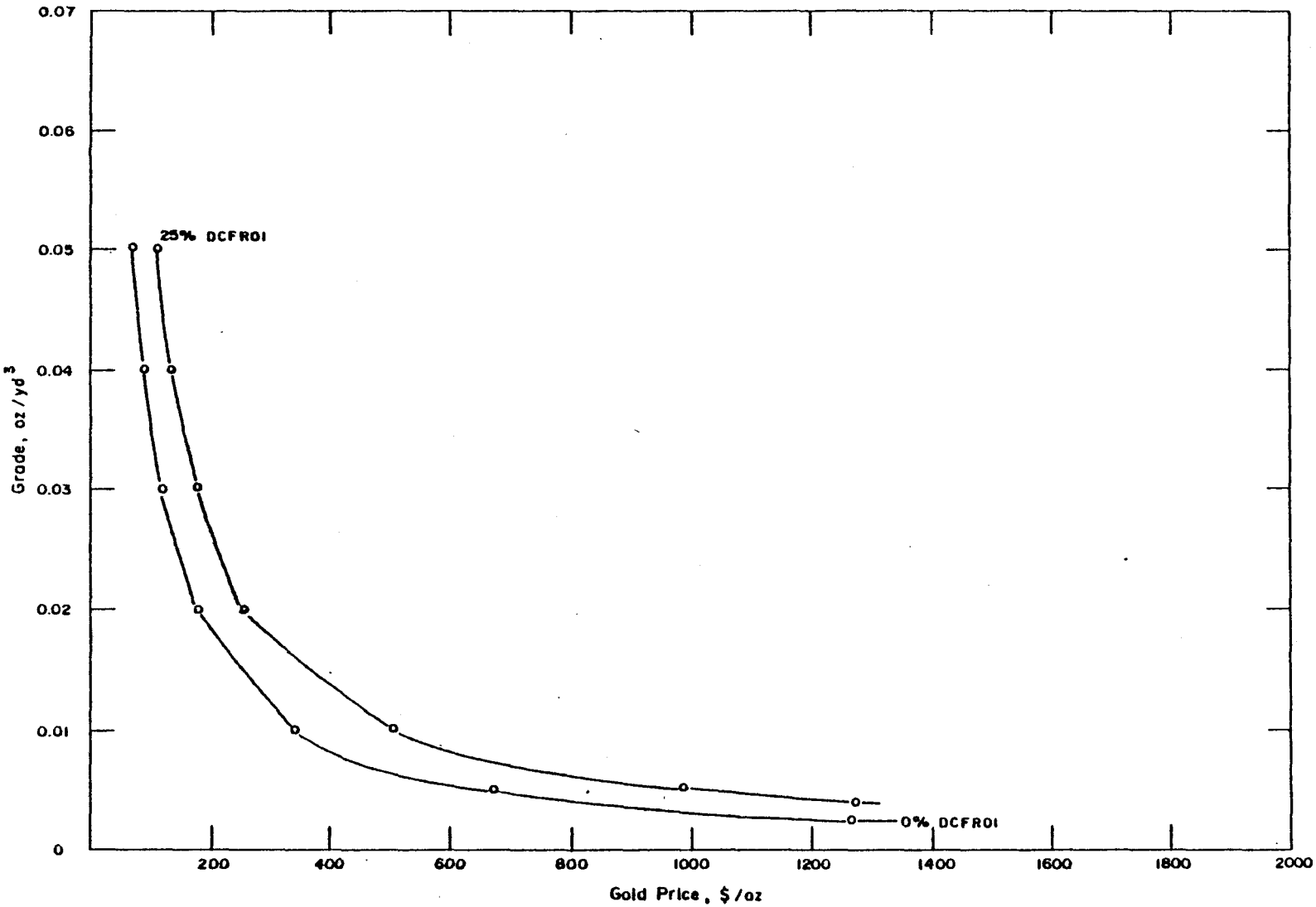


FIGURE 7. - Grade, gold price, and rate of return relationship, 1,000 yd^3/day placer mine, Chugach National Forest, Alaska.

TABLE 13. - Cash flow analysis of a 1,000 yd^3/day placer mine, Chugach National Forest, Alaska. Gravels have a grade of 0.0125 oz/yd^3 and plant recovery is 80 pct. Price of gold is $400/oz.

Year	0	1	2	3		
Capital Expenditures	(371,500) [1/]	(61,813) [2/]				
Gross Sales		400,000	400,000	400,000		
Smelting Costs		(5,500)	(5,500)	(5,500)		
Operating Costs		(123,625)	(123,625)			
Depreciation		(63,447)	(51,551)	(41,885)		
Depletion		(59,175)	(59,175)	(59,175)		
Taxable Income		148,253	160,149	169,815		
Mining License Tax		0	0	0		
Taxable State Income		148,253	160,149	169,815		
State Income Tax		(9,975)	(11,093)	(12,002)		
Taxable Federal Income		138,278	149,056	157,813		
Federal Income Tax		(59,872)	(65,046)	(69,248)		
Income After Taxes		78,406	84,010	88Z565		
Cash Flow						
Income After Taxes		78,406	84,010	88,565		
Depreciation		63,447	51,551	41,885		
Depletion		59,175	59,175	59,175		
Net Cash Flow	(371,500)	139,215	194,736	251,438 [3/]		
Cumulative Present Value @ 23.92% DCFROI	(371,500)	(259,397)	(132,585)	(90)		

1/ Parentheses indicates negative value.
2/ Working capital.
3/ Includes working capital.

