ore reserves

861504

PLACER DEVELOPMENT LIMITED

MEMORANDUM:

TO:	W. A. Triggs	DATE:	18 February 1980
FROM:	H. J. Matheson	FILE:	V. #164
RE:	GEOLOGIC RESERVES - ADANAC.		

Geologic reserves for the Adanac property have been calculated in cooperation with the Computer group. Interpolation between drill holes was calculated by the kriging method rather than inverse squares resulting in definition of substantial volumes previously undefined. Reserves were also added by the drilling program peripheral to the previously known mineralization. Geologic reserves are as follows:-

270,000,000 tons at 0.053% Mo at .03 Mo cut-off, or

187,000,000 tons at .061% Mo at .04% Mo cut-off.

Should these figures be tonnes?

H. J. MATHESON.

HJM:mg

cc: L. Adie/file
D. C. Rotherham/D. A. Howard
S. J. Tennant

ANALYSIS OF A RECENT RE-ESTIMATE OF THE ADANAC ORE RESERVES

Introduction
Basic Data and Procedure
Findings
Geologic Reserves - Effects of Kriging
Mineable Reserves
Economic Effects

H.K. Taylor

Vancouver
February 4, 1980

cc: J.H.Eastman
W.A. Triggs
J.A. Brunette
Engineering File

All figures are adjusted to metric tons, percentages of elemental molybdenum and Canadian dollars.

INTRODUCTION

Two recent pit studies of Adanac have yielded these results:

- April 1979 — 84 million tonnes at 0.069% Mo and 0.85/1 S.R.
- January 1980 — 242 million tonnes at 0.054% Mo and 1.13/1 S.R.

The purpose of these notes is to examine the reasons for the increase, and to analyse the economic implications.

For easy reference a tabulation of the last three studies follows; interpolated to various common cut-off grades in order to facilitate comparisons.

Cut-Off Grade	%MoS_2 / %Mo	0.05 / 0.030	0.055 / 0.033	0.06 / 0.036	0.08 / 0.048	Total Pit
January 1978	1000 t.	-	-	67900	52600	124900
	% Mo	-	-	0.073	0.082	-
	Strip Ratio	-	-	1.84	1.38	-
Increment	1000 t.	-	-	11800	6580	30300
	% Mo	-	-	0.059	0.082	-
	Strip Ratio	-	-	1.57	3.60	-
April 1979	1000 t.	86800	84000	79700	59200	155200
	% Mo	0.068	0.069	0.071	0.082	-
	Strip Ratio	0.79	0.85	0.95	2.62	-
Increment	1000 t.	154800	138500	121500	67100	359200
	% Mo	0.046	0.049	0.051	0.058	-
	Strip Ratio	1.32	1.59	1.96	4.35	-
January 1980	1000 t.	241600	222500	201200	126300	514400
	% Mo	0.054	0.0565	0.059	0.069	-
	Strip Ratio	1.13 ✓	1.31	1.56	3.07 ✓	-

BASIC DATA AND PROCEDURES

The January 1978 study used inverse distance weighting to estimate block values, from which the geologic and mineable reserves were then determined. The April 1979 study accepted the same block values and geologic reserves, but by reason of changed economic entries this study generated a new and augmented figure for the mineable reserve.

The January 1980 study has used a form of kriging to estimate the block values, and again the economic entries have been changed, mainly by the use of a much higher molybdenum price. Both geologic and mineable reserves increased substantially, the former by about 70% and the later by 180%. As a check, both reserves have been recalculated by inverse distance weighting. These results are discussed later.

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The economic data entries for the three pit studies have been:

	Molybdenum Can $/lb Mo in MoS_2 Conc.	Mining Can $ per Tonne	Milling & Other Can $ per Tonne
January 1978	4.44	0.71	2.67
April 1979	6.68	0.78	3.83
January 1980	9.78	0.75	3.33

FINDINGS

1. I cannot comment on the technical validity of the kriging technique, only on its effects. These effects have been to extend the areas of influence of drill-holes, mainly in the lower-grade areas, and thus to redefine areas previously regarded as "undefined waste."

2. For the mineable reserve, the effects can be roughly analysed as:-

   a. From improved price-cost ratios: +45- 50 million tonnes
   b. From kriging: +90-100 million tonnes
   c. From lowering cut-off grade: +15- 20 million tonnes

   The overall increase is 157.6 million tonnes at 0.046% Mo and 1.28:1 strip ratio. At a net Mo price of Can. $9.78 per pound (in MoS_2) and costs recently re-estimated by W.D. Baker, the net profit of this increment is Can. $2.72 per tonne.

