National Exams May 2018

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. This is a CLOSED BOOK exam with only an approved Sharp or Casio type calculator permitted. One reference sheet, 8.5 x 11 inch, hand written on both sides, containing notes and formulae is allowed in the exam.

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.

09-MMP-A4 Mine Valuation and Mineral Resource Estimation

Format: A Casio or Sharp approved calculator is permitted; Closed Book, but one aid sheet written on both sides containing notes and formulae is permitted

Suggested Timing: 30 minutes to read the exam and consider answers to Q1, and choose 3 of 5 multiple choice questions. 1.5 hours to answer 3 multiple choice questions chosen from the five questions, 2 to 6, 30 minutes per question.

Question 1, 40% or about 1 hour total, 4.44 marks/section.

1.1 Aspects of geological conditions and control relating to mineral resource estimation

Using (a) a deep narrow copper/tin vein and (b) an extensive epithermal gold deposit as examples, briefly describe how the geological conditions and controls affect how the respective mineral resources might be estimated.

(note each of 9 parts of this question carries 4 to 5 marks and should be answered in 6-7 minutes; also note that the time you should allocate to each mark is about 1.5 minutes. Values include 30 minutes to read through the exam)

1.2 Principles of mineral resource estimation using conventional and geostatistical methods

There are many distinct conventional mineral estimation methods including (a) method of sections, (b) inverse distance squared and (c) method of polygons. Briefly detail how geostatistical techniques would be applied to supplant these conventional methods.

1.3 Aspects of mine valuation - assessment of market conditions

To potential buyers, sellers and the stock market, what factors determine the value of a mineral resource. Using copper as an example, outline the supply and demand settings determining 'market conditions'.

1.4 Capital and operating cost estimation

T.A, O'Hara has produced a simplified method of estimating capital costs over a range of deposit sizes from visiting and analyzing costs at various mines. The same mathematical formulation is used for cost estimation of cost components and total cost in each case. Describe this formuation.

He also developed an empirical 'mine liife' rule used by producing operations in the minerals industry. Explain why you feel this rule to be accurate/inaccurate in its use in feasibility studies involving the 'time value of money'. What is the 'rule'.

1.5 Estimation of revenue including smelter contracts

Copper and gold are very different in terms of estimating revenues over a range of mined grades. One is extremely complex resulting in a mine value for the metal of as little as 50% of the 'street' value. The other is relatively simple and the product easily sold. Compare the anticipated revenues from mining the two metals, and describe how these revenues are arrived at.

1.6 Taxation, cash flow, sensitivity and risk analyses

What do you understand by the term 'cash flow' in the mining context. What factors affect the risks and sensitivities of the components of cash flow.
One such risk is taxation. Compare the tax rules of relatively stable countries (e.g. Canada, Australia) with unstable regimes in emerging economies (e.g. South America, Africa). What rates or return would you use in the two cases.

1.7 Economic optimization of mine development

Discuss how the application of 'incremental financial analysis' can result in more profitable mining operations. Include in your discussion the application at (a) the feasibility study of a mineral resource and (b) an operating mine.

1.8 Extraction variables including cut-off grade

Define (a) cut-off grade, (b) marginal cut-off grade and (c) cut-off grade yielding sufficient funds to cover mine operations, smelter and distribution, taxes and shareholder equity.

1.8 Extraction variables including cut-off grade continued

The 'cut-off grade' is typically applied at the 'rock face' but this restriction does not include the changes to profitability of changes to, for example, crushing and grinding, float cells and means of transporting concentrates. Discuss how other extraction variables affect the cut-off at the rock face.

1.9 Installed capacity utilization and sequencing

What do you understand by % utilization and how is this estimated using (a) trucks and shovels in open pits, (b) underground roof bolters, (c) size and number of float cell tanks and (d) pipelines to tailings dams. In order to improve utilization, the term '% use of utilization ' is sometimes used. How and why is this estimated and discus measures of utilization.

Describe and compare sequencing and sizing of (a) sinking cuts in open pits. (b) development headings for conventional underground caving and (c) tailing fill operations in close isolated stopes.

