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CALENDAR

- ***Diggers & Dealers Mining Conference***
  August 4 – 6, 2008
  The Goldfields Arts Centre
  Kalgoorlie, Australia
  Email:
  admin@diggersndealers.com.au

- ***MININ 2008 – III International Conference on Mining Innovation***
  August 6 – 8, 2008
  Sheraton Hotel & Convention Center
  Santiago, Chile
  Email: info@minin2008.com

- ***Argentina Mining Conference 2008 - 7th International Conference and Exhibition***
  August 25 – 28, 2008
  Emilio Civit Congress and Conventions Center
  Mendoza, Argentina
  Email: info@argentinamining.com

- ***47th Canadian Conference on Coal***
  September 6 – 9, 2008
  Sheraton Suites Calgary Eau Claur
  Calgary, Alberta, Canada
  Email: info@coal.ca

- ***Mining in Africa 2008***
  September 8 – 12, 2008
  Nasrec Black Eagle – Expo Centre
  Nasrec, South Africa
  Email: elna@saimm.co.za

- ***MINExpo 2008***
  September 22 – 24, 2008
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  September 24 – 28, 2008
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To High-Grade or Not to High-Grade
(with apologies to Shakespeare)

A considerable number of articles and papers have been written on the topic of optimizing mine economics, generally with an emphasis on quantifying the production rate of a new venture, identifying the preferred cutoff grade which will maximize project returns, or selecting an appropriate discount rate.[2] Over the years there have been refinements in theory, as well as the development of computer programs, that serve to assist the engineer in arriving at an appropriate conclusion for his particular circumstance.

There are, however, virtually no publications on the impact of high-grading a given mineral deposit, as compared with extraction either at the average grade, or near the cutoff grade, for the project. This may be of overriding importance in this present time of high metals prices, since the cutoff grades (and by association) the average grades of most all deposits are trending downward. The positive in this situation is an increasing tonnage of material that can now be classified as a reserve (all other conditions remaining constant) simply because it is possible to mine the lower grade material, process it, and refine the metal at a profit.

The term “high-grading” generally connotes a negative activity, i.e., “theft of valuable pieces of ore.”[4] As used in this paper, the term represents conscious extraction of higher-grade material in preference to lower-grade, without physically sterilizing the lower-grade portions of the deposit and rendering them unrecoverable in the future. The dilemma in high-grading or not high-grading typically involves motives of maximizing early cash flows with a potential reduction in operational life, versus maximizing resource recovery and extending mine life. Theoretically by not high-grading, a manager will be promoting job security for the employees, an extended revenue stream for the owners and taxing agencies, and corporate goodwill.

With any new venture, the objective is typically to extract higher grade material early in the project life in order to obtain near-term cash flows with which to pay off creditors or investors in the project. Once the project is well underway, or has been in production for a considerable length of time, should the policy of continuing to mine the best portion of the remaining reserve base stay in effect even though an acceptable cash flow could be obtained by extracting lower-grade material and leaving the better-grade reserves for a “rainy day”?

To simplify the problem, let us assume that future capital expenditures, mine production

rate, and operating costs will be the same in either case. Given that the grade-tonnage distribution of the deposit is known, this leaves only the forecast of future metal prices as the major variable in the analysis. Figure 1 illustrates a typical grade-tonnage curve for a gold deposit, and Table 1 presents hard data on the grade distribution in this example.[1] We have three cases to examine with regard to future gold prices; i.e., they are either: 1) declining, 2) remaining constant, or 3) increasing.

Taking the middle ground first, if the price of metal remains constant over the duration of the mine life, then the total current reserve base will be produced no matter whether the higher-grade or lower-grade portion of the deposit is mined initially. Intuitively, the exact same number of gold ounces will be recovered and sold in either situation, with the only difference being the net present value (NPV) of the cash flows generated. Table 2 presents two mining sequences based on the deposit criteria, and shows that essentially the same tons, average grade, and ounces will be produced. By simply discounting the ounces to the present at a 12 percent discount rate, it can be readily determined that the high-grade option provides the best NPV by a factor of 47 percent over the low-grade case.

