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INTEROFFICE MEMORANDUM

December 1, 1969

Mr. C. T. Penney, General Manager
B. C. Molybdenum Ltd.

Subject: British Columbia Molybdenum Limited - Ore Reserves

At the oral request of Mr. C. T. Penney, General Manager, B. C. Moly, I visited the property from November 5th through 11th to review B. C. Moly's latest ore reserve estimates. These ore reserves were prepared as a preliminary to determine whether an expansion of the operation would improve its economic prospects.

## Summary

The ore reserves have been re-estimated both manually and by computer to incorporate recent drilling results and using costs which the mine estimates would be attainable on a 12,800 TPD operation. A break-even pit limit increment was determined using a pit limit cut-off grade of 0.113% $MoS_2$, variable stripping ratios and a stripping cost of $0.32 per ton waste. A pit limit slope of 45° was used. Close agreement was reached between the manually estimated and computerized ore reserves because the same distribution of values based on DDH assay results and geological predictions was used in both cases. The computerized ore reserves are:

> 119,419,326 tons at a grade of 0.181% $MoS_2$ with an overall strip ratio of 1.48:1 and a milling cut-off grade of 0.113% $MoS_2$. Within this pit there are 82,656,000 tons with a grade of 0.207% $MoS_2$ and a strip ratio of 2.6:1, using a milling cut-off grade of 0.16% $MoS_2$.

I checked the ore reserves by reviewing the level maps and sections and by manually estimating the stripping ratios at the pit limits on six sections and found that, with the parameters used, they are valid.

## OPINION

I am concerned about the inclusion of the deep ore (amounting to roughly 20,000,000 tons below the 1360' level), in the positive ore reserves for the following reasons:

1. The stripping cost of $0.32 per ton used in the determination of the pit limit increment is, in my opinion, too low in light of the current mining and stripping costs of $0.43/ton.

2. Inclined holes have shown that grade cut-offs within the ore body are sharp and are vertical. These inclined holes are relatively shallow and although deep drilling has indicated that the ore body extends to depth, the distribution of values and the outline of the ore body, particularly below the 1360' level, have had to be determined mainly by geological interpretation. Deep and sparsely drilled ore reserves of this nature should be called "probable" ore.

The pit limit cut-off grade was derived from the mine's estimate of what the operating costs would be for a 12,800 TPD operation. Even if the parameters used were valid, the ore reserves would not be valid until approval has been given for the expenditure of funds on an expansion. For reporting purposes for January 1970, it is recommended that the January 1969 ore reserves, amended to take into account mining during the past year, be used. These ore reserves (1/1/69) were:

| | Tons | $\%MoS_2$ |
|---|---|---|
| Positive Ore, 0.16% $MoS_2$ Cut-off | 37,792,000 | 0.23 |
| Probable Ore, 0.10% $MoS_2$ Cut-off | 36,000,000 | 0.15 |
| Total Ore, 1/1/69 | 73,792,000 | 0.19 |

Ore reserves estimated by using a pit limit break-even cut-off grade include an unknown quantity of ore which cannot support depreciation of the existing plant or depreciation of capital expenditures on new plant. They cannot, therefore, be used "per se" for expansion considerations, but must be broken down into mining periods to reflect the order in which the ore will be mined. The most convenient way of developing these mining periods is to compute ore inventories using a series of arbitrary pit limit cut-off grades, e.g. 0.24%, 0.20%, 0.16%, 0.14%, 0.12%, 0.10% and 0.08% $MoS_2$, giving rise to several essentially concentric pits. The highest cash flow pit, i.e., the one with the highest pit limit cut-off grade will be mined first followed by the one with next highest pit limit cut-off grade, and so on until the break-even pit limit increment is reached. Practical operating slopes are used in all the

pits except the last when the slope is steepened to an engineered safe slope. The contents of the ore inventories in terms of different mill cut-off grades will be developed at the same time as the ore inventory is developed.

