Nearest water = 5 miles
No provision here for tailings disposal. ✓

WESTERN CLAIMS

673695

Denak Mines, Canada.

1. Introduction

This project includes the planning of open pit mining of the Denak molybdenum mines, Canada. The planning is based on the report of exploratory drilling, dated January 25th, 1968.

In the mentioned report ore reserves are calculated to 11.6 M ton of ore with 0.17 % Mo S_2. The cut-off grade in the calculations is 0.08 % Mo S_2.

2. Open pit planning

The molybdenum occurs as impregnation in quartz veins of limited width. The mineralized zone consists of a large number of approximately parallel veins with intermediate sections of waste rock.

Due to the large number of veins it is not possible in a planning to regard each vein as a unit. All minable veins in a profile must be regarded as an aggregate of ore requiring removal of intermediate waste. The separation has to be carried out during the production, as selective mining.

The exploratory drilling profiles are situated at rather long distances from each other. As the veins are of limited length and the area furthermore is disturbed by faults, the information from the drillings is not sufficient to allow a detail pit planning proceed from year to year. The profiles can however, be used separately to determine the outlines of an assumed open excavation. Summarizing the total ore and waste in each profile will give a comparatively reliable estimate of presumptive conditions.

On basis of the drilling profiles, the assumed open pit boundaries have been indicated in the drawings No. 14R-1358, -1, -2, -3. Those can be regarded as ultimate pit boundaries considering present drilling results. The pit has been designed to yield a maximum of ore and a minimum of waste.

It shall be pointed out that in practical mining, the pit boundaries will certainly not be the same. For instance it can be assumed that some veins are excavated to deeper levels. This pit design is however a practical method to determine waste--ore ratio and reserves and grade of minable ore, which are the basical data for a further study.

Drawing No. 14R-1358 shows the surface contours of the assumed pit. The smooth contour lines indicate that the pit boundaries designed in the profile can also be achieved practically.

Regarding the pit design, following information can be given:

Inclination of bench face is 70^0 (1 : 3) with a 6' berm left at each bench. No broader safety berms are left, as the granite rock is assumed to be stable.

The bench height has been assumed to be 30', as the selective mining probably will prevent higher benches.

The bottom of the pit is situated at 2 970' level, with exception of profile 5, where one more bench is excavated.

The road, inclined 1 : 12.5 enters the pit in profile 5, where the surface level is lowest. The road will then reach pit bottom in profile 4.

3. Calculation of minable ore and waste

On basis of the pit planning a revised calculation of ore and a calculation of waste to be removed have been carried out. In addition to this the amount of overburden and the oxidized top ore zone (assumed to be 4' thick) have been calculated.

The calculations can be found in the enclosed tables 1 - 4. It should be pointed out that in some cases the grades stated in the reserve report have been adjusted, where the pit does not include the total ore sections. The adjusted grades are underlined in the tables. A summary of the calculations can be found in the table below.

Summary ore waste calculation

Profile	Sh. tons ore	Grade % Mo S_2	Sh. tons waste	Waste/ore ratio	Overburden cu.yd.	Oxidized zone cu.yd.
1	3 558 000	0.20	4 753 000	1.33 : 1	400 000	35 000
2	2 533 000	0.17	4 772 000	1.86 : 1	270 000	24 000
3	1 326 000	0.12	2 422 000	1.83 : 1	250 000	19 000
4	1 116 000	0.42	2 880 000	2.48 : 1	320 000	14 000
5	372 000	0.23	444 000	1.19 : 1	290 000	10 000
Total	8 905 000	0.21	15 091 000	1.7 : 1	1 530 000	102 000

The values from the tables will have to be adjusted somewhat, as the profiles not always give the right impression, especially at the E - W boundaries of the pit. For the following planning of the mine the values below are used.

Ore	8.5 M ton
Waste	16.0 M ton
Waste/ore ratio	1.9 : 1
Overburden	1.5 M y^3
Oxidized zone	100 000 y^3

4. Mine planning

4.1 Assumptions

Yearly production	800 000 ton ore
	1 500 000 ton waste
Initial overburden stripping	200 000 y^3
Yearly stripping	150 000 y^3
No. of shifts per day	2 ?
No. of shifts per year	470
Ore production per shift	1 700 ton
Waste removal per shift	3 200 ton
Overburden stripping per day	640 y^3
Average transport distance from pit to crusher or waste dump	1 mile
Cost figures in	Canadian $ or cent
Ton = short ton	2 000 lbs.

