THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF MINING ENGINEERING

2021 SECOND SEMESTER EXAMINATION

FOURTH YEAR MINING ENGINEERING

MN322 – ORE RESOURCES ESTIMATION & GEOSTATISTICS

DATE: THURSDAY, 28TH OCTOBER, 2021

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 **FOUR** questions altogether. Answer **ALL FOUR** questions. Marks to each question are shown on the paper.
3. **ALL** answers must be written on 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). What is the purpose of ore reserve estimation?

(b). (i). There are two important aspects that are considered in confidence classification of mineral resources and ore reserves. State these aspects and under each aspect list at least two factors affecting mineral resources or ore reserve.

(ii). For the factors listed above, choose one and explain briefly how it affects mineral resources and or ore reserve status.

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

(2 + 5 + 10 marks)

(d). The distribution of gold grades of a deposit have been plotted as shown on the graph below in figure 1.

(i). Model this statistical plot and describe the distribution (model on the separate sheet provided below).

(ii). Estimate the following statistical parameters from the modeled in (i); mean, standard deviation, variance, and coefficient of variation.

(iii). Explain why statistical assessment of sample data is essential prior to ore reserve estimation.

(3 + 4 + 3 marks)

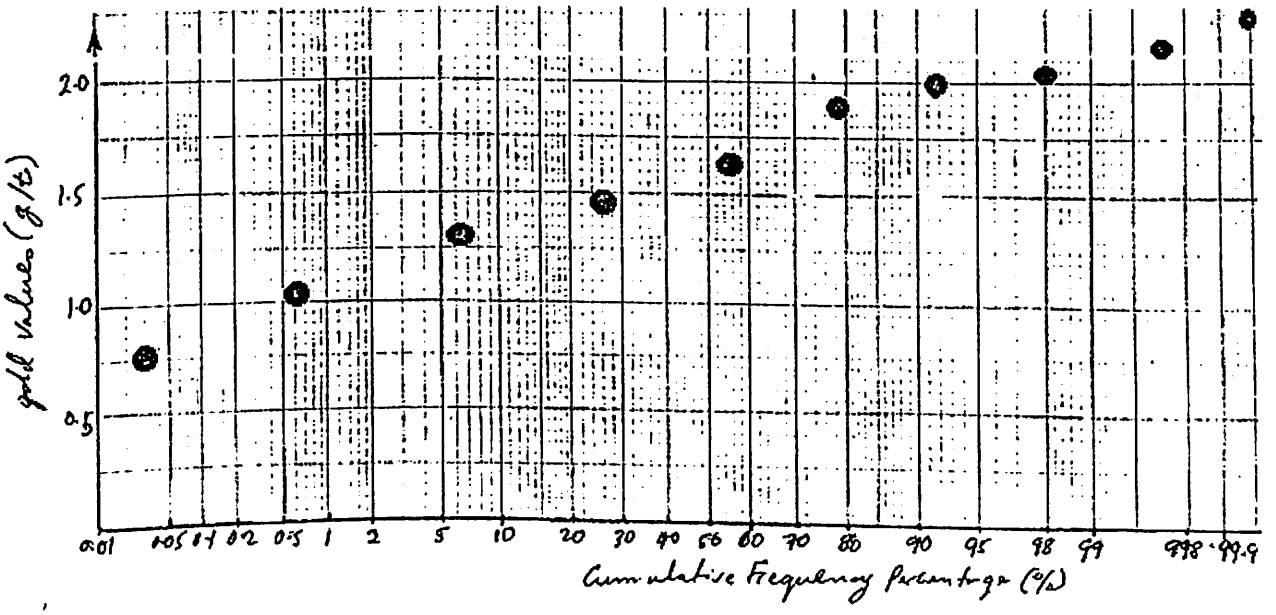

Figure 1: Cumulative probability plot of gold values from sample data

Question 2:

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

(6 marks)