With the above data, fourteen financial evaluations can be prepared. In each evaluation, mining will be in the sequence of high cash flow pit through intermediaries to the break-even pit and each evaluation will include the most financially attractive method of handling depreciation. The fourteen financial evaluations would be based on:

1. Two production rates - the present 6,400 TPD and an expanded operation of 12,800 TPD.

2. For each production rate, seven milling cut-off grades, namely 0.24%, 0.20%, 0.16%, 0.14%, 0.12%, 0.10% and 0.08% $MoS_2$.

The evaluation which gives the highest net present value will be the one which indicates future action in the sense of whether an expansion is worthwhile and what the milling cut-off grade should be. The ore inventory which provides the highest net present value, providing the parameters used in respect to production rate and mill cut-off grade are implemented, will then become the ore reserves of the mine. In the meantime, it is recommended that the January 1969 ore reserves updated for operations during 1969 be amended to January 1970 reporting.

## ORE RESERVE ESTIMATES

The ore reserves estimated both manually and by computer based on 0.113% $MoS_2$ pit limit cut-off and variable stripping ratios are:

| | Tons Ore | Grade | Waste | S.R. |
|---|---|---|---|---|
| Manual | 129,641,400 | 1.180% $MoS_2$ | 223,378,000 | 1.72:1 |
| Computer | 119,419,326 | 0.181% $MoS_2$ | 176,927,436 | 1.48:1 |

### Parameters

In estimating B. C. Moly's ore reserves, the pit limit increment was determined on the valid basis that, in any open pit, mining will continue until such time as the mining and processing of an increment does not provide a cash flow. In this increment the revenue from a block of ore on surface is required to cover operating costs, through to sales, including its share of replacement capital necessary to maintain operations but excluding depreciation of existing plant. The grade of this block is the pit limit cut-off grade. A block of ore at depth is required to be of a higher grade such that the additional revenue over and above that of a cut-off grade block will cover the costs of stripping necessary to expose it for mining.

The parameters used in both manual and computerized reserves were:

| | |
|---|---|
| Ultimate pit slope | 45° |
| Minimum pit bottom width | 120' |
| Pit limit cut-off grade | 0.113% $MoS_2$ |
| Stripping cost | $0.32 per ton waste |

The ultimate pit slope is conservative. Studies by Mr. K. H. Rippere of MMD-ED indicate that the following safe ultimate pit slopes are feasible:

49° in the NE quadrant
55° in the SE quadrant
60° in the SW quadrant, and
38° in the NW quadrant.

The minimum pit bottom width is realistic.

The critical parameters which affect the ore reserve estimate are the pit limit cut-off grade and the stripping cost.

Pit Limit Cut-off Grade

The operating costs used for determining the cut-off grade are shown below together with B. C. Moly's operating costs for Jan. - Sept. 1969:

| | B. C. Moly's Costs Jan. - Sept. 1969 $/ton ore | Costs Used for Cut-off Grade $/ton ore |
|---|---|---|
| Mining (w/o stripping) | 0.453 (1) | 0.430 |
| Concentrating | 1.040 | 0.800 |
| General Plant | 1.111 | 0.795 |
| Depreciation | 0.656 | 0.107 (2) |
| Sales @ $0.059/lb Mo | 0.143 | 0.072 |
| | $3.403 | $2.204 |

(1) Includes $0.02 per ton deferred expense amortization.

(2) For replacement capital of $500,000 per year only.

The cut-off grade used, 0.113% $MoS_2$ would yield 1.22 lbs Mo/ton ore for sale assuming a 90% mill recovery at this grade. Revenue at $1.80 per lb Mo would, therefore, be $2.196 per ton ore which equates with the operating costs used.

The costs used for the cut-off grade are the mine's estimate for a milling rate of 12,800 TPD. The ore reserves developed are, therefore, on this one factor alone, only suitable for a 12,800 TPD operation and could not be justified for the present production rate.

For reporting purposes the ore reserves should be based on the present production capacity and associated costs.

Stripping Costs

The cost of stripping used in pit limit determinations has a profound effect on the magnitude of the ore reserves. A ton of ore which will support four tons of stripping at, say, 32¢/ton of stripping will only support two tons of stripping at 64¢ per ton of stripping.

