Volume 5-Chapter 17

STATE MINERAL POLICY AND COPPER-NICKEL MINING PROFITABILITY

Minnesota Environmental Quality Board
Regional Copper-Nickel Study

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A NOTE ABOUT UNITS

This report, which in total covers some 36 chapters in 5 volumes, is both international and interdisciplinary in scope. As a result, the problem of an appropriate and consistent choice of units of measure for use throughout the entire report proved insurmountable. Instead, most sections use the system of units judged most common in the science or profession under discussion. However, interdisciplinary tie-ins complicated this simple objective, and resulted in the use of a mix of units in many sections. A few specific comments will hopefully aid the reader in coping with the resulting melange (which is a reflection of the international multiplicity of measurement systems):

1) Where reasonable, an effort has been made to use the metric system (meters, kilograms, kilowatt-hours, etc.) of units which is widely used in the physical and biological sciences, and is slowly becoming accepted in the United States.

2) In several areas, notably engineering discussions, the use of many English units (feet, pounds, BTU's, etc.) is retained in the belief that this will better serve most readers.

3) Notable among the units used to promote the metric system is the metric ton, which consists of 2205 pounds and is abbreviated as mt. The metric ton (1000 kilograms) is roughly 10% larger (10.25%) than the common or short ton (st) of 2000 pounds. The metric ton is quite comparable to the long ton (2240 pounds) commonly used in the iron ore industry. (Strictly speaking, pounds and kilograms are totally different animals, but since this report is not concerned with mining in outer space away from the earth's surface, the distinction is purely academic and of no practical importance here).

4) The hectare is a unit of area in the metric system which will be encountered throughout this report. It represents the area of a square, 100 meters on a side (10000 m^2), and is roughly equivalent to 2½ acres (actually 2.4710 acres). Thus, one square mile, which consists of 640 acres, contains some 259 hectares.

The attached table includes conversion factors for some common units used in this report. Hopefully, with these aids and a bit of patience, the reader will succeed in mastering the transitions between measurement systems that a full reading of this report requires. Be comforted by the fact that measurements of time are the same in all systems, and that all economic units are expressed in terms of United States dollars, eliminating the need to convert from British Pounds, Rands, Yen, Kawachas, Rubles, and so forth!

Conversions for Common Metric Units Used in the Copper-Nickel Reports

1 meter	=	3.28 feet = 1.094 yards
1 centimeter	=	0.3937 inches
1 kilometer	=	0.621 miles
1 hectare	=	10,000 sq. meters = 2.471 acres
1 sq. meter	=	10.764 sq. feet = 1.196 sq. yards
1 sq. kilometer	=	100 hectares = 0.386 sq. miles
1 gram	=	0.037 oz. (avoir.) = 0.0322 Troy oz.
1 kilogram	=	2.205 pounds
1 metric ton	=	1000 kilograms = 0.984 long tons = 1.1025 short tons
1 m^3	=	1.308 yd^3 = 35.315 ft^3
1 liter	=	0.264 U.S. gallons
1 liter/minute	=	0.264 U.S. gallons/minute = 0.00117 acre-feet/day
1 kilometer/hour	=	0.621 miles/hour
degrees Celsius	=	(5/9)(degrees Fahrenheit -32)

Volume 5-Chapter 17 STATE MINERAL POLICY AND COPPER-NICKEL MINING PROFITABILITY

17.1 INTRODUCTION AND SUMMARY OF FINDINGS

The purpose of this chapter is to provide information on what conditions would affect the economic feasibility of potential copper-nickel operations, how these conditions compare to one another and what relative impact state policies might have on future copper nickel developments. Under no condition should this report be construed to be applicable to any site specific proposal. If the variables were defined for a specific proposal the cash flow methodology used herein would be a valid analytical tool. On the aggregate it is expected that the operating and capital costs used in the basic mine models are within 30% of actual costs (1977 dollars) should development occur as described in Volume 2. However, as demonstrated in the text a 30% variance in costs can have a large impact on economic feasibility.

Discounted cash flow rate of return analysis is made on three hypothetical mine models documented in Volume 2, Chapter V: an open pit mine model producing 20 million metric tonnes per year (mtpy) of ore with a processing plant, smelter and refineries (i.e. fully integrated), a combination open pit/underground fully integrated model producing 16.68 million mtpy of ore and an underground fully integrated model producing 12.35 million mty of ore. Major variables affecting the cash flow of each mine model were changed and their impact on dcfror was noted. In addition the price of copper required to reach a target dcfror was calculated for each cash mine model.

The base case open pit model with a copper and nickel price respectively of $.91/lb and $2.10/lb ($1977) provides an 11.93% dcfror and requires a copper price of $1.05/lb and a nickel price of $2.10/lb ($1977) to reach a 15% dcfror, the base case combination model provides a 8.51% dcfror and a copper price of $1.34/lb and a nickel price of $2.10/lb ($1977) the base case underground model results in a 6.90% dcfror and requires $1.54/lb of copper and $2.10/lb nickel ($1977) to reach a 15% dcfror. Recently the price of copper has been running at the $.87 ($1977) level and nickel at the less than $2.00/lb ($1977) level.

The sensitivity of dcfror to the 13 major cashflow variables was analyzed only for the open pit model. Each variable was changed on a percentage basis from the value it held in the base case mine model, the relationship of the dcfror to the variable was plotted, often there was a curvilinear relationship and sometimes a linear. In those instances of curvilinear relationship an approximation to a linear relationship was calculated.

Variations in copper price, copper mill recovery and copper ore grade had the greatest impact on dcfror. For every 10% change in these variables the dcfror changed an average of 1.9 percentage points. The cost of initial capital and operating cost had the next highest sensitivity with an average change of 1.66 dcfror percentage points for every 10 percent change in the variable. Nickel price, nickel mill recovery and nickel ore grade are the third most sensitive group of variables: they averaged a .8 percentage point change in dcfror for each 10% change in the variable. The last group of variables, property tax rates, state income tax rates, the debt/equity ratio, the production tax rate and the occupation tax rate vary significantly from one another but as a group they have considerably less impact on dcfror than the previous variables. On the average, dcfror would change .04 percentage points for every 10% variation in these 5 variables.

The above comparison of the impact of cashflow variables and dcfror is on a percentage basis which depends on whatever value one starts with for each variable. For example a ten percent change in operating cost is equivalent to $12 million annually while a ten percent change in production tax rates is only $91 thousand annually. Thus if one were equate the variables on a dollar for dollar basis a far different comparison would emerge.

The dcfror for the base case open pit model was calculated six times; each time representing the tax rates of six different mineral producing states: Montana, Minnesota, Utah, New Mexico, Arizona and Wisconsin. There respective dcfror's are 12.04%, 11.93%, 11.88%, 11.78%, 11.17% and 9.25%. This indicates that the tax structures of five of the states have a similar impact on dcfror while Wisconsin's is the most severe.

Another tax comparison was made between copper-nickel taxes levied on the fully integrated open pit model and taconite taxes levied on the copper-nickel fully integrated open pit mine model. The dcfror under the copper-nickel taxes was 11.93%, while under the taconite taxes it was 10.10%.

Changes in copper price, copper mill recovery, copper ore grade, initial capital cost, operating cost, nickel price, nickel mill recovery, and nickel ore grade can all make a significant change in dcfror and change an economically unacceptable project in to a "bonanza". Conversely, unfavorable changes on these variables can drastically change the potential profitability of a project.

Changes in property tax, state income tax, debt/equity ratio rating, production and occupation tax are less significant (on a percentage basis) but they could change a marginal operation to economically unacceptable operation or vice-versa.

The time it takes to reach full production is also a significant factor in its impact on dcfror. Lengthly delays could make an economically marginal opertion into an economically unacceptable one.

Forecasts for the price of copper in 1985 range from $.91/lb ($1977) by Commodities Research Unit to $1.36/lb ($1977) by Chase Econometrics. At $.91/lb of copper and $2.10/nickel the open pit mine model will produce an 11.93% dcfror while at $1.36/lb copper and $2.10/lb nickel it will give a dcfror of greater than 20%. CRU forecasts a 1985 nickel price of $2.10/lb ($1977) but the USBM nickel analyst thinks a $3.00/lb ($1977) is more reasonable. At $3.00/lb for nickel the open pit mine model would give approximately a 15.8% dcfror. If both copper and nickel reach the $1.36/lb and $3.00/lb respectively the open pit mine model becomes extremely profitable.

State policies could have a significanct impact on the economic acceptability of already marginal operations. For example, if the open pit base case mine model at 11.93% dcfror is delayed by permit proceedings for one year (assuming 7% inflation) this would decrease the dcfror to 10.73% making it a very marginal if not untenable investment. However if one assumes the nickel price was the equivalent of $3.00/lb ($1977) for the life of the mine the dcfror would be 15.8%, and a 1.2 percentage point decrease would result in a 14.6% dcfror, still within what some would consider an acceptable range. Based on the relative sensitivity of dcfror to changes in the variables influenced by state sections, it is less likely that state policies will significantly affect the investment quality of an already acceptable investment than non-state influenced variables such as price of copper and ore grade.

Introduction

The state has several interests in copper-nickel development: the protection of environmental quality, the generation of revenues from taxes and royalties and economic opportunity and stability for its citizens. How these interests proceed if copper-nickel mining develops will be directly influenced by the economic viability of each mine development.

This chapter will present:

1) The impacts on the profitability of hypothetical copper-nickel mining developments by state influenced elements;

- state tax policy relating to copper-nickel developments
- environmental control capital and operating costs
- time to achieve full production

and the impacts of the following non-state influenced elements;

- the price of copper and nickel metal
- the percent recovery of copper and nickel from the ore in the processing mill
- the amount of copper and nickel contained in the ore
- the debt/equity ratio
- the amount of initial capital required to begin operations
- the operating cost

2) The effect on the profitability of the operation and generated tax revenues by the tax laws of Arizona, Montana, New Mexico, Utah, and Wisconsin on a Minnesota operation as if these tax laws were in effect in Minnesota.

3) The relative likelihood and timing of the development of different sections of the Duluth Gabbro based on ore grades and forecasts of copper and nickel prices.

17.1.1 dcfror Summary

Economic viability and state policy influences are analyzed using a cash flow model developed by Harold Bennett and Joe Toland of the U.S. Bureau of Mines, Minerals Availability System, in Denver, Colorado, and adapted to use for the Regional Copper-Nickel Study. The model calculates the discounted cash flow rate of return (dcfror) for a particular mine development specified by the user. dcfror is one measurement of the financial feasibility of a project and is especially useful for aiding investment decisions between competing projects. It is widely used in private business and is a major tool for investment decision making.

The dcfror method is a simple concept. The model adds all the expenses for any given year and subtracts them from the annual income and then discounts the remainder back to the initial time of investment at a discount rate necessary to make all of the future cash flows equal to the total investment. It then adds the dcfror from each year so that the result at the end of the mine life is a cumulative dcfror from each year. In actual practice, it is relatively more complex since there are carry forwards and lags in taxes, depreciation and other non-obvious expenses and revenues. The discounting process is perhaps the most difficult concept for the layman. In its simplest terms, discounting compares the value of money invested today against the present value of the future returns of that investment, understanding that there are alternative investments to make which could provide a minimum rate of return, such as 8% on municipal bonds. There is no magic minimum dcfror for a go/no go decision on any particular project. An industry rule of thumb is 15%, but actual values may range from 9% to over 20% depending on any particular corporation's circumstances, such as risk, available capital, and long-range corporate goals.

The cash flow model provided by the Bureau of Mines, called Minesim-4, has two alternative analytical capabilities. The FINANCIAL EVALUATION capability calculates the dcfror given other variables including the prices of copper and nickel. The PRICE DETERMINATION capability calculates the price of copper necessary to produce a required dcfror given all other variables. These two capabilities provide a tool with which to analyze policy questions. For example, use of the model answers "what price would copper have to be to warrant investment in a project, given an investment return requirement of a 15% dcfror (an industry rule of thumb); and "what would be the dcfror if a given copper price was projected into the future?" The model is also used to examine how much the dcfror (profitability) will vary if the characteristics of a mine model are changed. For example, one may ask "how sensitive is profitability to changes in tax rates, ore grade, and recovery rates?"

Profitability and dcfror are used interchangeably in this section. In fact, they are not exactly the same since profits or profitability is a loose term denoting gain on an investment which could come about in a variety of ways and dcfror is a result of an exact calculation. It is intended here that profitability be a comparative term which relates the different alternatives to one another.

17.1.2 Mine Model Summary

The technology assessment report (Volume 2) presents three different hypothetical mine development models:

1) a 20 million metric ton per year (20 X 10^6 mtpy crude ore) open pit operation vertically integrated with a processing mill, smelter, copper refinery, and nickel refinery;

2) a 16.68 X 10^6 mtpy combination open pit (11.33 X 10^6 mtpy crude ore) and underground (5.35 X 10^6 mtpy crude ore) mine fully integrated; and

3) a 12.35 X 10^6 mtpy crude ore underground mine fully integrated.

Each hypothetical operation is constructed to produce 100,000 mtpy of refined metal (approximately 85,000 mtpy copper and 15,000 mtpy nickel). Contained in Table 1 are the vital statistics of each operation which has been designed to reflect known Minnesota circumstances. See Volume 2-Chapter 5 for more information on these models.

Table 1

Table 1. Summary of model variables for fully integrated mine, mill, smelter and refineries.

	RATED ANNUAL CAPACITY, 10^6 mtpy ORE		
	underground 12.35	combination 16.68	open pit 20.00
Total Life of Operation	30	30	30
Actual Production Life, yr	26	27	27
Average Ore Grade			
% Cu	.80	.587	.494
% Ni	.17	.125	.114
Tons of Cu/Ni Metal Produced	100,000	100,000	100,000
Cu metal	84,500	84,500	84,500
Ni metal	15,500	15,500	15,500
Capital Cost[a]			
Initial capital X 10^6	579.47	625.80	618.06
Total X 10^6	665.73	764.78	761.03
$/annual mt ore	53.91	45.85	38.05
Average Operating Cost			
$$10^6$/yr	137.05	126.41	119.47
$/mt metal produced	1,370.50	1,264.10	1,194.70
Construction Manpower, peak	2,520	2,760	2,818
Operating Manpower, full production	2,478	2,220	1,999
Energy Requirement, 10^{12} BTU/yr	14.25	15.27	16.21
Area requirement, acres[b]	5,026	8,246	10,241

SOURCE: Volume 2-Chapter 5, Table 11, 1979.

[a]All cost estimates are in 1977 dollars.
[b]Actual area plus undisturbed area.

As can be seen, many elements of each operation are different, although each model produces identical amounts of metal. Each mine complex will earn identical gross revenue since it is directly dependent on the amount of metal times the price. In practice, rounding errors cause gross revenues to differ by an insignificant amount. Different dcfror among the models is caused by different costs and timing of income. Capital and operating costs are in line with existing literature and are reasonable estimates for Minnesota operations as defined by the Study (see Volume 2, Technology Assessment).

17.1.3 Summary of Variables Affecting dcfror

In the following discussion, allthree mine models are analyzed and compared to one another, moreover the 20 million mtpy open pit mine model is used to analyze the sensitivity of dcfror to changes in thirteen mine model variables. The thirteen variables, listed in descending order of their influence on dcfror, are: the price of copper, the recovery rate of copper in the processing mill, the copper content of the ore, the amount of initial capital investment, the annual operating costs, the price of nickel, the recovery of nickel in the processing mill, the nickel content of the ore, the property tax, the state income tax, the debt to equity ratio, the production tax, and the occupation tax (Table 2). Each of these variables are examined in detail in this chapter. All three models react similarly to sensitivity analysis albeit at different but not widely divergent rates.

Table 2

Table 2. The susceptibility of some mining variables affecting profitability to events which may or may not be influenced by the state.

	STATE INFLUENCED	NON-STATE INFLUENCED
Cu price		X
Cu mill recovery	X	X
Cu ore grade		X
Initial capital	X	X
Operating costs	X	X
Ni price		X
Ni mill recovery	X	X
Ni ore grade		X
Property tax	X	
State income tax	X	
Debt/equity		X
Production tax	X	
Occupation tax	X	
Timing of production	X	X

In addition to the above mentioned variables, the amount of time it takes a mine to reach full production is also a crutial factor in determining profitability. This timing may be affected by delays, such as strikes, supply shortages, and permit applications.

The fourteen variables will themselves be influenced by events; some are altered by state policies, some are not.

The price of copper has been characteristically volatile, but over the long term has remained about the same in real terms. It is set in the international market through an interplay of supply, demand, and politics. The recovery of copper and nickel in the mill is accomplished through technology and management efficiency. The copper and nickel ore grades are preset by geological conditions, but knowing where and how much is controlled by exploration techniques. The amount of capital needed to start production depends on many factors. The state's policy influence may be felt through required pollution control equipment, safety equipment, delays, or incentives to hasten time to full production and incentives or disincentives for capital acquisition. Non-state influenced changes in initial capital cost could come through: delays caused by supply delivery, labor strikes, bad weather, inflation, and price increases. Operating costs are influenced by state policies through: pollution control and safety regulations; state control of infrastructure; and tax rates. Non-state influenced events are; labor, supply, energy, and maintenance costs. The price of nickel, like copper, is set in the international market place. Characteristically, the price of nickel has risen steadily over the years due to the control of the market by the International Nickel Company, Ltd. In recent years, it has lost a large share of its market dominance. At present (early

1979) there are depressed nickel prices because of an oversupply. The property tax rate is locally controlled, under the present Minnesota laws its only significant impact would be on a smelter/refinery operation, since mining and milling operations are exempted from property tax except for land not being used in the mining or milling process. The state income, production, and occupation taxes are controlled by the state. Their influence on profitability is minimal under present tax laws. The debt/equity ratio is the amount of money borrowed for initial capital investment divided by the amount invested from the coffers of the mining company. Present wisdom has it that the greater the amount borrowed under reasonable conditions, the higher the profitability since the risk is being taken with someone else's money. The influence of the debt/equity ratio on dcfror is controlled by the amount borrowed, the interest rates, and the payback period.

17.1.4 MINESIM-4 Summary

Financial Evaluation--The U.S. Bureau of Mines' Minesim-4 cash flow model is a computer-interactive program which calculates the discounted cash flow rate of return of a mining venture based on the input values specified by the user (Bennett, 1976).

The user specifies values for each variable listed in Table 3 for each year the project is in operation, preproduction as well as production years. (See Appendix A for actual input values.)

Table 3

Table 3. Input variables for the Cash Flow Model Minesim-4.

1. Exploration costs
2. Land acquisition costs
3. Mining preparation (predevelopment costs)
4. Mine plant investment
5. Mine equipment investment
6. Mill plant & equipment investment
7. Smelter plant & equipment investment
8. Copper refinery plant & equipment investment
9. Nickel refinery plant & equipment investment
10. Loan required
11. Working capital
12. Mine operating costs
13. Mill operating costs
14. Units of ore treated
15. Copper ore grade
16. Copper mill recovery
17. Copper mill concentrate grade
18. Copper refinery recovery
19. Copper smelter operating cost
20. Copper refinery operating cost
21. Copper transportation costs mill to smelter
22. Copper transportation costs smelter to refinery
23. Copper price
24. Royalty rate
25. Nickel ore grade
26. Nickel mill recovery
27. Nickel mill concentrate grade
28. Nickel smelter recovery rate
29. Nickel smelter concentrate grade
30. Nickel refinery recovery
31. Nickel smelter operating cost
32. Nickel refinery operating costs
33. Transportation costs mill to smelter
34. Transportation costs smelter to refinery
35. Nickel price
36. Precious metal ore grade
37. Precious metal mill recovery
38. Precious metal mill concentrate grade
39. Precious metal smelter recovery rate
40. Precious metal smelter concentrate grade
41. Precious metal refinery recovery
42. Precious metal price
43. Tax rates

The computer uses the above inputs plus internal formulas for depreciation, tax rates, etc. to calculate total revenues, subtracts from that the cost of producing the metals and then discounts each year's cash flow back to the present value where it is summed providing the dcfror. Table 4 is a brief explanation of how the annual cash flow is calculated. If the reader is interested in more detailed explanation, he is referred to the relevant works listed in the bibliography.

Table 4

The following subheadings denoted by numbers refers to the numbers of the subdivisions indicated in Table 4.

1. Total Revenue

Total revenue from metal sales is calculated by multiplying the amount of ore mined (units treated) by recovery rates for each process for each metal by the price of each metal.

To illustrate, assume there is 1 million short tons (2,000#/ton) of ore containing 1% copper. Thus, the contained copper in the ore is 1 pound of copper for every 100 pounds of ore, or 20 pounds/ton X 1 million tons = 20 million pounds of contained copper. Assume that: the concentrating (milling) process loses 25% or 5 million pounds, so there are 15 million pounds left in the concentrate, the smelting process loses 10% or 1,500,000 pounds so there are 13,500,000 pounds left in the anodes, the refining process loses an additional 1% or 135,000 pounds leaving 13,365,000 pounds (67% of total) of copper

Table 4. The derivation of the annual cash flow.

1	TOTAL REVENUE FROM METAL SALES
1a	minus operating costs
1b	minus loan interest payments
1c	minus depreciation
1d	minus royalty payments
1e	minus property taxes
2	EQUALS INCOME BEFORE TAXES
2a	minus total depletion allowance
2b	minus production taxes
2c	minus occupation taxes
3	EQUALS TAXABLE INCOME
3a	minus state income tax
3b	minus federal income tax
4	EQUALS NET INCOME
4a	plus depreciation
4b	plus depletion allowance
4c	minus equity investment
5	EQUALS CASH FLOW

available to sell. For Minnesota's ore, the same process is applicable to nickel and precious metals including cobalt. The program figures the amount of metal available from the various process recovery rates, multiplies that times the estimated price for each metal, and produces total gross revenues from metal sales.

Total annual full production revenues from each operation is about $260 million. Approximately 65.4% ($170 million) comes from the sale of copper metal, 27.5% ($71.5 million) derives from the sale of nickel metal and approximately 7.1% ($18.5 million) is from the sale of precious metals. Each operation has different start-up schedules leading to full production, thus each produces different total revenues over the life of the operation.

1a) Operating costs are the day-by-day expenditures required to produce the metal. In this model, the operating costs are entered as dollars per unit treated by operation. For example, the operating cost for the base case 20 million mtpy open pit mine is $2.27 per ton of ore removed, for the smelter, the operating cost is $78 per ton of concentrate processed. Operating costs are divided by major categories into supplies, labor, energy, and equipment. For the open pit mine model, operating costs for all integrated operations are approximately $120 million per year at peak production.

