

National Exams May 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. FIVE (5) questions constitute a complete exam paper.
Only the first five questions as they appear in the answer book will be marked.
4. Each question is of equal value (20 points).
5. Most questions require an answer in essay format. Clarity and organization of the answer are important. Use drawings to illustrate your answers.

Question 1

Non ferrous metallic mineral deposit types can be broken into several main groups comprising about 90% of the value of the Canada's production. These are summarised below, and example mining districts or mines are attached in brackets.

- Magmatic Ni-Cu-Platinum Group Element (e.g. Sudbury)
- Volcanic Massive Sulphide (VMS) (e.g. Bathurst)
- Lode Gold (e.g. Timmins)
- Porphyry (e.g. Highland Valley)
- Sedimentary Exhalative (SEDEX) (e.g. Sullivan)
- Mississippi Valley Type (e.g. Pine Point)
- Uranium (e.g. Athabasca and Elliot Lake)
- Miscellaneous (e.g. Redstone, Mactung, Cobalt and Chibougamau)
- Kimberlite Diamonds (e.g. Ekati)

Select **five** of the above deposit types that you feel you are best able to describe. In about 200 words with suitable sketches for each of five chosen, compare and contrast the geological conditions exhibited by the deposit types (the deposit examples you choose need not be Canadian), and describe the ease or complexity of grade control exhibited during their mining. How do geological conditions and grade control impact resource estimates in each case.

Question 2

2.1 What data is typically used to build a semi-variogram, how are the calculations made and what information is provided by the experimental model. Note that for the rest of this exam paper, and in your answer book, the term "variogram" is taken to mean "semi-variogram".

With regard to variograms, describe the following terms and their significance with the aid of a graph.

- 2.1.1 Spherical Model
- 2.1.2 Nugget
- 2.1.3 Sill
- 2.1.4 Range
- 2.1.5 Step or Lag
- 2.1.6 "Gamma" and the units it is expressed in

2.2 A spherical variogram has a nugget of 0.2, a sill of 1.0 and a range of 200 m. What is the variogram value at the following distances,

- 2.2.1 0.0m
- 2.2.2 100m
- 2.2.3 300m

2.3 What do you understand by the terms "nested spherical model" and "anisotropy".

2.4 Describe how variograms can be used to define trends in ore-bodies. In this regard, and with the aid of neat sketches, describe/explain the following,

2.4.1 Tolerance

2.4.2 Band Width

2.4.3 Why the variogram at "azimuth 90, dip 0" is the same as "azimuth 270, dip 0".

2.4.4 Why the variogram at "azimuth 90, dip 45" is not necessarily the same as "azimuth 270, dip 45".

Question 3

3.1 In the early 1970's McKelvey produced a box diagram relating "Increasing degree of feasibility of recovery" to "Increasing degree of geological assurance" for the US Geological Survey. Make a sketch of the McKelvey diagram including the various classifications of mineral resources and reserves within it.

A very few fraudulent "reserves" have been produced for mineral occurrences over the last few decades, and have resulted in stricter regulations in Australasia, Canada, Europe, South Africa, the United Kingdom, the United States and other jurisdictions. Perhaps one of the best known is the Canadian "National Instrument 43-101".

3.2 In the context of 43-101 (or similar), discuss the following (a short 50-100 word paragraph for each is sufficient).

3.2.1 Mineral inventory

3.2.2 Data verification

3.2.3 Mineral resource

3.2.4 Ore reserve

3.2.5 Measured, indicated and inferred

3.2.6 Qualified Person "QP"

3.2.7 Technical report

3.2.8 System for Electronic Document Analysis and Retrieval (SEDAR)

3.2.9 Producing issuer

3.2.10 "Independence"

Question 4

4.1 With respect to typical standard smelter contracts for base metal (copper, zinc, etc) mines shipping concentrate overseas, describe **five** of the following (a short 50-100 word paragraph for each is sufficient).