4.2 Capacity of main production equipment

The selective mining with alternating excavation of ore and waste calls for mining machinery of a rather limited size, which can be transported easily from one place to the other. The frequent dislocations affects the capacity of the equipment, which must be estimated somewhat lower than standard practice.

Drilling

Crawler rock drill with about 3" hole diameter will be necessary for the selective mining. A suitable type is Atlas Copco ROC 600, together with the portable compressor PR 600.

Drilling capacity can be estimated to 250' per shift, including dislocations. Drilling pattern 10' x 12' with 38' deep holes for 30' benches, inclined 70° gives 7 tons per foot drilled. The shift capacity will be 1 750 tons and 3 units are required, one in ore and two in waste.

Loading

For the loading standard diesel excavators are assumed, with 2.3 y^3 bucket. The long-period capacity for such an excavator will be about 240 tons/hour.

For removal of overburden the capacity will be about 700 y^3/shift. Four units are required, one loading ore, two waste and one for overburden.

For auxilliary loading a front-end loader with about 3 m^3 bucket is required.

Transport

Standard dump trucks with 40 ton capacity are assumed to be used. With the average 1 mile transport distance two trucks will normally be sufficient per excavator, provided that road dump conditions are good.

4.3 Mining equipment

As the capacity for the various production units corresponds approximately to each other, the total machinery requirement can be combined in four production units. Each unit consists of excavator, trucks and a crawler drill. One unit is used for ore production, two for waste removal and one (without crawler drill and working one shift per day) for overburden stripping. Various auxilliary machinery is required as well as spare units.

In table 5 a complete list of machinery and a calculation of the machinery investment cost can be found. Total machinery investment amounts to ~~2.5 M~~ 2,9 M Can. $.

4.4 Personnel requirement

The personnel requirement for the mine is listed in table 6. The total number of workers in the pit amounts to 55, and an additional 25 are required in workshop and office. The total number of workers and staff including reserves for absences is calculated to 88.

5. Production costs

The production costs are calculated up to delivery at crusher. Cost calculations can be found in tables 7 and 8. The total cost including stripping and waste removal is calculated to 1.80 $ per ton of ore. Labour cost has been estimated to 30 $ per shift.

6. Capital investment

The machinery investment is, in table 5, calculated to 2.5 M $.

Other necessary investments are:

Office incl. laboratory and furiture	100 000 $
Workshop excl. machinery	80 000 $
Warehouse	30 000 $
Other buildings	60 000 $
Preparation of industrial area	80 000 $
Totally	350 000 $

The necessary pre-production costs can also be regarded as investment.

Initial stripping, 200 000 y^3	150 000 $
Road and drop-cut, prep. of dump	200 000 $
Totally	350 000 $

The total investment therefore amounts to 3.2 M $. No investment of social type, houses, canteen etc. is included.

← 421,575

3.6 M

Housing may enter here

7. Depreciation Costs

A five-year depreciation period is estimated for machinery equipment valued at 1, 3 million $. All remaining equipment and investment will last at least 11 years, equal to the approximate lifetime of the planned mine. The yearly depreciation cost will be:

for 5 years: equipment	$ 260,000	
for 11 " : investment	$ 170,000	210,000
	$ 430,000	470,000

No value remaining after the depreciation period.

Per ton depreciation cost = $ 0. 54.

0.59

DENAK

MACHINERY LIST

TABLE 5

MACHINE	PROPOSED TYPE	COST PER UNIT CAN $	NO OF UNITS PROD.	SPARE	TOTAL	TOTAL INVESTMENT
CRAWLER DRILL	ROC 600	22.000 ~~27,000~~	3	2	5	110.000 ~~135 000~~
COMPRESSOR	PR 600	~~14.000~~	3	2	5	~~70.000~~
EXCAVATOR	PH 955A	108.000 OK	4	1	5	540.000
DUMP TRUCK	HAULPAK 40	95.000	8	3	11	1.045.000
FRONT LOADER	Bucket Cap. 3 cu. Hough H90C	~~45.000~~ 55,000	1	-	1	55,000 ~~45.000~~
BULLDOZER	CAT D8 D6H	~~70.000~~ 85,000	2	-	2	170,000 ~~140.000~~
ROAD GRADER	CAT 12	~~30.000~~ 38,000	1	-	1	38,000 ~~30.000~~
JEEP	LAND-ROVER	5.000	2	1	3	15.000
PICK-UP TRUCK		6.000	2	-	2	12.000
CHARGING TRUCK		10.000	1	-	1	10.000
REPAIR TRUCK		15.000	1	-	1	15.000
MOBILE CRANE	LINK-B. HC77	68.000	1	-	1	68.000
SEC. BLAST. EQ.		10.000				10.000
PUMPS		15.000				15.000
WORKSHOP		35.000				35000
TOTAL						2.170.000
VARIOUS, SPARE PARTS ETC.	~ 15%					330.000
TOTAL MACHINERY INVESTMENT						2.500.000

