ADANAC DEPOSIT 861502

Ore Reserve Estimate Using Kriging

J.A. Brunette March 1980

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SUMMARY

1. The Adanac orebody was modelled using kriging to interpolate the molybdenum grades. The geological ore reserves are estimated as:

Cut-off % Mo	Tons '000s	Grade % Mo
.04	186,831	.061
.06	78,734	.079

2. The mineable reserves in the deposit have been estimated for two metal prices and corresponding minimum profit margins.

Mo Price Minimum Profit	Total Tons '000s	Waste Tons '000s	Ore Tons '000s	Mo %	Strip Ratio
$9.94 U.S. $1.75 min.	466,615	299,930	166,685	.063	1.80
$8.87 U.S. $1.00 min.	369,009	217,038	151,971	.063	1.43

DATA

1. The data used in the study was basically the same as that used in December 1977. An additional 39 holes (200 - 238) were drilled in 1979, but these were located in the Stage 1 and Stage 2 area of the 1977 design.

2. All MoS_2 assays were converted to Mo as MoS_2 assays.

3. The assays used from the pre-1977 data were those selected as the most reasonable in 1977.

4. The coordinate system used in this study is the UTM metric system and all hole coordinates were converted to this system. This conversion involves a slight rotation of the axes - see the attached notes from Hosford, Impey and Welter Limited.

5. The topography digitized for the 1977 study was converted to UTM metric and utilized again. Additional topography was required to the south and west. For some reason no maps south of 6,619,600 N were converted to UTM metric so an old 1" = 500' map was digitized and converted to UTM metric.

6. When the pre-1977 holes were converted to UTM metric and Mo, they were also renumbered to make them simpler to identify.

7. The "Geostatistical Study of the Adanac Deposit" by M. Dagbert and M. David was used as a reference and source of data.

8. The specific gravity of the ore and waste was taken as 2.65 and that of the overburden as 1.8.

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KRIGING

1. The Exploration Department decided to use kriging to estimate the reserves of the deposit. A.J. Sinclair of U.B.C. was retained to provide guidance with the geostatistics and kriging.

2. The geostatistical study made by David was examined by Sinclair who could see no reason for not using the variogram models contained in it. The drilling completed in 1979 did not suggest anything at variance with the existing information.

3. It was agreed to model the orebody in terms of 30 x 30 x 12 metre blocks and make use of the computer to determine each block uniquely from the surrounding samples.

4. From the "Geostatistical Study of the Adanac Deposit":

   a) We are dealing with relative variograms in this section. The vertical and horizontal variograms are thought to represent the same grade structures, however they show directional anisotropy and the ranges are quite different. For punctual samples the vertical range of the first spherical component is 50 feet and the horizontal range for the same component is 600 feet. This means that there is a geometrical anisotropy ratio of 12. Samples taken 50 feet apart vertically are as different as samples taken 600 feet apart horizontally. There appears to be no anisotropy in the horizontal plane.

   b) The model of the vertical relative variogram when regularized for 40 foot composites (we are using 12 m = 39.37') is given as:

$$\gamma(h) = 0.15 + 0.24\,(1.5\,(h'/27.4) - 0.5\,(h'/27.4)^3) + 0.05\,(1.5\,(h'/88.4) - 0.5\,(h'/88.4)^3) \qquad h' \leq 27.4 \text{ m}$$

$$= 0.39 + 0.05\,(1.5(h'/88.4) - 0.5\,(h'/88.4)^3) \qquad 27.4 \text{ m} < h' \leq 88.4 \text{ m}$$

$$= 0.44 \qquad h' > 88.4 \text{ m}$$

   where $h' = \sqrt{(0.15\,h_x)^2 + (0.15\,hy)^2 + hz_2}$

   h' adjusts the distance between points for the anisotropy. This model was the one used to generate gamma values for kriging.

5. The density of the data varies considerably across the deposit. In the Stage 1 and Stage 2 areas there is a drill hole spacing of approximately 30 metres, however there are also duplicate holes in some locations. To the south-west the spacing goes out to 120 metres or more.

   The area out of which information was selected to calculate each block was related approximately to the density of the information. In the least dense areas the maximum area was a flat circular disk of radius 195 metres. This is just over the range of the first structure in the variogram.

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The number of composites used in calculating a block ranged from 1 on the margins of the orebody to over 35 in the Stage 1 and Stage 2 area.

6. The ground to the north of the Adera fault was considered to be barren. To reflect this, holes on the northern side of the fault were removed from the data and the interpolation was cut off at the fault line.