Questions 2 to 6, select 3 out of 5, 20% each or 30 minutes each

Question 2

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.

Describe, with the aid of sketches/sections, the geologic settings and ore deposit models of three (3) of the following types of deposit. Specify the constituent economic minerals/products, Describe typical mining methods and operating costs as applicable to resource estimation in the Canadian mining industry for the three chosen. (5+1,67 marks / section)

- Magmatic Ni-Cu-Platinum Group Element (e.g. Sudbury)
- Volcanic Massive Sulfide (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)

5 marks for each of the three chosen and 5 marks for the comparison, Total 20 marks

Question 3

Note that for the rest of this exam paper, and in your answer book, the term "variogram" is taken to mean "semi-variogram" as these terms are used interchangeably in practice

3.1) Types of variogram model include (a) spherical, (b) exponential and (c) Gaussian. Describe each type and explain why mathematical models are used in the variogram modelling process.

What data is typically used to build a semi-variogram, how are the calculations made and what information is provided by the experimental model. The 'Y' axis of the variogram is often described as 'gamma' (γ). What are the units used in this parameter.

With regard to variograms, describe the following terms and their significance with the aid of a graph. (5 marks)

3.1.1 Spherical Model
3.1.2 Nugget
3.1.3 Sill
3.1.4 Range
3.1.5 Step or Lag

3.2) A nested spherical (semi) variogram consists of a nugget and two structures.

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

Draw a neat sketch graph of this type of variogram model.

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

3.2.1.1	0 meters
3.2.1.2	50 meters
3.2.1.3	250 meters
3.2.1.4	1000 meters

10 marks total

3.3) 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, (5 marks)

3.3.1 tolerance (included angle)
3.3.2 band width

3.3 Variogram usage continued

3.3.3 anisotropy
3.3.4 Why the variogram at "azimuth 90, dip 0" is the same as "azimuth 270, dip 0".
3.3.5 Why the variogram at "azimuth 90, dip 45" is not necessarily the same as "azimuth 270, dip 45".

Question 4

4.1 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. (3 marks)

4.2) In sketch 4,2 below, a "point" grade estimate is made using 'simple' kriging from 3 surrounding samples, i, ii and iii and a "medium average representative" variogram with respect to sill, range and nugget,

Note, an estimate is made using the weight (total of one or percent of the total) for each sample.

4.2.1 What do you understand by the "simple kriging" matrix
4.2.2 Describe the kriging matrix and input vectors and explain how the values are obtained.
4.2.3 Why is it unlikely that the sum of weights will equal unity. (total 5 marks)

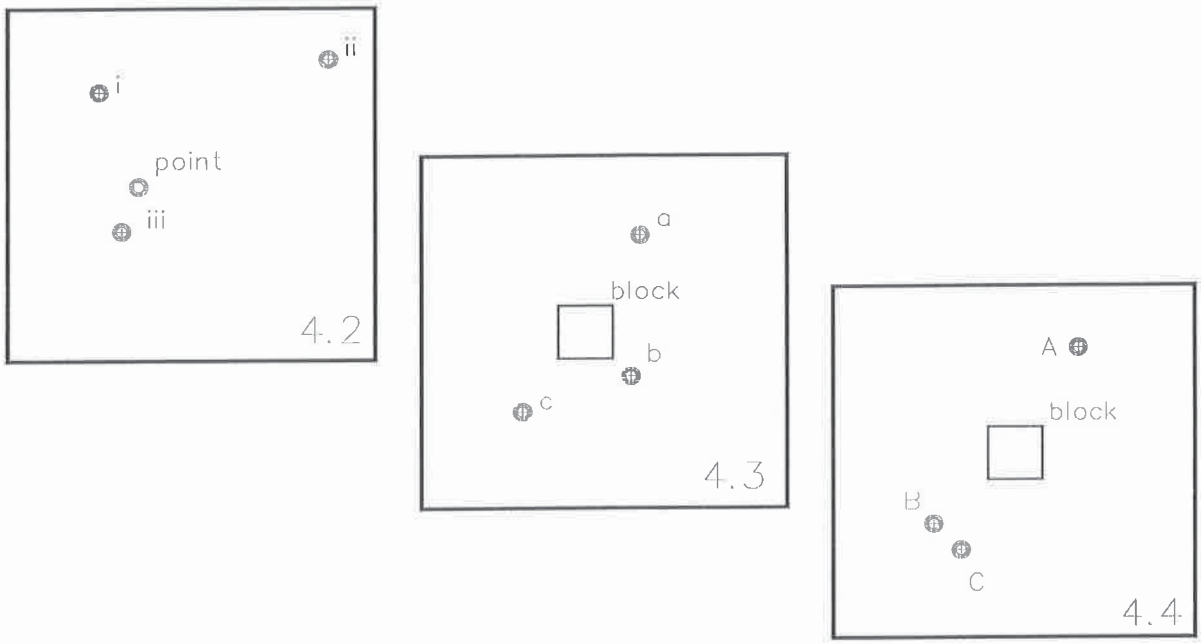
4.3) A 'block' "ordinary" kriging estimate is made from 3 surrounding samples, a, b and c (see sketch 4.3 below). (total 7 marks)