TABLE 14. - Summary of grade requirements for break-even (0 pct) and 25 pct DCFROI for four placer mine models, Chugach National Forest, Alaska.1/

Mine Model	Grade (oz/yd^3) for 0 pct return on invest.	Grade (oz/yd^3) for 25 pct return on invest.
100 yd^3/day	0.03	0.0395
500 yd^3/day, bulldozer and loader	0.012	0.017
500 yd^3/day, bulldozer only	0.0115	0.016
1000 yd^3/day, bulldozer and loader	0.009	0.014

1/ Gold price of $400/oz.

To economically mine a small placer deposit (50,000 yd^3) at a rate of 100 yd^3/day, the grade of all mined material must average 0.03 oz/yd^3 at a gold price of $400/oz.

Economic mining at 500 yd^3/day and 1000 yd^3/day is feasible at grades of approximately 0.012 and 0.009 oz/yd^3, respectively. The use of additional equipment in the 500 yd^3/day bulldozer-loader operation requires a slightly higher grade than by using only a dozer (0.0115 vs. 0.016 oz/yd^3). This reflects the effect of the additional capital and operating costs of a second piece of equipment for the mining phase.

COPPER MINING FEASIBILITY

Although most copper mining operations in the Chugach National Forest have been small and short lived, some large scale reserve potential exists(5). The Beatson Mine on Latouche Island (figure 2) was the largest copper

producer within the CNF. This mine operated continuously from 1903 until 1930 and produced more than 5 million tons of ore averaging 1.7 pct copper and 0.23 oz/ton silver.

At the Beatson Mine the sulfide orebody is located along the footwall of the Beatson Fault which cuts interbedded graywacke and slates. Geological continuity and distribution of other copper prospects along this trend suggest a possibility for similar large or larger tonnage copper ore bodies. More recently, diamond drilling and underground sampling along the trend suggest that zinc and gold, in addition to the copper and silver, are present in recoverable and salable amounts.

ASSUMPTIONS

Economic mining feasibility studies were done for both an open-pit and an underground copper mine. Both mines operated 330 days per year. The ore grades were based on values determined for various mines and prospects in the Horseshoe Bay area on Latouche Island.

The major characteristics of the mining operations are summarized on table 15. Two products, a copper and a zinc concentrate, both containing by-product gold and silver, were produced for sale. The gold price of $400/oz and silver price of $10/oz remained constant in the calculations.

TABLE 15. - Major attributes of the hypothetical open pit and underground copper mines, Chugach National Forest, Alaska.

Mine	Reserves	Grades				Mining method	Concent. procedure	Preproduction (years)	Mine life (yrs)
		Cu	Zn	Au	Ag				
Open pit 11,000 tons/day	24.2x106 tons	1%	1.5%	0.03 oz/t	1.2 oz/t	open cast 6:1 strip ratio truck & shovel	froth flotation	3	7
Underground 1,650 tons/day	6x106 tons	1.7%	2%	0.02 oz/t	0.23 oz/t	cut & fill stopes	froth flotation	5	11

OPEN PIT COPPER MINE

The hypothetical open-pit mine would operate for seven years and produce 11,000 tons of ore and 66,000 tons of waste per day. Proposed reserves were 24.2 million tons of ore at 1 pct copper, 1.5 pct zinc, 0.03 oz/ton gold, and 1.2 oz/ton silver. Mining was done by truck and shovel methods. Mill tailings were disposed underwater and no costs were considered for tailings storage reservoirs or other tailings related costs, other than piping, pumps, etc. Total costs including pre-production, exploration, development, and capital equipment, are estimated at approximately $159 million (table 16). The costs for the operation are itemized in appendix C.

TABLE 16. - Capital and operating costs for the open pit copper mine, Chugach National Forest, Alaska.

	Item	$ Amount
Capital:	Exploration	$ 6,656,300
	Acquisition	5,169,800
	Development	7,282,000
	Mine plant & equipment	68,293,000
	Mill plant & equipment	58,081,100
	Working capital	13,423,500
	Total	$158,905,700
Operation:	Mine & mill	$ 13.78/ton

The DCFROI for this operation was calculated for various combinations of copper and zinc prices. The zinc prices required to give a particular DCFROI at a given copper price are shown on table 17. The calculated mining and milling costs per ton of the ore are $8.76 and $5.02, respectively. A cash flow analysis for a 15 pct DCFROI is shown on table 18.