1b) Loan interest payments are subtracted from revenue, they have recently become a significant contribution to operating cost for the mining industry, especially at the prevailing interest rates. In the past when fortune smiled more warmly on mining activities, new mining ventures were primarily financed by the internal funds of mining companies. Recently, almost all new ventures are financed in part by outside money. Many new operations are requiring $500 million to $1 billion to develop and 50% financing is not uncommon. Annual payments on a loan ranging from $250 million to $500 million are quite substantial.

1c) Depreciation is an accounting procedure which reflects the annual loss in value due to deterioration of capital (machinery, equipment, and buildings). It is a deduction against taxes to allow the operator to invest the tax savings in new capital.

1d) Royalties are a payment to the owner of the mineral rights for the privilege of extracting the minerals.

1e) Property taxes are levied against the value of property (land, buildings) owned by the operation. In Minnesota, taconite and copper-nickel mining and milling operations are exempt from property taxes except for the land owned but not directly used in the operation. A smelter and refinery are assumed to be manufacturing operations and are liable for a property tax on the buildings and land, machinery is exempt.

2. The annual depletion allowance, production, and occupation taxes are subtracted from income before taxes.

2a) The depletion allowance is like depreciation in that it is an income tax deduction based on the use of the ore body. Theoretically, the money saved from the depletion allowance would be used for the exploration and development of new ore bodies.

2b) The production tax, a severence tax, is a deduction against income tax.

2c) The occupation tax is esssentially a net proceeds tax and acts as a credit against state income tax.

3. Taxable income provides the base from which to calculate the state corporate income tax and the federal corporate income tax. These taxes are then subtracted from taxable income in the cash flow determination.

3a) All states examined levy a state corporate income tax, but the rate varies considerably in this analysis from 5% to 12%.

3b) The subtraction of the federal corporate income tax from revenues left after the state corporate income tax produces Net Income.

4. Net Income

4a and 4b) At this point, the amount saved by using depreciation and depletion as income tax deductions is added back in to the calculation because the amount saved represents an addition to annual cash flow.

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4c) From the above net income is subtracted equity investment which is the expenditures to payments of principle on loans and capital replacement necessary to maintain operations.

5. The result of these calculations is the annual cash flow which is discounted to the present value.

Table 5. The present value of $1 for 24 years in the future, using a discount rate of 12%.

YEAR	DISCOUNT VALUE	YEAR	DISCOUNT VALUE
1	$1.00	13	$ .22
2	.88	14	.19
3	.77	15	.17
4	.68	16	.15
5	.60	17	.13
6	.53	18	.11
7	.46	19	.10
8	.41	20	.09
9	.36	21	.08
10	.32	22	.07
11	.28	23	.068
12	.24	24	.060

The impact of a 12% discount rate on the present value of future earnings is presented in Table 5. It indicates the value of a dollar at X years in the future discounted at 12%. From this, one can see that a dollar's income in year 15 is equivalent to $.17 of a dollar's income today. Many of the conclusions in this section are based on the effect of discounting on future cash flows as illustrated in Table 5.

Table 5

Metal Price Determination Capability

The cash flow model determines the metal price necessary to achieve a desired dcfror. For this analysis, a target dcfror of 15% has been set. Several key variables have been changed to ascertain their impact on the copper price required to reach the target dcfror. In addition, the forecast of copper and nickel prices is used to predict the financial viability of each mine model based on a desired 15% dcfror. A comparison is made of the estimated different ore grade distributed along the Duluth Gabbro and when they might be able to achieve a 15% dcfror based on forecast metal prices.

17.2 PROFITABILITY CHANGES RESULTING FROM CHANGES IN CASH FLOW VARIABLES

The hypothetical copper-nickel development models presented in the Technical Assessment volume (Volume 2) of this report are generic representations of realistic copper-nickel development complexes located in northeastern Minnesota and are based on available information having widely varying degrees of detail and application to the Minnesota situation.

The dcfror is 11.93% for the 20 million mtpy open pit, 8.51% for the 16.68 million mtpy combination open pit and underground, and 6.90% for the 12.35 million mtpy underground mine based on the assumptions presented in Table 1, present Minnesota tax laws, and a forecast price of $.91/pound for copper and $2.10/pound for nickel ($ 1977). These forecasts form a base against which the affects of changes in the above assumptions are compared. If all of the assumptions made for each model hold true, then in fact each mine produces the above results. However, one does not expect that each assumption will turn out as it has been estimated. Therefore, the forecasts should be seen as relative, not absolute, comparisons of different types of copper-nickel operations. That is, the open pit mine model which comes to full production in its first year of operation and whose operating costs are generally lower per pound of metal produced can be expected to produce a higher rate of return than the other two models which arrive at full production slower and have higher operating costs per pound of metal produced.

Direct comparison of the results previously presented to similar information on site specific proposals, such as the Amax and INCO proposal, should be done with extreme caution. Many of the assumption and design criteria used by the Regional Copper-Nickel Study and used by the companies active in the region will differ and these differences can significantly change the economic feasibility of the model in question. To increase the usefulness of the information presented in this chapter and to better understand the significance of various economic variables studied, a series of sensitivity analyses where conducted.

This section examines the impacts on profitability of: timing to full production, changes in gross revenue and changes in initial capital costs, operating costs, and taxes. Each variable which affects cash flow and thereby dcfror is varied in 10% increments. These variations are plotted against the resulting changes in dcfror to produce sensitivity curves. The more nearly vertical the sensitivity curve, the more sensitive the dcfror is to changes in that variable. All curves have been approximated by a linear regression fit so they may be more easily compared. The slope of linear regressions fit gives a good approximation of the relative sensitivity of the dcfror to the variable. The steeper the slope the more sensitive the dcfror's to the variable. For example, the price of copper has a slope of approximately 2, meaning that for every 10% change in the price of copper there is a 2 percentage point change in the dcfror. The variations are plus or minus 50% of the value specified by the base case mine model. It is expected that a range of this magnitude will cover most contingencies and provide a useful comparison of the sensitivity of the different variables.

17.2.1 Timing: Time to Full Production and Life of Mine

The faster an operation comes to full production, the greater the chances for increased profitability. The reverse is equally true. The copper-nickel mine models each produce about $260 million annually in gross revenues at full production. However, the open pit mine comes to full production during its first year of operation, the underground and combination take five and six years, respectively, to come to full production. By the tenth year of development life, including construction, the open pit has produced approximately $1.3

billion in gross revenues, the underground $790 million, and the combination $1.13 billion. By year 17, each operation is providing a cash flow sufficient to produce a positive dcfror: 7.98% for the open pit, 3.5% for the combination, and .40% for the underground. This implies that early full production is a major factor in these disparities. In fact, if one assumes that the underground model comes to full production in its first year of production (technically not possible), then by the seventeenth year its dcfror is close to 7.0%. Concurrently, if one delayed full production on the open pit, its gross revenues and dcfror would drop precipitously.

The economic implications are clear: delays once significant investment have been made are highly detrimental, rapidly achieving full production is highly advantageous to relative profitability.

More is at stake than a simple determination of profitability. All things considered, the open pit model is an acceptable investment, the combination is marginal, and the underground is clearly unacceptable. All that it takes to turn the acceptable open pit investment to the unacceptable underground investment is the spector of delays. Or all that is required to turn the borderline combination into an acceptable investment is the potential for more rapid full production. The state has obvious influence on timing through its permitting system, and its ability to support infrastructure and provide incentives.

The life of the operation has little effect on the profitability after a certain point. The industry rarely considers dcfror analysis for more than twenty years because forecasts that far in the future are almost certain to be wrong and the discounting process places very little value on net income as demonstrated by

Table 5. The open pit model is the first model to show a positive dcfror, 2.97% in the fourteenth year of its operation, five years later it shows a 8.9% dcfror, an increase of 5.93 percentage points. In the last five years of operation, the open pit shows an increase of only .45 percentage points, because the positive cash flows from that far in the future are discounted so heavily.

The dcfror is an investment decision-making tool that emphasizes the early years of a project in its analysis of cash flows. Consequently, the financial success or expenditures of the later years are of less importance in the investment decision-making process.

17.2.2 Revenue: Income From the Sale of Metals and By-products

Income after expenses and the amount of time it takes to reach full-scale production determine profitability. Gross income for copper-nickel companies would result from the sale of metals: copper, nickel, cobalt, silver, gold, and other precious metals, plus potential byproducts such as sulfuric acid. Each of these products has its own market and each market responds to a combination of supply, demand, and politics; therefore, its relative contribution to gross revenues will vary over time.

Annual gross revenues from each mine model are approximately $260 million. Copper revenue is $170 million (65% of total), nickel revenue is $71.5 million (27.5% of total), and precious metals revenue is $18.5 million (7.5% of total) (Figure 1). The contribution from each revenue source is based on a set of assumptions involving price, ore grade, and recovery. Each revenue source is subject to considerable variation as a result of changes in the assumptions. However, it is expected that the percent contribution of revenue from each source will remain relatively constant over time.

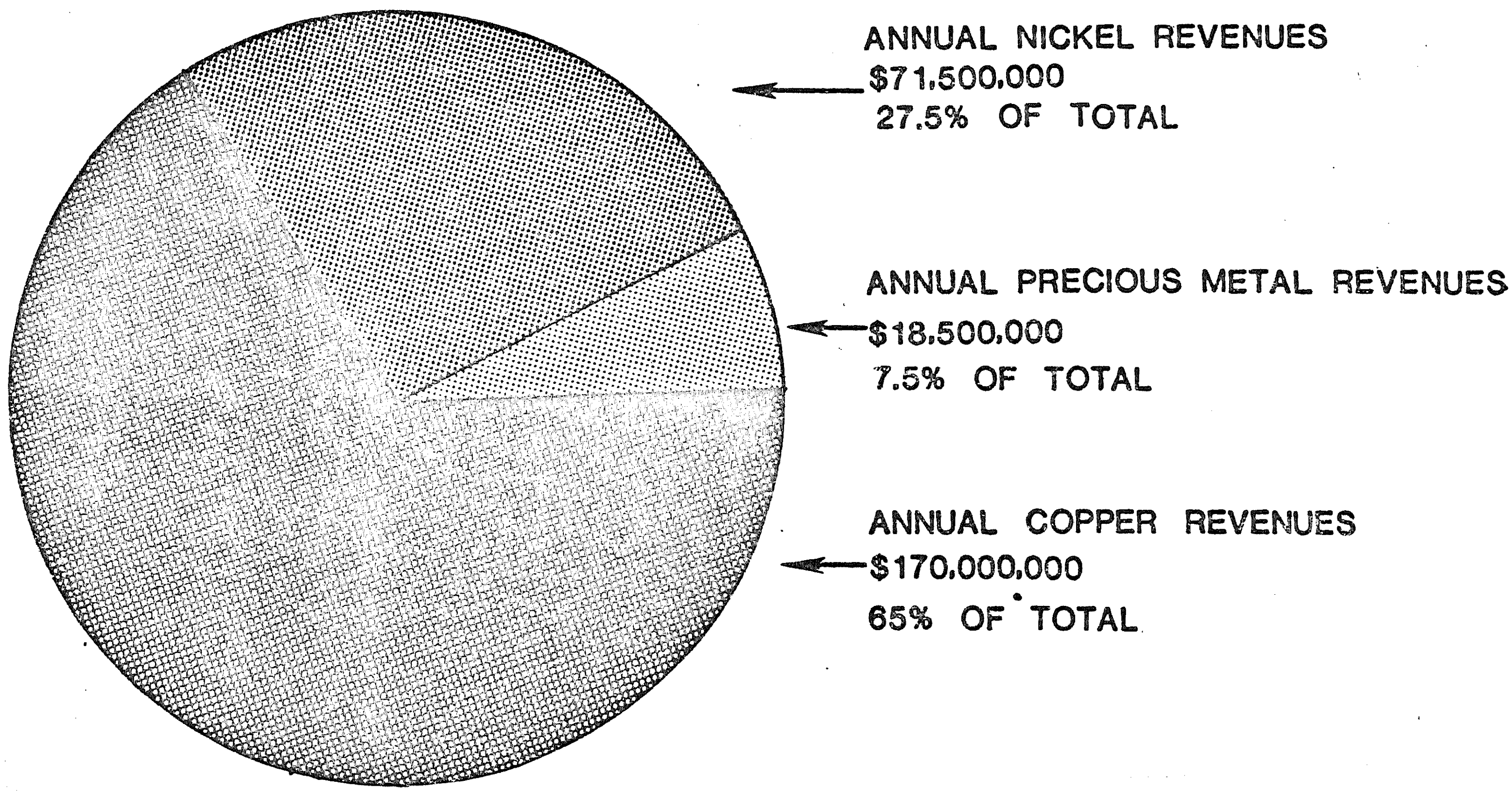
Figure 1

17.2.2.1 Copper Market--Copper has had a traditionally volatile market with wide ranging prices over a short period of time. During the last twenty years the price of copper has remained steady in real terms, while it has actually declined over the last 200 years. In 1974 the copper prices were very high, but they declined drastically by 1976 and 1977 when a severe oversupply existed. At present, an excess of supply continues to exist, but low prices have forced production cutbacks and delayed new and expanded production capacity. However, over recent months prices are slowly beginning to rise. Meanwhile, demand continues to grow and some analysts forecast a copper shortage in the mid to late 1980s. The rate of growth of demand will be a crucial factor in the width of the gap between supply and demand. The world experienced a recession following the oil price rise of 1974. Since then growth has been relatively slow and many western nations have not yet fully recovered. The price and supply of energy may be the controlling factor in worldwide growth and therefore demand for copper. Professor Malenbaum of the University of Pennsylvania has predicted a very low rate of just under 2% growth in the demand for copper (Malenbaum, W., 1977). On the other hand, other forecasters are expecting a recovery from the present world recession and a more rapid rate of growth.

Copper revenues are approximately $170 million or 65% of the total full production income of $260 million for each model. They are a product of the amount of

FIGURE 1

CONTRIBUTIONS TO ANNUAL GROSS REVENUE



copper (84,500 metric tonnes in these models) and the price of copper ($.91/pound for the base case).

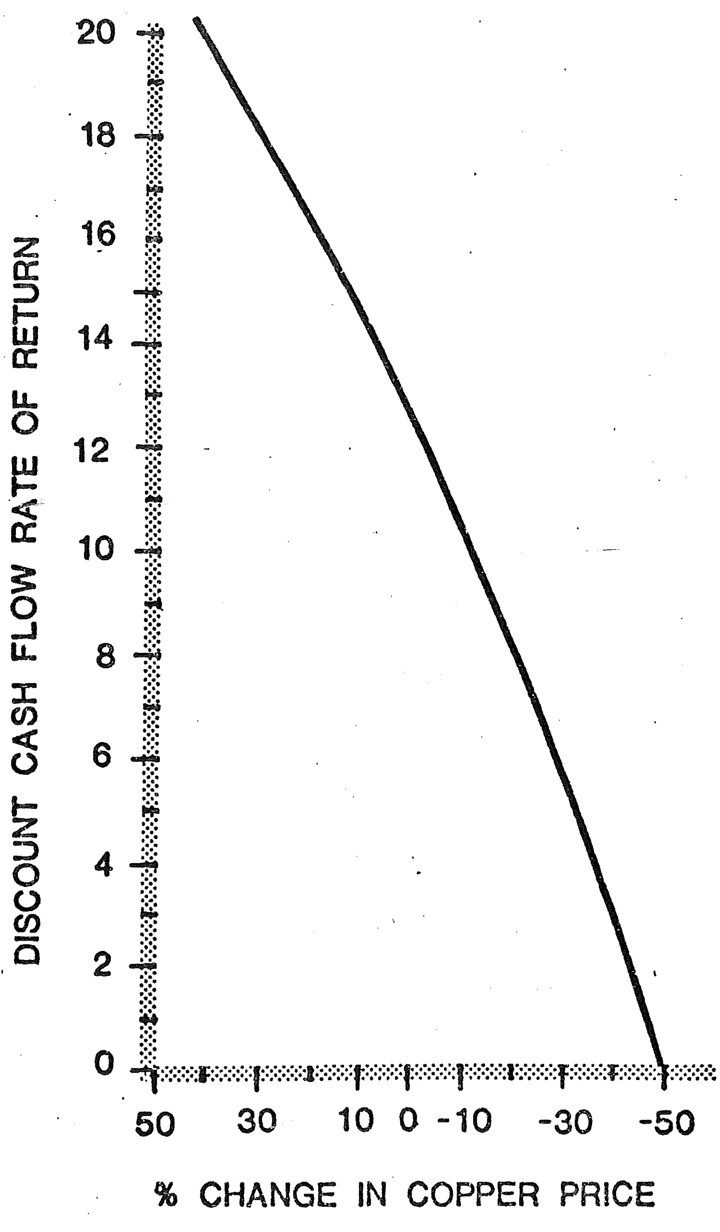
17.2.2.2 Copper Price Sensitivity--The open pit model was used to determine how changes in assumptions (sensitivity analysis) affect the dcfror. The price of copper is assumed to be $.91/lb (1977 dollars) based on a forecast for 1985 by Commodities Research Unit (CRU 1977). This is varied in 10% increments to plus and minus 50% of the base case ($.91/lb) and the change in dcfror was calculated. Analysis demonstrates that for every 10% change in the price of copper, there is a concommitant change in the dcfror of two percentage points. Therefore, when the price of copper moves from $.91/pound to $1.00/pound, the dcfror would increase from 11.93% in the base case to 13.93%. Copper price is the most sensitive variable effecting profitability. A 50% increase in copper price to $1.36/pound would mean a very profitable operation providing a 21% dcfror while a 50% decrease in price would result in insufficient income to provide a positive rate of return. Figure 2 is a graph for the open pit model of the sensitivity of the dcfror resulting from changes in the price of copper.

Figure 2

This demonstrates why knowledge of the market and price forecasts are so strenuously pursued by the mining industry. Referring back to the section on development timing, one can see that if a high price cycle occurred during the early production stages it would be most helpful, while the reverse would be true if the operation began under low prices (see Volume 5-Chapter 14, Mineral Economics, for more information on supply, demand, and price).

FIGURE 2

SENSITIVITY OF D.C.F.R.O.R. TO CHANGES IN THE PRICE OF COPPER



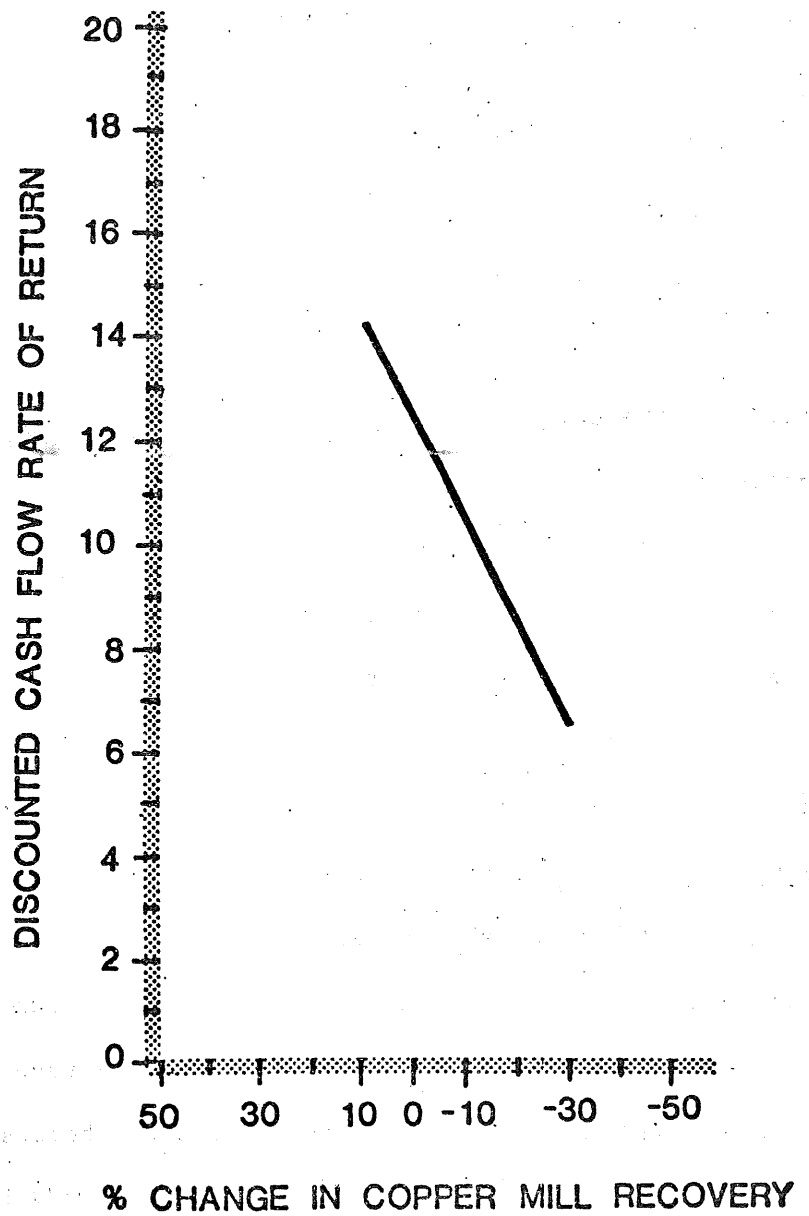
17.2.2.3 Copper Recovery in the Mill--The amount of copper produced is a product of the ore grade and the percent recovery of copper in the mill, smelter, and refinery. The mill is the most important link of the three processing units and the one subject to the greatest variations. Next to the price of copper, the recovery of copper in the mill is the most important variable affecting profitability. For every 10% change in recovery rate, the dcfror varies by 1.92 percentage points. Operating efficiency and technological improvements are of utmost importance in this phase of the operation. Realistically, variations of more than 10% from the base case are unlikely because of technological limitations, but a 20% variation from the base case could make a tremendous difference in overall profitability.