4.3.1 What is the sum of sample weightsy.
4.3.2 How does the size of the block affect the grade estimate and the kriging variance.
4.3.3 Why is it possible that some weights could be negative, and briefly describe how you would deal with this outcome.

4 .4) In the sketch below (4.4), the block is being estimated from the three samples A, B and C. Assuming the nugget is small in comparison to the sill, and the variogram range is three times the longest sample to block, sample to sample distance, (total 5 marks).

4,4.1 What is the sum (total) of the weights for samples A + B + C in the sketch 4.4 below.
4.4.2 Assuming the sample configuration shown in the sketch 4.4, what might the weights reasonably be.

Question 4.4 continued



Sketches for point, blocks and samples for questions 4.2, 4.3 and 4.4 are shown above.

Question 5

5.1) 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. (6 marks)

5.2) 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". Summarize these regulations (7 marks)

5.3) In the context of 43-101 (or similar), discuss the following (a short 50 ~ word paragraph for each is sufficient) in terms of what it represents and why it is a part of the 43-101 process .

(7 marks)

5.3.1 Mineral inventory
5.3.2 Data verification
5.3.3 Mineral resource

Question 5.3 continued

5.3.4 Ore reserve
5.3.5 Measured, indicated and inferred
5.3.6 Qualified Person "QP"
5.3.7 Technical report
5.3.8 System for Electronic Document Analysis and Retrieval (SEDAR)
5.3.9 Producing issuer
5.3.10 "Independence"

Question 6

6.1 With respect to typical standard smelter contracts for base metal mines (copper, zinc, etc) which ship their concentrate overseas, describe **five** (5) of the following (a short 50 ~ word paragraph for each is sufficient). (7 marks)

6.1.1 Stoppages
6.1.2 Shipment and discharge conditions
6.1.3 Environmental concerns
6.1.4 Minimum payable
6.1.5 Deduction
6.1.6 Treatment charge
6.1.7 Refining charge
6.1.8 Price escalation and participation
6.1.9 Impurities
6.1.10 Splitting limits and Umpires

6.2) What do you understand by the terms (a) NSV (Net Smelter Value) and (b) NSR (Net Smelter Return), and define and differentiate between them. How does the mining engineer use such values, and what are the essential variables that allow these values (a) and (b) to be estimated. (5 marks)

6.3) Estimate the NSV at the smelter for a base metal (copper) mine given the table below, (4 marks)

6.4 Estimate the NSR at the smelter given the table below. (4 marks)

Grade of copper in concentrate (M) %	38%
Copper Metal price (P) US$/lb metal	US$ 0.90 /lb

Question 6.3 continued

Unit deduction (D) %	1.20%
Concentrate transportation cost US$/tonne	US$ 340 /tonne
Treatment charge (T) US$/tonne	US$ 100 /tonne

End of Exam