TABLE 17. - Relationship of zinc and copper prices to DCFROI for an open-pit copper mine, Chugach National Forest, Alaska.[1/]

Copper price ($/lb)	Zinc price required ($/lb)		
	0 pct DCFROI	15 pct DCFROI	25 pct DCFROI
0.25	0.60	0.93	1.22
0.50	0.41	0.74	1.05
0.75	0.23	0.55	0.87
1.00	0.04	0.37	0.69
1.25	0.00 [2/]	0.19	0.52

1/ Gold and silver prices held constant at $400/oz and $10/oz respectively.
2/ Sale of zinc not required.

TABLE 18. - Cash flow analysis of the open pit copper mine where the copper and zinc prices are $0.75/lb and $0.55/lb respectively.

Year	-2	-1	0	1	2	3	4
Capital Expenditures	(8,497,950) 1/	(70,156,200)	(66,828,050)	(13,423,500) 2/	0	0	0
Gross Sales				144,872,531	144,872,531	144,872,531	144,872,531
Operating Costs				(50,028,000)	(50,028,000)	(50,028,000)	(50,028,000)
Smelting Costs				(45,438,461) 3/	(45,438,461)	(45,438,461)	(45,438,461)
Depreciation				(11,377,725)	(20,218,239)	(15,716,675)	(12,229,903)
Depletion				(19,014,172)	(14,593,915)	(16,844,697)	(18,588,083)
Taxable Income				19,014,173	14,593,916	16,844,698	18,588,084
Mining License Tax				0	0	0	0
State Income Tax				(1,787,332)	(1,371,828)	(1,583,402)	(1,747,280)
Federal Income Tax				(7,905,096)	(6,062,910)	(7,000,946)	(7,727,519)
Income After Taxes				9,321,745	7,159,178	8,260,350	9,113,285
Depreciation				11,377,725	20,218,239	15,716,675	12,229,903
Depletion				19,014,172	14,593,915	16,844,697	18,588,083
Net Cash Flow	(8,297,950)	(70,156,200)	(66,828,050)	26,290,142	41,971,332	40,821,722	39,931,271
Cumulative Present Value @ 15% DCFROI	(7,389,521)	(60,437,687)	(104,378,215)	(89,346,742)	(68,479,572)	(50,831,215)	(35,819,572)

1/ Parentheses indicate negative value.
2/ Working Capital.
3/ Includes Transportation to Smelter.

TABLE 18. - Cash flow analysis of the open-pit copper mine where the copper and zinc prices are $0.75/lb and $0.55/lb, respectively. - Continued

Year	5	6	7				
Capital Expenditures	0	0	0				
Gross Sales	144,872,531	144,872,531	144,872,531				
Operating Costs	(50,028,000)	(50,028,000)	(50,028,000)				
Smelting Costs	(45,438,461) 1/	(45,438,461)	(45,438,461)				
Depreciation	(9,526,345)	(7,841,857)	(7,338,507)				
Depletion	(19,939,862)	(20,020,497)	(20,020,497)				
Taxable Income	19,939,863	21,543,716	22,047,066				
Mining License Tax	(1,391,590)	(1,503,860)	(1,539,095)				
State Income Tax	(1,874,347)	(2,025,109)	(2,072,424)				
Federal Income Tax	(7,650,755)	(8,267,533)	(8,461,101)				
Income After Taxes	9,023,171	9,747,214	9,974,446				
Depreciation	9,526,345	7,841,857	7,338,507				
Depletion	19,939,862	20,020,497	20,020,497				
Net Cash Flow	38,489,378	37,609,568	50,756,950 2/				
Cumulative Present Value @ 15% DCFROI	(23,237,327)	(12,546,341)	0				

1/ Includes Transportation to Smelter.
2/ Includes working capital.

UNDERGROUND COPPER MINE

The hypothetical underground copper mine produced 1,650 tons of ore per day from a 6 million ton sulfide ore body. The average grade was 1.7 pct copper, 2 pct zinc, 0.02 oz gold/ton, and 0.23 oz silver/ton. The cut-and-fill mining method was used and access to the workings was provided by an adit. Mill tailings were used as backfill. The total pre-production costs, including exploration, development, and capital equipment for this operation are approximately 46 million dollars (table 19). The costs for the underground mine are itemized in appendix D.

TABLE 19. - Capital and operating costs for the underground copper mine, Chugach National Forest, Alaska.

	Item	Amount ($)
Capital:	Exploration	$ 1,140,300
	Acquisition	738,500
	Development	4,703,800
	Mine plant & equipment	15,556,700
	Mill plant & equipment	18,326,400
	Working capital	5,573,700
	Total	$ 46,039,400
Operation:	Mine & mill	$ 56.31/ton

The zinc prices required to give a particular DCFROI at a given copper price are shown on table 20. The calculated mining and milling costs for the assumed project are $42.96/ton and $13.35/ton, respectively. A cash flow example for the mine which gives a 15 pct DCFROI is shown on table 21.

