National Exams May 2010

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 is compulsory** and answers to all seven parts 1.1 through 1.7 must be attempted. This question is worth 40 marks out of a total of 100.

4. Of the remaining questions six questions (2 through 7), ***FOUR* (4)** questions constitute a complete exam paper.

5 Only the **first four** questions in the group 2 through 7 will be marked in the order they appear in the answer book. Each of these four questions is of equal value (15 marks).

6 Including question 1, five questions in total must be answered.

7 Most questions require an answer in essay format. Clarity and organization of the answer are important. Use neat sketches to illustrate your answers.

8 Be aware of the marks allocated to each part of any question, and spend the appropriate amount of time on your answer, not more, not less.

Question 1 (40 marks) This question is compulsory, all sections 1 to 7 must be attempted

1.1) What are the prices of the following products as given by say "Metals Week" or the BNN and similar media ***on the day before this examination***. Answers are expected in US$, the customary currency of such products, and per pound, troy ounce or barrel are commonly used. You may use metric units if you prefer. Answers +/- 20% of actual will receive half marks, and +/- 10% full marks.

1.1.a) copper 1.1.b) gold 1.1.c) silver 1.1.d) zinc 1.1.e) oil

(1 mark each, total 5)

1.2) With regard to the semi-variogram (commonly termed "variogram") and with the aid of a sketch describe the following;

1.2.a) Random Component
1.2.b) Regional Component
1.2.c) Nugget
1.2.d) Sill
1.2.e) Range
1.2.f) Indicate on your sketch variogram the units of the X and Y axes.

(1 mark each, total 6)

1.3) Describe the "ordinary kriging matrix" for block estimates, and how the input values are determined. After the "matrix" has been solved, what output values are typically produced.

(5.5 marks)

1.4) A low grade open pit porphyry copper deposit located in central British Columbia is at the advanced stage of a feasibility study.

1.4.a) As an investment analyst, what typical values would you expect for the average head grade of copper milled.

1.4.b) Payable by-products are molybdenum, gold and silver. What typical head grade values would you expect for these metals.

1.4.c) If the deposit has not been oxidized, and the milling process consists of flotation of crushed and rod and ball milled ore, what, typically, would be the percentage of copper in the concentrate.

1.4.d) Would a separate molybdenum concentrate be produced.

1.4.e) Where would the "payable" gold and silver be found and accounted for after the milling process.

(1.5 marks each, total 7.5)

1.5) In the context of inflation in the evaluation of mining projects, discuss, and differentiate between, "constant money" and "current money".

(5 marks)

1.6) Calculate the "Net Present Value" (NPV) for the mineral project with expenditures and revenues shown in the table below. Assume a discount rate of 10% and use the common "start of year" convention.

Year	Revenue ($ millions)	Expenditure ($ millions)
0	0	5
1	0	10
2	0	20
3	10	5
4	20	10
5	40	20
6	40	20

(5 marks)

1.7) Describe the decision making process that determines whether a mining deposit will be mined by underground or open pit methods.

(6 marks)

Of the following 6 questions (Q2 through Q7), only 4 (four) must be answered. If more than four are answered, only the first 4 on the answer booklet will be marked. Questions 2 through 7 carry equal marks, 15 each.

Question 2 (15 marks)

2.1) A nested spherical semi-variogram (the more usual term "variogram" is used interchangeably in this exam) consists of a nugget and two structures.

Nugget		0.1		
Structure (1)	Sill	0.5	Range	100m
Structure (2)	Sill	0.4	Range	500m

What is the gamma (γ) value at distances of;

2.1.a) 0 meters
2.1.b) 50 meters
2.1.c) 250 meters
2.1.d) 1000 meters

(1 mark each, total 4)

2.2) Practitioners often use the same variogram to estimate block grades in "high grade" areas and "lower grade" areas. Explain any pitfalls in such an approach.

(5 marks)

2.3) During the kriging process, a "kriging variance" is determined. Discuss typical values for, and the usefulness of, such a variance when comparing the supposed accuracy of estimates in high and low grade areas based on the same variogram.

(6 marks)

Question 3 (15 marks)

3.1) Describe and compare the "ordinary" and "simple" kriging methods of obtaining block grade estimates from dispersed assay data.

(5 marks)

3.2) In "simple" kriging, the sum of weights is seldom 1 (100%). How is the problem of systematically underestimating block grades resolved.

(4 marks)

3.3) In recent years "indicator" kriging has become a more mainstream method of estimating block grades. Describe how the method can be used to estimate the volume and average grade of both the ore and the waste contained in a block given a cut-off grade.

(6 marks)

Question 4 (15 marks)

The porphyry copper ore-body (Question 1.4) contains amounts of lead slightly less than the grade of molybdenum. As the potential mine is located in central British Columbia, the copper concentrate could be sent to smelters in eastern Canada or to ports on the Pacific rim.

4.1) As an analyst, describe a typical smelter contract for the copper concentrate. Include items such as;

4.1.a) Charges and deductions,
4.1.b) How refining of the copper will be accounted for
4.1.c) What effect the lead will have on revenue
4.1.d) How gold and silver will be accounted for

(2 marks each, total 8 marks)

4.2) Transporting concentrates from the mine to the smelter incurs substantial costs. Use a diagram to help describe the various modes of transportation employed in getting concentrate from mine site to smelter destinations in both eastern Canada and the Pacific rim.
Include some estimates of costs and justify a choice of either destination.

(3 marks)

4.3) Why does molybdenum provide almost as much revenue as copper, despite the molybdenum grade being typically less than a quarter that of the copper in the ore.

(4 marks)

Question 5 (15 marks)

5.1.a) Given simple 10% straight line depreciation, sketch a graph showing DCF Yield (Y) against General Rate of Inflation (X) with a tax rate of 45%. Does the DCF Yield increase or decrease with inflation.