Figure 3

17.2.2.4 Copper Ore Grade--Copper ore grade closely follows mill recovery in its impact on profitability. If the ore grade changes by 10%, there is a resultant change in the profitability of 1.79 percentage points. Since the ore grade in the open pit model is only .494% copper, a 10% change is .05% copper. A +30% increase to about .65% copper would cause an increase in the dcfror from 11.93% to 17.30%. The average estimated copper content of ore in the Duluth Gabbro is .66% (Volume 3-Chapter 2). Since the average ore grade is .66%, there are higher and lower ore grades contributing to this average. Except for the AMAX and INCO sites, the specifics of distribution and volume of different ore grades is unknown. However, the probability exists that there is sufficient higher grade ore at a specific location to significantly affect the economics on a site specific level. The reverse is also true that there exists much larger amounts of lower grade ore. Considering the importance of early revenues, one

FIGURE 3

SENSITIVITY OF D.C.F.R.O.R. TO CHANGE IN THE RATE OF COPPER RECOVERY IN THE MILL



can appreciate that if it is possible to mine higher grade ore in the early part of the operation this could significantly add to the overall economic feasibility of the project.

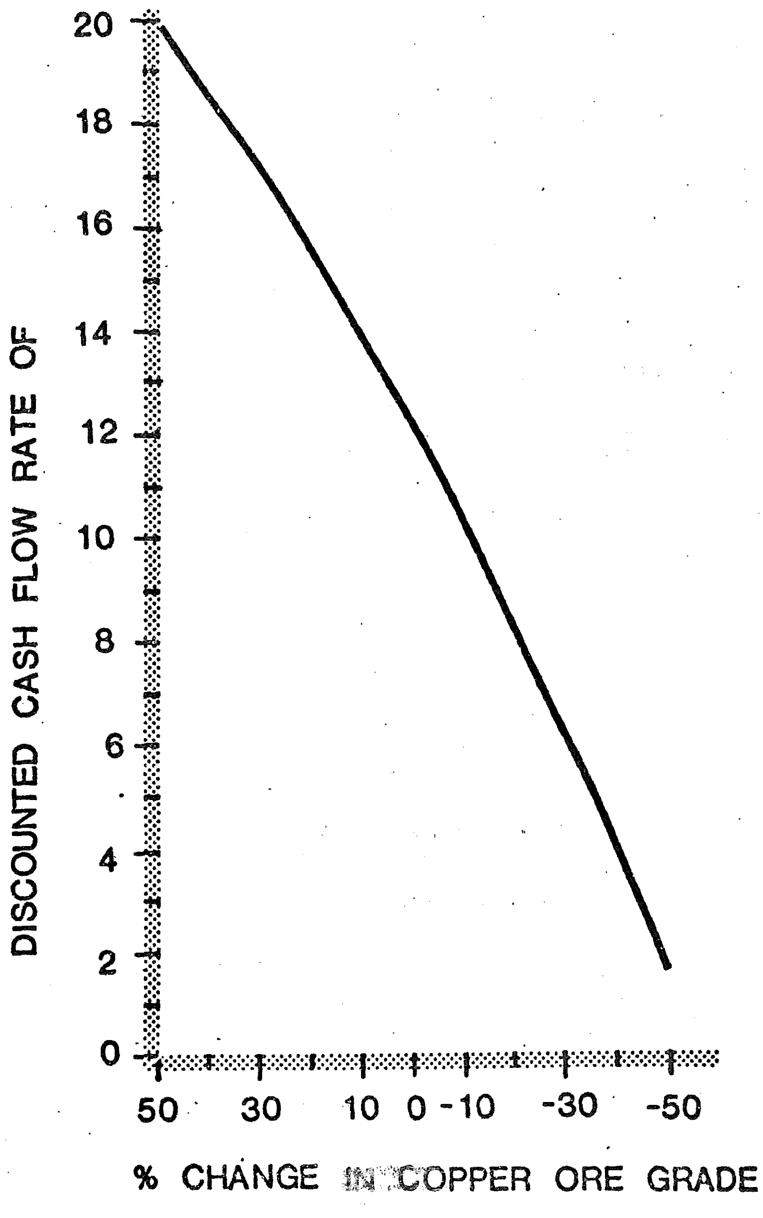
Figure 4

17.2.2.5 Nickel Market--Nickel sales from the model open-pit operation produce \$71.5 million in gross revenue annually during full production. This assumes a nickel price of \$2.10/lb (1977 dollars), an open pit model ore grade of .114%, and mill and smelter/refinery recovery of 74% and 92%, respectively. This \$71.5 million constitutes 27.5% of total annual revenues arising out of the production of 15,500 metric tons of nickel.

Historically, the price of nickel has been controlled by one company, International Nickel, Ltd. Presently it holds only about 30% of the world market, but it still exercises a large influence. Under INCO's control, the price of nickel rose steadily through the years. However in the recent past there has been a large oversupply which has held prices steady. The nickel price situation is similar to copper's in that there is currently an oversupply with a cutback in production and a diminished ability to expand to meet future demand growth. Nickel forecasts are less believable and not as abundant as copper forecasts because the market is not as well understood. Commodities Research Unit has forecast a nickel price of \$2.10/pound in 1977 dollars for 1985 based on an assumption of continued nickel oversupply. The U.S. Bureau of Mines nickel analyst believes this is pessimistic because of the laterite mines in operation will require close to a \$3.00/lbs ($1977) price (Corrick, 1978) to meet production costs. Nevertheless being the only one available, it is used here as the base case assumption.

FIGURE 4

SENSITIVITY OF D.C.F.R.O.R. TO CHANGES IN THE COPPER ORE GRADE



17.2.2.6 Nickel·Price Sensitivity--The price of nickel is only about half as important as the price of copper to dcfror for these mine models. The profitability changes by only .9 percentage points for every 10% change in the nickel price, compared to a 2% increase for a similar copper price change. When the price of nickel is increased by 10% to $2.31/lb, the dcfror increases to 12.83% from 11.93%. Even though the price of nickel is only half as influential on profitability as is the price of copper, it is still extremely crucial understanding that the line between economically acceptable and unacceptable can be very small. AMAX has indicated that it would need the price of nickel to be about $3.00/lb (1977 dollars) to make its proposed operation financially feasible (Arend, Jr. 1977). If the nickel price for this mine model were $3.00/lb, the dcfror would increase to about 15.7%. It is fairly certain that the minimum price expected for nickel in 1985 will be $2.10/lb (1977 dollars), because the production cost will be near or above that level in the near future (USBM Nickel Commodity Analyst, J.D. Corrick, personal communication, 1978).

Figure 5

17.2.2.7 Nickel Recovery in the Mill--The recovery of nickel in the processing mill and the concentration of nickel in the ore are variables which contribute to revenues in the same manner as copper recovery and concentration. The profitability changes .77 percentage points for a 10% change in the recovery of nickel in the mill. Figure 6 presents the sensitivity curve for the nickel recovery rate in the processing mill.

Figure 6

FIGURE 5

SENSITIVITY OF D.C.F.R.O.R. TO CHANGES IN THE PRICE OF NICKEL

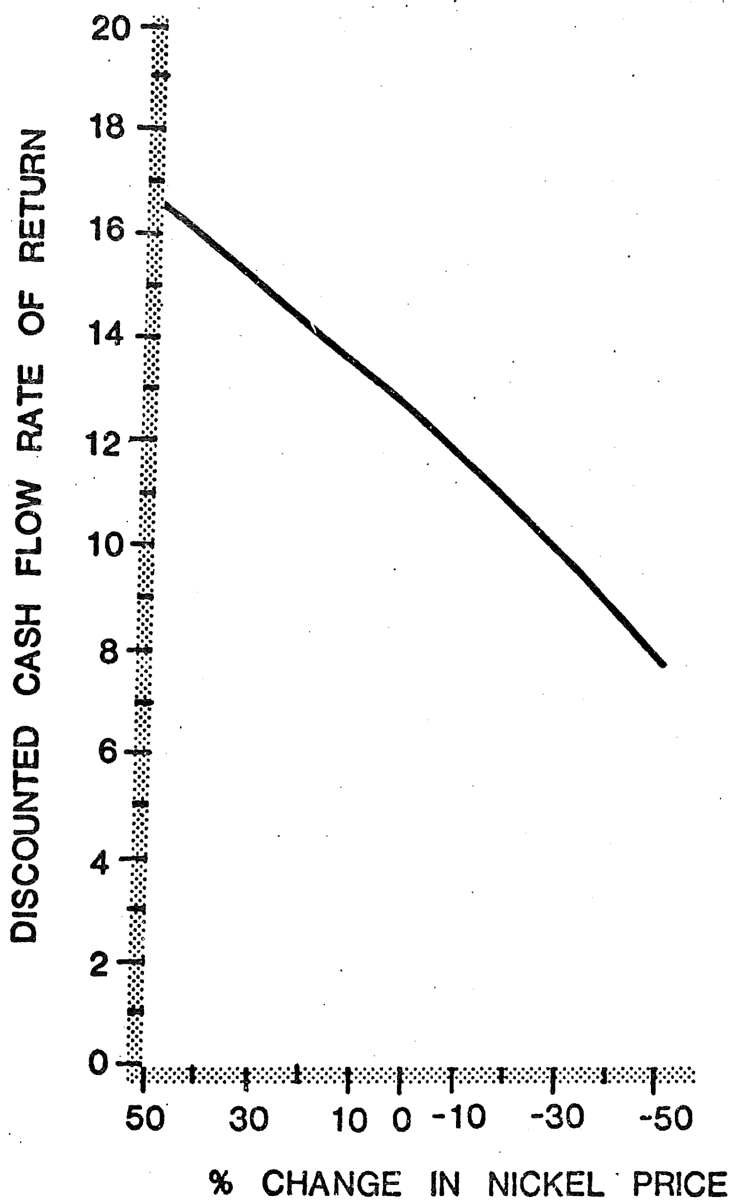
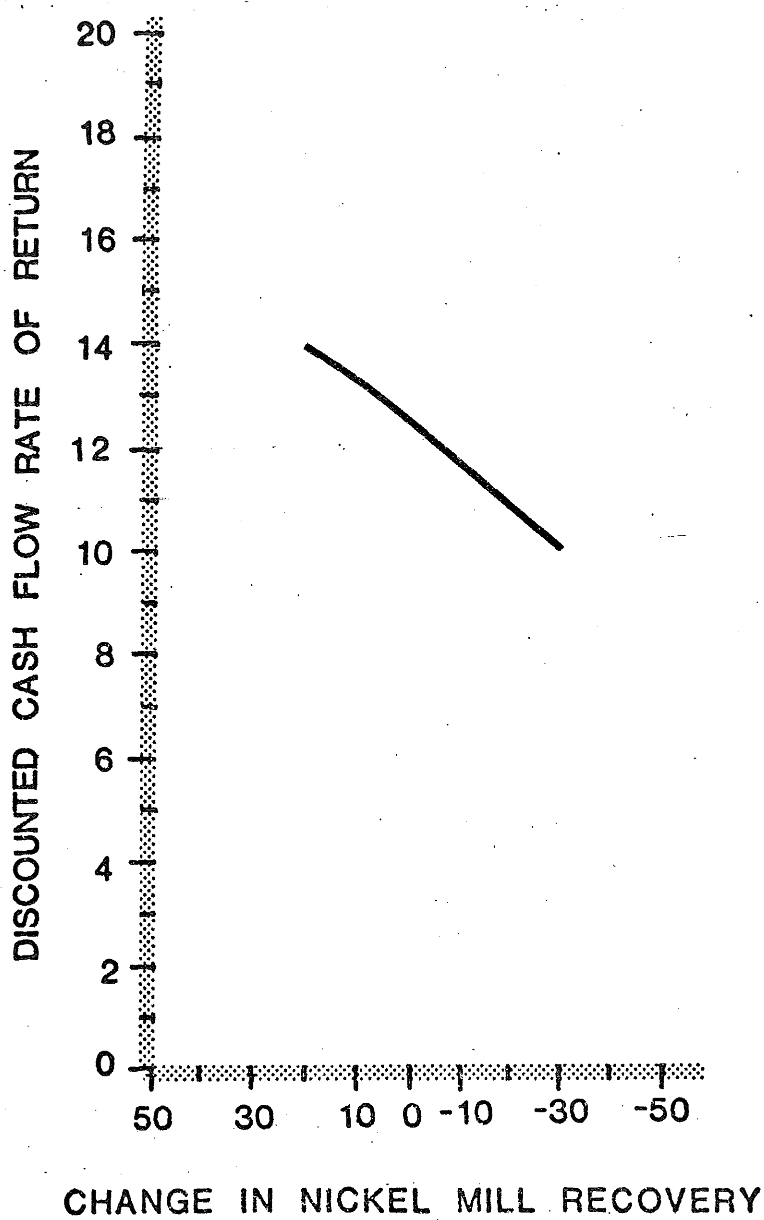


FIGURE 6

SENSITIVITY OF D.C.F.R.O.R. TO CHANGES IN THE MILL RECOVERY RATE OF NICKEL



The rate of recovery of nickel in the mill is, like copper, a matter of operating efficiency and technical innovation. The base case assumption for the bulk flotation process is 74% recovery. A 10% improvement in this estimate would be a reasonable expectation, while a 20% increase would not be achievable given existing technology (Volume 2-Chapter 3). A 10% increase in nickel mill recovery results in a 12.7% dcfror.

17.2.2.8 Nickel Ore Grade--The dcfror changes .75 percentage points for every 10% change in nickel ore grade. Moreover, the nickel ore grade is so low (.114%) that a 10% change (.0114%) is very small. Hence, a change of +50% would be equal to a nickel concentration of .171%; this ore grade would not be unexpected. This nickel ore grade would raise the profitability from 11.93% to 15.68%, a very acceptable rate by today's standards.

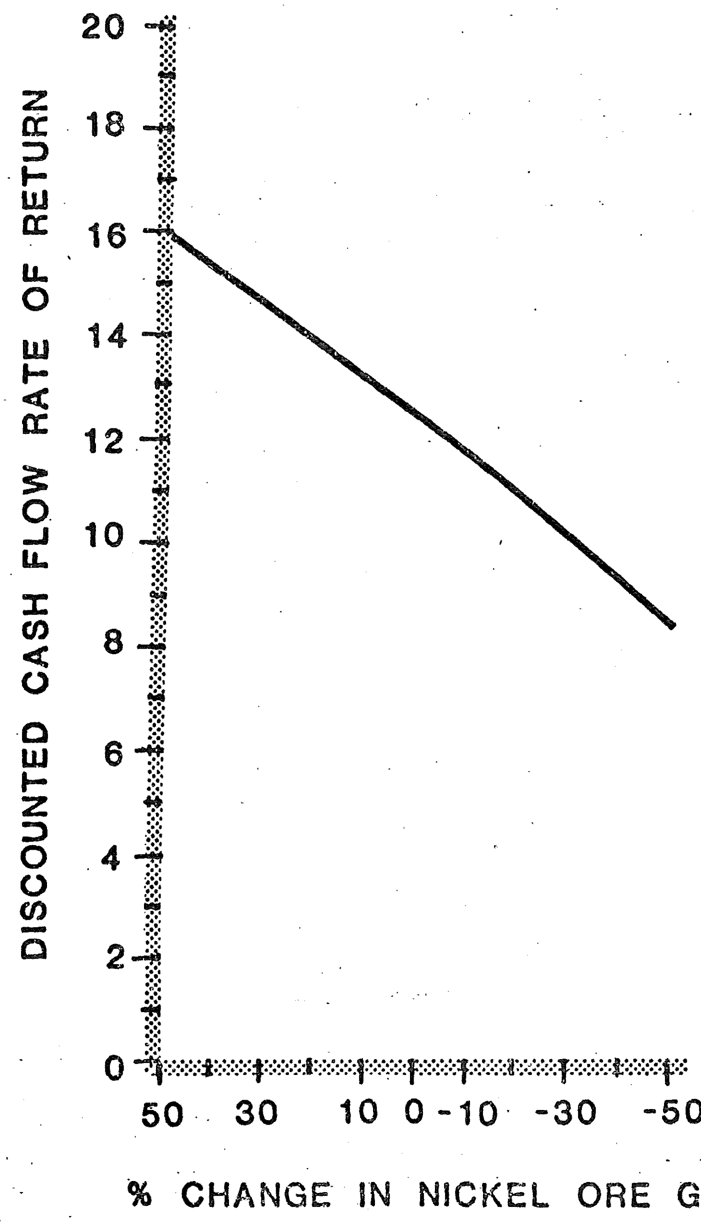
Figure 7

The sensitivity curve for the nickel ore grade helps to demonstrate again the attractiveness of selectively mining higher ore grades first. In the Duluth Gabbro, the nickel tends to increase with increases in copper so that higher ore grades in one usually means higher concentrations in the other. However, they do not necessarily increase at the same rate. The implication is that a higher copper concentration is generally more financially attractive than just the copper ore grade alone would indicate.

17.2.2.9 Precious Metals and Byproducts--Sale of precious metals and other byproducts, such as sulfuric acid, from the smelter would also add to total revenues. An operation in Minnesota would have to be economically feasible

FIGURE 7

SENSITIVITY OF D.C.F.R.O.R. TO CHANGES IN THE NICKEL ORE GRADE



based on the estimates of revenue from the sale of copper and nickel. If it were so marginal that byproducts made a significant difference, the operation probably would not be developed. However, if an operation were economically feasible without byproducts, their recovery and sale could be financially very rewarding. In the three mine models, it is assumed that recovery of precious metals contributes about $18.5 million a year to total revenue of $260 million, or about 7.5%. This figure was based on lab work done and prices prevalent in the early 1970s (Iwasaki et al. 1978). The latest lab work completed in 1978 (Iwasaki et al. 1978) and calculated with present prices shows a potential contribution of about $27 million from the recovery of precious metals plus cobalt. Approximately 450,000 tons of sulfuric acid would be produced as a smelter byproduct (Volume 2-Chapter 4). It is impossible to forecast with any degree of certainty what contribution sulfuric acid would make to total revenues. If a market were available which justified shipping costs, it could have a significant impact. For example, a 1978 price of sulfuric acid of about $60/ton delivered would provide an additional $27 million of revenues (less transportation costs) exclusive of additional costs. However, if no market is available, the acid may have to be neutralized and disposed which would incur an additional operating expense. Since the question of acid use or disposal is so nebulous, it is considered an economically neutral element. Sensitivity analysis on changes in precious metals and byproducts revenues was not done because of the above stated difficulties, however, a doubling of income from precious metals and byproducts is roughly equivalent to a 10% increase in the price of copper.

17.2.3 Costs: Operating, Capital, Taxes

Costs are divided into two categories, capital and operating. Capital expenditures go to building the physical plant, and equipment: they are considered to be expenditures made for long-term generation of income. Capital expenditures are depreciable expenses for income tax purposes. A useful distinction is between initial capital and replacement capital. Initial capital expenditures are made to bring an operation into full production. Capital replacement expenditures are made to replace only worn out mine machinery. The repair of equipment in the mill, smelter, and refinery is considered to be an operating costs. This distinction is significant because the size of the initial loan is based on initial (not total) capital expenditures. The dcfror is much less severely affected by changes in replacement capital than initial capital because of timing. The following discussion on capital expenditures is limited to changes in initial capital.

Operating expenditures are made to produce a marketable product and are deducted from total annual revenue in the calculation of federal and state corporate income taxes. They include the cost for labor, supplies, maintenance, energy, debt repayment, and pollution control equipment operation.

17.2.3.1 Initial Capital Variations--Change in initial capital costs ranks fourth (behind copper price, recovery rate, and ore grade) in its influence on the operation's dcfror. For every 10% change in initial capital cost of a project (a relatively significant occurrence), the dcfror is estimated to change by about 1.68 percentage points. The influence on dcfror of change in operating cost ranks closely behind that of initial capital cost.

Differences between estimates and actual capital expenditures may occur in a myriad of ways. Engineering efficiency, new technology, and increased worker productivity could all decrease initial capital expenditures while delays from strikes, permit proceedings, supply deliveries, and engineering changes could all add to initial capital cost. A 10% change in initial capital in the open pit model is equivalent to $62 million dollars and as mentioned above produces a 1.68 percentage point change in profitability.

Table 6

Capital cost estimations by both mining industry and governmental sources can show large deviations. Experience indicates that the degree of reliability for initial cost estimates is directly related to the cost of engineering studies undertaken: the larger the planning expenditure, the smaller the difference between estimated and actual cost of a project. Barring large-scale economic changes, it is felt that the above estimates are within 30% (1977 dollars) of the actual expenditures for similar operations in northeastern Minnesota. Using the open pit model as an example (1.68 percentage points for 10% change in initial capital), a 30% increase in initial capital would decrease the dcfror to 6.89% while a 30% decrease in initial capital would increase the profitability to 16.97%. It should be noted that the 1.68% change in dcfror per 10% change in initial capital is a straight line approximation to the curve in Figure 8 which describes the actual relationship between initial capital and dcfror.

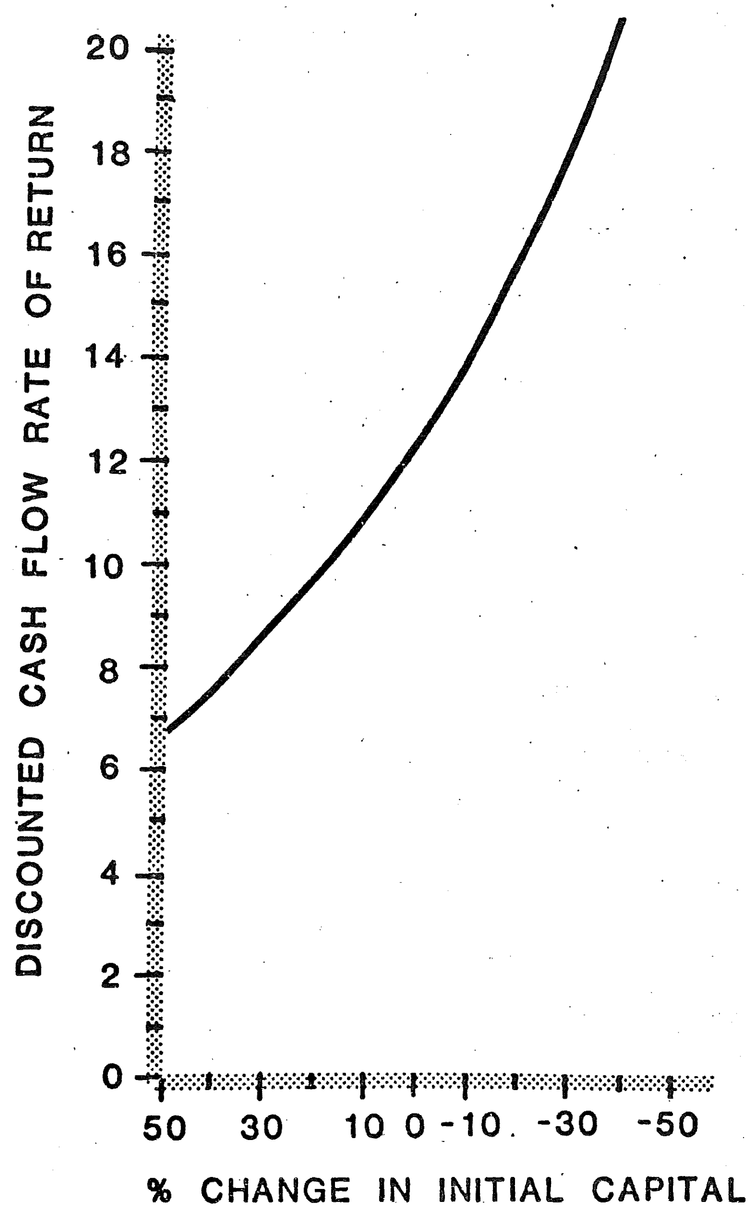
Figure 8

Table 6. Initial capital expenditures (1977 dollars).