TABLE 20. - Relationship of zinc and copper prices to DCFROI for an underground copper mine, Chugach National Forest area, Alaska.1/

Copper price ($/lb)	Zinc price required ($/lb)		
	0 pct DCFROI	15 pct DCFROI	25 pct DCFROI
0.25	2.44	3.00	3.56
0.50	2.20	2.76	3.32
0.75	1.96	2.52	3.08
1.00	1.72	2.28	2.84
1.25	1.48	2.04	2.60

1/ Gold and silver prices held constant at $400/oz and $10/oz, respectively.

DISCUSSION OF RESULTS

The DCFROI for the two copper mines was calculated for a range of copper and zinc prices (figure 8, tables 17 and 20). If the copper price is $0.75/lb a 0 pct DCFROI is obtained when zinc prices are $0.23/lb and $1.96/lb for the open-pit and underground mines, respectively.

An additional factor important in feasibility studies of copper mines is the precious metal content in the ore. For example, the gross metal value of the ore from the open-pit mine is $43.07/ton with metal prices (current, January, 1982) of $0.70/lb for copper, $0.37/lb for zinc, $347/oz for gold, and $6.30/oz for silver. However, if gold and silver prices increased to $400/oz and $10/oz respectively, the value of the ore would increase by 14 pct.

The open-pit mine appears to be economically borderline and may warrant a detailed feasibility study. The underground copper mine is considered uneconomic at today's (1982) metal prices.

TABLE 21. - Cash flow analysis of the underground copper mine, Chugach National Forest, Alaska, (copper and zinc prices are $0.75/lb and $2.42/lb respectively).

Year	-4	-3	-2	-1	0	1	2
Capital Expenditures	(1,905,960) 1/	(7,105,960)	(7,105,960)	(12,174,160)	(12,174,160)	(5,573,700) 2/	
Gross Sales						54,066,367	54,066,367
Operating Costs						(30,660,300)	(30,660,300)
Smelting Costs						(10,407,058) 3/	(10,407,058)
Depreciation						(2,250,523)	(4,038,645)
Depletion						(5,374,243)	(4,480,182)
Taxable Income						5,374,243	4,480,182
Mining License Tax						0	0
State Income Tax						(505,179)	(421,137)
Federal Income Tax						(2,220,520)	(1,847,911)
Income After Taxes						2,648,544	2,211,134
Depreciation						2,250,523	4,038,645
Depletion						5,374,243	4,480,182
Net Cash Flow	(1,905,960)	(7,105,960)	(7,105,960)	(12,174,160)	(12,174,160)	4,699,610	10,729,961
Cumulative Present Value @ 15% DCFROI	(1,657,356)	(7,030,482)	(11,702,766)	(18,663,382)	(24,716,091)	(22,684,319)	(18,650,530)

1/ Parentheses indicate negative value.
2/ Working capital.
3/ Includes transportation to smelter.

TABLE 21. - Cash flow analysis of the underground copper mine, Chugach National Forest, Alaska, (copper and zinc prices are $0.75/lb and $2.52/lb respectively).- Continued