(1 mark)

5.1.b) Sketch a further graph using the same axes showing how a project financed with 60/40 loan/equity ratio capital will behave in an inflationary environment. Ignore any taxes paid by the lender and investor. Assume again 10% straight line depreciation and a 45% tax rate. Does the DCF Yield increase or decrease with inflation.

(1 mark)

5.1.c) Will the Inflationary effects (of taxes and depreciation versus capital at 60/40) cancel in some cases, and is this a reason to ignore inflation when assessing mining projects.

(1.5 marks)

For the following sections of Question 5, use examples relating to Canadian mined products and to Canadian mining corporations working internationally where applicable.

5.3) Recent capital cost estimates for mine and plant construction have often been half of the eventual cost. How would you analyze and apportion the causes of such a huge increase that is obviously not due to inflation alone. Include your recommendations to avoid such problems in future capital cost estimates.

(2 marks)

5.4) For almost all mined products, selling prices can go down as well as up, sometimes double or half in a year. Compare and contrast the five approaches to price inflation/deflation listed below which can be used in estimating future selling prices.

5.4.a) Extrapolation of historical data

5.4.b) Long term econometric modeling

5.4.c) The 'inferred price' or historical relationship between production cost and average selling price

5.4.d) Estimation of the "breakeven price"

5.4.e) "Monte Carlo" simulation

(0.5 marks each, total 2.5)

5.5) In international project evaluation, the currency used is up to the evaluator. Discuss which currency is most appropriate for the following costs;

5.5.a) Engineering

5.5.b) Construction

5.5.c) Operating

and 5.5.d) Product sales revenues

(1 mark each, total 4)

5.6) Discuss the appropriateness of the following three methods of accounting for inflation in mining project feasibility over the life of a project;

5.6.a) Work in constant present day money

5.6.b) Work in current money

5.6.c) Work in current money for a number of years (say to start of production) and thereafter work in constant money terms

(1 mark each, total 3)

Question 6 (15 marks)

6.1) Discuss and differentiate between the following, giving examples of which mine expenditures are applicable, relevant methods of calculation, and effect on cash flows.

6.1.a) Depreciation

6.1.b) Depletion

6.1.c) Amortization

(1.5 marks each, total 4.5)

6.2) In Canada, mining resources are owned by Provinces/Territories/Aboriginal Groups. Discuss the role of Federal and Provincial Corporate Taxation, Provincial Mining Taxes and Royalties in providing a satisfactory return to Canada, the provinces and aboriginal groups when such resources are mined. (1.5 marks)

6.3) A mining company has discovered a small high grade gold deposit in Nevada and has decided to mine it over a 5 year period plus 1 year for development. The cash flows in millions of dollars are shown in the following table.

Year	0	1	2	3	4	5
Production (recovered Kozs @$1K/oz)	0	13.0	9.0	6.5	4.5	4.0
Revenue	0	13.0	9.0	6.5	4.5	4.0
Royalties (10%)	0	1.3	0.9	0.65	0.45	0.4
Net Revenue	0	11.7	8.1	5.85	4.05	3.6
Operating Costs	0	-2.0	-1.5	-1.0	-0.7	-0.5
Mine Acquisition & Construction	-5.0	-2.0	0	0	0	0
Depreciation	0	-1.5	-2.0	-1.5	-0.5	-1.5
Amortization	-0.5	-0.6	-0.6	-0.6	-0.6	-0.1
Taxable Income before Depletion	-5.5	5.6	4.0	2.75	2.25	1.5
50% Limit	0	2.8	2.0	1.375	1.125	0.75
Percentage Depletion (15% of Net Revenue)	0	-1.76	-1.21	-0.88	-0.61	-0.54
Cost Depletion	0	0.4	0	0	0	0
Loss Forward	0	-5.5	-0.35	0	0	0
Taxable Income	-5.5	-1.66	2.44	1.87	1.64	0.96
Tax (40%)	0	0	-0.98	-0.75	-0.66	-0.38
Net Income	-5.5	-1.66	1.46	1.12	0.98	0.58
Depreciation	0	0.9	1.6	1.1	0.8	0.6
Amortization	0.5	0.6	0.6	0.6	0.6	0.6
Depletion Taken	0	1.8	1.2	0.9	0.6	0.5
Loss Forward	0	5.5	0.4			
Mine Equipment	0	-6.7				
30% Development	-2.15	-0.85				
Mineral Property Acquisition	-1.0					
After Tax Cash Flow (ATCF)	-8.15	-0.41	5.26	3.72	2.98	2.28

6.3.a) Calculate the After Tax Net Present Value (NPV) at a discount rate of 15%.
If the corporate required rate is 15%, is the project acceptable.

(2 marks)

6.3.b) Calculate the Present Value Ratio for (6.3.a) above, and explain if this is not/is acceptable.

(3 marks)

6.3.c) Estimate the After Tax Discounted Cash Flow Rate of Return (DCFROR) for the project.

(4 marks)

Question 7 (15 marks)

Describe, with the aid of sketches/sections, the geologic settings and ore deposit models of the following types of deposit. Specify the constituent economic minerals/products, typical mining method and operating costs as applicable to resource estimation in the Canadian mining industry.

7.1) Volcanogenic massive sulphide (VMS)
7.2) Besshi type
7.3) Porphyry type
7.4) Evaporites such as those from Permian basins
7.5) Fluvial, estuarine, and marginal marine deposits of the Lower Cretaceous Wabiskaw-McMurray succession.
7.6) Sedimentary exhalative deposits (SEDEX)
7.7) Sudbury igneous complex (SIC)

(2 marks each except for 7.1 which has 3, total 15 marks)

End of Exam

References

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