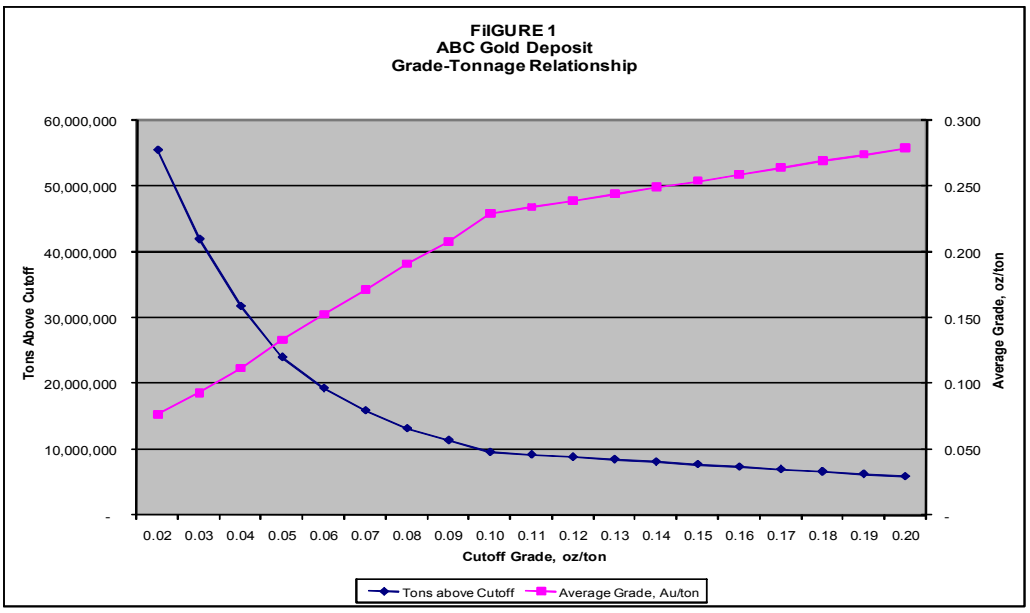
Presently, the industry is in an envious position with the price of gold ($900/ounce) exceeding an all-time high (current-dollar basis), and certainly well above its historical average. Five-, ten-, and 15-year averages for the metal (through 2007) have been: $504, $395, and $387 per ounce. Whether there will be a reversion to the mean is impossible to predict; however, conservative forecasts, mainly by lending institutions, suggest a measure of falling prices over the coming few years.

In examining the appropriate mining approach under a situation of declining metal price, let's assume the following forecast:

Year 1	$900/oz
Year 2	$875
Year 3	$850
Year 4	$800
Year 5+	$750

This suggests a permanent, significant increase in gold prices over the long term, and results (with some assumptions) in a finite reserve base contained within the overall resource tonnage.

Under a high-grade approach, the best material would be extracted initially regardless of calculated cutoff grade.



The rock grading above 0.20 oz/ton on Table 1 would be mined first, followed by lower-grade material until the then-current cutoff grade was reached. Taking a mining rate of 20,000 tons/day from underground, or 5,000,000 tons annually, a total of 13,172,000 tons would be mined through Year 3 (Table 3). By that time the cutoff grade has increased to 0.08 oz/ton, and it is seen that the commercial portion of the deposit has already been extracted.

Assuming the low-grade approach toward extraction, mining can progress into the fourth year in this example. Table 3 presents the comparisons and shows that the low-grade approach certainly extends mine life (by a half year) and allows both more tons mined and more ounces of gold to be produced and sold than does high-grading.

The economics of the two cases, under the declining price scenario, are given in Table 3. Here the pre-tax net present value for the high-grade case is nearly 24 percent better than that of the low-grade policy because of two factors: 1) fewer tons are mined and therefore operating costs are less, and 2) more ounces are produced in the near-term when prices are high, thereby providing increased revenues early on.

Now we must examine the situation where gold prices are expected to increase over time. The question to be asked is: under what price forecasts would an operations manager be willing to postpone extraction of higher grade material, rather than producing more metal at the present time? Similar to the constant-price forecast, the answer to this question is intuitive. Only if gold prices are expected to increase at a higher pace than the company's required discount rate (in this case, 12 percent per year) would the firm be better off by adopting the low-grade option. Starting with the current $900/oz gold price, future prices would have to exceed the following figures:

Year 1	$ 900/oz
Year 2	$1,008
Year 3	$1,129
Year 4	$1,264
Year 5+	$1,416

If gold prices are not forecast to increase at this compound rate, then the company should continue to follow a high-grade policy in order to maximize its net present value.

In summary, postponing extraction of high-grade material is meaningful economically if the future price of the product will increase at a rate exceeding the company's discount rate. In all other situations (conditions remaining constant), the firm should

TABLE 1
ABC Gold Deposit
Grade-Tonnage Data*

Interval	Tons Within Interval	Ave Grade Within Interval	Grade Cutoff	Tons above Cutoff	Ave Grade Above Cutoff	Total oz Au Above Cutoff
.02 - .03	13,576,000	0.025	0.02	55,513,000	0.077	4,246,745
.03 - .04	10,189,000	0.035	0.03	41,937,000	0.093	3,905,361
.04 - .05	7,742,000	0.045	0.04	31,748,000	0.112	3,548,746
.05 - .06	4,735,000	0.055	0.05	24,006,000	0.133	3,200,356
.06 - .07	3,387,000	0.065	0.06	19,271,000	0.153	2,939,931
.07 - .08	2,712,000	0.075	0.07	15,884,000	0.171	2,719,776
.08 - .09	1,799,000	0.085	0.08	13,172,000	0.191	2,516,376
.09 - .10	1,799,000	0.095	0.09	11,373,000	0.208	2,363,461
.10 - .11	371,000	0.105	0.10	9,574,000	0.229	2,192,556
.11 - .12	371,000	0.115	0.11	9,203,000	0.234	2,153,601
.12 - .13	371,000	0.125	0.12	8,832,000	0.239	2,110,936
.13 - .14	371,000	0.135	0.13	8,461,000	0.244	2,064,561
.14 - .15	371,000	0.145	0.14	8,090,000	0.249	2,014,476
.15 - .16	371,000	0.155	0.15	7,719,000	0.254	1,960,681
.16 - .17	371,000	0.165	0.16	7,348,000	0.259	1,903,176
.17 - .18	371,000	0.175	0.17	6,977,000	0.264	1,841,961
.18 - .19	371,000	0.185	0.18	6,606,000	0.269	1,777,036
.19 - .20	371,000	0.195	0.19	6,235,000	0.274	1,708,401
.20 - .358	5,864,000	0.279	0.20	5,864,000	0.279	1,636,056
Total	**55,513,000**	**0.077**				