(b). A mineral exploration program carried out on a gold deposit is shown by figure 2. The deposit is divided into ore blocks prior to reserve estimation and such a block is as shown in figure 2. Determine the reserve of the ore block shown by using;

(i). Polygonal method of estimation, and

(ii). Inverse Distance Squared (IDS) method of estimation. Use a search radius of 80m

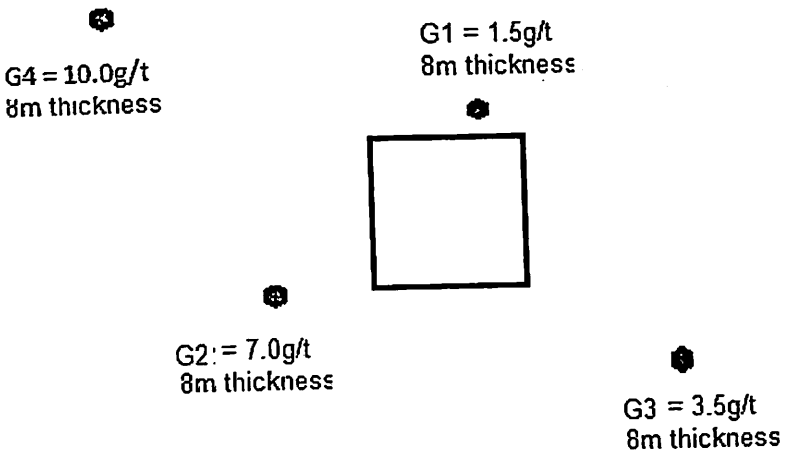

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Figure 2: Sampling program on a mineral deposit.

(iii) Explain the concept of a search radius as used in Q2b(ii) or during ore reserve estimation generally.

(3 + 5 + 5 marks)

Question 3:

(a). Dilution in mining affects predicted mineable ore reserves. State the possible source(s) of dilution during mining and explain specifically how these can be controlled.

(5marks)

(b). 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 3.0m. Therefore the expected stope size is 30.0m long x 20.0m high x 2.5m wide. If the average stope ore grade is 8.0g/t and the mine has a cut-off grade of 4.0 g/t, determine;

(i) percentage of dilution involved,

(ii) whether or not this stope should be mined/ extracted. (Justify your answer).

(iii) comment on the effects of dilution on minable ore reserves.

(5 + 3 + 2 marks)

(c). 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. Consider a gold mine to have the following characteristics:

- Deposit average grade is 1.5g/t Au.
- Gold has a fineness (purity) of 85%
- Mining cost: K25.00/tonne ore
- Milling cost: K40.00/tonne ore
- Depreciation cost: K10.00/tonnes ore
- Other Costs: K20.00/tonne ore
- Gold Price: K150.00 per gram Au, of fine gold
- Mill Recovery: 90%

(i). Based on these data, calculate the cut-off grade of the mine.

(ii). Calculate, the cut-off grade if dilution involved during mining is 10%.

(iii). Comment on the impact of dilution on cut-off grade

(iv). Generally describe the impact of cut-off grade on ore reserve with the help of a neat sketch.

(3 + 3 + 4 marks)

QUESTION 4:

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

(i). Consider that a sampling layout is as shown by figure 3 below, and the samples are spaced 20m apart. Based on this, compute the variogram for distance (h) is 20m, and 40m respectively. (Show your working to attract more marks).

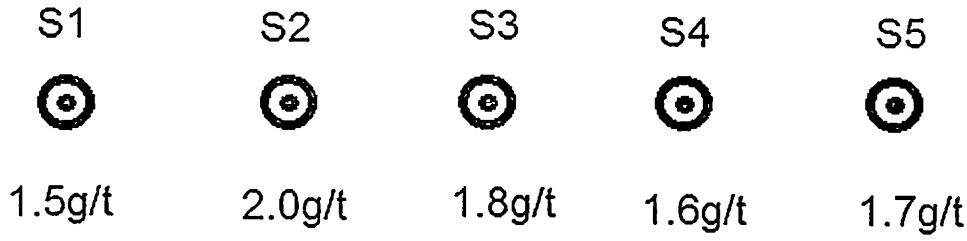

Figure 3: Exploration sampling layout show sample ID and assay values.