3. The additional tonnage, being low-grade, makes no improvement to the short and mid-term economics of the proposed 14,000 tonnes per day operation. Neither does it offer any economic inducement for establishment of a substantially larger operation.

GEOLOGIC RESERVES - EFFECT OF KRIGING

In kriging, use is made of the correlation of adjacent assays and the distances in various directions to which such correlations can be shown to be statistically significant. This information is used to assign weights to the various sample points, and blocks are then given the weighted averages that have the lowest calculated expectations of error. Broadly, the effect is to extend the areas of influence of holes and thus to fill up inter-hole gaps that under "radius of influence" restrictions would be classified as "undefined waste".

From lack of experience in this technique I am unable to appraise the validity of the kriging technique. Though originally developed for South African gold reefs, the technique seems now to

be accepted by mineral statisticians for general use in a wide variety of types of deposit. My only reservation concerns possible over-projection of determined relationships. Thus, it was determined for the higher-grade core that correlations were valid horizontally for twelve times the distance of equivalent vertical correlations. Only in this zone - which was tunneled - was it possible to measure this effect. But the same ratio was assumed to be valid also for the peripheral low-grade material, whose grades form part of a different grade population and whose geographical distribution pattern may likewise differ.

Turning to practical effects, I compare three estimates of geologic reserve, the first in January 1978 (which has had to be interpolated for intermediate cut-offs) and two of January 1980, one of which was done by kriging.

January 1978 Geol. Reserves
Calc. & Interpolated)

Cut-off % Mo.	1000 t.	% Mo
0.0400	110000	0.071
0.0420	101887	0.073
0.0500	80000	0.080
0.0600	58666	0.090
0.0700	44100	0.099
0.0720	41355	0.100
0.0800	32800	0.108
0.0900	22308	0.118

Comparative Table

Cut-Off	1978 Inv Dist.		1980 Inv Dist.		1980 Kriging		Effect of Kriging	
% Mo	1000 t	% Mo	1000 t	% Mo	1000 t	% Mo	1000 t	% Mo
0.00	-	-	297104	0.039	584478	0.033	+287374	0.027
0.01	-	-	261472	0.044	521857	0.036	+260385	0.028
0.02	-	-	200655	0.053	371573	0.045	+170918	0.036
0.03	-	-	156780	0.061	272863	0.053	+116083	0.042
0.04	110000	0.071	115568	0.070	186831	0.061	+ 71263	0.046
0.05	80000	0.080	82054	0.081	124697	0.070	+ 42643	0.049
0.06	58666	0.090	59243	0.091	78734	0.079	+ 19491	0.043
0.07	44100	0.099	43273	0.101	47252	0.090	+ 3979	-
0.08	32800	0.100	31625	0.111	26674	0.102	- 4951	-
0.09	22308	0.118	22696	0.121	15941	0.113	- 6755	-
0.10	-	-	16829	0.131	10217	0.124	- 6612	-

First, there is virtually no difference between the 1978 and 1980 inverse distance-weighted reserves; as should well be expected. Secondly, there is a substantial increase from kriging as

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is tabulated in the right-hand column. For material above a cut-off at 0.03% Mo, the increase is 116 million tonnes at 0.042% Mo. For material above 0.033% Mo (used in mineable ore comparisons) the increase is 103 million tonnes at 0.043% Mo.

MINEABLE RESERVES

No less than three factors have caused the mineable ore reserve to increase:

a) The kriging method of grade interpolation;
b) The rise in molybdenum price, relative to operating cost;
c) A lowering of the design cut-off grade from 0.033% Mo (0.055% MoS_2) in April to 0.030% Mo in January.

It is not easy to compare different pit designs directly. Also, for each factor the effects overlap considerably. So any analysis must necessarily be crude, though it may still be indicative.

