THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF MINING ENGINEERING

2020 FIRST SEMESTER SUPPLEMENTARY EXAMINATION

FOURTH YEAR MINING ENGINEERING

MN419 – ORE RESERVE ESTIMATION

DATE: FRIDAY, 25TH 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 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. Ore reserve provides the basic data for mine planning, development, and operations. Write a short paragraph explaining the levels of precision or reliability of ore reserves estimates and the implications/ consequences of poor ore reserve estimates on mineral projects.

(5marks)

b. Ore reserve confidence classification system applied in PNG is adopted from the AusIMM Mineral resource/ reserve classification system. There are two main categories; Mineral Resource, and Ore Reserves. The mineral resources categories has 3 subcategories which includes; Inferred Mineral Resource, Indicated Mineral Resource, and Measured Mineral Resource, and those project considered as having mineral/ ore reserve status fall into 2 sub categories; either Probable Ore Reserve or Proved Ore Reserves.

i. Explain so as to distinguish between the terms "mineral resource" and "ore reserve".

(3 marks)

ii. Explain so as to distinguish between the 3 "mineral resource" categories.

(5 marks)

iii. Explain so as to distinguish between the 2 "ore reserve" categories.

(5 marks)

c. Sampling provides the basic data for ore reserve estimation, therefore sampling survey planning and execution is an integral component of the ore reserve estimation process.

i. Explain briefly how ore reserve confidence and hole-spacing are related and explain the factor(s) affecting it in regards to mineral explorations and ore reserve estimations.

(5 marks)

ii. State the objective(s) of sampling survey planning?

(2 marks)

iii. Explain why one can select different grid spacing for different directions in a sampling survey.

(3 marks)

d. Estimate the following essential deposit information such as; mean grade, variance, and coefficient of variation from sample data plotted on the graph below in figure 1 and state what type of distribution is shown by the graph you modelled. (show all your working on the attached graph below and include it with the answer sheet).

(5 marks)

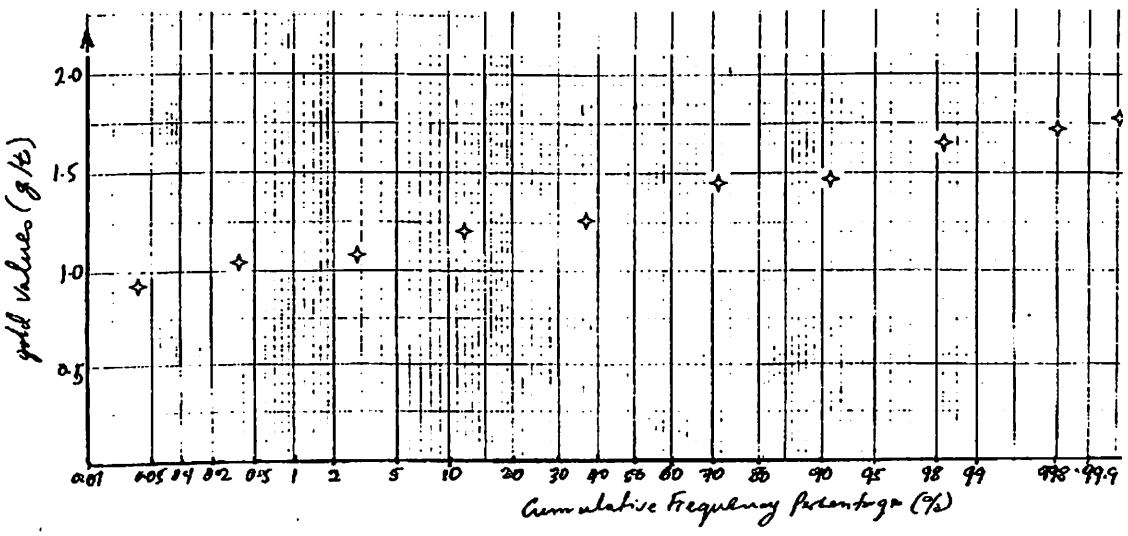

Figure 1: Sampling data plotted on a cumulative probability graph

Question 2:

a. Consider that the following is the characteristic of a stope panel that is planned to be mined:
   - Stope Panel - Length is 30m, height is 15m, and width is 2.0m
   - Ore thickness - 1.0m
   - Ore grade - 15.0g/t
   - Ore S.G - 3.0
   - Waste S.G - 3.0
   - Mill/Mine cut-off grade – 4.5g/t

   Given these determine whether the stope is mineable. (Justify your answer and show all workings).

