THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF MINING ENGINEERING

2021 FIRST SEMESTER SUPPLEMENTARY EXAMINATION

FOURTH YEAR MINING ENGINEERING

MN419 – ORE RESERVE ESTIMATION

DATE: THURSDAY, 10TH JUNE, 2020

TIME: 8:20 AM

TIME ALLOWED: 3 HOURS

INFORMATION FOR CANDIDATES:

1. You have 10 minutes to read this question paper you **SHOULD NOT** begin writing during this period.
2. There are **THREE** questions altogether. Answer **ALL THREE** questions. Marks to each question are shown on the paper.
3. **ALL** answers must be written on the LINED PAGE of the answer book provided. No other written material will be accepted.
4. Write your **NAME** and **NUMBER** clearly on the **ANSWER BOOK**. Do this **NOW**.

Question 1:

(a) State and briefly explain the implication of ore reserves on mining projects related to precision and reliability of ore reserve estimates.

(5marks)

(b) Sample spacing is a significant consideration in ore reserve estimation. State the factors controlling it, explain briefly their relationship with the help of a neat sketch.

(5marks)

(c) Explain briefly so as to distinguish comparatively between the ore reserve classification categories; Inferred Resource, Indicated Resource, Measured Resource, Probable Reserve and Proved Reserve.

(10marks)

(d) For definition of ore reserve in proven category, grade determination must be within 20% of estimated mean value. If the calculation of preliminary dataset indicates an average grade of 1.2% copper, and a standard deviation of 1.6, then determine the number of samples (N) required at 95% Confidence Interval (CI) to meet the proven criteria.

(5marks)

Question 2:

(a) Ore reserve estimation methods follow certain general rules or principles during estimation of reserves. State and explain concisely the 3 main principles with an example of a method utilizing each.

(9marks)

(b) Estimate the reserve of the block of ore shown in figure 1 below using the Inverse Distance Squared method of reserve estimation. Assume the S.G of the ore to be $2.8t/m^3$. *(show all your workings)*

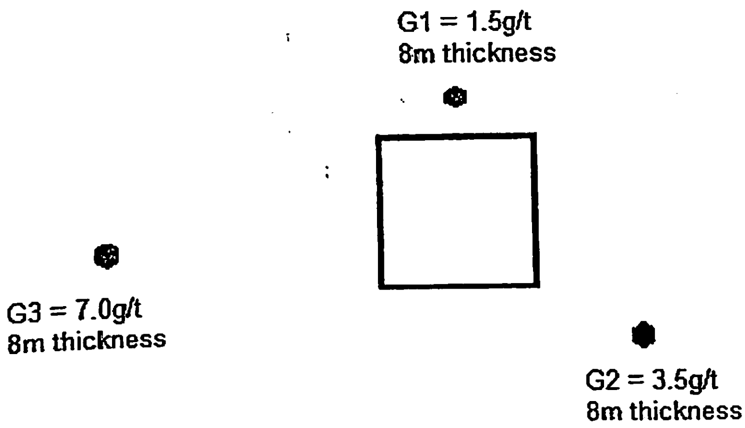

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Figure 1: Sampling program on a mineral deposit.

(c) A vertically dipping narrow-vein gold deposit having a thickness of 1.5m and ore density of $2.8t/m^3$ is planned to be mined by sublevel stopping method. The density of the host rock is $3.0t/m^3$. Mine plan and design constraints are that mining minimum stope drive width for extraction to cater for mining equipment is 2.0m. Therefore the expected stope size is 30.0m long x 20.0m high x 2.0m wide. If the average ore grade in the stope is 10.0g/t and the mine has a cut-off grade of 4.0g/t, determine;

(i) percentage of dilution involved,

(ii) whether or not this stope is mineable. (Justify your answer), and
(iii) comment on effects of dilution on minable ore reserves.

(4 + 5 + 2 marks)

(d) The main quantities computed for in ore reserve are tonnage and grade estimates. These estimates are affected by cut-off grade which are computed from modifying factors such as mine design, commodity price, etc. Briefly explain how cut-off grade affects ore reserve with the help of a neat sketch.

(5 marks)

QUESTION 3:

(a) Figure 2 below shows a probability plot for a set of sample data of a mineral deposit. Determine the following:

(i). What type of distribution is shown by this graph.

(2marks)

(ii) Describe what shape of distribution one would most likely observe on a histogram for the same dataset.

(2marks)

(ii). Estimate the following essential deposit information from the graph such as; mean grade, variance, and coefficient of variation. (show your working and attach the graph with the answer sheet).