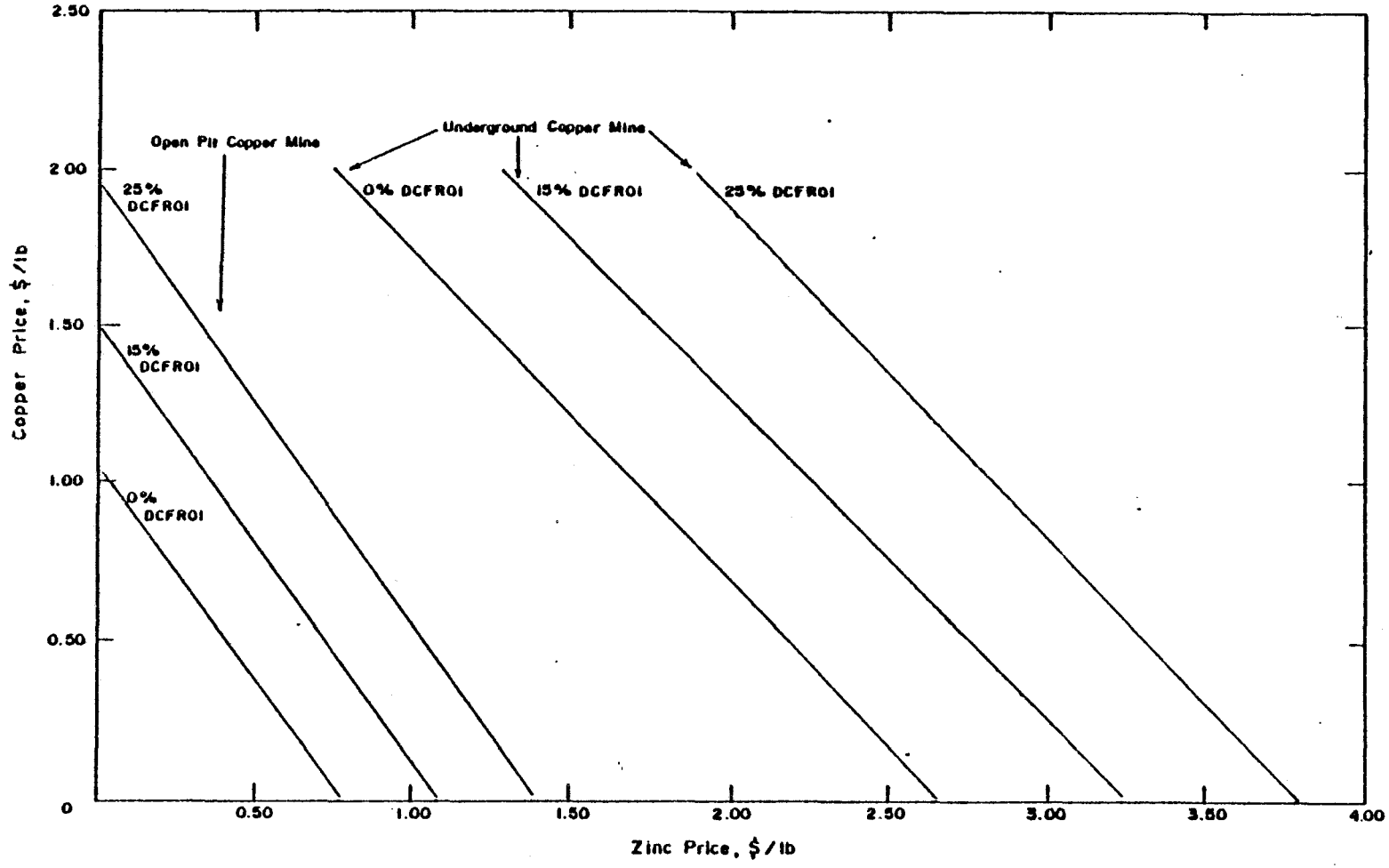
Year	3	4	5	6	7	8	9
Capital Expenditures							
Gross Sales	54,066,367	54,066,367	54,066,367	54,066,367	54,066,367	54,066,367	54,066,367
Operating Costs	(30,660,300)	(30,660,300)	(30,660,300)	(30,660,300)	(30,660,300)	(30,660,300)	(30,660,300)
Smelting Costs	(10,407,058) 1/	(10,407,058)	(10,407,058)	(10,407,058)	(10,407,058)	(10,407,058)	(10,407,058)
Depreciation	(3,209,399)	(2,551,381)	(2,029,001)	(1,633,575)	(1,469,358)	(1,469,358)	(1,391,549)
Depletion	(4,894,805)	(5,223,814)	(5,485,004)	(5,682,717)	(5,764,825)	(5,764,825)	(5,803,730)
Taxable Income	4,894,805	5,223,814	5,485,004	5,682,717	5,764,826	5,764,826	5,803,730
Mining License Tax	0	0	(379,750)	(393,590)	(399,338)	(399,338)	(402,061)
State Income Tax	(460,112)	(491,039)	(515,590)	(534,175)	(541,894)	(541,894)	(545,551)
Federal Income Tax	(2,020,709)	(2,157,827)	(2,091,995)	(2,168,028)	(2,199,603)	(2,199,603)	(2,214,564)
Income After Taxes	2,413,984	2,574,948	2,497,669	2,586,924	2,623,991	2,623,991	2,641,554
Depreciation	3,209,399	2,551,381	2,029,001	1,633,575	1,469,358	1,469,358	1,391,549
Depletion	4,894,805	5,223,814	5,485,004	5,682,717	5,764,825	5,764,825	5,803,730
Net Cash Flow	10,518,188	10,350,143	10,011,674	9,903,216	9,858,174	9,858,174	9,836,833
Cumulative Present Value @ 15% DCFROI	(15,212,115)	(12,269,958)	(9,795,226)	(7,666,596)	(5,824,033)	(4,221,894)	(2,831,578)

1/ Includes transportation to smelter.

TABLE 21. - Cash flow analysis of the underground copper mine, Chugach National Forest, Alaska, (copper and zinc prices are $0.75/lb and $2.52/lb respectively).- Continued

Year	10	11						
Capital Expenditures								
Gross Sales	54,066,367	54,066,367						
Operating Costs	(30,660,300)	(30,660,300)						
Smelting Costs	(10,407,058) 1/	(10,407,058)						
Depreciation	(1,313,741)	(656,871)						
Depletion	(5,842,634)	(6,171,069)						
Taxable Income	5,842,634	6,171,069						
Mining License Tax	(404,784)	(427,775)						
State Income Tax	(549,208)	(580,081)						
Federal Income Tax	(2,229,525)	(2,355,828)						
Income After Taxes	2,659,117	2,807,385						
Depreciation	1,313,741	656,871						
Depletion	5,842,634	6,171,069						
Net Cash Flow	9,815,492	15,209,025 2/						
Cumulative Present Value @ 15% DCFROI	(1,025,308)	0						

1/ Includes transportation to smelter.
2/ Includes working capital.