Expanding parts of the introductory table given earlier:

Cut-Off	% Mo	0.030	0.033	Total Pit.
April 1979	1000 t	86800	84000	155200
	% Mo	0.068	0.069	-
	Strip Ratio	0.79	0.85	-
Increment	1000 t	56000	48500	183500
	% Mo	0.053	0.057	-
	Strip Ratio	2.28	2.78	-
Jan. 1980	1000 t	142800	132500	338700
(Inv.Distance)	% Mo	0.062	0.0645	-
	Strip Ratio	1.37	1.56	-
Increment	1000 t	98800	90000	175700
	% Mo	0.042	0.045	-
	Strip Ratio	0.78	0.95	-
Jan. 1980	1000 t	241600	222500	514400
(Kriging)	% Mo	0.054	0.0565	-
	Strip Ratio	1.13	1.31	-

Summarizing:

	1000 Tonnes	% Mo
April 1979 mineable reserve	84000	0.069
Added by higher Mo price	48500	0.057
Added by kriging	90000	0.045
Added by lowering cut-off to 0.03	19100	0.031
	241,600	0.054

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I have already mentioned that effects overlap. In particular, the "ore" added by kriging reduces the waste to be stripped; and it may thus convert marginal underlying material into "ore" and so add indirectly to the reserve. The figure of 90 million tonnes added by kriging compares with 103 million tonnes above the same cut-off grade added to the geologic reserve.

ECONOMIC EFFECTS

In total, a former ore reserve of 84 million tonnes at 0.069% Mo and 0.85:1 strip ratio has been increased by another 158 million tonnes of 0.046% Mo and 1.28:1 strip ratio. Relative profitabilities are:

Category	Revenue $/Tonne	Mining $/t Milled	Other $/t Milled	Net Value $/t Milled	Net Value $ Million
Original reserve	12.72	1.39	3.33	8.00	672
Increment	7.76	1.71	3.33	2.72	429

On a purely operating cost basis, the additional tonnage is profitable. For an already established mine it would therefore be mined at some time or other, always provided that the same or better price-cost ratios prevailed.

On the other hand, this extra tonnage cannot be said to justify the capital expense of an expanded plant and fleet of mining equipment, nor can it contribute any improved economics to the presently-planned 14,000 tonnes per day operation. It has been noted for some years that the economics of large mines is determined more by capital costs than by operating costs. Adanac is a perfect example. Low operating costs generate a low break-even grade; but high capital costs require for the first several operating years a high margin of profit, which in turn requires a high average grade, one that may be sustainable only by cutting off well above the break-even grade.

I derive some very crude but indicative figures, firstly for operation at 14,000 tonnes per day or 5 million tonnes per year:-

A current estimate of contruction capital is $215 million, and with allowances for inventories and operating capital the total could reach $230 million. For adequate repayment and return, annual mine profit should not be less than 28% for the first 5 years or so, say about $65 million per year.

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Thus:

Required profit =	$13.00 per tonne			
Milling and other costs	3.33			
	16.33			16.33
Mining, at assumed stripping ratios of 1:1	1.50	3:1		3.00
	$17.83			$19.33
Equivalent lbs. Mo/tonne	1.82			1.98
Required % Mo recovered	0.083			0.090
Required % Mo in heads	0.093			0.100
Equivalent % MoS_2	0.155			0.166
Required 5-year reserve	25 million tonnes			

It had been shown previously that there was some possibility of extracting a higher-grade nucleus of roughly this tonnage and grade, and at low strip ratio. The extra tonnage which is largely peripheral to this nucleus makes therefore no new contribution to this economic picture.

Secondly, for an appropriately larger output:- A suitable rate for a 240 million tonne body would be 25,000 tonnes per day, or 8.75 million tonnes per year for about 27 years. The capital cost could hardly be less than $300 million; with an accompanying requirement for a minimum annual profit of $84 million per year or $9.60 per tonne in the early years.

Thus:

Required profit =	$ 9.60 per tonne			
Milling and other costs (assuming economies of scale are offset by an increased proportion of diesel power)	3.33			
	12.93			12.93
Mining, at assumed ratios of 1:1	1.50	5:1		4.50
	$14.43			$17.43
Equivalent lbs. Mo/tonne	1.48			1.78
Required % Mo recovered	0.067			0.081
Required % Mo in heads	0.077			0.091
Equivalent % MoS_2	0.128			0.151
Required 5-year reserve	44 million tonnes			

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It is unlikely that tonnages of these magnitudes and grades could be mined at any reasonable strip ratio. From the cumulative grade table applicable to the new ore reserve, an average grade of 0.077% Mo requires cutting off at 0.057% Mo to yield about 86 million tonnes at an apparent strip ratio of 5:1. But at that strip ratio, minimum grade needs to be 0.081% Mo, of which the availability is perhaps 71 million tonnes at a strip ratio of 6.4 to 1.

Clearly, incremental tonnage at 0.046% Mo has made no economic improvement here either.