	OPEN PIT	COMBINATION	UNDERGROUND
Mine	$69.2 million	$98.4 million	$94.8 million
Mill	231	203	154
Smelter/refinery	324	324	324
TOTAL	$624.2	$625.4	$572.8

FIGURE 8

SENSITIVITY OF D.C.F.R.O.R. TO CHANGES IN THE AMOUNT OF INITIAL CAPITAL



Impact of Delay--If one assumes that inflation is increasing 7% annually and that the capital is committed at the start of construction, then simplifying matters greatly, a one year's delay would increase initial capital expenditures \$43 million and cause a decrease in profitability of 1.2 percentage points. The same logic implies that a month's delay adds \$3.6 million and causes a decrease of .1 percentage point in the dcfror.

Pollution Control Capital Costs--Examples of pollution control capital and operating costs estimates are presented in Table 7 for air and water control methods. The acid plant and scrubber which are part of a smelting operation represent some potential for air pollution control costs. The water pollution control costs examples are for the tailing basin. They include a cut-off trench, polyvinyl chloride (pvc) dam liner, pvc basin liner, and a drain field.

Table 7

An acid plant treats strong SO_2 streams (see Volume 2-Chapter 4) from the smelter operation and converts the gas into sulfuric acid. Since all alternative smelter models studied included an acid plant as part of the smelter operation, its construction and operating costs are included in the base case presented in this chapter. A scrubber cleans the weak SO_2 gas stream and incidentally traps some particulates by passing it through a liquid. The scrubber does not usually produce a potentially economical by-product such as sulfuric acid in the case of the acid plant.

Air pollution control capital costs for the acid plant are already included in the estimates of initial capital expenditures for the smelter so that a change

Table 7. Capital and operating costs for selected pollution control costs for the open pit model (1977 dollars).

	CAPITAL	OPERATING/YR
Air Pollution Control		
Acid plant	$28 million	$ 4 million
Scrubber	6 million	2.6 million
Water Pollution Control		
Cut off trench	7.1 million	N.A.
PVC dam liner	1.4 million	N.A.
PVC basin liner	44.6 million	N.A.
Drain field	3.6 million	N.A.

SOURCE: Volume 2-Chapter 3.

would entail reducing overall capital costs by $28 million or 4.5% of total initial capital if it is removed from the operation. If this cost were removed and the total operating cost remained the same, the dcfror would increase .76 percentage points to 12.69%. The scrubber capital cost is $6 million or 1% of total capital costs. Its inclusion without considering the additional operating expense would result in a decrease of profitability of .17 percentage points to 11.76%.

Water pollution control costs in the tailing basin are exemplified by the four methods mentioned above, the cut-off-trench would be constructed under the tailings dam, dug to bedrock and filled with a material impervious to water. It costs $.8 million per mile to construct. The open pit tailing dam circumference is about 8.8 miles, so the total cost is $7.1 million. The PVC dam liner is a plastic sheet laid on the inside of the tailing dam to retard seepage. Its cost is $160,000 per mile of dam, totaling $1.4 million for the open pit model tailing basin. The PVC basin liner is laid on the floor of the tailing basin to prevent downward seepage. It costs $11,000/acre for a total of $44 million. The drain field is constructed of a gravel bed laid in the floor of the basin and extending under the retaining dam to direct seepage to the collection facilities. It costs $.4 million per mile of basin circumference for a total of $3.6 million. None of these costs have been included in the initial capital costs. Table 8 demonstrates the effect that additions to initial capital costs by these water pollution control measures have on the profitability of the open pit model.

Table 8

Table 8. Open pit mine model selected water pollution control capital costs and their impact on profitability.

	ADDITIONS TO[a] TOTAL CAPITAL	CHANGE IN DCFROR
Cut off trench	$7.1 million	11.93-.19 = 11.74
PVC dam liner	1.4	11.93-.04 = 11.89
PVC basin liner	44.6	11.93-1.2 = 10.73
Drain field	3.6	11.93-0.1 = 11.83

[a]Source: Volume 2-Chapter 3.

Reclamation Costs--Reclamation is another activity which may fairly be called pollution control. In most instances reclamation would occur over the life of the operation with a large effort at the end to complete reclamation activity. Details on possible reclamation measures may be found in Volume 2. There are 13 separate waste rock piles 61 meters high covering a total surface area of 843 hectares associated with the open pit model. Covering each pile with four inches of soil plus hydroseeding to introduce vegetative cover would cost between $988 and $3,000 per hectare. Total cost would range from $833,000 to $2.5 million. A 12-inch soil cover plus hydroseeding would range between $2 million and $5.5 million (Volume 2-Chapter 2). The following table indicates the expected change in dcfror for different capital expenditures made in year 28, 2 years before shut down.

Table 9. Impacts on profitability from waste rock pile reclamation capital expenditure in year 28.

AMOUNT (million)	dcfror (%)
$0	11.93
$5	11.752
$10	11.746
$20	11.733
$40	11.708
$100	11.631

This table demonstrates quite conclusively that reclamation costs contemplated in the distant future should not have an effect on investment decision making now because the change in dcfror is small compared to the future capital expenditures.

Impacts of Different Borrowing Strategies--The mining industry traditionally did not borrow money to finance new ventures, but instead used its own capital. This has been changing since the early 1970s due to a variety of factors:

1) The mining industry has fallen on hard times and is no longer as rich as it once was.

2) Has ore grades have dropped, new operations have become larger and more expensive requiring outside money to aid development.

3) The understanding of the advantages of the use of borrowed money has increased.

Many new operations have initial capital costs between $500 million and $1 billion, some more than $1 billion:borrowing 50% of initial capital is not uncommon for those projects which can find lenders.

All three mine models contain an assumption that the developer borrows 50% of its initial capital costs (referred to as debt/equity ratio of 50%). The open pit model debt/equity ratio is varied from 25% to 75% and the effect on dcfror is noted. A loan of about $300 million was made in $150 million increments over two years, each increment payable in 7 years at 10% interest rate. A loan of 75% debt/equity or $470 million increases the dcfror from 11.93% to 12.03% and a loan of 25% debt/equity or $155 million decreases the profitability to 11.83%. Lower interest rates and longer payback periods would have the expected salutary effect on the dcfror.

The interest rates and payback period for 50% debt/equity ratio were varied to determine their influence on profitability. Table 10 indicates the degree of change in dcfror resulting in changes in the terms of the loan.

Table 10. Change in dcfror resulting from different loan terms on the open pit mine model with 50% debt/equity.

INTEREST	PAYBACK PERIOD	dcfror (%)
10% base case	7 years	11.93
9%	7 years	12.09
8%	7 years	12.43
10%	10 years	12.17
10%	15 years	12.87

It is evident that the size of the loan has less impact on profitability than the terms of the loan. The terms can have a hefty impact on the investment decision because of the influence of the discounting method: the larger and the earlier the payback the more negative the impact on dcfror.

The terms of the loan can be affected by the financial condition of the company, the quality of the ore body, political atmosphere, and the nature of the lender among other factors. The state may influence the terms of the loan through reducing the risk to the lender by guaranteeing low tax rates and time tables for granting permits.

17.2.3.2 Operating Costs--Annual operating costs for each mine model are large comprising 46% of total revenues at full production for the open pit, 48% for the combination, and 52% for the underground.

Operating costs are made up of payments to labor, energy, supplies, and debt. Total annual full production operating costs, excluding debt repayment, are $120 million for the open pit, $125 million for the combination, and $134.0 million for the underground. As indicated in Table 7, the operating costs for pollution control in the acid plant are included, cost for the scrubber is not.

Operating Cost Sensitivity--Operating costs is the fifth most important variable in its impact on profitability after initial capital costs. There is a 1.63 percentage point change in dcfror for every 10% change in operating costs. The factors affecting operating costs are complex and volatile and probably not completely defineable. Needless to say, forecasts for operating costs are correspondingly chancy, but nonetheless necessary. Those factors (such as energy and labor) which are common to all operating units of an integrated operation would have the largest impact.

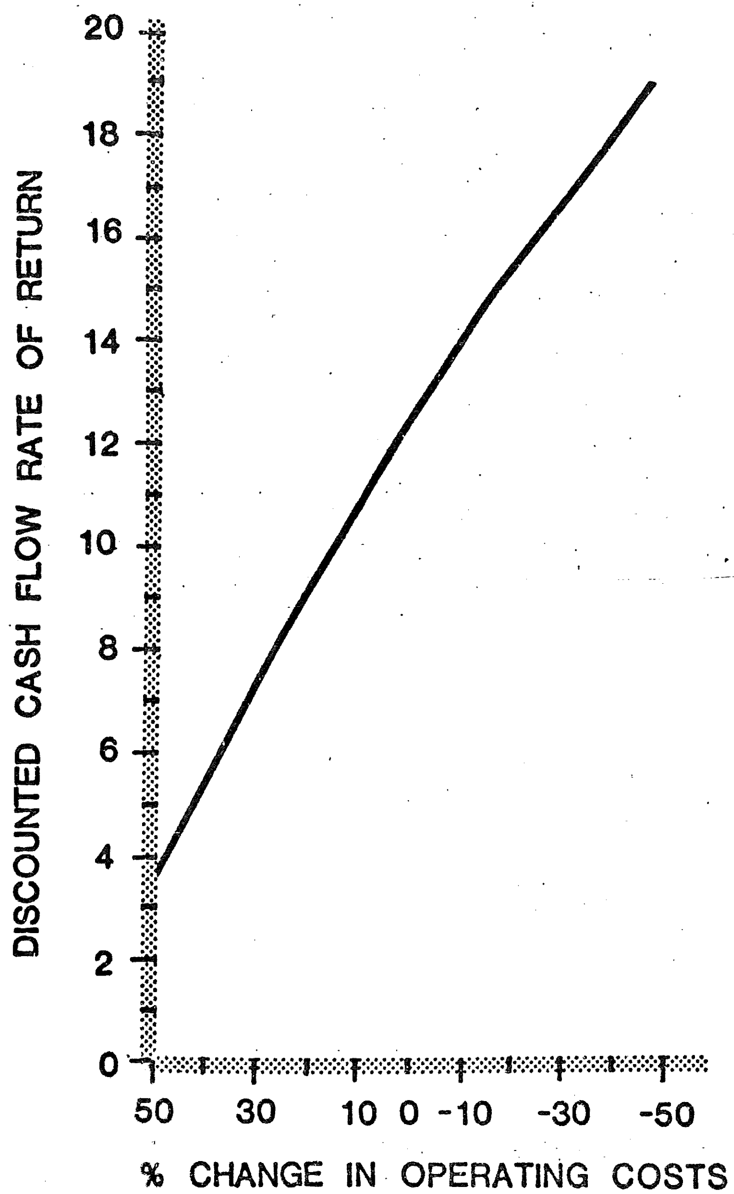
The relationship between changes in operating cost and profitability is portrayed in Figure 9.

Figure 9

Since the mine models each produce 100,000 mtpy of Cu and Ni, the cost per ton of metal is $1,200, $1,250, and $1,340, respectively, for the open pit, combination, and underground models. This is equivalent to $.54, $.57, and $.61, respectively, per pound of Cu and Ni metal (Volume 2-Chapter 5).

FIGURE 9

SENSITIVITY OF D.C.F.R.O.R. TO CHANGES IN OPERATING COSTS



Percent Distribution--The percent distribution of the total operating costs to the different phases of the mining process is demonstrated in Table 11.

Table 11. Percent distribution of operating costs.

	OPEN PIT	COMBINATION	UNDERGROUND
Mine	34.0	43.0	54.0
Mill	38.0	31.0	22.0
Mine & mill	62.0	74.0	76.0
Smelter	16.0	15.0	14.0
Copper and nickel refinery	12.0	11.0	10.0
TOTAL	100.00	100.00	100.00

The mine and mill are the most costly units to operate. In the underground model, the mine itself requires the largest percent of total operating costs while the open pit mine is the least expensive of the three types of mining. The smelter operating cost is about 15% of the total for all three operations. The smelter has the greatest potential for air pollution and air pollution control cost will probably be concentrated in this unit. If one assumes a 50% increase in the operating cost of the smelter from about $18 million to $27 million, this would result in a 7.5% increase in operating cost for the entire integrated operation. Since all units contribute to the overall profitability of the operation, a drastic change in one unit may result in only a minor change to the whole operation.

Pollution Control Operating Costs--Pollution control operating cost for a scrubber has been estimated at $2.6 million per year (1977 dollars) or about a

2% addition to total operating costs equivalent to a .33 percentage point change in dcfror. This would change the open pit base case of 11.93% dcfror to 11.60% dcfror.

Operating Cost Estimates and Variability--On the aggregate, the operating cost per metric ton of metal agrees closely with estimates in the literature and with industry projections for Minnesota operations. When estimates for capital and operating costs are made, one has three options:

1) to design a facility, produce blue prints and flow charts, cost out the individual items and aggregate estimates;

2) to develop a compatible system based on large units such as mine, mill, smelter, and refinery, and to question experts in the field, forming a reasonable composite from these sources;

3) to develop a compatible system of large units and rely on published costs for such units.

The first option is usually carried out by private consulting firms and billed at 1% of total estimated initial capital costs. In this case, an engineering estimate would cost about $6 million. Barring uncontrollable events, this type of estimate is expected to be within 10% of actual costs. The second option is far less costly and its accuracy may vary widely depending on the care taken in getting estimates. This method is expected to be within 30% of actual costs. The third option is quick and dirty and may or may not produce reliable results. Government rarely has the luxury of the first option due to cost, uncertainty on the specifics of a project or lack of access to privileged information.

The estimates developed here are actually a combination of all three methods with the most reliable costs attached to the mine, mill, and smelter and the least reliable accorded to the refineries. Since there is no comparable smelter-refinery complex in the United States, costs were developed based on information from consultants, industry, and with reference to the literature. These estimates were developed on a total cost per unit of metal produced with little verification of the component costs such as labor and supplies. Later as more information was unearthed on these types of operations, operating costs for components were developed. When summed, these added to more than original estimates for the nickel refinery, less than original estimates for the copper refinery and less than original estimates for the smelter. The combined total is very nearly the same for both smelter/refinery complexes.

The point is clear, most estimates by both industry and government may be regarded as subject to large variations. It is for this reason that the cash flow analysis is presented for variations of 50% of the base case for most variables.

In addition, these estimates were made in 1977 for an operation forecast to begin in 1985. Operating cost for copper mining and milling components of energy, labor, and supplies changed drastically from 1972 to 1976 and it is not certain how they will change in the future. Costs in the copper industry increased an average of 13% per year for the 5 years from 1972 thru 1976 (Lewis, Chase, Bhappu 1977). However, the relative cost contribution of labor declined from 19% of the total in 1972 to 15% of the total in 1976 and total energy increased from 9% of the total in 1972 to 13.5% of the total in 1976. The percent contribution of all other components remained essentially constant. In

1976 total operating costs increased an average of 9%, and they are expected to maintain that rate if current economic conditions continue (Lewis, Chase, Bhappu 1977).

17.2.3.3 Minnesota Taxes and Royalties and Their Impact on Profitability--In Volume 5-Chapters 12 and 13 the impact of taxes and royalties on government revenues was analyzed and this analysis indicated that significant revenue shortfalls compared to government service costs could occur. This condition will likely precipitate the re-examination of present tax rates and taxing approaches, which if changed could have significant economic impacts on the mining industry. This section examines the impact on dcfror of changes in the production, occupation, property, sales, state corporate income tax, and royalties. The profitability of an operation is not particularly sensitive to changes in tax rates relative to the other elements discussed here. For example, the dcfror is most sensitive to changes in the property tax rate which is 23 times less influential than changes in the price of copper.

Minnesota has three types of taxes levied against the open pit mine model; a tax on investment (property tax, sales tax), a severance tax (the production tax) and two taxes on income, the occupation tax, (a tax on the occupation of mining actually a net proceeds tax), and the corporate income tax. The reader is referred to Volume 5-Chapter 12 for further explanation.

It should be noted that the occupation tax is a credit against the state corporate income tax. Therefore, for every dollar increase in the occupation tax there is a corresponding dollar decrease in the state corporate income tax. Thus, the total tax burden of an operation will increase only if its occupation tax liability is more than its income tax liability for any year. Further, the occupation tax law provides a three-year carry-forward of the income tax credit. This allows the operation to spread over three years any unused tax credit resulting from an occupation tax liability greater than its calculated income tax liability in that particular year.

Volume 5-Chapter 13 (Community Services, Costs, and Revenue Sources) states that significant population growth at the local level will create a need for additional services requiring physical plant additions. If local government makes such capital improvements, they would likely be funded with municipal bonds. Unfortunately, sufficient revenues at present tax rates would not be available to cover the debt service. There are several different solutions to this problem. Tax rates could be increased, but this would increase the taxes of the existing population in addition to the new population associated with copper-nickel development. Production and/or occupation taxes on the mining industry could be increased, but there would be a lag as long as six years between the start of increased community debt service payments and the start of increased local revenue generated by the tax increases on the industry. A local sales or investment tax would make more revenue available during the early development stages, but government costs would still precede revenues and the profitability of the mining venture would decrease because of the impact of high front end costs, as previously discussed. The responsibility for providing necessary infrastructure could be shifted from government to industry to eliminate the need for increasing tax rates, and the financial impact of the high front end costs on industry can be reduced through the use of loans. Use of tax exempt municipal bonds with their lower interest rates, combined with the mining company having the responsibility for paying the debt service, such as is done with pollution control revenue bonds, would have the least impact on industry and government and still provide the necessary revenue for government service needs.

Taxes Compared to Gross Revenues--There are about $6.5 billion in revenues generated by the open pit model over the 30 year life of the mine. Total state and federal taxes comprise approximately 12.7% of total revenue state taxes constitute $346 million or 5.3% of total revenues. State tax revenues in turn are made up of $149 million in property tax (23% of total revenue), $121 million in state income tax (1.86% of total revenue), $33 million in sales tax (.5% of total revenue), $23 million in production tax (.35% of total revenue), and $22 million from the occupation tax (.35% of total revenue).

Increasing the rates of these taxes and therefore the total tax burden has, surprisingly enough, little impact on the profitability. This is due to the small amount of taxes relative to total revenue, the timing of the income tax burden, and the allowable deduction of state taxes against federal taxes.

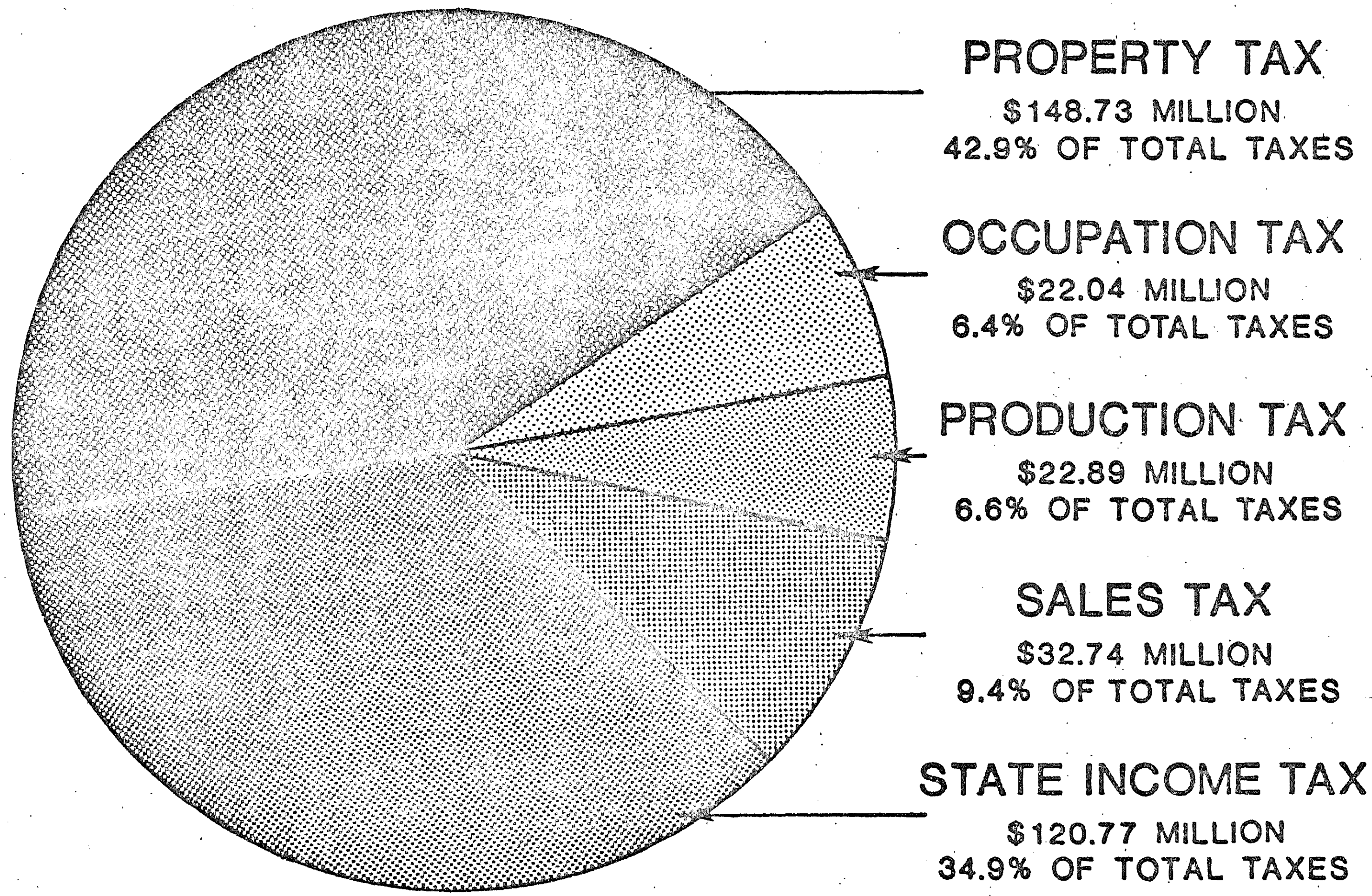
Figure 10 presents the distribution of taxes relative to total tax burden. The property tax is 43% of total taxes, most of which is from the smelter/refinery. State corporate income is 35%, the sales tax equals 9% and the production and occupation are 6.5% each. The degree of sensitivity of the dcfror to each of the taxes is partially a result of their relative amount and partially a result of when they are levied.