FIGUPE 8. - Copper and zinc price relationships for given rates of return for the two hypothetical copper mines, Chugach National Forest, Alaska.

SUMMARY

The economic mining feasibility studies presented above are of a preliminary nature. Some costs and other factors may have been overlooked for any particular operation. The studies are adequate in pointing out the feasibility of a deposit in terms of economic operation under the assumed conditions of the models.

Placer and lode gold mining appear feasible for the reserves and grades assumed.

The hypothetical open-pit copper mine appears to be marginally economic at 1982 copper and zinc prices. The underground copper mining model presented in this study appears to be uneconomic.

REFERENCES

1. Hoekzema, R. B. Placer Sampling and Related Bureau of Mines Activities on the Kenai Peninsula, Alaska. U.S. BuMines OFR 138-81, 1981, 28 pp.

2. Whitney, J. W., and R. E. Whitney. Investment and Risk Analysis in the Mineral Industry. Whitney & Whitney, Inc., Reno, Nevada 1979, 197 pp.

3. Clement, G. K., Jr., R. L. Miller, L. Avery, and P. A. Siebert. Capital and Operating Cost Estimating Handbook. Mining and Beneficiation of Metallic and Nonmetallic Minerals, Except Fossil Fuels, in the United States and Canada. U.S. BuMines OFR 10-78, 1978, 184 pp.

4. Johnson, B. L. Mining on Prince William Sound. U.S. Geol. Survey Bull. 622, 1915, pp. 131-139.

5. Trent, R. H. The Feasibility of Mining a Low Grade Copper Deposit in a Remote Area. Unpublished M.S. thesis, University of Utah, 1972, 159 pp.

APPENDIX A

Itemized Capital and Operating Costs for the
100 ton/day lode gold mine.

Capital Expenditures

I.	Exploration (assumed)		$230,000[1/]
	Property Acquisition (assumed)		33,000
II.	Development		
	3,500 ft drifts and crosscuts @ $140/ft		$490,300
	3,600 ft of raises @ $100/ft		$360,000
	Site preparation		$ 40,000
			$890,300
III.	Surface Plant		
	Compressor & building	1,200 cfm	$ 68,700
	Ventilation	4,000 cfm	7,500
	Mine office and lamp room	20 ft x 30 ft	27,000
	Machine & repair shop	40 ft x 50 ft	100,000
	Shop equipment and tools		52,500
	Warehouse	30 ft x 30 ft	40,500
	Explosives magazine		3,000
	Lamps and charger		10,000
	Tailings pond		50,000
	Tailings dewatering & transport system		70,000
			$429,200
IV.	Underground Plant and Equipment (used)		
	Locomotive (3 ton)	1	$ 19,500
	Mine Car (3 ton)	10	21,800
	Mucker	2	14,300
	Slusher	3	5,400
	Drifter drill	4	14,000
	Stopers	4	12,300
	Drill steel	600 ft x 1 in.	4,800
	Bits	350	7,600
	Hose	3,500 ft of 1 in.	4,000
	Piping	3,500 ft 3 of 3 in.	21,000
	Pump	1 3 1/2 in. sump	2,500

1/ Numbers rounded to nearest hundred dollars.

Rails	3,500 ft	$ 10,500
Ties		4,000
Blower	2 portable	1,400
Hand tools		7,500
		$150,600
Transportation		22,600
Total		172,950

V. Mill Plant

Complete 100 tpd gravity mill, installed	$750,000

IV. Support Facilities

Office in town		$ 35,000
Cookhouse		30,000
Bunkhouse		80,000
Generating plant & ancillary equip.	440 kw	100,000
Fueling system	15,000 gal.	50,000
Port facilities		400,000
Vehicles	(pickup, flatbed, crane)	150,000
D-6 bulldozer		70,000
Lab-assay office		40,000
Boat		100,000
Water supply		70,000
		$1,125,000

VII. Mine Operating Costs

Stope preparation	$ 225,000
Cut & fill stopes	$1,474,000
Haulage	115,000
General operations	59,000
Ventilation	15,000
Compressed air	143,000
Water	1,000
Camp operation	304,000
Administrative costs including salaries, purchases, equipment operation	282,000
	2,618,000
Contingency	393,000
Total	$3,011,000

= $91.24/short ton

Mill Operating Costs

Crushing	$ 108,000
Grinding	343,000
Concentration	138,000
Tailings dewatering	12,000
Transport & place tailings	26,000
	$ 627,000
Contingency	94,000
Total	$ 721,000
	= $21.85/short ton

VIII. Working Capital at approximately 1/3 of Annual Operating Costs: $1,243,900

IX. Refining

Poured into 1 kg bars $5.50/oz

X. Cost Summary

Exploration	$ 230,000
Acquisition	33,000
Development	890,300
Surface plant	429,200
Underground plant	173,200
Mill plant	750,000
Support facilities	1,125,000
	$3,630,700

Operating Costs	
Mill	$21.85/ton
Mine	$91.24/ton
Working Capital @ 1/3 year op. cost	$1,243,900
Recovery	70%

APPENDIX B

Itemized Capital and Operating Costs[1/] for the 100 yd^3/day, 500 yd^3/day, and 1,000/yd^3 day Placer Mining Operations.

