National Exams | December 2014

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 Closed book exam, therefore only the approved Sharp or Casio type calculators are permitted.
3. Compulsory Question 1 and FOUR (4) other questions constitute a complete exam paper. Only question 1 and the first four optional questions as they appear in the answer book will be marked. You must select four questions from the "optional" Questions 2 to 7. Be sure you understand that two of Questions 2 to 7 must not be answered.
4. Compulsory Question 1 is worth 40 marks. Each optional question is of equal value (15 marks). Four 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. Use neat sketches and drawings to illustrate your answers whenever possible.

Question 1 (40 marks) *You must answer all of this question, parts 1.1 to 1.7 inclusive*

Question 1, General Knowledge (total 40 marks)

1.1 Within 15%, what is the LME price of copper and gold. Again within 15%, what is the price of West Texas Intermediate Crude Oil. The valuations should be those on the day before your exam and you must state the currency used. (6 marks)

1.2 Compare and contrast the methods of grade control used in open pit porphyry copper deposits and underground relatively steeply dipping vein deposits. (6 marks)

1.3 Using a neat sketch, draw a typical spherical variogram model and indicate the sill, nugget and range. What do these values represent. (6 marks)

Note that in this exam the more usual term "variogram" is used interchangeably with, and refers to, the semi-variogram.

1.4 Why is a "block model' used at many mining projects, and differentiate/discuss how block models are applied to porphyry copper and irregular vein like ore-bodies. (6 marks)

1.5 What is the difference between a mineral resource and a mining reserve (Canadian National Instrument 43-101 or NI 43-101). (5 marks)

1.6 Why is it necessary for a small copper mining company to have a smelter contract in place before commencing work on their property. Under what conditions can a large mining conglomerate mining ~20% of world production operate without such a contract. (5 marks)

1.7 Describe methods of determining the optimum value of mines over their working lives in terms familiar with accounting principles including Net Present Value (NPV) . Are there alternatives to NPV which allow the value of mines be maximized. (6 marks)

Question 2, Geology (total 15 marks)

Mineral deposit types can be broken into several main groups comprising about 95% of the value of Canadian production. These are summarised below, and example mining districts or mines are attached in brackets.

2.a. Magmatic Ni-Cu-Platinum Group Element (e.g. Sudbury)
2.b. Volcanic Massive Sulphide (VMS) (e.g. Bathurst)
2.c. Lode Gold (e.g. Timmins)
2.d. Porphyry (e.g. Highland Valley Copper)
2.e. Sedimentary Exhalative (SEDEX) (e.g. Sullivan)
2.f. Mississippi Valley Type (e.g. Pine Point)
2.g. Uranium (e.g. Athabasca and Elliot Lake)
2.h. Miscellaneous (e.g. Redstone, Mactung, Cobalt and Chibougamau)
2.i. Kimberlite Diamonds (e.g. Ekati)
2.j. Quebec/Labrador Iron Ore in Proterozoic geosyn-cline Labrador Trough. (e.g. IOC & Quebec Cartier)
2.k. Bitumen Oil Sands of the Athabasca Wabiskaw-McMurray formation (e.g. Suncor & Syncrude)

2.1 For five of the above (2.a to 2.k) and in about 50 words for each of the five, and with suitable sketches, compare and contrast the geological conditions exhibited by the deposit types. The deposits you choose need not be Canadian but must be geologically similar. Approximately 2 pages of text in total (not including diagrams) are required for this part of question 2. (10 marks)

2.2 For each of the five chosen deposit types, describe the ease or complexity of grade interpretation/extrapolation and how this impacts grade control during their mining. How do geological conditions and grade control impact resource estimates in each case. (5 marks)

Question 3, Variography (total 15 marks)

3.1 What is the mathematical description of a spherical variogram model, and what do you understand by the term "nested spherical". (2 marks)

3.2 Why is it necessary to use a nested spherical model for most practical variogram modelling. (2 marks)

3.3 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

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

3.3.a	0 meters	(1 mark)
3.3.b	50 meters	(2 marks)
3.3.c	250 meters	(2 marks)
3.3.d	1000 meters	(1 mark)

3.4 Describe the following in relation to the variogram and how the values/results are used.

(Total 5 marks)

3.4.a "Support"
3.4.b Co-variogram
3.4.c Correlogram
3.4.d Trend
3.4.e Variogram map

Question 4, Kriging (total 15 marks)

4.1 For a block grade being estimated from 2 point samples by "ordinary" kriging (Figure 4.2), what is the general form of the "ordinary" kriging matrix in this case. (2 marks)

The block shown below is to be kriged to find its grade using the two samples (grades v1 of 0.5 and v2 of 0.3 % Copper) shown.