* modified from Dagdelen

TABLE 2
ABC Gold Deposit Production Statistics
Mining Sequence through 0.03 oz/ton cutoff

High-Grade @ 5,000,000 tons/year	Tons	Av Grade	Ounces
Year 1	5,000,000	0.279	1,395,000
Year 2	5,000,000	0.168	838,000
Year 3	5,000,000	0.084	420,500
Year 4	5,000,000	0.065	325,500
Year 5	5,000,000	0.053	265,000
Year 6	5,000,000	0.045	225,000
Year 7	5,000,000	0.039	192,500
Year 8	5,000,000	0.035	175,000
Year 9	1,937,000	0.035	67,795
	41,937,000	0.093	3,904,295

Low-Grade @ 5,000,000 tons/year	Tons	Av Grade	Ounces
Year 1	5,000,000	0.035	175,000
Year 2	5,000,000	0.035	175,000
Year 3	5,000,000	0.045	223,000
Year 4	5,000,000	0.049	245,000
Year 5	5,000,000	0.060	298,500
Year 6	5,000,000	0.075	377,000
Year 7	5,000,000	0.115	576,500
Year 8	5,000,000	0.259	1,294,500
Year 9	1,937,000	0.279	540,423
	41,937,000	0.093	3,904,923

Discounted High Grade Oz =	2,866,313	oz
Discounted Low Grade Oz =	1,949,053	oz
High Grade/Low Grade =	47.1	% better

strive to maximize early returns by mining the best part of the deposit initially, then continue to extract the best of the deposit which remains.

This conclusion is not new. As long ago as 1925 another author summarized the situation as follows:[3]

A rich block of ore should be extracted at the first suitable opportunity and the profits therefrom distributed. If it is left in the mine it will often be drawn upon to make up for deficiencies, short-comings, and mistakes, and frittered away without benefiting the shareholders by a penny. Cash in the bank is worth more than the equivalent quantity of gold in the mine.

To save an accessible portion of the deposit for a "rainy day" is to deprive management of cash flow that possibly could be reinvested in the property to increase efficiency, lower operating costs, and expand the reserve base.

References

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3. Marriott, H., *Money & Mines*, The Macmillan Company, 1925

4. U.S. Bureau of Mines, *A Dictionary of Mining, Mineral, and Related Terms,* U.S. Department of the Interior, 1968

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TABLE 3
ABC Gold Deposit
Cash Flow Comparison, Declining Gold Price

High-Grade Option		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**TOTAL**
Revenues						
Gold Sales	oz	1,395,000	838,026	283,350		2,516,376
Gold Price	$/oz	900	875	850		
Revenues	$	1,255,500,000	733,272,750	240,847,500		2,229,620,250
Costs						
Production	tons	5,000,000	5,000,000	3,172,000		13,172,000
Op. Costs	$/ton	63	63	63		
Total Costs	$	315,000,000	315,000,000	199,836,000		829,836,000
Pre-Tax Net	$	940,500,000	418,272,750	41,011,500		1,399,784,250
NPV @ 12%	**$**	**1,202,367,794**				

Low-Grade Option		**Year 1**	**Year 2**	**Year 3**	**Year 4**	
Revenues						
Gold Sales	oz	402,770	677,950	1,393,320	246,636	2,720,676
Gold Price	$/oz	900	875	850	800	
Revenues	$	362,493,000	593,206,250	1,184,322,000	197,308,800	2,337,330,050
Costs						
Production	tons	5,000,000	5,000,000	5,000,000	884,000	15,884,000
Op. Costs	$/ton	63	63	63	63	
Total Costs	$	315,000,000	315,000,000	315,000,000	55,692,000	1,000,692,000
Pre-Tax Net	$	47,493,000	278,206,250	869,322,000	141,616,800	1,336,638,050
NPV @ 12%	**$**	**972,955,049**				

Pincock, Allen & Holt is a consulting and engineering firm serving the international mineral resource industry. Your comments and suggestions are always welcome. Contact Pincock, Allen & Holt • 165 S. Union Blvd., Suite 950, Lakewood, Colorado 80228 • TEL 303.986.6950 • FAX 303.987.8907 • www.pincock.com. Pincock Perspectives is published as a free information service for friends and clients.

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