(ii) Plot and model the experimental variogram calculated for a mineral deposit as shown in table 1. Your model should also indicate the type of variogram modeled and the variogram parameters.

Table 1. Computed variogram values for a copper deposit.

Dist. (m)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
$\gamma(h)$	0.8	1.2	1.5	1.7	1.8	2.1	1.9	2.3	2.1	1.9	2.4	2.0	2.1	2.5	1.2

(5 + 10 marks)

(b). A sampling survey conducted on a mineral deposit is as shown in figure 4 below, along with the transitive variogram of the deposit. Supposing that the point "A" is to be estimated using kriging;

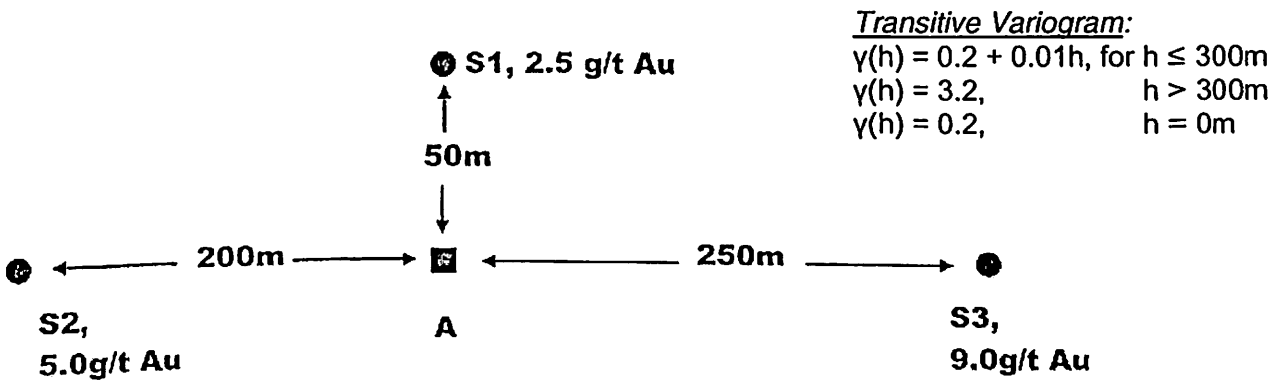

Figure 4: Sampling survey arranged as shown.

(i). Setup the matrix to solve for the Krige weights using the Krige system of equations.

(ii). Assuming the weights (λ_i) assigned to estimate the grade of point are as follows; $\lambda_1 = 0.5$, $\lambda_2 = 0.3$, $\lambda_3 = 0.2$, estimate the grade of point "A" and calculate its estimation variance.

(iii). Explain briefly what estimation variance is.

(5 + 5 + 2 marks)