   (7 marks)

b. Associated with mineral resource grade is cut-off grade, which is used to include the economic aspect of developing a mineral resource.

   i. Explain generally how cut-off grade affects ore reserve with the help of a neat sketch.

   (5marks)

   ii. Explain why a tonnage-grade curve is needed in ore reserve estimation reports.

   (5marks)

c. All ore reserve estimation methods used in the mining industry follow three (3) basic rules or principles when applied to make estimates of mineral reserves. State the rules or principles precisely and give an example of a method applying the rule/ principle.

   (6 marks)

d. Consider the sampling layout shown in figure 3 below, and determine:

   i. the expected reserve of "block A" if one was to use the polygonal method of estimating reserve and if the tonnage factor is 3.0t/m^3.

   ii. the reserve of "block A" using Inverse Distance (ID) method of estimating reserve if the tonnage factor is 3.0t/m^3.

   (5 + 5 marks)

Question 3:

a. Variogram is the most important and basic tool for geostatistical methods of ore reserve estimation. Its computation and accurate modelling of variogram is key to obtaining accurate ore reserve results.

i. Consider that a sampling layout is as shown by figure 2 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 on the figure attached below to attract marks).

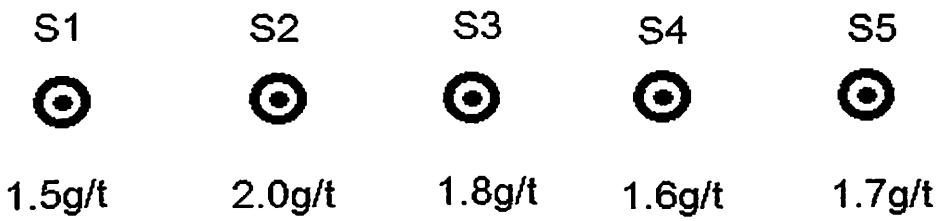

Figure 2: Exploration sampling layout show sample ID and assay values.
(5marks)

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

(7 marks)

Table 1. Variogram computed for a gold deposit.

Dist.(m)	10	20	30	40	50	60	70	80	90	100	110
γ(h)	0.6	1.2	1.8	2.1	2.3	2.7	3.1	2.1	2.8	2.0	3.7

iii. Explain what the variogram you modelled in Q3a(ii) above show.

(3 marks)

b. For the sampling layout shown by figure 3 below, assuming that one is to estimate the grade of block "A" using kriging, but krige weights are unknown, therefore setup the matrix for the krige system of equations to solve for krige weights. Consider that the average variogram between the sample and the block can be obtained by calculating the variogram using

distance from each sample to the center of the block only. Use the transitive variogram shown below in figure 3.

c. For the same problem in Q3(b), assuming that the weights assigned by krige to each sample is; $\lambda 1 = 0.6$, $\lambda 2 = 0.3$, $\lambda 3 = 0.1$, what will be the grade of the block estimated at 95% confidence interval.

To answer this question, consider the following to be true; the average variogram between each sample point and the block is calculated using the distance from each sample to the center of the block only, and that the average point-grade variance of block "A" is said to be 0.5. (Use the transitive variogram shown below by figure 3 and show all your workings).

The transitive varogram function:

$$\gamma(h) = 0.1 + 0.01h, \ \mathrm{h} \leq 220\mathrm{m}$$

$$\gamma(h) = 2.3, \mathrm{h} > 220\mathrm{m}$$

$$\gamma(h) = 0.1, \mathrm{h} = 0$$

Ore Block size: 50m x 50m x50m

Distance to center of block A:

$S_1 = 50\mathrm{m}$

$S_2 = 200\mathrm{m}$

$S_3 = 250\mathrm{m}$

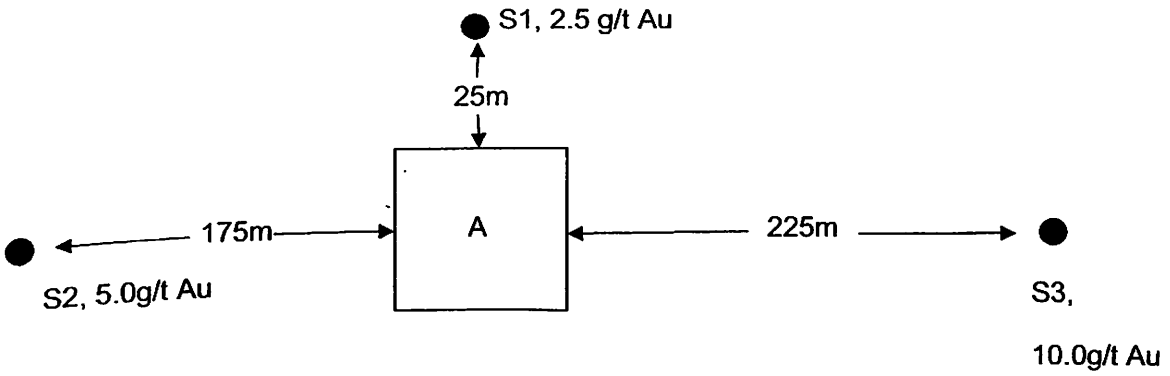

Figure 3: Sampling layout

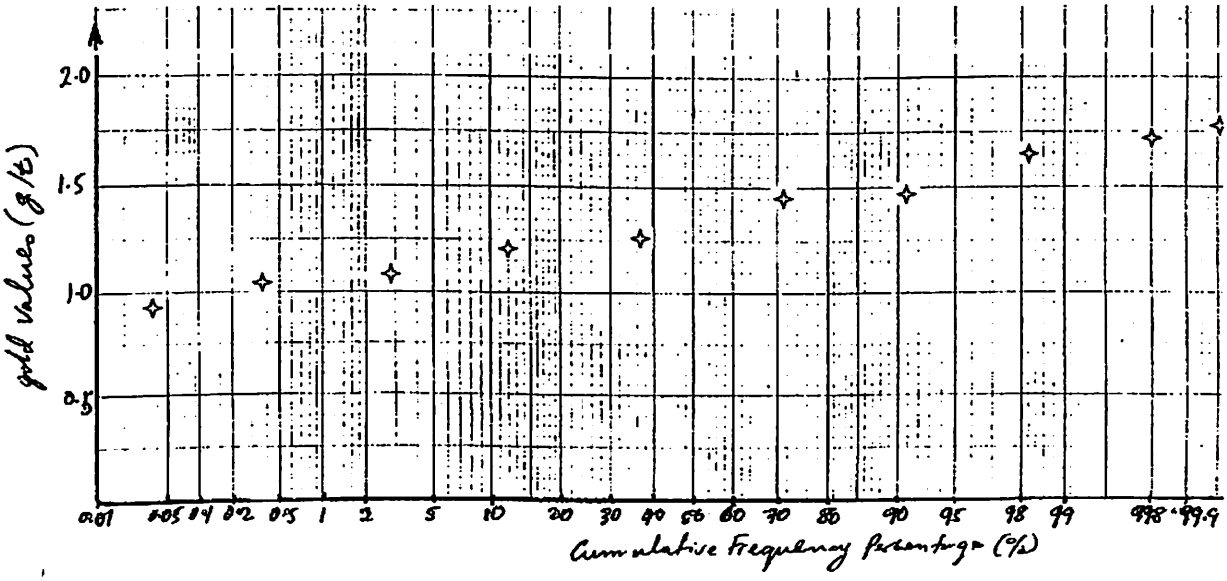

Figure 1: Sampling data plotted on a cumulative probability graph

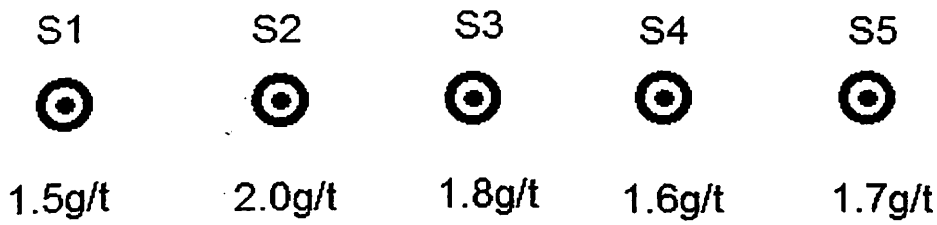

Figure 2: Exploration sampling layout showing sample ID and assay values.

(Show your workings, write your name on this sheet and attach it with the answer book)