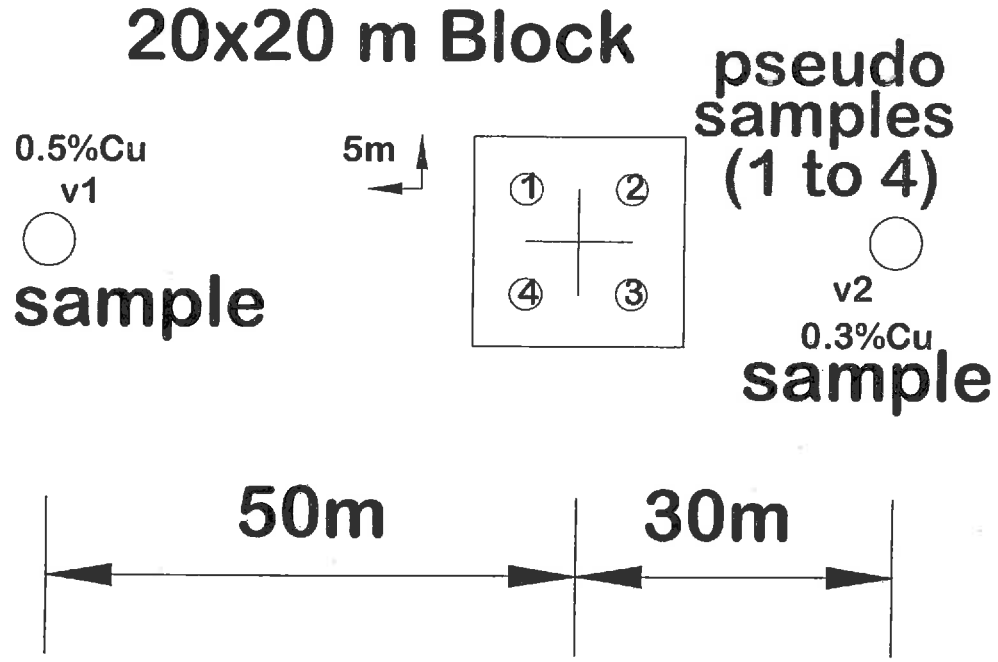

Figure 4.2 Plan of samples and block for grade estimation.

4.2.1 What are the "pseudo samples" (1 to 4) and will the pseudo samples shown adequately describe the variogram value for samples to block. (2 marks)