4.1.1 Contract duration

4.1.2 Shipment and discharge conditions

4.1.3 Environmental concerns

- 4.1.4 Minimum payable
- 4.1.5 Deduction
- 4.1.6 Treatment charge
- 4.1.7 Refining charge
- 4.1.8 Price escalation and participation
- 4.1.9 Impurities
- 4.1.10 Splitting limits and Umpires

4.2.1 Define and differentiate between "NSV" (Net Smelter Value) and "NSR" (Net Smelter Return).

4.2.2 Estimate the NSV in Canadian dollars for a base metal (copper) mine given the following,

| | |
|---------------------------------|-----------------------|
| Grade of concentrate (M) | 28% |
| Unit Deduction (D) | 1 unit |
| Exchange Rate | 1.00 US\$ = 1.2 CDN\$ |
| Metal Price (P) | US\$ 1.80/lb |
| Refining Charge (r) | US\$0.90/lb |
| Treatment Charge (T) | US\$100.00/DMT metal |
| Credits for Precious Metals (C) | US\$40.00/DMT metal |

4.2.3 Estimate the NSR (% based on Canadian \$) for the example given in (4.2.2)

4.2.4 If the concentrate costs CDN\$125.00 to transport from mine to smelter, what is the NSR as produced at the mine-site for the example given in (4.2.3).

Question 5

In about 50 to 100 words for each of 8 topics (5.1.1 to 5.1.8) below, describe the following terms and their usefulness in determining the value of a mineral deposit. Indicate how you would choose which deposit to focus on given that several similar deposits are available. Include usage, strengths and weaknesses of each of the 8 criteria.

- 5.1.1 Cash flows
- 5.1.2 Net present value (NPV)
- 5.1.3 Rate of return (ROR)
- 5.1.4 Discounted cash flows
- 5.1.5 Discounted cash flow rate of return (DCF-ROR)
- 5.1.6 Internal rate of return (IRR)
- 5.1.7 Modified internal rate of return (MIRR)
- 5.1.8 Payback period

5.2 A junior mining company has the opportunity to purchase certain non-core assets (a nearly depleted small mine) of a much larger corporation. The cash cost of purchasing the assets is \$0.7 million, and the salvage value on completion of mining (scrap minus environmental) is \$0.1 million.

The following table lists the revenues, operating costs and anticipated taxes.

| Year | 1 | 2 | 3 | 4 |
|-------------------------------|-------|-------|-------|-------|
| Revenues (\$ millions) | 1.0 | 1.0 | 1.0 | 1.0 |
| Operating Costs (\$ millions) | 0.4 | 0.4 | 0.4 | 0.4 |
| Taxes (\$ thousands) | 159.0 | 161.5 | 165.6 | 168.4 |

Using a 10% cost of capital, what are the after tax cash flows and what is the net present value of the asset.

5.3 What do you understand by "Capital Cost Allowance", and what is the rate for Class 41 with respect to Canadian Federal Taxation. Discuss Class 41a with respect to "commencement of production" and "availability for use".

Question 6

6.1 With respect to an adequately drilled simple porphyry type copper ore-body, why are the grade estimates produced by "kriging" and "inverse distance squared" often so similar. What are the advantages of using the kriging method in this case.

