National Exams May 2017

09-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. One only reference sheet, 8.5 x 11 inch, hand written both sides is allowed in the exam. This is not an open book exam, therefore only the approved Sharp or Casio type calculators are permitted.

3. Compulsory Question 1 and THREE (3) other questions constitute a complete exam paper.

   Only question 1 and the first three optional questions as they appear in the answer book will be marked. You must select three questions from the "optional" Questions 2 to 6.

4. Compulsory Question 1 is worth 40 marks. Each optional question is of equal value (20 marks). Three optional questions plus Question 1 constitute a complete exam paper.

5. Many questions require an answer in essay format. Clarity and organization of the answer are important.

6. Use large (½ page or larger) neat sketches and drawings to illustrate your answers when possible.

Compulsory Question 1 (40 marks)

You must answer <u>all</u> of this question, parts 1.1 to 1.6 inclusive

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

Total 6 marks

1.2) With regard to the semi-variogram (commonly termed "variogram") and with the aid of a neat 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, a to e inclusive and 2 marks f, Total 7 marks

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

Total 7 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.

2 marks each 1.4.b and 1.4.c and 1 mark each 1.4.a, d and e, Total 7 marks

1.5) In the early 1970's McKelvey produced a box diagram relating "increasing degree of feasibility or recovery" versus "increasing degree of geological assurance" for the US Geological Survey. Make a neat sketch of the McKelvey diagram including and showing the various classifications of mineral resources and reserves.

Total 6 marks

1.6) 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.

1.6.a) copper 1.6.b) gold 1.6.c) silver 1.6.d) zinc 1.6.e) oil 1.6.f) nickel 1.6.g) molybdenum

1 mark each, Total 7 marks

You must now choose three questions to answer from the remaining questions 2 to 6. If you answer more than three questions of your choice, the first three of questions 2 to 6 chosen will be marked, and the remainder discarded.

Question 2 (20 marks) Only answer this question if it is one of three chosen from questions 2 to 6

2.1 A nested spherical variogram has a range (1) of 15 meters, and a range(2) of 100 meters. The nugget is 0.05 $\%Cu^2$ and sill(1) 0.10 $\%Cu^2$ and sill(2) 0.5 $\%Cu^2$.

What are the variogram values (gamma γ) at

2.1.1 0 meters
2.1.2 10 meters
2.1.3 50 meters
2.1.4 150 meters
2.1.5 Draw a neat sketch to scale of the variogram.

1 mark each, Total 5 marks

2.2 With reference to variograms, what do you understand by the following terms

2.2.1 included angle (tolerance)
2.2.2 band width
2.2.3 anisotropy

1 mark each, Total 3 marks

2.3 Describe and differentiate between the following commonly applied kriging methods

2.3.a Ordinary (1 mark)
2.3.b Simple (1 mark)
2.3.c Indicator (2 marks)
2.3.d What are the resulting values produced from these methods. (2 marks
2.3.e What post-kriging calculations have to be applied to obtain grades for 2.3.b and c (3 marks)
2.3.f How are the results from 2.3.c used to find the amount of material above a user defined cut-off grade, and the grade above cut-off. (3 marks)

Question 3 (20 marks) Only answer this question if it is one of three chosen from questions 2 to 6

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;

$$K/T^{(1-x)}$$

3.1 Comment on these claims. (5 marks)

3.[2] An open pit mine moves 50,000 tonnes per day of rock (ore plus waste). The component costs per day of mining are;

Drilling	$2.85\ T^{0.7}$	Blasting	$4.76\ T^{0.7}$
Loading	$4.01\ T^{0.7}$	Haulage	$27.10\ T^{0.6}$
	General	$9.98\ T^{0.7}$	

3.2.a What are the individual component and total costs per day and per tonne based on the formulae given as claimed. (10 marks)

3.2.b What would you expect these individual and total costs per tonne to be, and comment on using such formulae for 'automating' feasibility studies. (5 marks)

Question 4 (20 marks) Only answer this question if it is one of three chosen from questions 2 to 6

You are expected to know how to calculate discounting factors. You may also have included them in your reference sheet or may calculate them using the calculator you brought to the exam.

An investment pays a net cash flow of $1000 per year for 4 years. The interest rate is assumed constant at 5%.

4.1 What is the NPV of the investment assuming payments are made at year end. (3 marks)

The capital invested today to achieve the cash flows is $3500.

4.2 Is the investment justified at the 5% interest rate. (5 marks)

With regard to mine feasibility and operations

4.3.a Some practitioners use the maximum NPV generated in a mining project to estimate cut-off grades. How is such a study carried out to determine which material meets or exceeds the cut off and falls into "Category 1".