DEPRECIATION PERIOD 10 YEARS,

FOR CRAWLER DRILLS, COMPRESSORS, TRUCKS 5 YEARS

4.2.68

DENAK

LABOUR REQUIREMENT

TABLE 6

	NO OF WORKERS PER SHIFT	DAYSHIFT	TOTAL
PIT			
SHIFT BOSS	2	–	4
DRILLER	3	–	6
BLASTING AND CHARGING	2	–	4
SHOVEL OPERATOR	3	1	7
TRUCK DRIVER	6	2	14
FRONT LOADER OPERATOR	1	–	2
BULLDOZER OPERATOR	1	1	3
ROAD GRADER OPERATOR	–	1	1
SHIFT REPARS AND LUBRICATION	2	–	4
SAMPLER	1	–	2
TRANSPORTS	1	1	3
BULLGANG	2	1	5
PIT TOTAL	24	7	55
WORKSHOP AND STORE			
MEC. ENGINEER			1
FORMAN			1
MECANICS			8
STORE			2
WORKSHOP TOTAL			12
OFFICE			
MANAGER			1
PLANNING ENGINEER			2
SURVEYOR			1
ACCOUNTANT			1
LABORATORY			2
CLERK			3
VARIOUS			3
OFFICE TOTAL			13
RESERVE FOR ABSENCES			8
TOTAL PERSONAL			88
			+ 40

A 59

4.2.68

PRODUCTION COST CALCULATION

TABLE 7

		cents per ton ORE	cents per ton WASTE
1. DRILLING			
ROCK DRILL AND RIG RUNNING COST	6c/ft	0.86	0.86
DRILL STEELS	17c/ft	2.43	2.43
COMPRESSOR RUNNING COST	26 $/shift	1.48	1.48
WAGES (1 MAN / ROCK DRILL)	30 $/shift	1.72	1.72
TOTAL DRILLING		6.49	6.49
2 BLASTING			
BLASTING AGENTS 0.4 lbs/ton à 5c (low)		2.00	2.00
DETONATORS ETC		0.75	0.75
SECONDARY BLASTING		1.20	0.50
WAGES (TOTAL 2 MEN)	60 $/shift	1.22	1.22
TOTAL BLASTING		5.17	4.47
3 LOADING			
EXCAVATOR, RUNNING COST	8.5 $/h	3.50	3.50
FRONT LOADER, RUNNING COST	8 $/h	1.25	1.25
WAGES (3+1 MEN)		2.45	2.45
TOTAL LOADING		7.20	7.20
4 TRANSPORT			
TRUCK, RUNNING COST	9 $/h. cap 12ot	7.50	7.50
WAGES,		3.50	3.50
TOTAL TRANSPORT		11.00	11.00
5. WASTE DUMP			
BULLDOZER, RUNNING COST	6 $/h	—	1.50
WAGES		—	0.95
TOTAL WASTE DUMP		—	2.45
TOTAL COST		29.86	31.51

RUNNING COST INCLUDE REPAIRS.

4.2.62

Denak Mines, Canada. TABLE 8

Calculation of total cost			Cents/ton ore
1. Overburden stripping 0.19 y^3/ton à 75 c.			14.2
2. Oxide zone removal 0.013 y^3/ton à 100 c.			1.3
3. Waste removal 1.9 ton/ton ore à 31.5 c. (table 7)			60.0
4. Ore production (table 7)			29.7
5. Various pit costs			
Roads	2.0		
Sampling	2.0		
Drainage	3.0		
Shift supervision	4.0		
Miscellaneous	8.0		
	19.0		19.0
		Pit total	124.2
6. Workshop and store			
Wages and material not included in running costs			15.0
7. Office and management			
Wages			15.0
Miscellaneous			11.0
		Total	165.2
8. Not specified			14.8
		Total	180.0/ton

C. CRUSHING, GRINDING AND BENEFACTION

Below follows a proposal for a mill. The mill has a capacity of 1, 5 million tons per year. The crushing plant is operated on a two-shift basis, about 12 hours per day, corresponding to 420 tons/hour. The mill is operating some 7, 000 hours per year or 220 tons/hour. Equipment lists and rough drawings are attached.