Figure 10

Sensitivity of dcfror to Changes in Minnesota Tax Rates--The following paragraphs present the impacts on profitability for the open pit mine model of

FIGURE 10

TAX DISTRIBUTION FOR THE OPEN PIT MINE MODEL



changes the property, state corporate income, production, and occupation tax rates.

Sales Tax--The sensitivity of the dcfror to changes in the sales tax is determined under two conditions; levy under the present laws, or not imposed at all. The sales tax is levied against only the smelter and refinery machinery equipment and supplies. It is equivalent to a tax on investment during the preproduction stages and therefore is the first tax to have a significant effect during the life of the mine model. As noted in Volume 5-Chapter 12, there is some possibility that the mine and mill will be liable for the sales tax levy. Cummulative sales tax revenues through years 3, 4, and 5 are $12.97 million or 1.6% of total taxes. However, the fact that it is levied so early in the mine life causes a .42 percentage point difference in the dcfror. If the sales tax is not in effect the dcfror increases from 11.93% to 12.35%.

Property Tax--The majority of the property tax revenue comes from the assessment against the smelter and refinery which is considered to be a manufacturing facilities by Minnesota tax laws. The property tax is calculated by multiplying the mill rate times the assessed valuation of the smelter and refinery. The mill rate used for analysis is an average of the rates found in the Study Area and is the cumulative rate for the county, school district, and city. The assessed valuation used for analysis is considered to be 43% of total market value. A 10% change in the property tax rate is equivalent to a 4.3% change in assessed valuation. It was found that for every 10% change in the property tax there was a .086 percentage point change in the profitability. A 100% increase or doubling of the property tax rate results in a .86 percentage point change in dcfror from 11.93 to 11.07%. This would in turn cause an increase in property tax revenues to the local governments from $149 million to $298 million.

State Corporate Income Tax--Corporate income in Minnesota is taxed at 12% of net taxable income. A 10% change in the tax is equivalent to 1.2% rate change on net taxable income. Figure 11 demonstrates that for every 10% change in the corporate income tax there is a .027 percentage point change in profitability. This means that a doubling of the corporate income tax rate from 12% to 24% would result in a decrease in the dcfror from 11.92% to 11.66% and an increase of tax revenues to the state from $121 to $242 million. Consequently if zero income tax is levied the profitability rises to 12.20% dcfror while total state tax revenues drop by $121 million.

As mentioned above all state taxes are deductible from federal corporate income tax at a rate of about $.50 per dollar of state tax liability. That is, for every $1.00 increase in state taxes there is a $.50 decrease in federal income taxes. This accounts in part for the relatively small impact of a change in state corporate tax rate on profitability. The other factor contributing to the relatively minor impact is the timing of the state corporate income tax relative to the mine life, with the majority of corporate income tax burden coming during the last third of the mine life.

This analysis assumes that the integrated mine, mill, smelter, and refinery is a wholly owned corporation with all operations in the state of Minnesota. A corporation owned and operated in part outside of Minnesota would have the ability to trade off deductions and losses from all its operations to give it the most advantageous tax returns. This implies that the trade off of state taxes against federal income taxes would probably be greater than $.50 on the dollar. This analysis represents, therefore, a conservative assumption from the point of view of the corporation.

Production Tax--The production tax used is a severance tax of 2.5 cents per ton of ore mined, with a grade of less than 1% combined copper and nickel. The rate increases 10% for every increase of .1% ore grade above 1% and varies directly with the consumer price index. The sensitivity analysis in Figure 11 shows that for every 10% change in the production tax rate there is a .01 percentage point change in the dcfror. If the production tax were increased 500% from 2.5 cents per ton of ore to 27.45 cents per ton, the profitability would decrease from 11.93% to about 11.43%. This would provide a increase in the total production tax revenues from $22.9 million to $137 million. The annual production tax levies increases from $.915 million to about $5.5 million. The major impact on profitability from this would also come from the discount rate on the tax levy of the early production years.

The Impact on the Profitability of the Open Pit Mine/Mill Only of a Change in the Production Tax--In Chapter 13, it was postulated that if a 20 million mtpy open pit mine and mill only were located in resource zone 7 (just southeast of Hoyt Lakes), the cost of services for the development-related population growth would be greater than the development-related revenue received by the Study Area communities and school districts.

The projected shortfalls are a product of the assumptions about the amount and distribution of development-related population and the estimated governmental operating and capital costs of services. If any of the assumptions change, the projections would change. Evaluations of site specific proposals should examine these assumptions and, if appropriate, present alternative scenarios. The total annual shortfall for the communities and school districts of the Study Area is estimated to be about $2.2 million when the copper-nickel mine model is at full production and the population growth has stabilized.

Chapter 13 assumes that the copper-nickel production taxes are distributed according to the taconite production tax formula established in 1977. Based on this interpretation, only 30% of the production tax revenue goes directly to the schools and communities in the Study Area. The remaining 70% of production tax revenue would be placed in special funds designated to deal with mining-related problems or distributed over the remainder of the taconite area. One method of mitigating the projected shortfall would be to increase the production of tax from 4.57 cents per ton of ore mined to 42 cents per ton of ore mined. An increase of approximately 800%.

To be consistent with Chapter 13, a minesim-4 price determination run was made for the mine/mill only (as opposed to the fully integrated model). It was assumed that the smelter/refinery operates essentially as a service facility (i.e. with lesser profit). If the mine/mill provides a 15% dcfror, an increase in the production tax from 4.57 cents per ton to 42 cents per ton will result in a 1.8 percentage point decrease of the mine/mill dcfror to 13.20%. At 15% dcfror, this decrease, at first glance, may not seem particularly drastic. However, if an operation is projected to produce a 12% dcfror (marginally acceptable) and it is faced with a 1.80 percentage point decrease, its economic acceptability is decreased precipitously.

As mentioned in Volume 5-Chapter 13 (Community Government Service Cost and Revenue Projections), there would be other options available to the state for the alleviation of the projected shortfall. These include the use of economic development funds for capital expansion projects, increases in local property taxes or reallocation of taxes paid by the mining firm to the state general fund back to the local government levels. The above analysis indicates in a general way the influence of an increase in tax revenues necessary to cover the projected shortfall. Site specific conditions could significantly change these impacts and should be analyzed before specific mitigation measures are implemented.

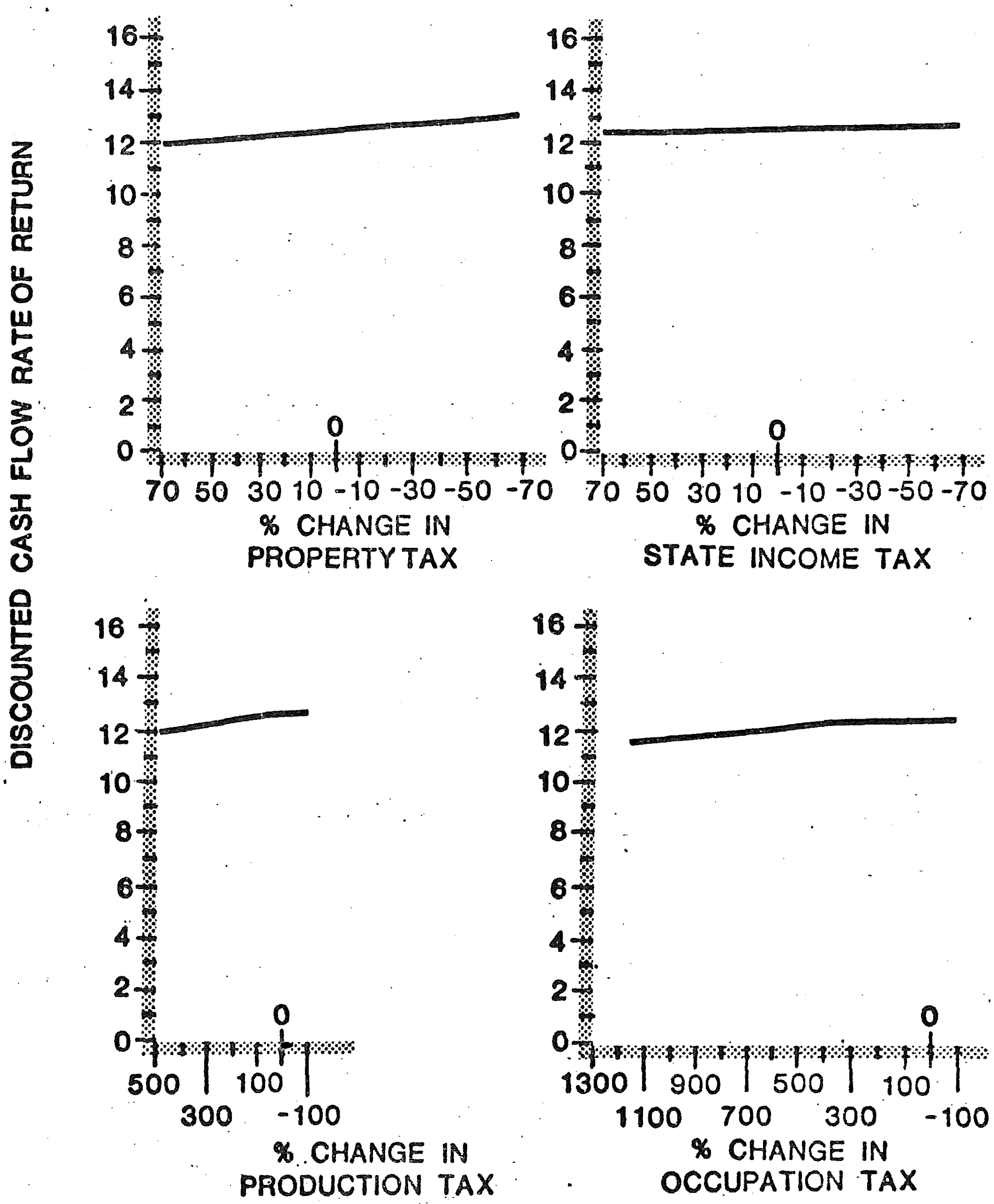
Occupation Tax--The occupation tax is on 1% of the net value of ore removed (revenue minus expenses) less credits for research, exploration and concentrate processed in Minnesota. This analysis assumes that the smelter/refinery complex is located on site so that the .67% credit applies, making the effective occupation tax rate .33% of taxable valuation. In addition, the occupation tax is a credit against the state corporate income tax so any increase in the occupation tax merits an equal decrease in the state corporate income tax. As the occupation tax increases it simply delays the levy of the state income tax until the state income tax is greater than the occupation tax. At that point the sum of the state income tax and the occupation tax is equal to the amount the corporate income tax would be without the occupation tax credit. This means that the impact of the occupation tax on profitability is minor because the rate is relatively small and the tax is a credit against the income tax. As shown in Figure 11, the dcfror changes .008 percentage points for every 10% change in the occupation tax. A 1,000% increase in the occupation tax rate results in an .8 percentage point decrease in dcfror from 11.93% to 11.13%.

Figure 11

Royalties--Royalties are payments to the mineral rights owner by the mining developer for the privilege of extracting minerals. Mineral rights may be owned by either private parties or any level of government. The owner of mineral

FIGURE 11

SENSITIVITY OF D.C.F.R.O.R. TO CHANGES IN THE RATES OF THE PROPERTY, STATE CORPORATE INCOME, PRODUCTION AND OCCUPATION TAXES.



rights does not necessarily own the surface rights; if he does not, the mineral rights are termed severed. The state of Minnesota lets bids to determine royalty rates for its mineral leases, the federal government negotiates royalty rates, and other levels of government have both options. Private owners usually negotiate royalty rates for their mineral rights. The three mine models examined in this chapter all assume that the mine developer leases 100% of its development rights and pays a 6% royalty on the value of all minerals. This amounts to an annual royalty payment at full production of about $16 million. If the mine developer owned 100% of his mineral rights, this amount wold be additional net income and would contribute to over a 2 percentage point increase in dcfror. U.S. Steel is the only mining company in this region which could approach 100% mineral ownership for copper-nickel resources, all others have little mineral copper-nickel resource ownership (Isle 1977).

Among the present sources of state revenue, royalties represent a large potential for state revenue generation. Royalty revenue depends upon the degree of state ownership of mineral rights and the rate at which royalties are paid by a mining operation. Since the location of minerals cannot be altered, the acquisition of mineral rights could become prohibitively expensive once the location of mineralization is common knowledge. The only direct influence the state can have on revenue generation from royalties is through alteration of the royalty rates. In the base case scenario under consideration here, it is assumed that the state owns 100% of mineral rights, each 1% increase in royalty rate generates approximately $2.6 million annually. If the state owns only 33% of the open pit operation's mineral rights, for example, annual state royalties would decrease from $16 million to about $5.33 million.

17.2.3.4 The Impact of Profitability of Taconite Tax Rates Applied to the Copper-Nickel Mine Models--The basic framework of taconite and copper-nickel tax laws was established following adoption of the taconite amendment to the State Constitution in 1964. With the tremendous expansion of the taconite industry in Minnesota since 1970, the state legislature periodically made changes in this basic framework for taconite, but not for copper-nickel (probably since no copper-nickel development existed at the time the copper-nickel portion of state laws were overlooked).

If copper-nickel mining were in existence today, it would be taxed differently than taconite mining despite the similarity of the names of the taxes which apply to the mining of each ore.

To determine the implications of an "equal" taxing policy by its impact on dcfror, the copper-nickel open pit model is assumed to be taxed like a taconite operation. The copper-nickel mine/mill is equated with the taconite mine/pelletizing plant while the smelter/refinery which produces copper and nickel metal is equated with the steel making blast furnace. Appendix A presents the algorithms used to calculate the taconite taxes applied to copper-nickel mining, and Table 12a shows the differences between the two tax policies.

Table 12

A major element of the two taxing schemes is the credits allowed against the occupation tax. Taconite operations are allowed a credit for the cost of labor in the mine/mill as a percentage of total cost or if the ore from the mine/mill is further converted to pig iron within the state, the firm may choose a credit

Table 12. Comparison of copper-nickel and taconite tax rates.

OCCUPATION TAX	RATE
Copper-Nickel	1% of valuation of ore mined or produced--with a credit for smelting and refining within the state.
Taconite	15% of valuation of ore mined or produced--with a credit for excess labor costs. After consideration of labor credits the effective tax rate is about 7%.
PRODUCTION TAX	**RATE**
Copper-Nickel	4.6 cents ($ 1977) per gross ton of ore inflated by the wholesale price index plus 10% of base tax for each .1% over 1% ore content (for the open pit model, this is equivalent to $1.60 per gross ton of bulk copper-nickel concentrate).
Taconite	$1.25 ($ 1977) per gross ton of concentrate inflated by the wholesale price index plus 1.6% of the base rate for each 1% over 62% ore content.
ROYALTY TAX	**RATE**
Copper-Nickel	1% of royalties received for copper-nickel on private lands plus 1% of royalties for precious metals.
Taconite	15% of royalties received for taconite on private lands.
CORPORATE INCOME TAX	**RATE**
Copper-Nickel	There is a 12% corporate income tax with a credit for its occupation tax liability.
Taconite	There is no corporate income tax (the occupation tax is in lieu of the corporate income tax) on a mine/mill operation. Further conversion processes in Minnesota are not addressed.
PROPERTY TAX	**RATE**
Copper-Nickel	For the fully integrated mine/mill/smelter/refinery in Minnesota, there is property tax on the value of the smelter/refinery buildings and land and on the value of land associated with the mine/mill but not actually used for mining or processing.
Taconite	The property tax is on the land of the mine/mill not actively used for mining or processing.

Table 12 continued.

SALES TAX	RATE
Copper-Nickel	As a manufacturing facility, the smelter/refinery is liable for sales tax on the purchase of materials, equipment, and supplies. It is stated that the production tax is in lieu of all other taxes; therefore, this analysis assumes no sales tax liability for the mine/mill operation. However, this assumption is open to interpretation.
Taconite	It is assumed for this analysis that a taconite mine/mill operation is exempt from the sales tax.

of 2/3 of 1% for every 1% of ore converted in the state. In 1976, average labor credits for Minnesota's taconite industry reduced the 15% occupation tax rate to an effective rate of about 7% (i.e. the labor credits reduced the occupation tax liability by about 50%). In this analysis, it is assumed that existence of the smelter/refinery in the state allows for the 2/3 credit against the occupation tax and, therefore, the effective tax rate is 5% of the value of the concentrate.

It should be noted that the statute calls for the tax to be based on the value of the taconite ore which is to be determined by the Commissioner of Revenue. The commissioner has determined that the value of taconite ore is the "Lake Erie price" of taconite pellets minus the cost of transportation. In effect, the value of the ore equals the value of the iron in the concentrate. Following this example, the present analysis assumes that the value of the metal contained in the copper-nickel concentrate is subject to the occupation tax rather than the value of the metal in the ore.

The smelter/refinery is subject to the taxes typical for manufacturing operations: sales, property, corporate income. The mine/mill is subject to the occupation, production tax on royalties and corporate income. Since it is a wholly-owned, fully-integrated operation, the whole entity of mine/mill/smelter/refinery is subject to the federal corporate income tax.

The copper-nickel open pit mine model, if taxed as a taconite operation, produces a 10.10% dcfror versus an 11.93% dcfror, if taxed under present copper-nickel laws.

Under taconite tax laws, over the 30-year life of the operation, it generates $620 million in total state tax revenues (see Appendix C) as opposed to $347.16 million if taxed under copper-nickel laws.

According to published sources and conversation with academic mineral economists and industry people, an 11.93% is a marginally acceptable dcfror with which to justify investment: a 10.10% dcfror is more marginal. If the 10.10% dcfror were deemed unacceptable by the management of this hypothetical mine model, the tax revenues drop to zero since the operation would not be in existence.

Figure 12 portrays the generation of total tax revenues over the life of the operation as if it were taxed under the taconite tax laws and under the copper-nickel tax laws.

Figure 12

In section 17.3.3, present Minnesota copper-nickel tax impacts are compared to other mineral-producing states, and based on dcfror Minnesota tax has the second lowest impact on profitability. If the results of the taconite tax law analysis presented above was compared to other mineral-producing states, it would have the second highest tax impacts on profitability exceeded only by Wisconsin.

Table 13 demonstrates the relative influence of taconite taxes applied to copper-nickel mining versus copper-nickel taxes applied to copper-nickel mining. The taconite tax laws take a greater portion of both gross revenues on net income before taxes, resulting in the correspondingly lower dcfror.

Table 13

FIGURE 12

MINNESOTA TAX LAWS APPLIED TO THE COPPER-NICKEL OPEN PIT MODEL

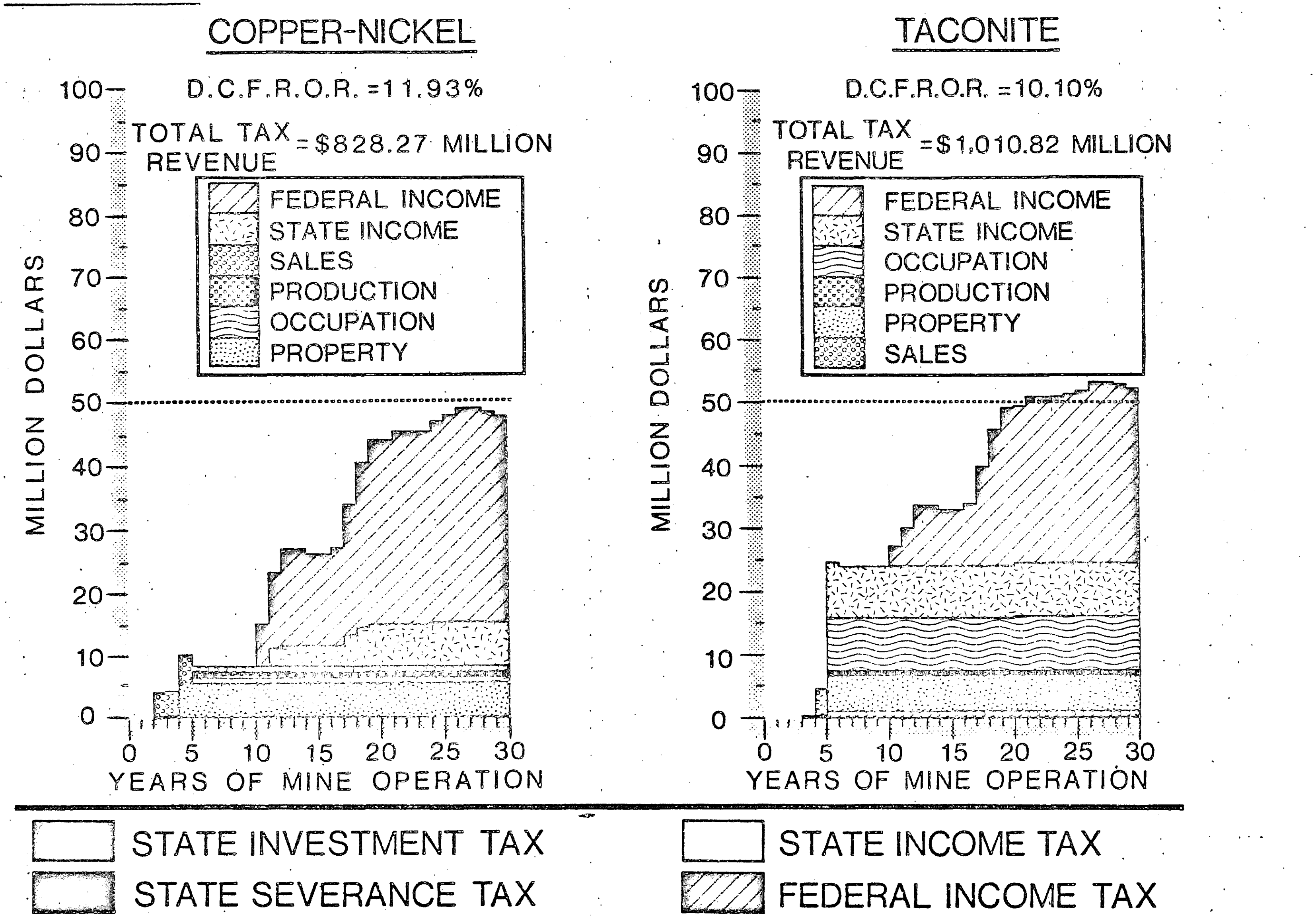


Table 13. The percent of gross and net revenues before taxes allocated under the taconite and copper-nickel tax laws.