It is my opinion that the stripping cost of 32¢/ton used in the determination of the ore reserves, compared with the current stripping cost of 43¢/ton, is too low.

The use of a lower than current stripping cost which is out of line with current KCC practice would:

1. Be suspect in the eyes of KCC's Management and almost impossible to defend. The first step in determining the best course of action for B. C. Moly and obtaining acceptance for such a course is to develop ore reserves which are defensible.

2. Include in the reserves, ore at depth which is mined toward the end of the life of the mine and which, because of the time value of money has little effect on the NPV. This ore, in any event, is sparsely drilled and its existence is due almost entirely to geological predictions.

For the above reasons I recommend using a stripping and mining cost of 43¢ per ton material, assuming that higher future haulage costs will be offset by future operating economies. This would follow the practice used in the other Divisions where current mining and stripping costs are used for long-range ore reserve calculations.

Manual Estimation of Ore Reserves

The ore reserves were prepared manually by Mr. Eldon Bray, Supervisor of Engineering and Geology at B. C. Moly. The method used was:

1. Sections of the ore body were prepared, from DDH assay information and using judgment to delineate ore containing 0.100% - 0.159%, 0.160% - 0.239%, 0.240% - 0.319%, and + 0.320% $MoS_2$ together with waste below 0.099% $MoS_2$. Inclined DDH's have indicated steep assay cut-off walls, and this information was used in the sections to delineate ore grades.

2. Leval maps were prepared at 35' bench height intervals, containing color contours of the different grades of ore and waste.

3. A stripping ratio graph was prepared (Exhibit 1) showing acceptable stripping ratios for the pit limit increment against the grade of the ore. For this purpose a pit limit cut-off grade of 0.113% $MoS_2$ (based on estimated operating costs for a 12,800 TPD operation of $2.204 per ton ore excluding stripping but including depreciation of replacement capital) and a stripping cost of 32¢/ton was used.

4. An ultimate pit slope of 45° and a minimum 120' pit bottom width were used.

5. Leval maps of segments of trial pits were drawn and the waste content compared with the contained ore grade. By a process of trial and error an ore reserve was developed which conformed with the stripping ratio graph.

Computer Estimation of Ore Reserves

Subsequently (Sept. 21, 1969), the ore reserves were estimated by computer using the following parameters:

1. Geological model and level maps as prepared manually.

2. A pit limit cut-off grade of 0.113% $MoS_2$ and a stripping cost of $0.32 per ton. (Same as manual.)

3. An ultimate pit slope of 45° and a minimum 120' pit bottom width. (Same as manual.)

4. Blocks sized 25' x 25' x 35' bench height.

The computerized ore reserves are:

| 0.113% $MoS_2$ Pit Limit Cut-off, Variable Stripping Ratios | | | | |
|---|---|---|---|---|
| Mill Cutoff | Tons Ore | Grade | Tons Waste | S.R. |
| 0.113% $MoS_2$ | 119,419,326 | 0.181% $MoS_2$ | 176,927,436 | 1.48:1 |
| 0.160% $MoS_2$ | 82,656,800 | 0.207% $MoS_2$ | 213,689,962 | 2.59:1 |

These are in close agreement with the manual estimates of ore reserves, but, because the geological model and interpretation of values were the same in both cases, it is simply a tribute to the meticulous accuracy and care used by Mr. Eldon Bray in his manual computation.

## EXAMINATION OF ORE RESERVES

1. The files contain a substantial amount of correspondence between Mr. Eldon Bray and the S&ECC concerning DDH bearings, collar locations, depth of holes, etc. and it is accepted that the information used in this regard is correct.

2. For checking the ore reserves, the graph showing supportable stripping ratio vs. ore grade developed by the mine was used.

3. Using the ultimate pit contour map (Exhibit 2) and sections of the ore body prepared by Mr. Eldon Bray, six sections were drawn showing the relationship of the ore to the ultimate pit on E104,500; E105,000; E105,600; N106,800; N107,400 and N180,000 (Exhibit 3). The pit limit stripping ratio was determined from the sections so drawn and compared with the supportable stripping ratio graph. In each case, it was found that the ore at pit limits could support a larger amount of stripping than was indicated by the supportable stripping ratio graph used in the ore reserve estimation.