The materials flow is the following:

The dump trucks unload the ore directly into the gyratory crusher. Then follows a smaller bin, feeder plus a belt conveyor which leads to a double screen. From the screen a middle fraction of 40-75 mm can be removed to be used as pebbles in the pebble grinder. This removal may be continuous or intermittent. After the screen follows a cone crusher. Below there is a belt conveyor which transports the material to a screen followed by another cone crusher. The crushed product (< 20 mm) is fed on a conveyor to stockpiles located outside the plant. The pebbles are transported on a separate conveyor to the same place.

Under these stockpiles there are feeders and conveyors which lead to the plant. The grinding section consists of two parallel circuits, each of 110 tons/hour. The grinding takes place in rod mills working in open circuit with hydrocyclones. Each rod mill is on 5 kwh/ton which should provide sufficient grinding for the raw flotation. The raw concentrate is then further ground.

The raw flotation circuits consist of two parallel series, each with a capacity of 110 tons/hour. First a raw concentrate is obtained which is reground. Then it is flotated in a series consisting of somewhat lesser flotation machines. The final flotation repetition takes place in five steps. A concentrate with a grade of 85 % MoS_2 and with 90 % recovery is obtained. The tailings are pumped to the tailings pit.

The concentrate is pumped to a thickener. The thickened product is filtered on a drum filter. It is then dried so that water content is reduced to about 2 %.

The labour requirements of the mill are one foreman and three workers per shift. Including office staff and maintenance men the total requirements will amount to some 40 men. → 30

The total investment amounts to Sw. Cr. 24, 350, 000, as shown in the attached summary of capital costs. ≈ 5,154,895

For a mill with a capacity of 800,000 tons per year the investment is estimated to 75 % of the above or about $ 3.7 million. The equipment will last more than the mine life, estimated to 11 years. Therefore, the annual depreciation is $ 270, 000 (14 years) or $ 0. 34 per ton.

The production costs of the mill are estimated to $ 1 per ton of ore. Detailed production cost calculations are being done, based on an annual capacity of 800, 000 tons. Also, complete lay-out drawings will be prepared as well as new capital cost estimates.

Molybdenum plant in British Columbia

Crushing station

1. Gyratory crusher, Allis-Chalmers 42 x 65, opening 42" x 108" (105 x 270 mm), capacity 600 tons/h at 5" O.S.S.

2. Bin 500 tons volume

3. Feeder 500 tons/h

4. Belt conveyor 1000 mm x 30 m

5. Screen 6' x 14', 3" resp. 1 1/2" mesh openings

6. Cone crusher, Allis-Chalmers 108¼, 3/4" O.S.S. 350 hp motor

7. Belt conveyor

8. Screen 6' x 20', 7/8" mesh openings

9. Cone crusher, Allis-Chalmers 58¼, 3/8" O.S.S. 350 hp motor

10. Belt conveyor 1000 mm x 60 m

11. Belt conveyor 650 mm x 60 m

Molybdenum plant in British Columbia
Grinding section

1. 10 units feeders (cyclic feeding), each 220 tons/h

2. One belt conveyor 800 mm x 50 m

3. Two feeders (pebbles)

4. Two belt conveyors (pebbles) with scales 650 mm x 50 m

5. One distributing bin

6. Two belt feeders + scales

7. Two rod mills 10' x 16' 600 kW including motors etc.

8. Two pebble mills 13' x 14' 600 kW including motors etc.

9. Four pumps 6"

10. Four pumps 8"

11. Twelve hydrocyclones D20LB

Molybdenum plant in British Columbia

Flotation section

1. 2 x 10 double cell flotation machines
   BFP-240-2B

2. 10 double cell flotation machines
   BFP-120-2B

3. 5 double cell flotation machines
   BFP-120-2L

4. One ball mill 10' x 10'
   400 kW

5. 10 pumps 6" x 4"

6. One blowing machine
   (flotation low pressure air)

7. Two tailings pumps 12"

8. Reagent feeders

Molybdenum plant in British Columbia

Concentrate handling section

1. Thickener dia. 30 ft

2. Drum filter TF-58
   12 m^2 filter area
   including vacuum station

3. Dryer dia. 4 ft x 12 ft
   including burner equipment, fans, etc.

Molybdenum plant in British Columbia
Summary of capital costs

Kvarnar
,2117

		Swed. Crowns Sw. Kr.
Crushing plant		3.100.000:-
Grinding section		3.950.000:-
Flotation section		2.000.000:-
Concentrate handling section		250.000:-
Instrumentation		200.000:-
		9.500.000:-
Unforeseen 10%		950.000:-
Equipment total		10.450.000:-
Crating, transport, insurance 15% of total equipment costs		1.600.000:-
Buildings 65% of total equipment costs		6.750.000:-
Investment costs total	$3,979,960	18.800.000:-
Mechanical and electrical erection costs including pipework 25% of total equipment costs		2.650.000:-
Central switch control room 14% of total equipment costs		1.450.000:-
Engineering 14% of total equipment costs		1.450.000:-
Total costs		24.350.000:-