	TACONITE	COPPER-NICKEL
Gross Revenues	$6.49 billion	$6.49 billion
- production tax	0.3	.35
- occupation tax	3.3	.34
- corporate income tax	3.3	1.86
- sales tax	0.5	.50
- property tax	2.2	2.29
- federal income tax	6.0	7.42
Total	15.6%	12.8%
Net Income[a] Before Taxes	$2.92 billion	$2.92 billion
- production tax	.6	.78
- occupation tax	7.25	.76
- corporate income tax	7.25	4.14
- sales tax	1.13	1.12
- property tax	4.84	5.09
- federal income tax	13.40	16.50
Total	34.5%	28.4%

[a]Net income before taxes = gross income - operating costs - loan interest payments - royalty payments.

17.3 COMPARISON OF TAXES AND PROFITABILITY IN MINNESOTA, WISCONSIN, ARIZONA, UTAH, NEW MEXICO, AND MONTANA

Many factors are considered by a legislature while developing a state mineral tax policy and by an investor while considering investment alternatives. In many cases, the outcome of these analyses is largely dependent on relative differences between reasonable options. The relative difference in the impact of taxes in different locations could be a major factor in an investor's decision to proceed with a new venture, since many other costs (labor, energy, transportation, etc.) do not vary significantly from state to state. A legislature faced with the issue of a new minerals industry has no perspective by which to judge the reasonableness of a tax policy, except for other industries which may not be applicable to the new industry being judged. A comparison with other states which have a history involving the new industry or with states which have recently addressed the issue of tax policy for the industry may provide the needed perspective.

This section examines the relationship between taxes and profitability in Minnesota and compares this with taxes and profitability in Wisconsin, Arizona, Utah, New Mexico, and Montana. The cash flow model was altered to represent each state's taxing policy as it existed in 1978. The dcfror and the amount of federal, state, and local taxes levied against the base case model development was calculated for each state. The actual algorithms used for calculating taxes paid in each state is found in Appendix A. Personal communication with Dr. Thomas Stinson and officials in various state tax departments provided the basis for the algorithms.

17.3.1 Comparison of dcfror

As may be recalled the dcfror for the open pit model in Minnesota is 11.93%. Table 14 compares the dcfror which this model would generate if it were situated in the above states, everything else but taxes being equal.

Table 14. Comparison of the impact of alternative state mineral tax laws on profitability.

STATE	dcfror (%)
Montana	12.04
Minnesota	11.93
Utah	11.88
New Mexico	11.78
Arizona	11.17
Wisconsin	9.25

A mining operation in Minnesota fares pretty well compared to tax burdens in other states. The following explanation of the size and timing of the tax burden for the model operation will highlight the differences among each of the states.

15.3.2 Types of Taxes

Taxes paid by a mine development are grouped into categories of investment taxes (sales, use, property), income taxes (corporate income, net proceeds) and severance taxes. All sales and use taxes are not true investment taxes, since they are levied on the purchase of supplies during the production years as well as on initial equipment, machinery, and supplies. However, the greatest affect of the sales tax on dcfror occurs in the preproduction years; all sales and use taxes are considered investment taxes. Taxes can also be classified as a part of fixed costs and variable costs. Fixed costs are those costs that the operations must maintain regardless of the amount of production while variable costs change as the amount of production changes.

Taxes on investments are levied on capital expenditures and are usually large during the development phase of the project when, in this case, initial capital costs are on the order of $500 million. Taxes on investments are independent of profit and are a fixed cost.

Sales and use tax payments can be controlled by limiting purchases but taxes on real property are a constant fixed cost. If allowed to depreciate they are still a fixed cost, but decline over time.

Taxes on income are a variable cost based on the gross or net value of the product. The deductions, credits and rates for different income taxes vary from state to state. A net proceeds tax is usually a true income tax depending on the type and number of deductions allowed. This tax and the corporate income tax are the types most favored by the mining industry. The state corporate income tax is usually based on the federal corporate income tax with a much lower tax rate and some minor variations in deductions and credits. It is a tax on net income and decreases to zero when net income approaches zero. In general, the net proceeds tax behaves like the state corporate income tax but rates and deductions vary considerably.

A severance tax is imposed on the minerals "severed" from the ground. It is based on the amount or value of the material mined with no deductions allowed.

It is a variable cost depending on amount and value of production. The severence tax is levied regardless of levels of profits. The severance tax is unique to the extractive industry and is founded on the philosophy that the minerals are part of the natural heritage of the people of the state and that their irreplaceable removal requires an additional fee to compensate for their loss. A gross proceeds tax is actually a severance tax since it implies no deductions or credits and is therefore a tax on production, except that the tax proceeds vary with the price of the products.

Table 15 demonstrates the mineral taxes and their characteristics in the 6 states which are reported. There are many different names for the same type of tax and as will be pointed out later the same type of tax may have grossly different characteristics from one state to another.

Table 15

17.3.3 Comparative Tax Revenues

Each state receives a considerable amount of tax revenue over the life of the mine but Utah reaps less than the other states (Table 16), yet Utah has a smaller dcfror than Minnesota and Montana. This paradox demonstrates the impact of the timing of the tax burden levied by the three states against the mine model.

Table 16

Figure 13 demonstrates that there are two general patterns of tax burdens for the six states examined: those dominated by federal income taxes (Minnesota,

Table 15. Types of taxes levied on the open pit mine model in 6 mineral producing states.

	INVESTMENT	SEVERANCE	INCOME
Minnesota	property tax	production tax	occupation tax corporate income tax
Wisconsin	property tax		net proceeds tax corporate income tax
Arizona	sales, use and property tax	education excise tax	corporate income tax
Utah	sales, use and property tax	mine occupation tax,	corporate income tax
Montana	property tax	metalifferous mines license, resource indemity trust	corporate income tax
New Mexico	property tax	resources excise tax	corporate income tax severance

Table 16. Mineral tax revenues of six states generated by the open pit mine model.

STATE	INVESTMENT[a]	SEVERANCE	INCOME	STATE TOTAL	FEDERAL INCOME	TOTAL TAX
Minnesota	181.47	22.88	142.81	347.16	481.87	829.03
Montana	59.52	156.18	78.49	294.19	502.9	797.09
Utah	77.95	48.68	39.11	165.74	570.69	736.43
New Mexico	162.00	75.10	57.89	294.99	512.56	807.55
Arizona	195.87	170.48	54.01	420.36	459.88	880.24
Wisconsin	387.36	0.0	797.25[b]	1182.61	260.43	1445.04

[a]All figures in $ millions.
[b]702.70 from net proceeds tax
94.55 from state income tax.

Montana, Utah, New Mexico, and Arizona); and one dominated by state (and local) taxes (Wisconsin). A more subtle pattern can be discerned in the states other than Wisconsin by looking at the relationship of state tax payments versus time. The state taxes for Utah and New Mexico both peak out very early in the operating life of the mine and then declines thereafter. The other states follow a general pattern of increased tax payments per annum over time.

Figure 13

The impact of tax policy on minerals development can be evaluated in many ways. A typical approach is the ranking of states on the basis of total tax payments. In this case (Table 17), Utah ranks number 1 with the lowest tax payments, Minnesota ranks number 4, and Wisconsin ranks number 6 with the highest tax payments. The problem with this evaluation approach is that it ignores the variability of the tax payments over the life of the operation (Figure 13). Since the discounting method used in determining the dcfror brings all future cash flows forward to their present value, the impact of tax payment variations is recognized. Table 17 also ranks the states using the dcfror. Utah under this ranking is now number 3, Minnesota number 2, and Wisconsin is still number 6 with the lowest rate of return.

Table 17

The impact of tax payments on dcfror is the same as any other capital or operating expense in that the earlier the payments are made the larger the impact on dcfror. For example, Utah has relatively large taxes early, it only develops an 11.88% dcfror (compared to Minnesota's 11.93%) even though it produ-

FIGURE 13

BREAKDOWN OF TOTAL TAX LEVIES ON A FULLY INTEGRATED OPEN PIT MINE MODEL

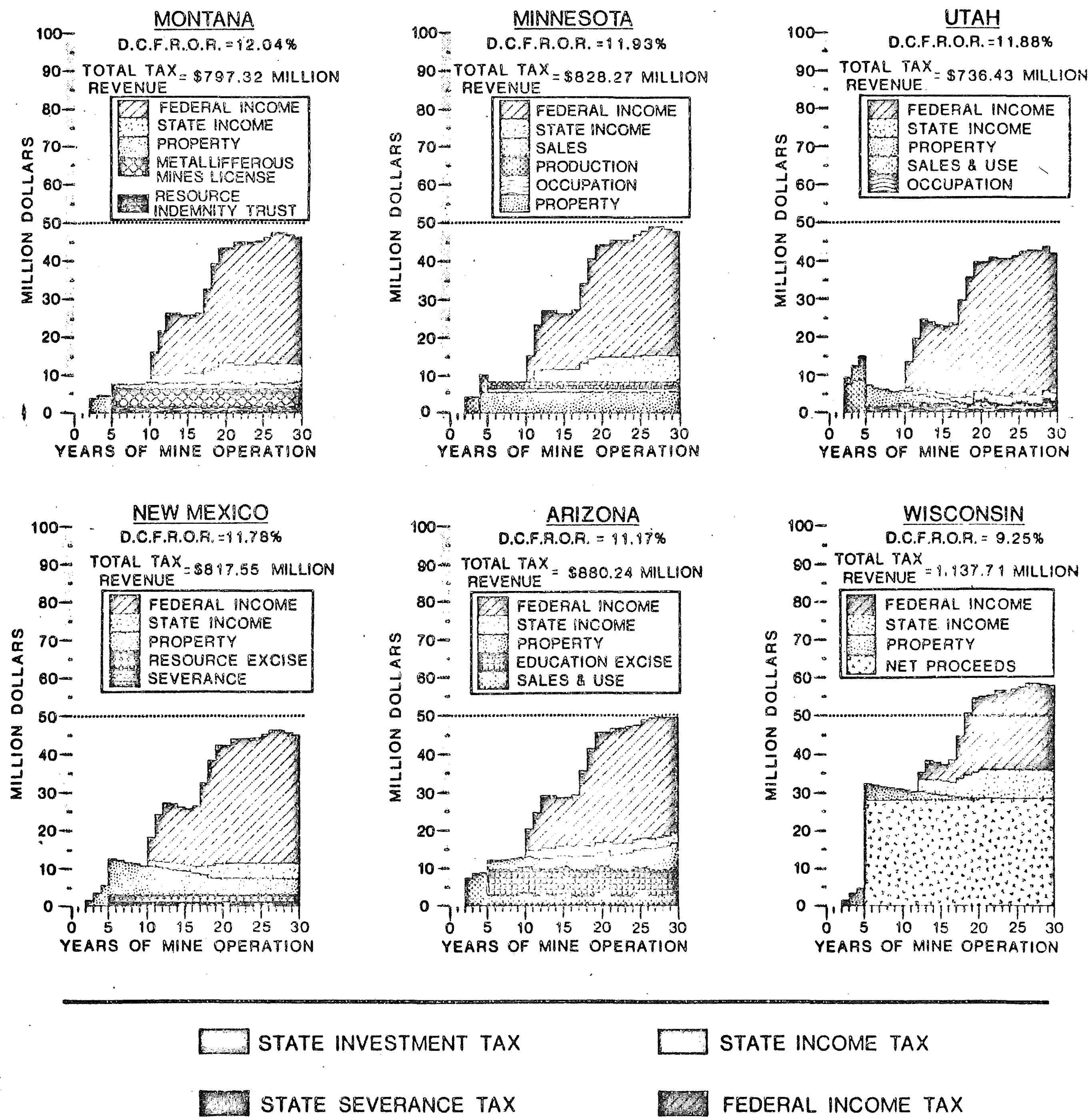


Table 17. Ranking of the tax impact on mineral development of six mineral producing states.

STATE	RANKING BASED ON TOTAL TAX PAYMENTS	RANKING BASED ON dcfror
Utah	(1) least	(3)
Montana	(2)	(1)
New Mexico	(3)	(4)
Minnesota	(4)	(2)
Arizona	(5)	(5)
Wisconsin	(6) most	(6)

ces $181 million less in total state tax revenues over the life of the mine. As Table 16 and Figure 13 demonstrate a second major factor influencing the difference in dcfror between the states is the difference in federal corporate income taxes paid. Since all state taxes are a federal corporate income tax deduction, the smaller the state tax burden the larger the federal tax levy. In this analysis, the corporation recaptures about $.50 on its federal tax bill for every $1.00 it pays to the state.

This phenomenon is demonstrated by comparing the state and federal taxes which would be paid by an operation in Minnesota and Utah. As discussed earlier, the operation, if located in Utah, would pay $181 million less in state taxes than if it were located in Minnesota. However, the difference between total (state and federal) tax burden is estimated to be less than $92.6 million for the operation. Federal income taxes are the factor which smooths the total estimated tax burden.

It is because of this characteristic of the federal income tax levy that the total tax burdens of Minnesota, Montana, Utah, New Mexico and Arizona do not differ as much as their state tax rates might indicate.

17.3.4 Generalized Tax Impacts

This analysis points out some interesting aspects of the impact of taxing policy on the firm and on the state.

1) Taxes levied early (investment, severance) in the development life of a project have a greater impact on dcfror than those which are usually related to

profits (corporate income, net proceeds) and consequently imposed later in the project life.

2) The impact of an increase in the states tax burden is diluted by a reduction in the federal tax burden. (This reduction could be even larger for a national or international corporation because of potential tax deductions being transferred from a project in one political unit to a project in another.)

The state, like the corporation, is often interested in financial issues, such as: Can it get an early return on its expenditures for services?; Can it cover its expenditures? The state is also interested in the financial success of the firm because of its contributions to the welfare of the state's citizens. These goals may be in conflict especially in the case of marginal operations because an investment type tax which would help pay for government services during construction and early production has the greatest impact on the dcfror.

Minnesota's mineral tax regime for Cu-Ni is competitive with the other states examined if their tax laws were in effect in Minnesota. Minnesota's mineral tax laws for non-ferrous metals is as conducive to investment as the other states examined.

17.4 COMPARISON OF MAJOR CASH FLOW VARIABLES AFFECTING PROFITABILITY

As presently constituted, changes in Minnesota's mineral tax rates as herein analyzed have little impact on the profitability of the operation as compared to the other variables (e.g. metal price, ore grade, etc.). Figure14 is an estimate of the impact of each variable on the dcfror. It shows the slope of the linear regression approximation to the sensitivity curves in Figures 2 through

13. For example, the value for copper price is .2; this indicates that for every 10% variation in the copper price the dcfror changes by 2 percentage points. Similarly the value for nickel price is approximately .09, indicating that for every 10% change in nickel price, the dcfror varies by .9 percentage points. The dcfror is twice as sensitive to changes in the price of copper as it is to changes in the price of nickel.

Figure 14

Copper price, copper mill recovery rate and copper ore concentrate are the most influential. They are also elements over which the state has no control.

The cost of initial capital and operating costs over which the state has some control are the next most influential variables. The state may dictate the use of safety and pollution control equipment which could make a material addition to both initial capital and operating costs. However, additions to capital costs and operating costs made in the latter part of the mine life would be much less influential on dcfror than those made in the early part.

The next group of variables, nickel price, nickel mill recovery and nickel ore grade all behave exactly like those related to copper production. Nickel has a higher cost than copper, but there is less of it. The result is that nickel-related variables are less than half as influential on profitability as copper. The state has no influence on these variables but it does demonstrate the very significant influence that nickel has on profitability. One may surmise from this analysis that the existence of nickel in the ore accounts in large measure for the interest shown by mining companies in the Minnesota Duluth Complex which, based on its copper content alone, is not particularly attractive.

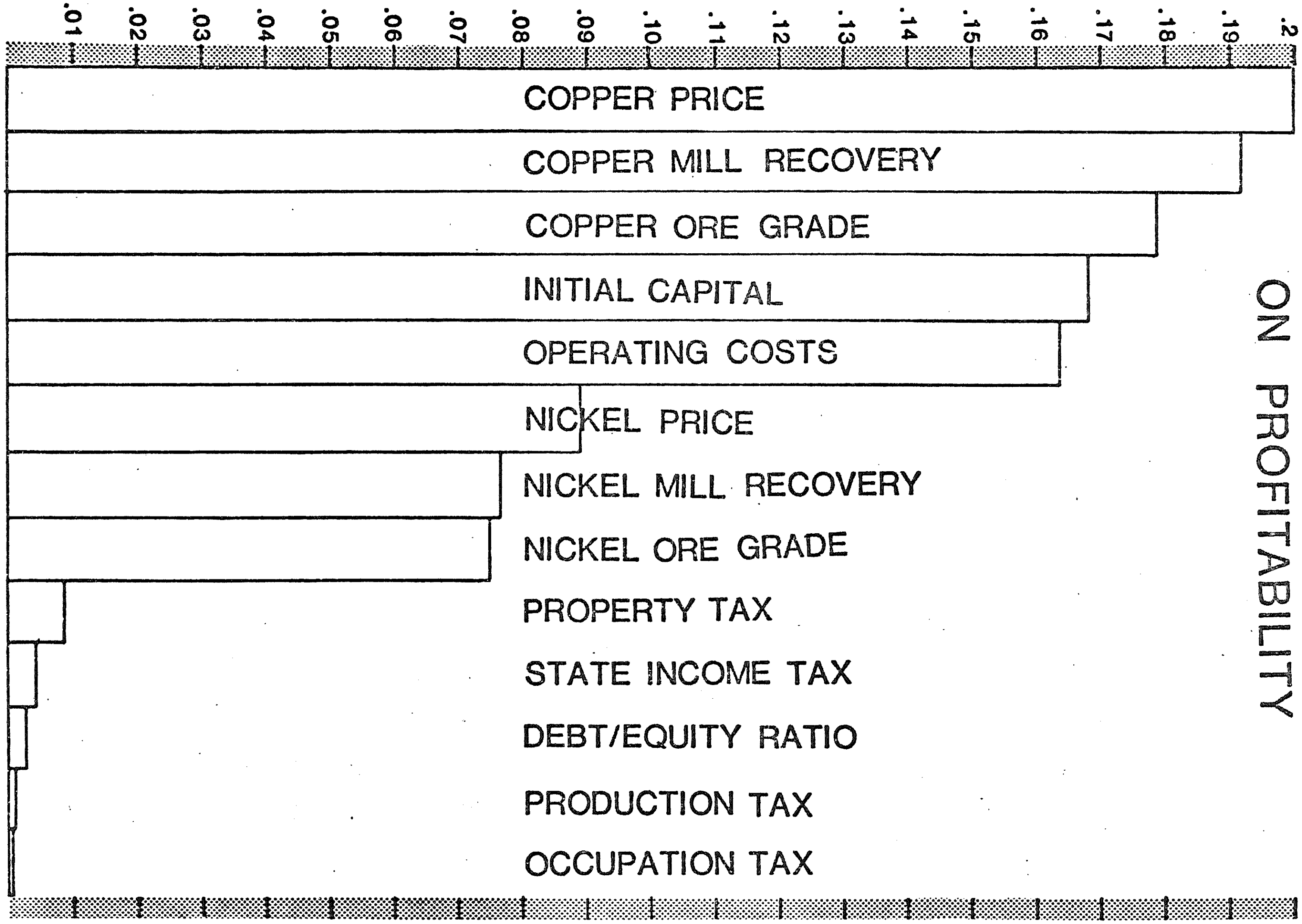


FIGURE 14

INFLUENCE OF ECONOMIC FACTORS ON PROFITABILITY

There is a precipitous drop in the effect on dcfror from nickel ore grade to the next group of variables, which includes all the taxes plus the debt/equity ratio. The state has minimal control over the debt/equity ratio but has total control over its tax policies. The subject of taxes has been examined in some detail. Little more will be said here except to point out that the property tax is 23 times less influential than copper price. The state income tax is 74 times less influential, the production tax is 200 times less influential and the occupational tax is 253 times less influential on the dcfror than the price of copper.

17.5 REQUIRED COPPER-NICKEL PRICES FOR 15% DCFROR ON SEVERAL ALTERNATIVES

A major question asked pertaining to the development of copper-nickel is: "When will copper-nickel development become economically feasible in Minnesota?" There is no one answer because inherent in the question are multiple elements which affect the answers. The term "economically feasible" is the key element and one which depends on the interpretation of the investors. If, for example, a firm were interested in developing the only domestic supply of nickel, it might be willing to accept a lower dcfror than if it were simply profit motivated. Another firm, on the other hand, may have several holdings throughout the world of which Minnesota copper-nickel holdings is only one and may be less attractive than the others. Consequently, it may require a higher price for its metals than if it had fewer alternatives.

There are many considerations which go into making an investment decision, and dcfror is only one of them, albeit one of the most important. Therefore, there is a range of minimum dcfror's and concommitantly a range of minimum metal prices which would trigger investment for a particular firm. An 8% dcfror is probably an absolute minimum that a mining company would consider because most investors can achieve that target in many low risk ways. Based on conversations with several industry analysts, a 10% dcfror would probably be the lowest acceptable level in very low risk mining environments.