   To the south and west the orebody was limited to a line running approximately through the outermost drill holes.

7. As the estimated grades of each block were calculated the variance of this estimate and the number of compesites going into the estimate were recorded.

8. The model was kriged down to 1,292 bench. Below 1,292 m the data becomes more widely spaced.

9. The topography and overburden were edited into the orebody to complete the model.

GEOLOGICAL RESERVES

1. The geological reserves were calculated down to 1,292 m which is the bottom bench in the model. There is data below 1,292 m, but much less than above 1,292 m.

2. Table 1 shows the in situ reserves by Mo cut-off. The 0.0% Mo cut-off includes all material that has a grade associated with it.

Table 1

Adanac Geological Reserves to 1,292 m

Cut-off % Mo	Tons '000s	Grade % Mo
0.00	584,478	.033
0.01	521,857	.036
0.02	371,573	.045
0.03	272,863	.053
0.04	186,831	.061
0.05	124,697	.070
0.06	78,734	.079
0.07	47,252	.090
0.08	26,674	.102
0.09	15,941	.113
0.10	10,217	.124

3. Figure 1 shows a histogram of the kriged block grades.

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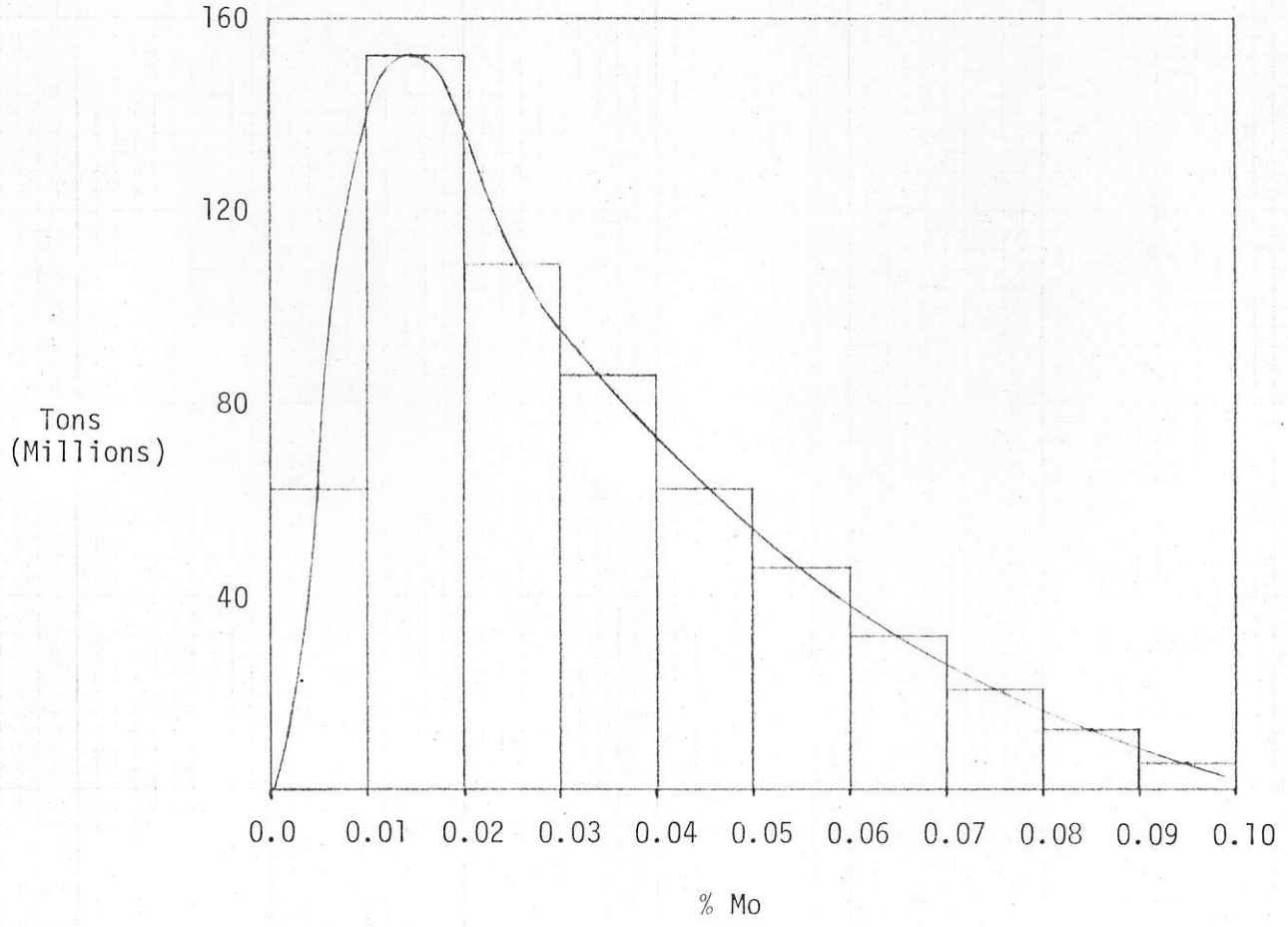