4.3.b What should happen to the material which is below the cut-off grade of 4.3.a but exceeds the "corporate" required interest rate for projects and which is placed in "Category 2".

4.3.c What should happen to material which has a positive cash flow at the time of mining but is not included in the above two categories (1 and 2) and is placed in a further "Category 3".

4.3.d Should category 2 and/or 3 material be placed in selective stockpiles close to the mill for re-loading and processing in the mill at the completion of the primary mining operation.

4.3.e Discuss how the value of this stockpiled material milled at the end of mine life could be included in a feasibility study as "ore" given that it is the most heavily discounted at start-up.

4.3.f Discuss how the maximum NPV process has destroyed the value of lower grades in the deposit, and is there a role for government in ensuring the maximum recovery of "ore" has been accomplished for the nation.

4.3.a to f, 2 marks each Total 12 marks

Question 5 (20 marks) Only answer this question if it is one of three chosen from questions 2 to 6

Comment on the ownership of natural resources within Canada and its Provinces and Terratories (2 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 methods and operating costs as applicable to resource estimation in the Canadian mining industry.

5.1) Volcanogenic massive sulphide (VMS)
5.2) Besshi type
5.3) Evaporites such as those from the Permian basins
5.4) Sedimentary exhalative deposits (SEDEX)
5.5) Sudbury igneous complex (SIC)
5.6) Athabascan Basin Uranium deposits

3 marks each, Total 18 marks

Question 6 (20 marks) Only answer this question if it is one of three chosen from questions 2 to 6

6.1 With reference to Smelter Contracts for metals such as copper, zinc, and molybdenum, discuss

6.1.a Stoppages (mine and smelter)
6.1.b Rules for assaying
6.1.c Date/time/location of metal price fixes
6.1.d Assay dispute rules and applicable courts in the event of an no agreement
6.1.e Mixing of concentrates from several mines to avoid demurrage.

1 mark each, Total 5 marks

6.2 A porphyry copper ore-body 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 eastern Pacific coast.

As an analyst and using a 'typical' smelter contract for the copper concentrate. Explain the following items;

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

1 mark each, Total 4 marks

6.3) 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.

Total 2 marks

6.4) Calculation of net smelter return using a simplified model for only copper. The question is expressed in a form which aids the flow of calculations.

A small copper mine produces a thousand tonnes (mt) of ore daily and the mine works for a 5 day week. The mill runs continuously including weekends. The mined ore grade is expected to be 2.5 % Cu. Mill recovery is 85%. The grade of concentrate is 21%. The copper price is $2.2/lb ($4850/mt).

One metric ton (mt) is referred to throughout as 2205 lbs and 1 lb is 0.4536kg.

6.4.1 The amounts of metal at each stage of processing must be estimated

6.4.1.1	What are the mt of the metal contained in ore
6.4.1.2	What are the mt of metal in ore after recovery
6.4.1.3	What are the mt of concentrate if the grade of concentrate is 21%
6.4.1.4	What are the mt of contained metal in concentrate
6.4.1.5	What are the lbs of contained copper in concentrate

0.5 marks each Total 2.5 marks

6.4.2 The payable metal must now be estimated

A fixed deduction of 1.1 units (22.05 lbs *1.1) is charged.
The treatment charge is equal to $100 per tonne of concentrate.
Transport, with loading and representation, costs $50 per tonne.
The refining charges are equal to $0.1 per pound of payable copper
Assume no penalties or price participation.

6.4.2.1	Find the contained metal in concentrate
6.4.2.2	Find the metal per mt concentrate
6.4.2.3	Find the metal per lb concentrate
6.4.3.4	Find the metal deduction (lbs Cu)
6.4.2.5	What is the payable metal

0.5 marks each Total 2.5 marks

6.4.3 Deductions and charges have to be accounted for

6.4.3.1	What is the refining charge per mt of concentrate
6.4.3.2	What is the total value of charges per mt concentrate
6.4.3.3	What is the total value of deductions in $ per mt concentrate
6.4.3.4	What is the value after deductions and refining per mt concentrate
6.4.3.5	Find the value per mt of ore after deductions

0.5 marks each Total 2.5 marks

6.4.4 The NSR (Net Smelter Return) must now be estimated

6.4.4.1	What is the NSR factor
6.4.4.2	Find the value per mt ore
6.4.4.3	What is the NSR in $ revenue per mt ore

0.5 marks each Total 1.5 marks

End of Exam