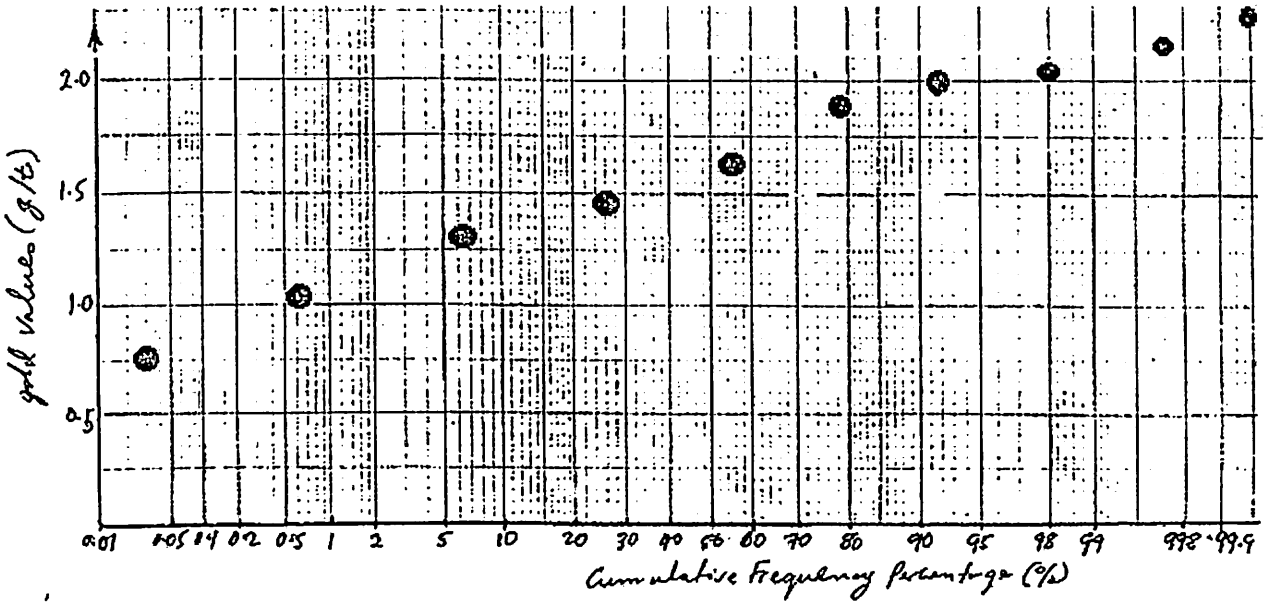

Figure 1: Cumulative probability plot of gold values from sample data

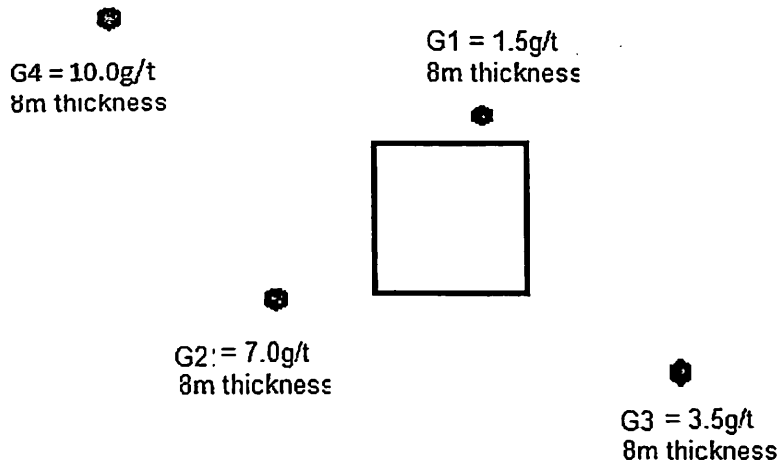

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Figure 2: Sampling program on a mineral deposit.

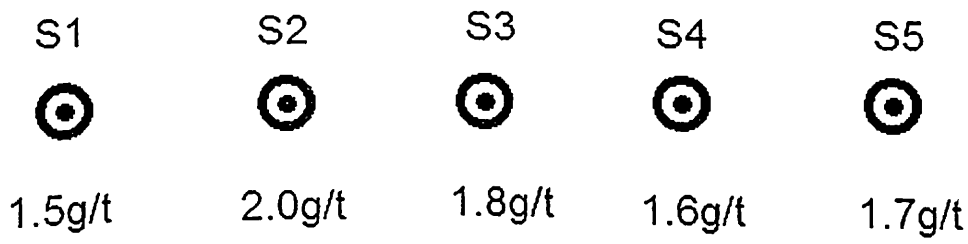

Figure 3: Exploration sampling layout show sample ID and assay values.

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