Figure 1

Adanac: Histogram Of Kriged Block Grades

MINING RESERVES

1. The economic and other parameters used for the pit designs were as follows:

   1st quarter 1980 dollars.

   50% probable molybdenum price U.S. $9.94/lb Mo in MoO_3 fob mine.
   70% probable molybdenum price U.S. $8.87/lb Mo in MoO_3 fob mine.

   $1 Cdn. = $0.95 U.S.

   Roaster recovery of Mo from MoS_2 to MoO_3 99%
   Freight, roasting, packing, etc. $0.58/lb

   Recovery in milling defined by constant 0.01% Mo tailing.

Mining Cost	$0.77/ton mined
Milling Cost	$2.49/ton milled
Overhead	$1.46/ton milled
	$4.72

   Hence value of Mo per pound recovered is:

50% price	$9.78/lb Mo rec.
70% price	$8.67/lb Mo rec.

   Slope angle is nominally 45^{o}.

2. Two ultimate pits were designed down to the 1,304 m elevation.

   a) Using the 50% probable molybdenum price (U.S. $9.94) plus a $1.75 minimum profit per ton to give a design cut-off grade of 0.04% Mo.

   b) Using the 70% probable molybdenum price (U.S. $8.87) plus a $1.00 minimum profit per ton to give a design cut-off grade of 0.04% Mo.

   The total mining reserves under these two sets of conditions are given in Table 2.

Table 2

Adanac Mineable Reserves With Two Alternative Design Schemes

0.04% Mo Cut-off Grade — Thousands of Tons

Parameters	Total Tons	Waste Tons	Ore Tons	% Mo	Strip Ratio
(a)	466,615	299,930	166,685	.063	1.80
(b)	369,009	217,038	151,971	.063	1.43

a) 50% probable molybdenum price U.S. $9.94 - $1.75/ton minimum profit.
b) 70% probable molybdenum price U.S. $8.87 - $1.00/ton minimum profit.

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PRODUCTION SCHEDULE

1. Alternative stage designs were made to allow for two production schedules. Schedule "A" runs with a 0.04% Mo cut-off for the life of the mine while Schedule "B" has a 0.06% Mo cut-off for the first six years of production and a 0.04% Mo cut-off subsequently. Material (0.04 - 0.06% Mo) stockpiled in Years 1 to 6 is reclaimed in Years 9 to 13.

2. The ultimate pit design used was the 70% probable molybdenum price plus $1.00 minimum profit.

3. Beyond year thirteen the schedules were run at approximately the remaining stripping ratio and not investigated in any detail.

4. Tables 3 and 4 show the stages used to produce Schedules "A" and "B".

Table 3

Adanac Mineable Reserves for Schedule "A"

0.04% Mo cut-off — Thousands of Tons

Stage	Total Tons	Waste Tons	Ore Tons	% Mo	Strip Ratio
1	17,973	8,214	9,759	.102	0.84
2	29,493	9,116	20,377	.079	0.45
3	62,683	32,546	30,137	.065	1.08
Ult.	258,860	167,162	91,698	.055	1.82
Total	369,009	217,038	151,971	.063	1.43

Table 4

Adanac Mineable Reserves for Schedule "B"

0.06% Mo and 0.04% Mo Cut-off — Thousands of Tons

Stage		Total Tons	Waste Tons	Ore Tons	% Mo	Strip Ratio
1	(.06)	16,285	8,214	8,071	.113	1.23*
	(.04)	1,688	-	1,688	.049	-
2	(.06)	35,573	14,194	21,379	.084	0.92*
	(.04)	5,524	-	5,524	.050	-
3	(.04)	51,079	27,468	23,611	.063	1.16
Ult.	(.04)	258,860	167,162	91,698	.055	1.82
Total		369,009	217,038	151,971	.063	1.43*

* Includes stockpiling, but not the reclaim from stockpiling.

There are also 28,000 tons stockpiled from Stage 3 during stripping.