	Capital Expenditures	100 yd3/day
I.	Exploration	$ 5,000
II.	Development Costs	
	Timber Removal	$ 2,000
	Plant Setup	Minimal
	Transportation	$ 2,000
		$ 4,000
	Contingency	600
	Total	$ 4,600
III.	Capital Investment - Equipment	
	Trommel 12 yd^3/hr	$ 15,000
	D4-size bulldozer	37,000
	Front-end loader 1yd^3 bucket	30,000
	Pumps	2,500
	Amalgamator	3,000
	Table	1,600
	Misc.	2,000
		$ 91,100
	Contingency	13,700
		$ 104,800
IV.	Operating Costs	
	Labor (2) @ $20/hr	$ 40,000
	Fuel 8.5 gph @ $1.50/gal	12,800
	Maintenance	3,000
	Supplies	5,000
		$ 60,800
	Contingency	9,120
	Total	$ 69,900
		= $6.99/$yd^3$
V.	Working Capital (approximately 50% of operating costs)	$ 34,930

1/ All costs rounded to nearest hundred dollars.

Capital Expenditures 500 yd^3/day

I. Acquisition and/or Exploration

Assume property is a raw prospect
Evaluation required in the form of
trenching.

One month spent in exploration and preproduction work prior to development.

Exploration Costs - by backhoe

2 men	- $3,500/month	$ 7,000
Backhoe	- $2,000/month lease	2,000
Pump	- $1,000	1,000
Sluice Box	- $2,000	2,000
Miscellaneous	- $5,000	5,000
		17,000
Contingency		2,600
Total		$ 19,600

II. Development Costs
Includes setup of plant and other ground prep.

Ground preparation	- Removal of timber	4,000
Plant setup	- Cost minimal	0
Transporation		2,000
		6,000
Contingency		1,000
Development -		$ 7,000

III. Capital Investments - Equipment

Trommel - 50 yd^3/hr	$ 25,000
D6 bulldozer	50,000
Front-end loader - 966C wheel	94,500
Pumps	5,000
Amalgamator	3,000
Table	6,000
Miscellaneous	2,000
	$ 185,500
Contingency	27,800
Total	$ 213,300

APPENDIX B - Continued

500 yd^3/day

IV. Itemized Operating Costs

Labor (3) @ $20/hr -	$ 60,000
Fuel 10gph/machine	30,000
Maintenance	7,500
Supplies	10,000
	$ 107,500
Contingency	16,000
Total operating cost/year	$ 123,500
	=$2.47/$yd^3$
Working Capital	$ 61,750

V. Summary of Capital Investments with Cat and Loader

Exploration	$ 19,600
Development	7,000
Equipment	$ 213,300
Operating Costs	$ 123,500
	($2.47/$yd^3$)
Working Capital	$ 61,800
Recovery	80%
Total Investment	$ 301,700
Depreciation Base	$ 213,300
Life of equipment for depreciation	8 yrs

IV. Summary of Capital Investments with bulldozer only

Exploration	$ 19,600
Development	7,000
Equipment	139,200
Operating Costs	$ 115,000 1/
Working Capital	57,500
Recovery	70%
Total Investment	$ 223,200
Depreciation Base	139,200
Life of equipment for depreciation	8 yrs

1/ same as 1,000 yd^3/day

APPENDIX B - Continued

1,000 yd^3/day

Capital Expenditures:

I.	Exploration (see 500 yd^3/day operation)		$ 19,600
II.	Development		
	Ground prep.		$ 5,000
	Transportation		2,000
	Plant setup		5,000
			$ 12,000
	Contingency		1,800
	Total		$ 13,800
III.	Equipment		
	Trommel	100 yd^3/hr	$ 35,000
	D8-size bulldozer (used)		80,000
	980-size front-end loader		161,000
	Pumps		7,000
	Amalgamator		3,000
	Table		6,000
	Misc.		2,000
			$ 294,000
	Contingency		44,100
			$ 338,100
IV.	Operating Costs		
	Labor	3 @ $20/hr	$ 60,000
	Fuel	20 gph @ 1.50/gal	30,000
	Maintenance		7,500
	Supplies		10,000
			$ 107,500
	Contingency		16,100
	Total		$ 123,600
			=$1.24/$yd^3$
	Working Capital		$ 61,813

