National Exams December 2009

98-MMP-A4, Mine Valuation and Mineral Resource Estimation

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

3. Question (1) and FOUR other questions constitute a complete exam paper.
   Question 1 is compulsory and will be marked.
   Only the first four of the other questions (questions 2 to 7) as they appear in the answer book will be marked.

4. Question 1 has a value of 28 points. The remaining questions are of equal value (18 points).

5. Most questions require an answer in essay format. Clarity and organization of the answer are important, especially any numeric calculations and tabulations. Use drawings to illustrate your answers.

Question 1 (28 points)

1.1 **Very briefly** define the following in the context of mine valuation; (4 points)

1.1.a Revenue
1.1.b Cash Flow
1.1.c Payback Period
1.1.d Cash Flow Ratio
1.1.e Net Present Value
1.1.f Present Value Ratio
1.1.g Rate of Return
1.1.h Operating Margin (Mining Definition)

1.2 Two new mine development opportunities A and B are available to a mining corporation.

Calculate a set of values 1.2.a to 1.2.h from your definitions 1.1.a to 1.1.h above for both A and B, and note that only an estimate of item 1.2.g (Rate of Return) is required for each mine using the data provided below: (8 points)

Mine Opportunity	**A**	**B**	
Mine Type	Underground	Open pit	
Mining Method	Cut and fill	2:1 Stripping Ratio	
Metals Produced	Cu-Zn-Ag	Cu-Mo	
Mill Capacity (t/year)	300,000	7,000,000	
Pre-production Period (years)	2	2	
Productive Life (years)	8	15	
Annual Revenue (million constant $)	$10,500,000	$50,800,000	
Cost of Capital (%)	12	9	
Capital Costs (constant $)			
Mine Access or Stripping	$4,750,000	$8,655,000	
Mine Plant and Equipment	$3,250,000	$19,000,000	
Mill	$7,400,000	$22,600,000	
Infrastructure	$3,900,000	$10,000,000	
Working Capital	$2,750,000	$5,000,000	
Total	$22,050,000	$65,255,000	
Operating costs (constant $/t ore)			
Mine	7.4	1.25	(ore cost includes stripping)
Mill	6.3	4.0	
Overheads	2.5	0.8	
Total	16.2	6.05	

All assessments are made on a potential value, before-tax basis.

In order to estimate the Rate of Return, the Net Present Values for A and B (m for $ millions) are shown below at the cost of capital (%) indicated:

NPV's at ROR's	$ 1.893m@15%	$ 7.422m@7.5%
NPV's at ROR's (note sign)	$ -1.371m@20%	$ -9.822m@12.5%

Present Value tables for 9% and 12% cost of capital for 20 periods are appended at the end of the exam paper (Table 1 for Question 1).

1.3 On the basis of the values for 1.2.a to 1.2.h you have calculated, which of the two alternatives should be chosen by the mining corporation. Fully explain why you have made your decision in each case 1.2.a to 1.2.h calculated. (16 points)

Question 2 (18 points)

2.1 Write a short description of the geostatistical technique for understanding variance in grades known as "variography". The description should be such that a geologist unfamiliar with the technique would be able to interface with you in determining the direction and extent of grade similarities and problems with sampling and assaying procedures. (3 points)

2.2 Explain why mixing drilling samples of various lengths (and size/orientation) would most probably obscure the true experimental variogram. (3 points)

2.3 In a typical porphyry or epithermal deposit, high and low grades often have distinctly different variograms.

On the same variogram (graph), sketch the variograms you might expect from high and low grade areas of such deposits, and describe how the concept of "stationarity" applies in these cases. (6 points)

2.4 Describe how the development of indicator variograms follows from your variogram (graph) in section (2.3). How are such indicator variograms constructed, and provide typical examples (of say - high, medium and low grade indicator groupings) showing how indicator variograms might be expected to behave. (6 points)

Question 3 (18 points)

3.1 Write a short description of the geostatistical grade estimation technique known as "kriging" which would be suitable for an ordinary person with a mining/geological background to comprehend. (4 points)

3.2 What do you understand by, and differentiate between, the following types/methods of kriging. Include notes on the data used and the formulation of the kriging matrix. (10 points)

3.2.a Point
3.2.b Block
3.2.c Simple
3.2.d Ordinary
3.2.e Indicator

3.3 The results of Indicator kriging of blocks are often only marginally different from ordinary kriging estimates. Briefly describe how indicator kriging, given a cut-off grade, allows each block to be subdivided into ore and waste by volume (tonnage) and grade, and comment on block size in this context. (4 points)

Question 4 (18 points)

4.1 In general, what are the benefits of Canada's mining tax system, and what are the criticisms. (5 points)

For the next part of the question indicate whether you are familiar with the very recently published 2009 "Canadian Mining Taxation" by Price Waterhouse Coopers or the 2007 edition. This will not affect your standing.