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Adanac Deposit

Schedule "A"

Ultimate is based on 70% price + $1.00 minimum profit.
Cut-off is 0.04% Mo: 4,900,000 tons milled per year.

Thousands of Tons

Year	Total Tons	Waste/Low Grade Tons	Ore Tons	% Mo	Strip Ratio
Pre.	5,300	5,214	(86)	.043	-
1	9,800	4,900	4,900	.088	1.0
2	9,800	4,900	4,900	.105	1.0
3	9,800	4,900	4,900	.074	1.0
4	12,250	7,350	4,900	.085	1.5
5	12,250	7,350	4,900	.079	1.5
6	12,250	7,350	4,900	.088	1.5
7	12,250	7,350	4,900	.068	1.5
8	12,250	7,350	4,900	.056	1.5
9	12,250	7,350	4,900	.068	1.5
10	12,250	7,350	4,900	.069	1.5
11	12,250	7,350	4,900	.064	1.5
12	12,250	7,350	4,900	.068	1.5
13	12,250	7,350	4,900	.063	1.5
14	12,250	7,350	4,900	.055	1.5
15	12,250	7,350	4,900	.055	1.5
16	12,250	7,350	4,900	.055	1.5
17	12,250	7,350	4,900	.055	1.5
18	12,250	7,350	4,900	.055	1.5
19	12,250	7,350	4,900	.055	1.5
20	12,250	7,350	4,900	.055	1.5
21	12,250	7,350	4,900	.055	1.5
22	12,250	7,350	4,900	.055	1.5
23	12,250	7,350	4,900	.055	1.5
24	12,250	7,350	4,900	.055	1.5
25	12,250	7,350	4,900	.055	1.5
26	12,250	7,350	4,900	.055	1.5
27	12,250	7,350	4,900	.055	1.5
28	12,250	7,350	4,900	.055	1.5
29	9,400	4,500	4,900	.055	0.92
30	9,400	4,500	4,900	.055	0.92
31	9,274	4,374	4,900	.055	0.89
32	71	-	71	.055	-
Total	369,095	217,038	151,971	.063	1.43

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Schedule "B"

Ultimate is based on 70% price + $1.00 minimum profit.
Cut-off is 0.06% Mo for first six years (stockpile 0.04 - 0.06) then 0.04% Mo for rest of life: 4,900,000 tons milled per year.

Thousands of Tons

Year	Total Tons	Waste/STKP Tons	Ore Tons	% Mo	Strip Ratio	Cut-off % Mo	
Pre.	7,000	7,000	-	-	-	-	
1	11,300	6,400	4,900	.109	1.31	.060	
2	11,300	6,400	4,900	.106	1.31	.060	
3	12,250	7,350	4,900	.088	1.50	.060	
4	12,250	7,350	4,900	.080	1.50	.060	
5	12,250	7,350	4,900	.087	1.50	.060	
6	12,250	7,350	4,900	.083	1.50	.060	
7	12,250	7,350	4,900	.061	1.50	.040	
8	12,250	7,350	4,900	.062	1.50	.040	
9	12,250	7,350	4,900	.059	1.50	.040	↑
10	12,250	7,350	4,900	.063	1.50	.040	STKP
11	12,250	7,350	4,900	.059	1.50	.040	Rec.
12	12,250	7,350	4,900	.062	1.50	.040	
13	12,250	7,350	4,900	.058	1.50	.040	↓
14	12,250	7,350	4,900	.055	1.50	.040	
15	12,250	7,350	4,900	.055	1.50	.040	
16	12,250	7,350	4,900	.055	1.50	.040	
17	12,250	7,350	4,900	.055	1.50	.040	
18	12,250	7,350	4,900	.055	1.50	.040	
19	12,250	7,350	4,900	.055	1.50	.040	
20	12,250	7,350	4,900	.055	1.50	.040	
21	12,250	7,350	4,900	.055	1.50	.040	
22	12,250	7,350	4,900	.055	1.50	.040	
23	12,250	7,350	4,900	.055	1.50	.040	
24	12,250	7,350	4,900	.055	1.50	.040	
25	12,250	7,350	4,900	.055	1.50	.040	
26	12,250	7,350	4,900	.055	1.50	.040	
27	12,250	7,350	4,900	.055	1.50	.040	
28	12,250	7,350	4,900	.055	1.50	.040	
29	9,400	4,500	4,900	.055	0.92	.040	
30	9,400	4,500	4,900	.055	0.92	.040	
31	9,278	4,378	4,900	.055	0.89	.040	
32	71	-	71	.055	-	.040	
Total	376,249	224,278	151,971	.063	-	-	

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