APPENDIX C

Itemized costs and data for the 11,000 ton/day open pit mine

3 preproduction years Mine life of 7 years

CAPITAL COSTS

I.	General:	
	Exploration	$ 6,656,300
	Acquisition	5,169,800
	Port facility	1,500,000
II.	Development	5,782,000
III.	Mine:	
	Water, communication, electrical, and fuel system	$ 2,173,628
	Repair shops and warehouses	5,180,035
	Offices and labs	588,507
	Surface buildings	405,694
	Townsite	12,771,729
	Mine equipment	41,866,587
	Restoration	332,597
	Engineering & construction management fees	4,970,199
		$ 68,293,000[1/]
IV.	Mill:	
	Crushing	$ 6,912,108
	Grinding	15,675,222
	Flotation	4,362,799
	Concentrate thickening	939,196
	Concentrate filtration	1,475,458
	Concentrate drying	856,419
	Tailings disposal system	1,147,057
	Water supply system	932,536
	Electrical system	5,205,612
	Buildings	7,605,624
	Offices & Labs	1,166,088
	Vehicles	789,897
	Miscellaneous	438,004
	Townsite	5,321,554
	Site preparation	132,182
	Restoration	332,597
	Engineering & construction management fees	4,788,724
		$ 58,081,100[1/]

1/ Data may not add to total shown because of independent rounding.

V. WORKING CAPITAL

Mine -	$ 10,111,500
Mill -	3,312,000
	$ 13,423,500

OPERATING COSTS

I. Mine ($/ton)

Production development	$ 4.75
Mining of ore	.88
Restoration during production	.13
General operations	1.52
Administrative	1.48
	$8.76/ton

II. Mill ($/ton)

Crushing	.78
Grinding	1.23
Concentrating	1.27
Tailings disposal	.08
Restoration	.08
General operations	1.09
Administrative	.48
	$5.02/ton

Concentrate grades	Smelter charge/ton conc.	Transportation/ton
Cu 26%	$ 77	$113
Zn 60%	$204	$ 91
Ag 99%	0	0
Au 99%	0	0

SUMMARY OF CAPITAL & OPERATING COSTS

Exploration	$ 6,656,300
Acquisition	5,169,800
Port	1,500,000
Development	5,782,000
Mine capital cost	68,293,000
Mill capital cost	58,081,100
Working capital	13,423,500
TOTAL CAPITAL COST	$158,905,700
Mine operating cost/ton	$ 8.76
Mill operating cost/ton	5.02
TOTAL OPERATING COST/TON	$13.78

APPENDIX D

Itemized costs and data for the 1,650 ton/day underground mine.

5 preproduction years Mine life of 11 years

CAPITAL COSTS

I.	General:	
	Acquisition	$ 738,500
	Exploration	1,140,300
	Port facility	1,500,000
II.	Development	3,203,800
III.	Mine:	
	Compressed air	$ 760,239
	Ventilation system	203,303
	Water, drainage, communication, fuel, and electrical systems	787,763
	Repair shops & warehouses	462,224
	Offices and labs	278,233
	Surface buildings	291,752
	Townsite	9,312,719
	Mine equipment	1,967,292
	Engineering & construction management fees	1,493,208
		$ 15,556,700[1/]
IV.	Mill:	
	Crushing	$ 2,084,012
	Grinding	3,785,350
	Flotation	1,781,888
	Concentrate thickening	163,237
	Concentrate filtration	520,177
	Concentrate drying	450,414
	Tailings disposal system	226,795
	Water supply system	228,205
	Electrical system	1,545,860
	Buildings	2,337,854
	Offices & Labs	594,626
	Vehicles	403,559
	Miscellaneous	152,251
	Townsite	1,064,311
	Restoration	1,330,388
	Site preparation	2,000
	Engineering and construction management fees	1,655,462
		$ 18,326,400[1/]

1/ Data may not add to totals shown because of independent rounding.

V. WORKING CAPITAL

Mine -	$ 4,253,400
Mill -	$ 1,320,300
	$ 5,573,700

OPERATING COSTS

I. Mine ($/ton)

Production development	$ 16.05
Mining of ore	17.30
Haulage of ore	3.27
General operations	3.84
Administrative	2.50
	$ 42.96/ton

II. Mill ($/ton)

Crushing	$ 1.64
Grinding	5.71
Concentrating	2.99
Tailings Disposal	.16
General operations	2.08
Administrative	.76
	$13.35/ton

Concentrate Grades		Smelter Charge/ton conc.	Transportation/ton
Cu	26%	$ 77	$113
Zn	60%	$204	$ 91
Ag	99%	0	0
Au	99%	0	0

SUMMARY OF CAPITAL AND OPERATING COSTS

Exploration	$ 6,656,300
Acquisition	5,169,800
Port	1,500,000
Development	3,203,800
Mine capital cost	15,556,700
Mill capital cost	18,326,400
Working capital	5,573,700
TOTAL CAPITAL COST	$ 46,039,400
Mine operating cost/ton	$ 42.96
Mill operating cost/ton	13.35
TOTAL OPERATING COST/TON	$ 56.31