We can summarize all this in simple terms. It has long been realized that Adanac must very largely depend on its "plum" to repay the construction capital; and that this plum is not very large, even in relation to the former and smaller mineable reserve. The new expansion of reserves does very little to change this position, though there is some indication that kriging may have expanded the "plum" slightly while lowering its grade. But beyond this, the still-limited plum would obviously be even less able to repay the greater capital cost of a larger-tonnage operation.

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ADANAC: SCHEDULE 1.

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

YEAR	TOTAL TONS ,000's	WASTE/LOW GRADE TONS	ORE TONS	%Mo	SR
Pre	5300	5214	(86)	.043	-
1	9800	4900	4900	.088	1.0
2	9800	4900	4900	.105	1.0
3	9800	4900	4900	.074	1.0
4	12250	7350	4900	.085	1.5
5	12250	7350	4900	.079	1.5
6	12250	7350	4900	.088	1.5
7	12250	7350	4900	.068	1.5
8	12250	7350	4900	.056	1.5
9	12250	7350	4900	.068	1.5
10	12250	7350	4900	.069	1.5
11	12250	7350	4900	.064	1.5
12	12250	7350	4900	.068	1.5
13	12250	7350	4900	.063	1.5
14	12250	7350	4900	.055	1.5
15	12250	7350	4900	.055	1.5
16	12250	7350	4900	.055	1.5
17	12250	7350	4900	.055	1.5
18	12250	7350	4900	.055	1.5
19	12250	7350	4900	.055	1.5
20	12250	7350	4900	.055	1.5
21	12250	7350	4900	055	1.5
22	12250	7350	4900	.055	1.5
23	12250	7350	4900	.055	1.5
24	12250	7350	4900	.055	1.5
25	12250	7350	4900	.055	1.5
26	12250	7350	4900	.055	1.5
27	12250	7350	4900	.055	1.5
28	12250	7350	4900	.055	1.5
29	9400	4500	4900	.055	092
30	9400	4500	4900	.055	0.92
31	9274	4374	4900	.055	0.89
32	71	-	71	.055	
TOTAL	369095	217038	151971	.063	1.43

ADANAC SCHEDULE B

Ultimate is based on 70% price + $1.00 minimum profit
Cut off is 0.06% Mo for 1st six yrs (stockpile .04 - .06)
Then .04% Mo for rest of life 4900000 tons milled/yr

YEAR	TOTAL TONS	WASTE/STKP TONS	ORE TONS	% Mo	SR	CUTOFF % Mo
	000's					
Pre	7000	7000			-	
1	11300	6400	4900	.109	1.31	.060
2	11300	6400	4900	.106	1.31	.060
3	12250	7350	4900	.088	1.50	.060
4	12250	7350	4900	.080	1.50	.060
5	12250	7350	4900	.087	1.50	.060
6	12250	7350	4900	.083	1.50	.060
7	12250	7350	4900	.061	1.50	.040
8	12250	7350	4900	.062	1.50	.040
9	12250	7350	4900	.059	1.50	.040
10	12250	7350	4900	.063	1.50	.040
11	12250	7350	4900	.059	1.50	.040
12	12250	7350	4900	.062	1.50	.040
13	12250	7350	4900	.058	1.50	.040
14	12250	7350	4900	.055	1.50	.040
15	12250	7350	4900	.055	1.50	.040
16	12250	7350	4900	.055	1.50	.040
17	12250	7350	4900	.055	1.50	.040
18	12250	7350	4900	.055	1.50	.040
19	12250	7350	4900	.055	1.50	.040
20	12250	7350	4900	.055	1.50	.040
21	12250	7350	4900	.055	1.50	.040
22	12250	7350	4900	.055	1.50	.040
23	12250	7350	4900	.055	1.50	.040
24	12250	7350	4900	.055	1.50	.040
25	12250	7350	4900	.055	1.50	.040
26	12250	7350	4900	.055	1.50	.040
27	12250	7350	4900	.055	1.50	.040
28	12250	7350	4900	.055	1.50	.040
29	9400	4500	4900	.055	.92	.040
30	9400	4500	4900	.055	.92	.040
31	9088	4188	4900	.055	.85	.040
32	71	-	71	.055	-	.040
TOTAL	376059	224088	151971	.063	-	-

STKP RECOVERY

Paul Relon

#2 Conveyor

Present 300 HP Motor 280 - 285 Amps

Would ~~310~~ HP Motor 310 Amps

Conveyor Kicks if Loaded cannot restart

Change Motor Say to 350 H.P.
would like to stay with our
Drive and our Motor)

~~water~~ Steel