(6marks)

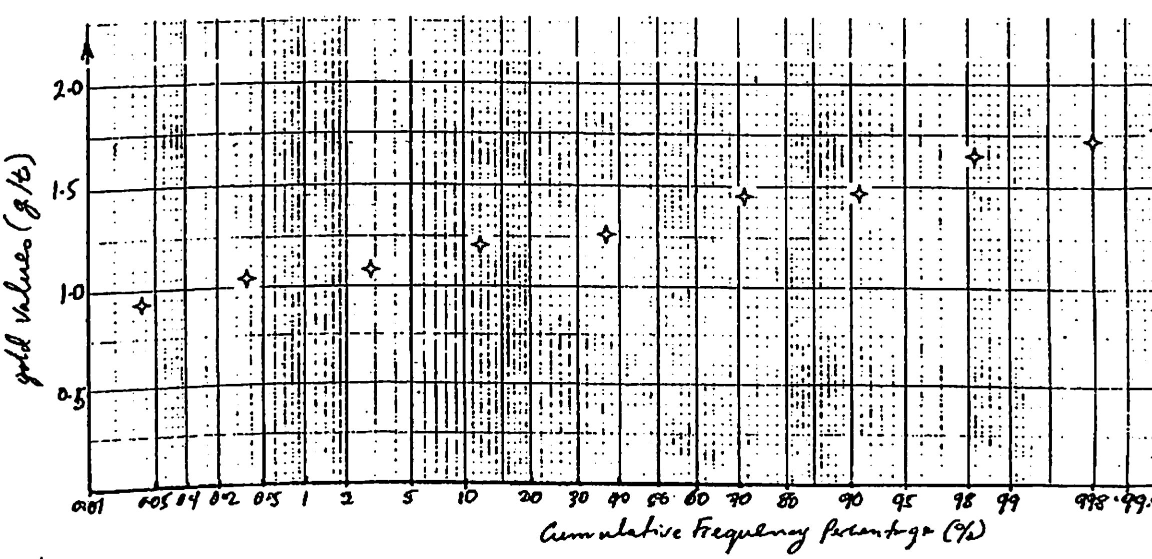

Figure - 2: Cumulative probability plot of gold values from sample data

(b) Variogram is the most important and basic tool of geostatistics. As such, the computation and accurate modelling of the variogram is key to obtaining accurate ore reserve results.

(i) Plot and model the variogram computed from a mineral deposit shown in table 1, and state the variogram type and the parameters modelled.

(10 marks)

Table 1. Variogram computed for a gold deposit.

Dist.(m)	10	20	30	40	50	60	70	80	90	100	110
ɣ(h)	0.8	1.6	2	2.4	2.6	2.8	3.4	2.1	2.8	2	3.7

(ii) Explain what the variogram you modelled in Q3b(i) above show.

(5 marks)

(c) (i) What is estimation variance?

(2 marks)

(ii). State the factors that affect estimation variance.

(5marks)

(d). (i) What is block variance?

(2 marks)

(ii) Explain briefly the significance of block variance in ore reserve estimation.

(5marks)

(c). Consider that figure 3 below shows a sampling arrangement of a gold deposit. The sample point marked "A" is not known however one is required to estimate its value using the Polygon method. As such, estimate the grade of point "A" and calculate its estimation variance if the variogram describing the grade characteristics is given by a transitive variogram as follows:

Variogram function:

$\gamma(h) = 0.01 + 0.001h$, for $h \leq 250$

$\gamma(h) = 0.26$, for $h > 250$

$\gamma(h) = 0.01$, for $h = 0$

(5 marks)

Useful formulae (all symbols carry the usual meaning):

$$\sigma^2_{EST} = 2\sum_{i=1}^{N}\lambda_i\bar{\gamma}(volume, x_i) - \sum_{i=1}^{N}\sum_{j=1}^{N}\lambda_i\lambda_j\gamma(point\, x_i, point\, x_j) - \bar{\gamma}(vol, vol)$$