does not appear to be included on page 41

5,154,895
3,979,960
Diff. $ 1,174,935

5,154,895

D. FINANCIAL ASPECTS

The calculations below are based on a production rate of 800,000 tons per year.

Investment

The total investment is estimated to be the following:

Mine pre-production expenses:	$ 350,000 - Page 20
Mine machinery investment:	" 2,500,000 Table 5
Office, workshops, buildings, etc.:	" 350,000 Page 20
Crushing, grinding and benefaction:	" 3,700,000
	$ 6,900,000

Projected Profit and Loss Statement

Revenues:		$ 3,500,000
Production costs		
mining	$ 1,80 /ton = $ 1,440,000	
milling	$ 1,00 /ton = $ 800,000	
	$ 2,240,000	
Depreciation:		
mine	$ 0.54 /ton = $ 430,000	
mill	$ 0.34 /ton = $ 270,000	
	$ 700,000	
Total Costs:		$ 2,940,000
Net profit before tax		$ 560,000
Net profit after tax (50 %)		$ 280,000
Depreciation		$ 700,000
Cash Flow (excluding tax)		$ 1,260,000
Cash Flow (including tax)		$ 980,000

Pay-back period

The two pay-back periods are the following:

Excl. tax $\frac{6,900,000}{1,260,000} = 5,5$ years

Incl. tax $\frac{6,900,000}{980,000} = 7$ years

Discounted cash-flow calculations

The calculation for the rate of return according to the discounted cash flow method for the case of no tax is shown below:

Year	Cash out-lay	Cash Flow	Discount Factor (14 %)	Discounted Cash Flow
0	6,900,000		0	
1		1,260,000	0,877	1,000,000
2		"	0,769	960,000
3		"	0,675	850,000
4		"	0,592	750,000
5		"	0,519	660,000
6		"	0,456	570,000
7		"	0,400	510,000
8		"	0,351	440,000
9		"	0,308	390,000
10		"	0,270	340,000
11		"	0,237	300,000
TOTAL	6,900,000			6,900,000

Thus, the rate of return is 14 %. If the corresponding calculation is made for the cash flow based on 50 % corporate tax, the rate of return will amount to 10 %.

E. SUMMARY AND CONCLUSIONS

The report starts with an assessment of the market for molybdenum. Based on Dr. Tryggve Eriksson's report on exploration drilling results, dated January 25, 1968 the feasibility of exploiting the ore body has been examined. In the above mentioned report ore reserves are calculated to be 11, 6 million tons with 0.17 % MoS_2. The cut-off grade in the calculations is 0.08 % MoS_2.

An open pit has been designed with assistance of the drilling profiles, in order to excavate an economical maximum of the ore. The design results in the following minable reserves and waste:

8.5 million tons of ore with 0.21 % MoS_2
16.0 million tons of waste
1.5 million y^3 overburden

The ore production is taken to 800, 000 tons per year and involves consequently a stripping of 1.5 million tons of waste yearly. Working two shifts per day and 235 days per year results in shift production of 1, 700 tons of ore and 3, 200 tons of waste. The following are the key mining data:

Mine machinery investment	$ 2.5 million
Other investment	$ 0.7 "
Total number of staff and workers	80
Production costs	$ 1.80/sh. ton
Depreciation costs (annual)	$ 0.54/sh. ton

The mill has been designed including circuits for crushing, grinding, flotation and drying. The total investment in the mill is estimated to $ 3.7 million and the production cost to $ 1.00/ton. The depreciation is estimated to amount to $ 0.34 annually.

The pay-back period will vary between 5. 5 and 7 years. The rate of return according to the discounted cash flow method amounts to 10 to 14 % annually. The mine and mill calculations are conservatively calculated. If conditions turn out to be favourable, it may very well be possible to trim the operations for an increase in production of approximately 10 % with a corresponding improvement in profitability.

Thus it appears that the ore body can be commercially exploited as a fully independent operation. The project is enhanced by the fact that further exploration in the area may very well block out additional reserves.

* * * * * .