The variogram model for Figure 4.2 is shown below

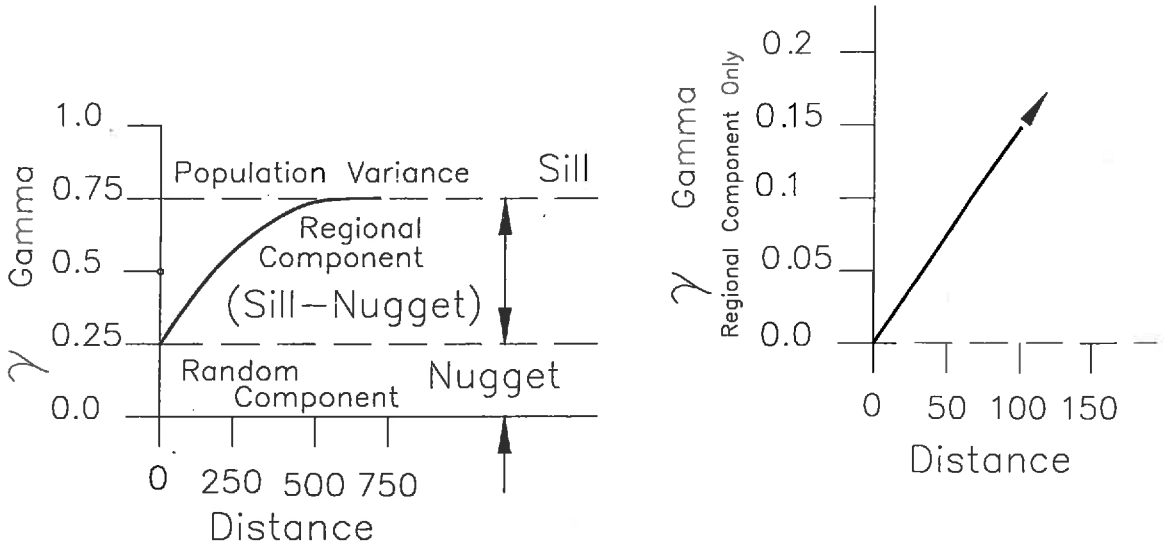

Figure 4.3 Variogram model

The input co-variogram sample/sample values are shown below

sample	1	2
1	0.75	0.38
2	0.38	0.75

4.2.2 How are the input co-variogram sample/sample values above found from the variogram shown in Figure 4.3 (3 marks)

The sample/block "average" co-variogram vector is shown below

sample	Block
1	0.425
2	0.455

4.2.3 How are the sample/block co-variogram values above estimated for the samples to the block

(2 marks)

4.2.4 Show the full input kriging matrix and output vector values in typical matrix format.

(3 marks)

The resulting vector of kriging "weights" after inversion/multiplication is shown below

Sample	Weight
1	+ 0.4595
2	+ 0.5405
	- 0.1250

4.2.5 What is the grade of the block. (1 mark)

4.2.6 What does the value – 0.1250 represent. (2 marks)

Question 5, Valuation and Feasibility (total 15 marks)

5.1 In the early 1970's the US Geological Survey produced a box diagram relating "Increasing degree of feasibility of recovery" to "Increasing degree of geological assurance" commonly referred to as the McKelvey diagram.

Make a sketch of the McKelvey diagram including the various classifications of mineral resources and mining reserves. Comment on McKelvey's 1970 work and NI 43-101. (4 marks)

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" (NI 43-101).

5.2 In the context of 43-101 (or similar), discuss the following (a short paragraph for each is sufficient, total 2 pages). (11 marks)

5.2.1. Measured, indicated and inferred
5.2.2. Mineral inventory
5.2.3. Mineral resource
5.2.4. Mining Reserve
5.2.5. Ore reserve
5.2.6. Qualified Person "QP"
5.2.7. Data verification
5.2.8. Technical report
5.2.9. Producing issuer
5.2.10. "Independence"
5.2.11. System for Electronic Document Analysis and Retrieval (SEDAR)

Question 6, Smelter Contracts and Net Smelter Return (total 15 marks)

6.1 With respect to typical standard smelter contracts for base metal mines (copper, zinc, etc) shipping concentrate overseas, describe any four (4 only) of the following (a short 25-50 word paragraph for each is sufficient, total 2 pages maximum). (4 marks)

6.1.1 Contract duration
6.1.2 Shipment and discharge conditions
6.1.3 Environmental concerns
6.1.4 Minimum payable
6.1.5 Deductions
6.1.6 Treatment charges
6.1.7 Refining charges
6.1.8 Price escalation and participation
6.1.9 Impurities
6.1.10 Splitting limits and Umpires

6.2 Define and differentiate between "NSV" (Net Smelter Value) and "NSR" (Net Smelter Return) and give the units each is expressed in. (2 marks)

6.3 Estimate the NSV in Canadian dollars for a base metal (copper) mine given the following; (4 marks)

Grade of concentrate (M)	28%
Unit Deduction (D)	1 unit
Exchange Rate	1.00 US$ = 1.10 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

6.4 Estimate the NSR (based on Canadian $) for the example given in (6.3) (3 marks)

6.5 If the concentrate costs CDN$125.00 to transport from mine to smelter, what is the NSR for the mine for the example given in (6.4). (2 marks)

Question 7, Mining Financial Appraisal (total 15 marks)

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

7.1 Using a 10% cost of capital, what are the after tax cash flows and what is the net present value of the asset. (8 marks)

7.2 What do you understand by "Capital Cost Allowance", and what is the rate for Class 41 with respect to Canadian Federal Taxation as described by PricewaterhouseCoopers in their annual guide ("Canadian Mining Taxation Guide 2013" pp6&7). Discuss Class 41a with respect to "commencement of production" and "availability for use" from a Federal and Provincial tax perspective. (7 marks)

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End of Exam