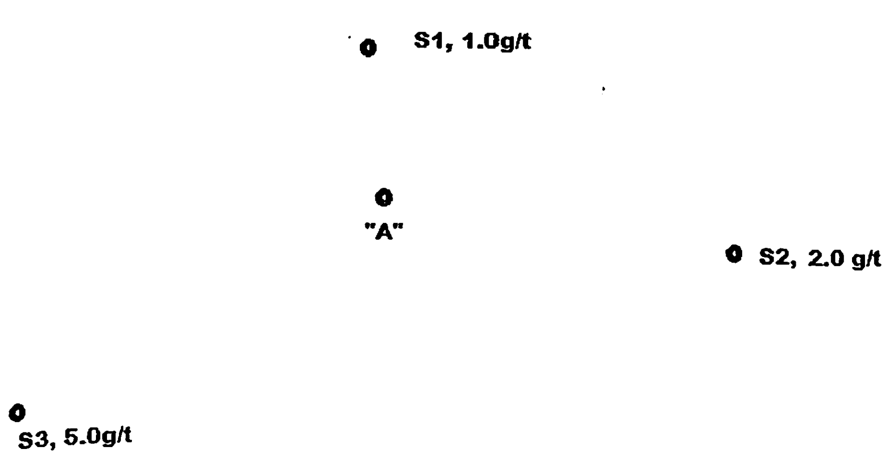

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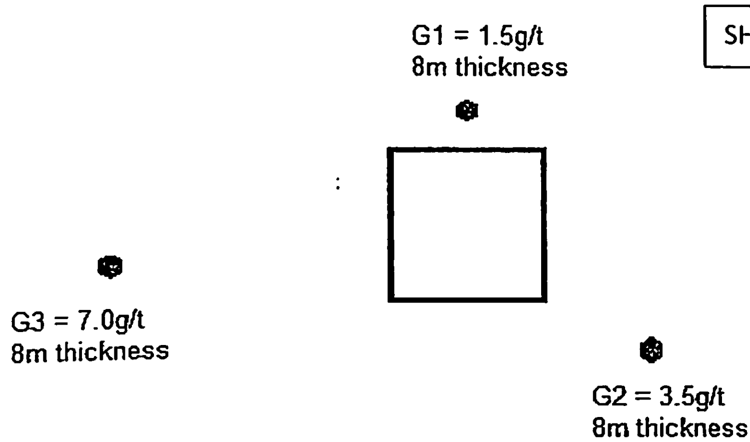
Figure. 3: Sampling arrangement of a gold deposit.

SHOW RELEVANT WORKINGS ON THIS PAGE



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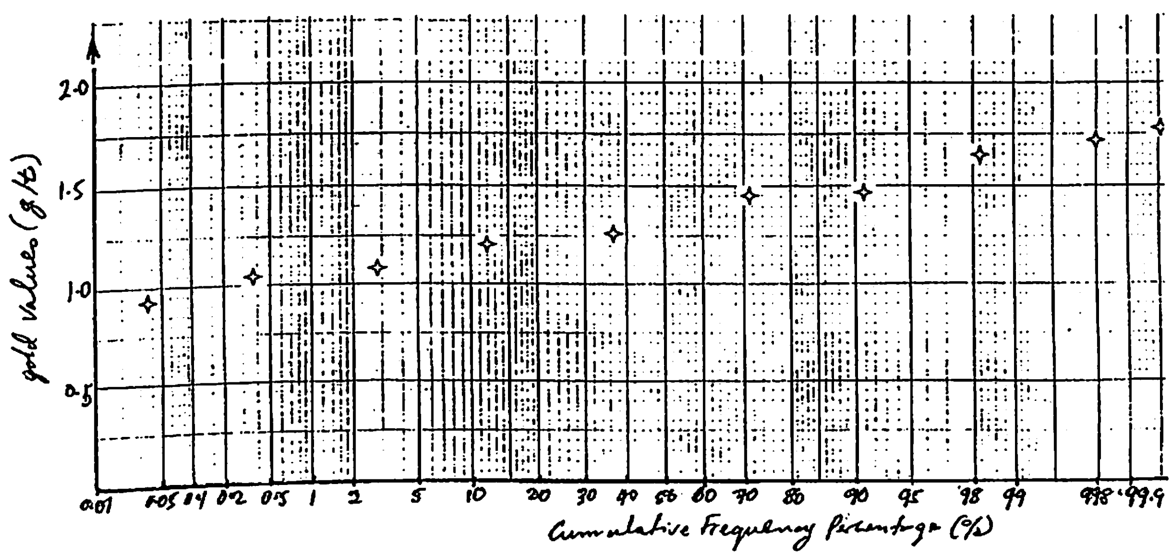

Figure - 2: Cumulative probability plot of gold values from sample data

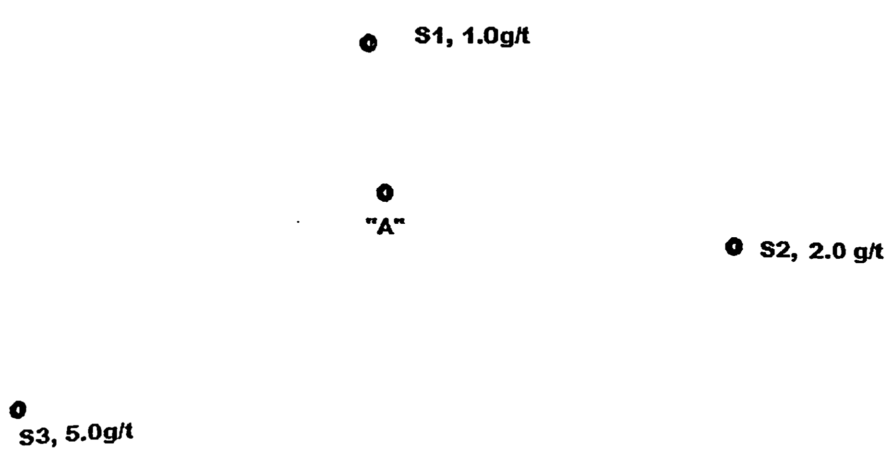

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Figure. 3: Sampling arrangement of a gold deposit.