4. A detailed check of the grade colored contour level maps from the 2025' level to the 835' level was made to determine to what extent the geological predictions concerning the extension of the ore body away from drill holes influenced the magnitude of the reserves. A portion of the worksheet covering levels 1360' and below and the 1430' level map are attached (Exhibits 4 and 5) and reveal that:

    a. There is a dearth of DDH information between D47 on the west and D11 on the east; that is, over most of the NE, N, and NW portions of the ore body from the 1430' level down.

b. DDH or assay information is available from 13 holes on the 1360' level, reduced to 6 on the 1185' level, to 3 on the 975' level, and 2 on the 905' level and below.

Ore down to the 1360' level is well covered by drilling and can be termed "proven ore". Ore below the 1360' level should be classified as "probable ore."

## DETERMINATION OF OPTIMUM ORE RESERVES

An improvement in operating costs has been recorded over the past year, such that B. C. Moly is now making a working profit, but this is insufficient to cover the interest payments on the debentures. An expansion of the operation to 12,800 TPD by mining ore to a lower cut-off grade with a consequent reduction of operating costs due to a bigger spread of the overheads is presently considered the most likely way of improving the economics of the operation.

However, care has to be taken in the use of ore reserves which have been estimated using a break-even pit limit increment for expansion purposes. Included in such ore reserves is an unknown quantity of ore which does not support depreciation of the existing plant, nor does it support the depreciation of capital expended on an expansion. From one pit it is impossible to estimate the quantity of this marginal ore. The only satisfactory way of determining "optimum ore reserves" for any property ("optimum" in the sense of providing maximum net present worth, maximum overall profits, maximum production of metal, or any other maximum required) is to estimate several ore inventories using a range of pit limit cut-off grades producing essentially a series of concentric pits. The pit with the highest pit limit cut-off grade is mined first followed by the others in sequence through to the break-even pit limit pit. Practical working slopes are used for all pits except the break-even pit limit pit where the slope is steepened to an engineered safe slope. Financial evaluations are then done at different milling cut-off grades and different rates of production, using the most advantageous method of handling depreciation and taxes. A comparison of the financial evaluations will reveal which of the ore inventories is most satisfactory for the "optimum" required, and this inventory then becomes the ore reserve for the time.

Important - For annual reporting purposes the ore reserves must be based on the current operating capacity of the mine. Ore reserves selected for expansion purposes must remain in embryo and used as supporting data only, until such time as the expenditure of funds on such an expansion is approved.

B. C. Moly Ore Reserves

In the case of B. C. Moly, the optimum ore reserves required are those that will, when milled at some to-be-determined-rate, yield the highest net present worth.

The recommended sequence for determining such ore reserves is as follows:

1. Computerize 7 ore inventories using the following parameters:

   a. Pit limit cut-off grades of 0.24%, 0.20%, 0.16%, 0.14%, 0.12%, 0.10% and 0.08% $MoS_2$.

   b. Stripping cost @ 43¢ per ton.

   c. Pit slopes of 45° throughout. Because of the configuration and the method of mining the ore body, an operating slope of 45° can be used.

2. Prepare 14 financial evaluations using the following parameters:

   a. Ore to be mined in sequence using the high cash flow (0.24% $MoS_2$ pit limit cut-off grade first).

   b. Two milling rates to be used - 6,400 TPD and 12,800 TPD.

   c. With each milling rate, milling cut-off grades of 0.24%, 0.20%, 0.16%, 0.14%, 0.12% 0.10% and 0.08% $MoS_2$ to be used.

   d. The best presently estimated capital costs for mill expansion, ancillaries, townsite, etc., and mine equipment to be incorporated where applicable.

   e. Determine the NPV of the mine in each case.

An examination of the financial evaluations will reveal whether or not an application for funds for the engineering of an expansion can be supported.

J. L. Halls

JLH:ff
Encl.
cc: Mr. S. D. Michaelson