4.2 From a taxation viewpoint, which is the best province/territory in Canada to invest in a mining project and why. (4 points)

4.3 There are several components to the taxation of mining companies. Briefly describe each of the following; (9 points)

4.3.1 Federal Income Tax
4.3.1.a Capital cost allowance
4.3.1.b Exploration/development expense
4.3.2 Provincial Income Tax
4.3.3 Provincial Capital Tax
4.3.4 Provincial Mining Tax

Question 5 (18 points)

5.1 Describe how the Porter "Five Forces" (supplier power, substitutes, buyer power, degree of rivalry, trade barriers) can be applied in the mining and minerals industries. You may use any four mined products you are familiar with as examples, or use the iron ore, coal, copper and limestone (cement/clinker) mining companies. (8 points)

How should a large integrated mining corporation (e.g. BHP) use "Five Forces". (2 points)

5.2 Using one metal (either copper, lead or zinc), describe the important parameters of a typical smelter contract. Use bullet form if you prefer. (8 points)

Question 6 (18 points)

6.1 What do you understand by the use of, and differentiate between, the following terms; (6 points)

6.1.a Mineral Inventories
6.1.b Mineral Resources
6.1.c Mineable Reserves

6.2 For this section of question 6, use three mineral deposit types; a large porphyry type copper (e.g. Highland Valley, BC); a magmatic sulphide nickel (e.g. Thompson, MB); and a gold-quartz vein (e.g. Snip, BC) as examples.

Explain how the following impact the development of mineral resources/mineable reserves for the above three deposit types, and comment on sampling procedures at the exploration and production stage of mine development; (8 points)

6.2.a Accuracy and Precision
6.2.b Geologic and Value Continuity

6.3 Contouring Methods have been used to estimate mineral resources and for later grade control. Comment on the effectiveness and appropriateness of such methods.
You may use the three mineral deposit types in 6.2 above to illustrate your comments. (4 points)

Question 7 (18 points)

7.1) You have discovered and own a mineral deposit which you would like to develop into a mine, and there are several methods of facilitating your objective.

Explain how each of the following can be applied. Include a description of the circumstances under which each could be used to your advantage. Also explain any disadvantages. (5 points)

7.1.a. Equity
7.1.b. Loan
7.1.c. Contract
7.1.d. Joint Venture
7.1.e. Lease

7.2) It is claimed that the cost per day of a component of mining activity equals KT^x where T represents the tonnes of material mined per day, K is a constant and x a power, with K and x depending on the cost component being estimated. Further the cost per tonne can be derived as $K/(T^{(1-x)})$. Comment on these claims. (4 points)

7.3) An open pit mine moves 50,000 tonnes per day of rock (ore plus waste). The component costs per day for mining are;

Drilling	$1.90\ T^{0.7}$
Blasting	$3.17\ T^{0.7}$
Loading	$2.67\ T^{0.7}$
Haulage	$18.07\ T^{0.6}$
General	$6.65\ T^{0.7}$

What are the component and total costs per day and per tonne based on the formulae claimed. (4 points)

7.4) Are these costs realistic given that the constants and powers were proposed in 1992 for North American applications. Suggest a better model for costing of all mine activities given short periods of rapid inflation. Your answer should include discussion on international mining costs. (3 points)

7.5) How do your suggestions impact "Mineable Reserves" at the feasibility stage. (2 points)

End of Exam

TABLE 1 for Question 1

Present Value of $1

PV = $1 / ((1 + i) ^ n)

n/i	9.0%	12.0%
1	0.91743	0.89286
2	0.84168	0.79719
3	0.77218	0.71178
4	0.70843	0.63552
5	0.64993	0.56743
6	0.59627	0.50663
7	0.54703	0.45235
8	0.50187	0.40388
9	0.46043	0.36061
10	0.42241	0.32197
11	0.38753	0.28748
12	0.35553	0.25668
13	0.32618	0.22917
14	0.29925	0.20462
15	0.27454	0.18270
16	0.25187	0.16312
17	0.23107	0.14564
18	0.21199	0.13004
19	0.19449	0.11611
20	0.17843	0.10367

Marking Scheme

28 points for **compulsory** question one, 18 points for each of four questions answered from six on the exam paper. Only question 1 and the first four remaining questions as they appear in the answer book will be marked.

Question 1 – Compulsory - 1.1 four points, 1.2 eight points, 1.3 sixteen points, total 28.

Question 2 – 2.1 three points, 2.2 three points, 2.3 six points, 2.4 six points, total 18.

Question 3 – 3.1 four points, 3.2 ten points, 3.3 four points, total 18.

Question 4 – 4.1 five points, 4.2 four points, 4.3 nine points, total 18.

Question 5 – 5.1 eight points, 5.2 two points, 5.3 eight points, total 18.

Question 6 – 6.1 six points, 6.2 eight points, 6.3 four points, total 18.

Question 7 – 7.1 five points, 7.2 four points,7.3 four points, 7.4 three points, 7.5 two points, total 18.