An industry rule of thumb investment requirement is a 15% dcfror. This is used as a target rate for the three fully integrated mine models described in Table 1. If one assumes a nickel price of $2.10/lb, a mine life of 30 years, and a dcfror of 15%, then in 1977 dollars:

- the open pit model requires $1.05/lb Cu
- the combination model requires $1.34/lb Cu
- the underground model requires $1.54/lb Cu

The historic trend of copper prices (in $1977) to 1977 and projected prices to 1985 are presented in Figure 15. The London Metals Exchange price is more volatile and generally higher than the United States producers' price. The trend for both is even indicating that the real price of copper is staying nearly the same. The dark line in the area after 1977 indicates the most likely LME copper price according to a forecast submitted to the Copper-Nickel Study by Commodities Research Unit (CRU). The shaded area represents the range of possible prices with the highest prices being possible but the least likely.

However, a recent paper presented at the 1979 American Institute of Mining Engineeers annual meeting (Adams, 1979) forecast a copper price of $1.36/pound in $1977. This is towards the upper end of C.R.U.'s forecast and if it comes true this price would provide a good investment incentive in Minnesota's copper-nickel resources.

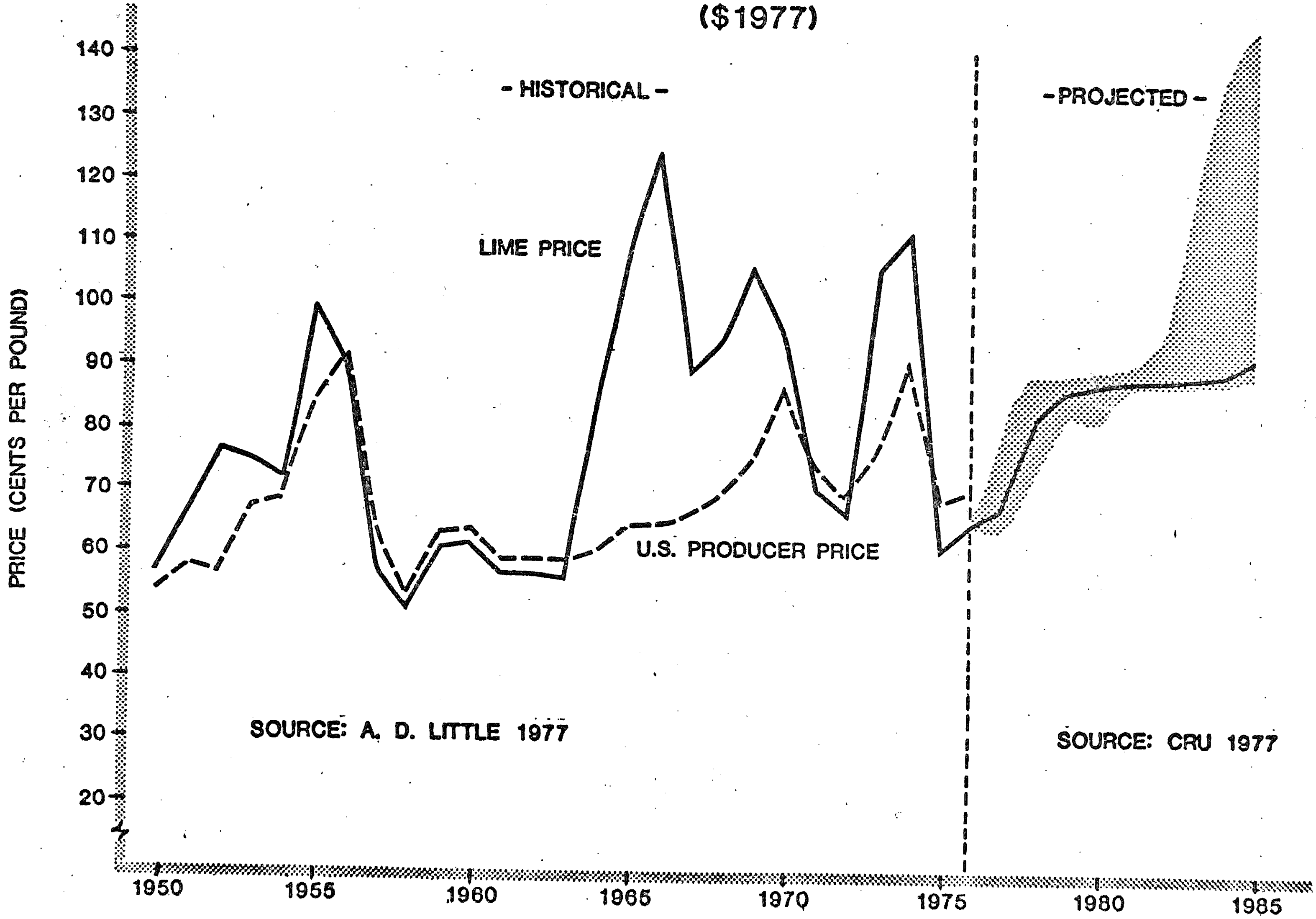
Figure 15

In the dcfror analysis, the copper price for the base case mine models is assumed to be $.91/lb in 1985 based on CRU's forecast of the most likely price. For the open pit mine model, this price results in approximately a 12% dcfror. The $1.05/lb copper which gives a 15% dcfror is well within the shaded area. The highest price possible by 1985 of $1.40/lb copper gives a 21% dcfror for the open pit model. The combination mine model requires a copper price of $1.34/lb to achieve a 15% dcfror.

The reader is cautioned when comparing the dcfror target price requirements to price forecasts and price quotations. The price requirements presented above are average prices for over the 30-year life of the development. Because of the volatile nature of historic base metal markets, investors are not looking for the year when metal prices first reach a target level, but are looking for a time period when average prices will be at or above the target price. Since metal prices seem to swing through demand/supply cycles, it is very important that a new venture come into production during a price upswing. (You will recall in the section on taxes that costs loaded in the first 5 years of an operation have significant impacts on the dcfror as compared to similar costs loaded at a later time period. The same is true for revenue changes.) If the reverse occurs (production starts during downswing), it could mean the financial death of the mining operation. The Lakeshore Mine in southern Arizona began production in the mid-1970s (a price decline period) and is now "mothballed."

FIGURE 15

LME COPPER PRICE
($1977)



Based on dcfror criteria alone, none of the hypothetical mine models would increase the pulse rate of investors. However, the open pit mine model is clearly an acceptable investment and one which may be very good. The combination open pit-underground mine model is a marginal investment, but if forecasts for copper and nickel prices improve, it could become acceptable or even good. The underground mine model is not acceptable within the foreseeable future based on forecast metal prices and known ore grades.

The average ore grade has a profound effect on the profitability of any operation. It follows then that the higher the ore grade, the less the price necessary to make a development financially acceptable. It has been estimated that the average ore grade for 4.0 billion metric tons of ore in the Duluth Gabbro is .66% Cu and .2% Ni. The open pit model would process .52 billion tons over its 26-year operating life. Assume that there is enough ore of the average grade in one place to supply the open pit model. It would give a 21.40% dcfror. Alternatively, it would provide a 15% dcfror with a copper price of about $.64/lb. There is, in fact, no known ore body which fits this description.

The average ore grade of INCO's proposed open pit mine is 0.46% Cu and 0.17% Ni (INCO 1975), and AMAX's proposed open pit mine is 0.46% Cu and 0.11% Ni (Malcom 1977).

The scenario is presented here to make the point that relative modest changes in average ore grade can have a significant effect on both profitability and possible start-up time.

The amount of initial capital required has a significant impact on the price of copper required to reach a target dcfror. For every 10% change in initial capital for the open pit model, the price of copper changes by $.079/lb. Therefore, if initial capital requirements increase by $61 million (10%), the price of copper would have to be $1.13/lb to provide a 15% dcfror.

Operating costs also have a notable effect on the price of copper required to reach a 15% dcfror. Copper price would have to increase by 6.87¢/lb for every 10% increase in total operating costs. The open pit model operating costs are approximately $120 million per year at peak production. Thus, if there were an increase of $12 million per year, copper would have to increase from $1.05/lb to $1.12/lb.

As noted in the section on profitability, changes in existing tax rates (±50%) have very little influence on dcfror relative to the other variables examined. The same is true when one considers the impact caused by changes in tax rates on the required price of copper. For every 10% change in the property, state corporate income, production, and occupation tax, the change in the required price of copper per pound is ¢.32, ¢.17, ¢.05, and ¢.03, respectively. For example, the property tax rate would have to increase 100% to increase the price of copper 3.2¢/lb to give a 15% dcfror.

REFERENCES

Adams, R. 1979. Why copper prices are going to triple over the next decade. American Society for Mining Engineers, Littleton Co. 80123.

Arend, Jr., C.A. President of Amax Nickel, 1977. Skillings Mining Review 66(42).

Bennett, H. 1976. Bench mark problem 2 (unpublished manuscript of user's manual for Minesim-4). U.S. Bureau of Mines, Denver, CO.

Berry, C.W. 1972. Wealth growth rate measurement for capital investment planning. The Pennsylvania State University, Ph.D. thesis.

Bradbury, P.J., Planning Analyst. Personal communication, Wisconsin Department of Revenue, Madison, WI.

Commodities Research Unit, Ltd. 1977. Survey of four metals. New York, NY.

-------. 1978. Comparative analysis of the mineral investment climate in American states and Canadian provinces, Volume 1 and 2. New York, NY.

Corrick, J.D., Physical Scientist, Division of Ferrous Metals. 1978. Personal communication. U.S. Bureau of Mines.

INCO. 1975. Description of operating concepts required to establish preoperational monitoring for INCO's proposed Spruce Road Project. The International Nickel Company, Inc.

Isle, C. 1977. Severed mineral rights map. Register of Deeds and Titles, St. Louis County, Duluth, MN.

Iwasaki, I., A.S. Malicsi and R.J. Lipp. 1978. Mineral processing studies. Final report to the Regional Copper-Nickel Study. Mineral Resources Research Center, Minneapolis, MN.

Laing, G.L.S. 1977. Effects of state taxation on mining industry in Rocky Mountain states, Quarterly of the Colorado School of Mines 72(2).

Malcom, J. 1977. 1977 Minnimax reserve estimates, goal presentation to state agencies, 1977.

Malenbaum, W. et al. 1977. World demand for raw materials in 1985 and 2000. University of Pennsylvania, Philadelphia, PA.

Lewis, F.M., C.K. Chase and R.B. Bhappu. 1978. Copper production costs update. Mining Engineering 30(4).

Ross, D. 1978. Personal communication. Arizona Department of Revenue, Phoenix, AZ.

REFERENCES (continued)

Stermole, F.J. 1974. Economic evaluation and investment decision methods, second edition. Investment Evaluations Corporation, Golden, CO.

Stinson, T. 1978. Personal communication. USDA, Department of Agriculture and Applied Economics, University of Minnesota, St. Paul, MN.

Veith, D.L., P.J. Kreisman and R.H. Poppe. 1977. Integrated development models. Minnesota Environmental Quality Board, Regional Copper-Nickel Study, St. Paul, MN.

Whitney, J.W. and R.E. Whitney. 1978. Investment and risk analysis in the minerals industry. John W. Whitney, Inc. Management Consultants, Reno, NV.

APPENDIX A

ARIZONA

Education Excise Tax

Tax = 0.025 * worth of concentration

$$\text{Worth of concentrate} = (\text{tonnes mined}) * \sum_{\text{all commodities}} \left[(\text{feed grade})*(\text{mill recovery rate})*\left(\frac{\text{price}}{\text{tonne}}\right)\right]$$

Sales & Use Tax

Tax = 0.04 * (price of all purchased equipment and supplies)

	mine	mill	smelter	refinery
supplies are a fraction of operating costs	0.55	0.68	0.56	0.64

Property Tax

$$\text{Tax} = 0.6*0.115*\text{PROC}*\frac{1-(0.84)^{L+1-J}}{1.16*(L+1-J)}$$

L=life of mine
J=year since beginning

PROC = 0.9651*worth-(federal tax)-(operating costs)
-(investments) + (depreciations)

0.9651 = 1 - 0.0099 - 0.025 (subtraction of excise and income tax)

If Tax < 0 set tax = 0

Corporate Income Tax

Tax = 0.0099 * worth

MINNESOTA

Production Tax

Tax = 0.025*(tonne mined) * (wholesale price index)

Occupation Tax

Tax = (tax rate) * [Worth - (operating cost of mine)
- (production tax) - (royalty payments)]

Worth of ore = (tonne mined) * $\sum_{\text{all commodities}}$ [(feed grade) * (price/tonne)]

Property Tax

In production: Tax = (mill rate) * 0.43 [0.35 * (land value) + 0.9 * (value of smelter) + (value of refiner)]
(no depreciation)

No production: Tax = (mill rate) * 0.43 * (land value)

Corporate Income Tax

Tax = 0.12 * [(federal taxable income) + (occupation tax) + (Federal tax refund)]
- 500.00 - (occupation tax)

Occupation tax has 3 year carry forward as a credit.

If tax <100.00 set tax = 100.00

Sales Tax

Tax = 0.04 * (price of smelter and refinery + supplies)

Supplies = 0.56 * (operating cost of smelter) + 0.64 * (operating cost of refinery)

MONTANA

Resource Indemnity Trust

If worth > \$5000.0 then trust = 0.005 * (worth - 5000)

If worth < \$5000.0 then trust = 0

Worth = (tonnes mined of ore) * Σ over all commodities [(feed grade) * (price/tonne)]

Metaliferous Mines License

If worth is	Then license is
≤\$100,000	0.0015 * Worth
≥\$100,000 but ≤\$200,000	\$150 + 0.00575 * (worth - 100,000)
≥\$200,000 but ≤\$400,000	\$725 + 0.0086 * (worth - 200,000)
≥\$400,000 but ≤\$500,000	\$2445 + 00.0115 * (worth - 400,000)
≥\$500,000	\$3595 + 0.01438 * (worth - 500,000)

Property Tax

Tax = 0.18 * (0.03 * worth + summ)

Summ = Σ (all non-land investments)

Corporate Income Tax

Tax = 0.0678 * (federal taxable income)

NEW MEXICO

Severance Tax

Tax = 0.005 * [Worth - (operating cost of mine) - (royalty payments)]

$$\text{Worth of concentrate} = (\text{tonnes mined}) * \sum_{\text{all commodities}} \left[(\text{feed grade}) * (\text{mill recovery rate}) \left(\frac{\text{price}}{\text{tonne}}\right)\right]$$

If tax <0 set tax = 0

Resources Excise Tax

Tax = 0.0075 * [Worth - (royalty payments)]

If tax <0 set tax = 0

Property Tax

Tax = 0.025 * [Worth - (operating cost of mine) - (operating cost of mill) - (royalty payments) + (total depreciation) + Summ]

Summ = 0.33 * Σ (all non-land investments - depreciation)

If tax <0 set tax = 0

Corporate Income Tax

Tax = 0.05 * (federal taxable income)

UTAH

Sales and Use Tax

$$\text{Tax} = 0.04 * [\ \Sigma(\text{all non-land investments})]$$

Occupation Tax

$$\text{Tax} = 0.00714 * \text{Worth}$$

$$\text{Worth} = (\text{tonnes mined}) * \sum_{\substack{\text{all} \\ \text{commodities}}} \left[(\text{ore grade}) * (\text{mill recovery rate}) * \left(\frac{\text{price}}{\text{tonne}}\right)\right]$$

Property Tax

$$\text{Tax} = 0.055 * (\text{summ} + \frac{5}{279} * \text{Suml})$$

$$\text{Suml} = \Sigma\ (\text{all land investments})\ [\text{assumes } \$279/\text{acre}]$$

$$\text{Summ} = 0.2 * \Sigma(\text{all non-land investments})$$

Corporate Income Tax

$$\text{Tax} = 0.031 * (\text{federal taxable income})$$

WISCONSIN

New Proceeds Tax

If Worth* is	Tax is
<4,000,000	0.06 * Worth*
>4,000,000 but ≤ 10,000,000	240,000 + 0.12 * (Worth - 4,000,000)
>10,000,000 but ≤ 20,000,000	960,000 + 0.16 * (Worth -10,000,000)
>20,000,000 but ≤ 30,000,000	2,560,000 + 0.18 * (Worth -20,000,000)
>30,000,000	3,336,000 + 0.2 * (Worth -30,000,000)

Worth = (tonnes mined) * Σ [(feed grade) * (mill recovery rate) * price/tonne)
of concentrate — all commodities — -operating cost of mine, mill, smelter, refinery]

*Worth = worth of concentrate

Property Tax

Tax = .018 * [(all mine, mill, smelter, and refiner buildings)
-depreciation) + (all land investments)]

Corporate Income Tax

Tax = 0.079 * [(federal taxable income) ± (federal tax refunds)
+ (depletion)]

TACONITE TAX LAWS APPLIED TO THE COPPER-NICKEL OPEN PIT MINE MODEL

Production Tax

Tax = 1.25 * (tonnes mined)

Occupation Tax

Tax = (tax rate) * [Worth - (operating cost of mine) - (operating cost of mill) - (production tax) - (royalty payments)]

$$\text{Worth of concentrate} = (\text{tonnes mined}) * \sum_{\text{all commodities}} \left[\text{feed grade} * \text{mill recovery rate} * \frac{\text{price}}{\text{tonne}}\right]$$

Property Tax

In production: Tax = (mill rate) * 0.43 * [0.35 * (land value) + 0.9 * (value of smelter) + (value of land)]
(no depreciation)

Preproduction: Tax = (mill rate) * 0.43 * (value of land)

Sales Tax

Tax = 0.04 * price of smelter and refinery + supplies)

Supplies = 0.56 * (operating cost of smelter) + 0.64 * (operating cost of refinery)

Corporate Income Tax

Tax = 0.12 * [Gross revenues - 245.25 * (tonnes of concentrate) - (operating cost of smelter) - (operating cost of refinery) + (federal tax refunds)] - 500.00

It tax less than 100.00 set tax = 100.00

Only smelter and refinery operation is taxed.

245.25 is concentrate shadow price

Smelter and refinery are considered separate from the mine and mill, therefore, there is no credit for occupation tax payments against the corporate income tax.

APPENDIX B

20 MILLION METRIC TONNE PER YEAR OPEN PIT MINE MODEL
CASH FLOW INPUT VARIABLES

INPUT VARIABLE	YEARS VARIABLE OPERATING		VARIABLE VALUE
Exploration	0001	0001	187000.0
Exploration	0002	0002	3700000.0
Land Acquistion	0001	0002	650.0
Land Acquistion	0003	0004	1395650.0
Land Acquistion	0005	0005	650.0
Mining Preparation	0004	0005	2635000.0
Mine Plant Invest.	0004	0005	9250000.0
Mine Equipment Inv.	0004	0005	22735500.0
Mine Equipment Inv.	0010	0010	10996000.0
Mine Equipment Inv.	0011	0011	12669000.0
Mine Equipment Inv.	0013	0013	1920000.0
Mine Equipment Inv.	0014	0014	738000.0
Mine Equipment Inv.	0015	0015	10996000.0
Mine Equipment Inv.	0016	0016	12669000.0
Mine Equipment Inv.	0020	0020	21394000.0
Mine Equipment Inv.	0021	0021	23339000.0
Mine Equipment Inv.	0022	0022	738000.0
Mine Equipment Inv.	0025	0025	10996000.0
Mine Equipment Inv.	0026	0026	12669000.0
Mine Equipment Inv.	0029	0029	1920000.0
Mine Equipment Inv.	0030	0030	11734000.0
Mill Capital Inv.	0003	0004	76500000.
Mill Capital Inv.	0005	0005	77900000.
Smelter Capital Inv.	0003	0004	70000000.0
Smelter Capital Inv.	0005	0005	72200000.
Refinery Capital	0003	0004	37000000.0
Refinery Capital	0005	0005	38010000.
Poll Control Equip.	0003	0005	
Loan Number 1	0004	0004	154771500.
Loan Number 2	0005	0005	154771500.
Loan Number 3	0002	0002	000000000.
Working Capital	0006	0006	20004000.0
Mine Operating Cost	0006	0020	2.07
Mine Operating Cost	0021	0032	1.94
Mill Operating Cost	0006	0032	2.27
Units Treated	0006	0032	20000000.0
Cu Feed Grade	0006	0032	0.00494
Cu Mill Recovery	0006	0032	0.8889143
Cu Mill Conc. Grade	0006	0032	0.1382503
Cu Smelter Recovery	0006	0032	0.964064
Cu Smelter Grade	0006	0032	0.985
Cu Refiner Recovery	0006	0032	0.999
Smelter Op. Cost	0006	0032	25.46
Refinery Op. Cost	0006	0032	76.78
Tran Mill-Smelt	0006	0032	0.00
Tran Smelt-Refin	0006	0032	0.00
Price/Unit	0006	0032	2006.55

16.68 MILLION METRIC TONNE PER YEAR MINE MODEL
CASH FLOW INPUT VARIABLES

INPUT VARIABLE	YEARS VARIABLE OPERATING		VARIABLE VALUE
Explortion	0001	0001	7700000.0
Explortion	0002	0002	7700000.0
Land Acquisition	0001	0002	650.0
Land Acquisition	0003	0004	1395650.0
Land Acquisition	0005	0005	650.0
Mining Preparation	0002	0002	8900000.0
Mining Preparation	0003	0004	8800000.0
Mine Plant Invest.	0003	0003	18000000.0
Mine Plant Invest.	0004	0004	10000000.0
Mine Plant Invest.	0005	0005	9776000.0
Mine Equipment Inv.	0003	0003	10000000.0
Mine Equipment Inv.	0004	0004	12000000.0
Mine Equipment Inv.	0005	0005	12110000.0
Mine Equipment Inv.	0006	0006	3346000.0
Mine Equipment Inv.	0007	0007	7772000.0
Mine Equipment Inv.	0008	0008	8791000.0
Mine Equipment Inv.	0009	0009	2554000.0
Mine Equipment Inv.	0010	0010	3902000.0
Mine Equipment Inv.	0011	0011	2027000.0
Mine Equipment Inv.	0012	0012	7812000.0
Mine Equipment Inv.	0013	0013	9304000.0
Mine Equipment Inv.	0014	0014	3923000.0
Mine Equipment Inv.	0015	0015	1905000.0
Mine Equipment Inv.	0016	0016	1336000.0
Mine Equipment Inv.	0017	0017	14458000.0
Mine Equipment Inv.	0018	0018	15667000.0
Mine Equipment Inv.	0019	0019	2699000.0
Mine Equipment Inv.	0020	0020	1848000.0
Mine Equipment Inv.	0021	0021	1909000.0
Mine Equipment Inv.	0022	0022	9534000.0
Mine Equipment Inv.	0023	0023	8249000.0
Mine Equipment Inv.	0024	0024	2446000.0
Mine Equipment Inv.	0025	0025	2666000.0
Mine Equipment Inv.	0026	0026	2806000.0
Mine Equipment Inv.	0027	0027	8625000.0
Mill Capital Inv.	0003	0004	65000000.
Mill Capital Inv.	0005	0005	72200000.
Smelter Capital Inv.	0003	0004	70000000.0
Smelter Capital Inv.	0005	0005	72200000.
Poll Control Equip.	0003	0005	
Loan Number 1	0004	0004	156449000.
Loan Number 2	0005	0005	156449000.
Loan Number 3	0002	0002	000000000.
Working Capital	0006	0006	21246667.0
Mine Operating Cost	0005	0005	4.96
Mine Operating Cost	0006	0006	4.40
Mine Operating Cost	0007	0007	3.14