6.2 A "point" "simple" kriging estimate is made from 3 surrounding samples, i, ii and iii (see sketch below).

6.2.1 What do you understand by the "simple kriging" matrix

6.2.2 Describe the kriging matrix and vectors and explain how the values are obtained.

6.2.3 Why is it unlikely that the sum of weights will equal unity.

6.3 A "block" "ordinary" kriging estimate is made from 3 surrounding samples a, b and c (see sketch below).

6.3.1 Why do the sum of weights equal unity.

6.3.2 How does the size of the block affect the grade estimate and the kriging variance.

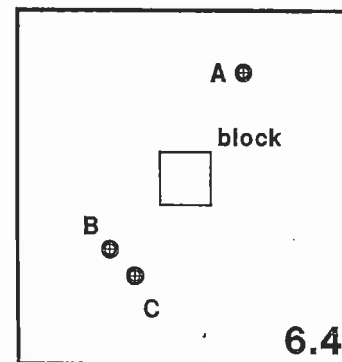
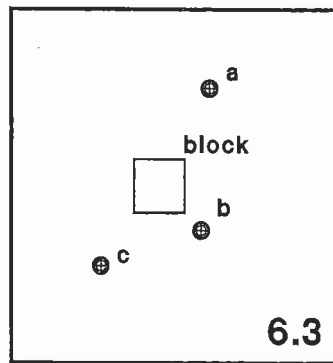
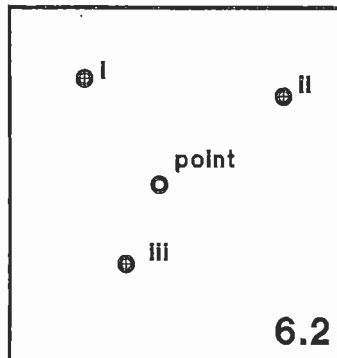
6.3.3 Why is it possible that some weights could be negative, and briefly describe how you would deal with this outcome.

6.4 In the sketch below, the block is being estimated from the three samples A, B and C using ordinary kriging.

6.4.1 Assuming the variogram nugget is small in comparison to the sill, and the variogram range is three times the longest sample to block distance, what weights might reasonably be expected for samples A, B and C.

6.4.2 Assuming the variogram nugget is almost equal to the sill, what might the weights reasonably be.

Sketches for questions 6.2, 6.3 and 6.4 follow;



Question 7

7 Discuss the marketing of nickel. Use the following headings as a guide, but these should not limit your answer. (a short 50-100 word paragraph for each is sufficient).

- 7.1 Major Sources (by country, cost/method of production, stage of production/purity, country and ore type/grade)
- 7.2 Major Consumption (by processing/fabricating county, stage of production/purity and eventual consuming country)
- 7.3 Use of substitutes and other nickel resources which are not yet profitable
- 7.4 Price history of the metal, price stability and contracts
- 7.5 Effect of Tariffs, Allowances, Taxation and Royalties on price

- 7.6 The relevance of Governmental organisations such as INSG (International Nickel Study Group) and Non Governmental Organisations (NGO's) including, but not limited to, environmental concerns.
- 7.7 International governmental policies related to developing countries with laterite resources
- 7.8 The role of forecasting by naïve, econometric and rational metal price modelling
- 7.9 Any other information you feel is relevant.

If you are unfamiliar with nickel, one of the following metals may be substituted; tin, zinc or copper, but you will lose 5, 15 and 20% respectively of your mark for this question.

End of Exam

Marking Scheme

20 points for each of five questions answered from seven on the exam paper. Only the first five questions as they appear in the answer book will be marked.

Question 1 - 4 marks for each of 5 chosen topics.

Question 2 – 2.1.1 to 2.1.6, 1 mark for each of 6 topics; 2.2.1 to 2.2.3, 2 marks for each of 3 topics; 2.3, 4 marks; 2.4.1 to 2.4.4, 1 mark for each of 4 topics.

Question 3 – 3.1, 5 marks; 3.2.1 to 3.2.10, 1.5 marks for each of 10 topics.

Question 4 – 4.1.1 to 4.1.10, 2 marks for each of 5 chosen topics; 4.2.1, 2 marks; 4.2.2, 4 marks; 4.2.3, 2 marks; 4.2.4, 2 marks.

Question 5 – 5.1.1 to 5.1.8, 1.5 marks for each of 8 topics; 5.2, 5 marks; 5.3, 3 marks.

Question 6 – 6.1, 4 marks; 6.2.1 to 6.2.3, 2 marks each; 6.3.1 to 6.3.3, 2 marks each; 6.4.1, 2 marks; 6.4.2, 2 marks.

Question 7 – 7.1 to 7.9, 2 marks each except 7.5 and 7.8 which are 3 marks each.