INPUT VARIABLE	YEARS VARIABLE OPERATING	VARIABLE VALUE
Mine Operating Cost	0008 0008	3.02
Mine Operating Cost	0009 0009	3.21
Mine Operating Cost	0010 0014	3.31
Mine Operating Cost	0015 0029	3.20
Mine Operating Cost	0030 0030	3.74
Mine Operating Cost	0015 0029	3.74
Units Treated	0005 0005	2830000.0
Units Treated	0006 0006	9168750.
Units Treated	0007 0007	13336250.
Units Treated	0008 0008	14673750.
Units Treated	0009 0009	16011250.
Units Treated	0010 0029	16680000.
Units Treated	0030 0030	12512500.
Units Treated	0031 0031	4167500.
Cu Feed Grade	0006 0030	0.005920
Cu Mill Recovery	0006 0030	0.88891
Cu Mill Conc. Grade	0006 0030	0.13825
Cu Smelter Recovery	0006 0030	0.96406
Cu Smelter Grade	0006 0030	0.985
Cu Refiner Recovery	0006 0030	0.999
Smelter Op. Cost	0006 0030	25.46
Refinery Op. Cost	0006 0030	76.78
Tran Mill-Smelt	0006 0030	0.00
Tran Smelt-Refin	0006 0030	0.00
Price/Unit	0006 0030	2006.55
Ni Feed Grade	0006 0030	0.00137
Ni Mill Recovery	0006 0030	0.73751
Ni Mill Conc. Grade	0006 0030	0.02647
Ni Smelter Recovery	0006 0030	0.9177177
Ni Smelter Grade	0006 0030	0.9000
Ni Refiner Recovery	0006 0030	0.999
Smelter Op. Cost	0006 0030	4.64
Refinery Op. Cost	0006 0030	440.34
Tran Mill-Smelt	0006 0030	0.00
Tran Smelt-Refin	0006 0030	0.00
Price/Unit	0006 0030	4630.50
PM Feed Grade	0006 0030	0.010
PM Mill Recovery	0006 0030	1.0
PM Mill Conc. Grade	0006 0030	1.0
PM Smelter Recovery	0006 0030	1.0
PM Smelter Grade	0006 0030	1.0
PM Refiner Recovery	0006 0030	1.0
Price/Unit	0006 0030	111.21
Copper		0.15
Nickel		0.22
PM		0.20
Royalty Par Cu	0006 0030	.06
Royalty Par Ni	0006 0030	.06
Royalty Par Met	0006 0030	.06
Occupation Tax	0006 0030	.00333
Production Tax		.025
State Tax		.12

12.35 MILLION METRIC TONNE PER YEAR UNDERGROUND MINE MODEL
CASH FLOW INPUT VARIABLES

INPUT VARIABLE	YEARS VARIABLE OPERATING	VARIABLE VALUE
Exploration	0001 0001	5750000.0
Exploration	0002 0002	5750000.0
Land Acquisition	0001 0002	650.0
Land Acquisition	0003 0004	1395650.0
Land Acquisition	0005 0005	650.0
Mining Preparation	0002 0005	8900000.0
Mine Plant Invest.	0002 0005	10175000.0
Mine Equipment Inv.	0002 0002	1056000.0
Mine Equipment Inv.	0003 0003	2112000.0
Mine Equipment Inv.	0005 0005	3696000.0
Mine Equipment Inv.	0006 0006	5283000.0
Mine Equipment Inv.	0007 0007	2433000.0
Mine Equipment Inv.	0008 0008	2545000.0
Mine Equipment Inv.	0009 0009	3988000.0
Mine Equipment Inv.	0010 0010	4443000.0
Mine Equipment Inv.	0011 0011	2541000.0
Mine Equipment Inv.	0012 0012	2497000.0
Mine Equipment Inv.	0013 0013	3356000.0
Mine Equipment Inv.	0014 0014	6194000.0
Mine Equipment Inv.	0015 0015	3008000.0
Mine Equipment Inv.	0016 0016	2109000.0
Mine Equipment Inv.	0017 0017	3688000.0
Mine Equipment Inv.	0018 0018	3857000.0
Mine Equipment Inv.	0019 0019	3602000.0
Mine Equipment Inv.	0020 0020	2917000.0
Mine Equipment Inv.	0021 0021	3014000.0
Mine Equipment Inv.	0022 0022	5216000.0
Mine Equipment Inv.	0023 0023	1689000.0
Mine Equipment Inv.	0024 0024	3862000.0
Mine Equipment Inv.	0025 0025	4210000.0
Mine Equipment Inv.	0026 0026	2713000.0
Mine Equipment Inv.	0027 0027	3121000.0
Mill Capital Inv.	0003 0005	51420000.
Smelter Capital Inv.	0003 0004	70000000.0
Smelter Capital Inv.	0005 0005	72200000.
Refinery Capital	0003 0004	37000000.0
Refinery Capital	0005 0005	38010000.
Poll Control Equip.	0003 0005	
Loan Number 1	0004 0004	144867500.
Loan Number 2	0005 0005	144867500.
Loan Number 3	0002 0002	000000000.
Working Capital	0006 0006	22847000.0
Mine Operating Cost	0006 0006	26.71
Mine Operating Cost	0007 0007	8.98
Mine Operating Cost	0008 0008	6.12
Mine Operating Cost	0009 0030	5.86
Mill Operating Cost	0006 0030	2.37

INPUT VARIABLE	YEARS VARIABLE OPERATING	VARIABLE VALUE
Units Treated	0006 0006	1543750.0
Units Treated	0007 0007	4631250.
Units Treated	0008 0008	7718750.
Units Treated	0009 0009	10806250.
Units Treated	0010 0028	12350000.
Units Treated	0029 0029	9262500.
Units Treated	0030 0030	3087500.
Cu Feed Grade	0006 0030	0.0080
Cu Mill Recovery	0006 0030	0.88891
Cu Mill Conc. Grade	0006 0030	0.13825
Cu Smelter Recovery	0006 0030	0.96406
Cu Smelter Grade	0006 0030	0.985
Cu Refiner Recovery	0006 0030	0.999
Smelter Op. Cost	0006 0030	25.46
Refinery Op. Cost	0006 0030	76.78
Tran Mill-Smelt	0006 0030	0.00
Tran Smelt-Refin	0006 0030	0.00
Price/Unit	0006 0030	2006.55
Ni Feed Grade	0006 0030	0.001846
Ni Mill Recovery	0006 0030	0.73751
Ni Mill Conc. Grade	0006 0030	0.02647
Ni Smelter Recovery	0006 0030	0.9177177
Ni Smelter Grade	0006 0030	0.9000
Ni Refiner Recovery	0006 0030	0.999
Smelter Op. Cost	0006 0030	4.64
Refinery Op. Cost	0006 0030	440.34
Tran Mill-Smelt	0006 0030	0.00
Tran Smelt-Refin	0006 0030	0.00
Price/Unit	0006 0030	4630.50
PM Feed Grade	0006 0030	0.010
PM Mill Recovery	0006 0030	1.0
PM Mill Conc. Grade	0006 0030	1.0
PM Smelter Recovery	0006 0030	1.0
PM Smelter Grade	0006 0030	1.0
PM Refiner Recovery	0006 0030	1.0
Price/Unit	0006 0030	151.29
Copper		0.15
Nickel		0.22
PM		0.20
Royalty Par Cu	0006 0030	.06
Royalty Par Ni	0006 0030	.06
Royalty Par Met	0006 0030	.06
Occupation Tax	0006 0030	.00333
Production Tax		.025
State Tax On		1.0

APPENDIX C

Arizona tax revenues generated over the life of the open pit model.

YEAR	SALES AND USE	EDUCATION EXCISE	PROPERTY	STATE CORPORATE INCOME	FEDERAL CORPORATE INCOME	TOTAL
1	0	0	0	0	--	--
2	0	0	0	0	--	--
3	7.34	--	--	--	--	7.34
4	8.62	--	--	--	--	8.62
5	8.80	--	--	--	--	8.80
6	2.94	6.82	2.27	--	--	12.03
7	2.94	6.82	2.25	--	--	12.11
8	2.94	6.82	2.44	--	--	12.20
9	2.94	6.82	2.53	--	--	12.30
10	3.38	6.82	2.64	--	--	12.84
11	3.44	6.82	2.75	2.70	4.72	20.43
12	2.94	6.82	2.77	2.70	9.58	24.81
13	3.01	6.82	2.79	2.70	13.72	29.04
14	2.96	6.82	2.63	2.70	13.73	29.04
15	3.37	6.82	2.97	2.70	12.79	28.65
16	3.44	6.82	3.14	2.70	12.56	28.66
17	2.94	6.82	3.30	2.70	13.57	29.33
18	2.94	6.82	3.45	2.70	19.55	35.46
19	2.94	6.82	3.48	2.70	25.48	41.42
20	3.79	6.82	3.50	2.70	28.66	45.47
21	3.81	6.82	3.69	2.70	28.65	45.67
22	2.91	6.82	3.92	2.70	30.41	46.76
23	2.87	6.82	4.10	2.70	30.39	46.88
24	2.88	6.82	4.38	2.70	30.26	47.04
25	3.32	6.82	4.68	2.70	30.16	47.68
26	3.38	6.82	5.02	2.70	30.88	48.80
27	2.89	6.82	5.36	2.70	31.88	49.65
28	2.88	6.82	5.72	2.70	31.71	49.83
29	2.96	6.82	6.18	2.70	31.14	47.80
30	3.35	6.82	6.71	2.70	29.95	49.53
TOTAL	102.91	170.48	92.96	54.01	459.83	880.24

Minnesota tax revenues generated over the life of the open pit model.

YEAR	PROPERTY	SALES	PRODUCTION	OCCUPATION	STATE CORPORATE INCOME	FEDERAL CORPORATE INCOME	TOTAL
1	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--
3	.090	4.28	--	--	--	--	--
4	.180	4.28	--	--	--	--	--
5	5.71	4.41	--	--	--	--	--
6	5.71	.791	.915	.875	--	--	--
7	5.71	.791	.915	.875	--	--	--
8	5.71	.791	.915	.875	--	--	--
9	5.71	.791	.915	.875	--	--	--
10	5.71	.791	.915	.875	--	--	--
11	5.71	.791	.915	.875	.029	6.85	15.17
12	5.71	.791	.915	.875	3.03	12.16	23.48
13	5.71	.791	.915	.875	3.54	15.40	27.23
14	5.71	.791	.915	.875	3.52	15.42	27.23
15	5.71	.791	.915	.875	3.52	14.73	26.54
16	5.71	.791	.915	.875	3.52	14.62	26.43
17	5.71	.791	.915	.875	3.52	15.46	27.27
18	5.71	.791	.915	.875	5.03	20.79	34.11
19	5.71	.791	.915	.875	6.52	26.02	40.83
20	5.71	.791	.915	.875	7.73	29.02	45.04
21	5.71	.791	.915	.887	7.82	29.08	45.20
22	5.71	.791	.915	.887	7.80	30.53	46.63
23	5.71	.791	.915	.887	7.80	30.58	46.68
24	5.71	.791	.915	.887	7.80	30.58	46.68
25	5.71	.791	.915	.887	8.05	30.72	47.07
26	5.71	.791	.915	.887	8.31	31.51	48.12
27	5.71	.791	.915	.887	8.33	32.42	49.05
28	5.71	.791	.915	.887	8.33	32.42	49.05
29	5.71	.791	.915	.887	8.28	32.13	48.71
30	5.71	.791	.915	.887	8.26	31.41	47.97
TOTAL	148.73	32.74	22.88	22.04	120.77	481.87	829.03

Montana tax revenues generated over the life of the open pit model.

YEAR	PROPERTY	RESOURCE INDEMNITY TRUST	METALLIFEROUS MINES LICENSE	STATE CORPORATE INCOME	FEDERAL CORPORATE INCOME	TOTAL
1	--	--	--	--	--	--
2	--	--	--	--	--	--
3	3.96	--	--	--	--	3.96
4	4.65	--	--	--	--	4.65
5	4.75	--	--	--	--	4.75
6	1.74	1.61	4.63	--	--	7.98
7	1.74	1.61	4.63	--	--	7.98
8	1.74	1.61	4.63	--	--	7.98
9	1.74	1.61	4.63	--	--	7.98
10	1.98	1.61	4.63	--	--	8.22
11	2.02	1.61	4.63	1.82	5.98	16.06
12	1.74	1.61	4.63	2.03	11.84	21.85
13	1.78	1.61	4.63	2.45	16.05	26.52
14	1.76	1.61	4.63	2.44	16.07	26.51
15	1.98	1.61	4.63	2.43	15.29	25.94
16	2.02	1.61	4.63	2.43	15.16	25.85
17	1.74	1.61	4.63	2.44	16.13	26.55
18	1.74	1.61	4.63	3.30	21.78	33.06
19	1.74	1.61	4.63	4.14	27.31	39.43
20	2.20	1.61	4.63	4.82	30.36	43.62
21	2.24	1.61	4.63	4.85	30.42	43.75
22	1.76	1.61	4.63	4.87	32.07	44.94
23	1.74	1.61	4.63	4.87	32.14	44.99
24	1.74	1.61	4.63	4.87	32.14	44.99
25	1.98	1.61	4.63	5.00	32.22	45.44
26	2.02	1.61	4.63	5.14	33.05	46.05
27	1.74	1.61	4.63	5.17	34.09	47.24
28	1.74	1.61	4.63	5.17	34.09	47.24
29	1.78	1.61	4.63	5.14	33.77	46.93
30	1.99	1.61	4.63	5.11	32.99	46.33
TOTAL	59.52	40.32	115.86	78.49	502.90	797.09

New Mexico tax revenues generated over the life of the open pit model.

YEAR	SEVERANCE	RESOURCE EXCISE	PROPERTY	STATE CORPORATE INCOME	FEDERAL CORPORATE INCOME	TOTAL
1	--	--	--	--	--	
2	--	--	--	--	--	
3	--	--	1.72	--	--	1.72
4	--	--	3.68	--	--	3.68
5	--	--	5.55	--	--	5.55
6	1.08	1.92	9.40	--	--	12.40
7	1.08	1.92	9.02	--	--	12.02
8	1.08	1.92	8.63	--	--	11.63
9	1.08	1.92	8.17	--	--	11.17
10	1.08	1.92	7.87	--	--	10.87
11	1.08	1.92	7.69	1.36	6.19	18.24
12	1.08	1.92	7.34	1.52	12.30	24.16
13	1.08	1.92	7.01	1.71	15.45	27.17
14	1.08	1.92	6.67	1.72	15.62	27.01
15	1.08	1.92	6.40	1.73	15.06	26.19
16	1.08	1.92	6.15	1.74	15.06	25.95
17	1.08	1.92	5.80	1.76	16.07	26.63
18	1.08	1.92	5.23	2.42	27.08	32.73
19	1.08	1.92	4.77	3.06	27.93	38.76
20	1.08	1.92	4.63	3.59	31.34	42.56
21	1.09	1.92	4.86	3.60	31.31	42.78
22	1.09	1.92	4.79	3.60	32.79	44.19
23	1.09	1.92	4.71	3.60	32.87	44.19
24	1.09	1.92	4.63	3.61	32.91	44.16
25	1.09	1.92	4.60	3.72	33.14	44.47
26	1.09	1.92	4.61	3.82	33.99	45.43
27	1.09	1.92	4.56	3.83	34.93	46.33
28	1.09	1.92	4.51	3.83	34.95	46.30
29	1.09	1.92	4.49	3.82	34.66	45.98
30	1.09	1.92	4.54	3.81	33.91	45.27
TOTAL	27.00	48.08	162.32	57.59	512.56	807.55

Utah tax revenues generated over the life of the open pit model.

YEAR	SALES AND USE	PROPERTY	OCCUPATION	STATE CORPORATE INCOME	FEDERAL CORPORATE INCOME	TOTAL
1						
2						
3	7.34	1.88				9.22
4	8.62	3.93				12.55
5	8.80		5.84			14.64
6		5.32	1.95			7.27
7		4.81	1.95			6.76
8		4.29	1.95			6.24
9		3.83	1.95			5.78
10	.44	3.51	1.95			5.9
11	.51	3.19	1.95	.93	6.97	13.55
12		2.72	1.95	1.05	14.14	19.86
13	.77	2.27	1.95	1.24	18.42	24.65
14	.30	1.80	1.95	1.25	18.67	23.97
15	.44	1.45	1.95	1.25	17.96	23.05
16	.51	1.12	1.95	1.25	17.97	22.80
17		.65	1.95	1.28	19.27	23.15
18		.31	1.95	1.69	25.30	29.25
19		.12	1.95	2.08	31.15	35.30
20	.86	.27	1.95	2.37	34.12	39.57
21	.93	.42	1.95	2.38	34.10	39.78
22	.30	.32	1.95	2.40	36.00	40.97
23		.21	1.95	2.41	36.11	40.68
24		.11	1.95	2.41	36.16	40.63
25	.44	.14	1.95	2.46	36.18	41.17
26	.51	.22	1.95	2.52	36.99	42.19
27		.16	1.95	2.54	38.17	42.82
28		.10	1.95	2.55	38.20	42.80
29	.77	.59	1.95	2.53	37.87	43.71
30	.47	.12	1.95	2.51	36.94	41.99
TOTAL	30.07	47.88	48.68	39.11	570.69	736.43

Wisconsin tax revenues generated over the life of the open pit model.

YEAR	PROPERTY	NET PROCEEDS	STATE CORPORATE INCOME	FEDERAL CORPORATE INCOME	TOTAL
1	--	--	--	--	--
2	--	--	--	--	--
3	14.73	--	--	--	14.73
4	30.03	--	--	--	30.03
5	44.31	--	--	--	44.31
6	41.06	27.90	--	--	68.96
7	37.51	27.90	--	--	65.71
8	34.56	27.90	--	--	62.46
9	31.31	27.90	--	--	56.21
10	28.06	27.90	--	--	55.96
11	24.81	27.90	--	--	52.71
12	21.56	27.90	--	--	49.46
13	18.32	27.90	--	--	46.22
14	15.06	27.90	--	--	42.96
15	11.82	27.90	--	--	39.72
16	8.57	27.90	2.89	--	39.36
17	5.32	27.90	3.73	1.69	38.64
18	3.10	27.90	4.90	9.07	44.97
19	1.92	27.90	5.97	15.95	51.74
20	1.80	27.90	6.81	19.21	55.72
21	1.67	28.42	6.81	19.11	56.01
22	1.65	28.42	6.81	20.60	57.48
23	1.43	28.42	6.82	20.71	57.38
24	1.30	28.42	6.83	20.76	57.31
25	1.18	28.42	7.00	21.00	57.60
26	1.06	28.42	7.18	21.89	58.55
27	.93	28.42	7.20	22.85	59.40
28	.81	28.42	7.21	22.91	59.35
29	.69	28.42	7.19	22.66	58.96
30	.56	28.42	7.19	22.00	58.17
TOTAL	387.36	702.70	94.55	260.43	1445.04

Minnesota tax revenues generated over the life of the open pit model (taconite tax laws).

YEAR	PROPERTY	SALES	PRODUCTION	OCCUPATION	STATE CORPORATE INCOME	STATE TOTAL	FEDERAL CORPORATE INCOME	TOTAL
1	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---
3	.09	4.28	---	---	---	4.37	---	4.37
4	.18	4.28	---	---	---	4.46	---	4.46
5	.18	4.41	---	---	---	4.46	---	4.49
6	5.71	.79	.794	8.44	8.95	24.68	---	24.68
7	5.71	.79	.794	8.44	8.49	24.22	---	24.22
8	5.71	.79	.794	8.44	8.49	24.22	---	24.22
9	5.71	.79	.794	8.44	8.49	24.22	---	24.22
10	5.71	.79	.794	8.44	8.49	24.22	---	24.22
11	5.71	.79	.794	8.44	8.49	24.22	3.03	27.25
12	5.71	.79	.794	8.44	8.49	24.22	5.97	30.19
13	5.71	.79	.794	8.44	8.49	24.22	9.45	33.67
14	5.71	.79	.794	8.44	8.49	24.22	9.45	33.67
15	5.71	.79	.794	8.44	8.49	24.22	8.78	33.00
16	5.71	.79	.794	8.44	8.49	24.22	8.66	32.88
17	5.71	.79	.794	8.44	8.49	24.22	9.51	33.73
18	5.71	.79	.794	8.44	8.49	24.22	15.56	39.78
19	5.71	.79	.794	8.44	8.49	24.22	21.51	45.73
20	5.71	.79	.794	8.44	8.49	24.22	25.10	49.32
21	5.71	.79	.794	8.57	8.49	24.35	25.13	49.48
22	5.71	.79	.794	8.57	8.49	24.35	26.57	50.92
23	5.71	.79	.794	8.57	8.49	24.35	26.62	50.97
24	5.71	.79	.794	8.57	8.49	24.35	26.62	50.97
25	5.71	.79	.794	8.57	8.49	24.35	26.88	51.23
26	5.71	.79	.794	8.57	8.49	24.35	27.80	52.15
27	5.71	.79	.794	8.57	8.49	24.35	28.71	53.06
28	5.71	.79	.794	8.57	8.49	24.35	28.71	53.06
29	5.71	.79	.794	8.57	8.49	24.35	28.40	52.75
30	5.71	.79	.794	8.57	8.49	24.35	27.68	52.03
TOTAL	143.20	32.72	19.85	212.30	212.71	620.68	390.14	1010.82