NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF APPLIED PHYSICS

BSC. EARTH SCIENCES PART III

ELECTRICAL AND ELECTROMAGNETIC METHODS

SES 3105

Second Semester Examination Paper

December 2024

This examination paper consists of 5 pages

Time Allowed: 3 hours

Total Marks: 100

Examiner's Name: Mr C.Chuma

INSTRUCTIONS

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ANSWER **ALL** PARTS OF QUESTION 1 IN SECTION A AND ANY **THREE** QUESTIONS FROM SECTION B. SECTION A CARRIES 40 MARKS AND SECTION B CARRIES 60 MARKS

QUESTION	MARKS
1.	40
2.	20
3.	20
4.	20
5.	20
6.	20
TOTAL	100

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1. (a) What are factors influencing *electrical conductivity* in the subsurface? [5]

   (b) Define *chargeability* and *metal factor*. [5]

   (c) How does conductivity effect the depth of penetration in GPR? [3]

   (d) (i) Why do you replace metal electrodes by *nonpolarizing electrode* in IP and SP methods [3]

   (ii) Describe the nature of non-polarizing electrodes used in SP. [2]

   (e) Distinguish between membrane and *electrode polarization* in *induced polarization* [8]

   (g) Consider a scenario where the fresh water in the pores of a disseminated lead sulphide ore were replaced by saline water. Discuss the repercussions on the values of the *frequency effect* and *metal factor*. [6]

   (h) What are the advantages and disadvantages of EM surveying compared to resistivity surveying for ground surveying? [8]

2. (a) State *Archie's law* and fine all the terms [4]

   (b) Explain why clay and graphite are associated with low electrical resistivities and *Archie's law* is not valid if clay is present. [4]

   (c) Describe the *topographic effect* in resistivity methods and how you minimize the effect. [4]

   (d) An exploration company you are working for got a tender to delineate sulphide ores using resistivity/IP and EM methods which were discovered by detailed aeromagnetic survey and then ground magnetics.

   (i) Give details of how you would carry out the surveys, the arrays to be employed you stating what would be the purpose of such follow up work. [4]

   (ii) Highlight all the data processing procedures to be done in order to come up with clear pseudo section of the ores. [4]

3. (a) Describe the configurations and the relevant equations of *Wenner, Dipole-dipole,* and *Schlumberger* arrays used in resistivity methods [10]

   (b) Explain in geophysical terms the type of target that can be found using GPR. Give two examples in geological terms? [4]

   (c) How does *Electrokinetic or streaming potential* differ from *Liquid-junction or diffusion potential*? [6]

4. (a) Describe the procedures of using *gradient array* and *absolute array* in SP method. [8]

   (b) What are the advantages of employing *Wenner* and Schlumberger arrays [6]

(c) Discuss the practical differences between *frequency domain EM* and *time domain EM* methods. [6]

5. (a) How does conductivity effect the depth of penetration in GPR? [3]

(b) Define *apparent resistivity*. [3]

(c) Distinguish the geological situations for which the following forms are most appropriate *VES (Vertical Electrical Sounding), Profiling, Imaging (Electrical Resistivity Tomography)*? [6]

(d) What are the sources of error in EM methods [5]

(e) How does the depth of penetration and electrical current electrodes vary? [3]

6. (a) Consider a single current electrode on the surface of homogeneous isotropic medium of uniform resistivity, ρ and the sinking electrode is large distance (Figure 1). Show that the potential due single current at surface is given by the following equation: Explain its implication.
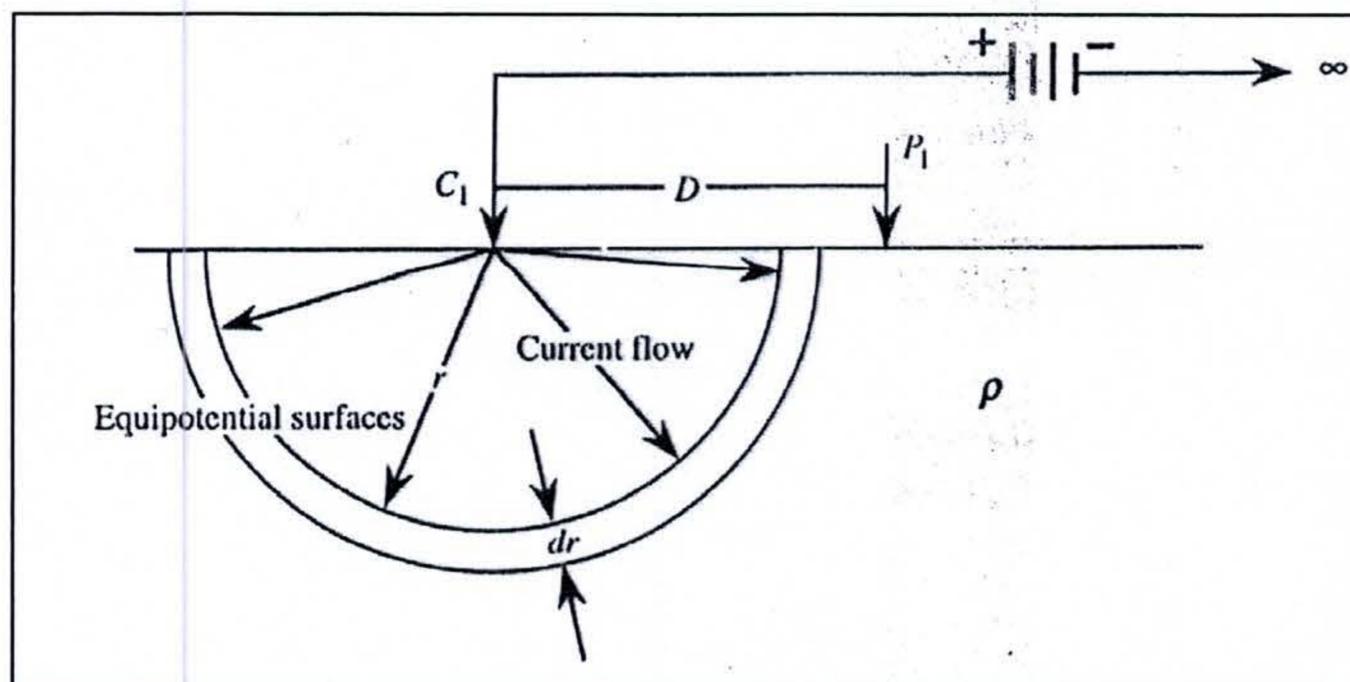
$$V = \frac{\rho I}{2\pi}$$

[10]

Figure 1. Potential from a single electrode

(b) Figure 2 is showing geological settings which is 50 km west of the Great Dyke, proximity to Kwekwe and Nkayi Road. Use qualitative interpretation of self-potential (SP) data to come up with possible two SP curves which derived from the following (use the section provided and attach it to the answer scripts):
- one produced by electrochemical processes associated with mineralised graphite phyllites, and

[6]

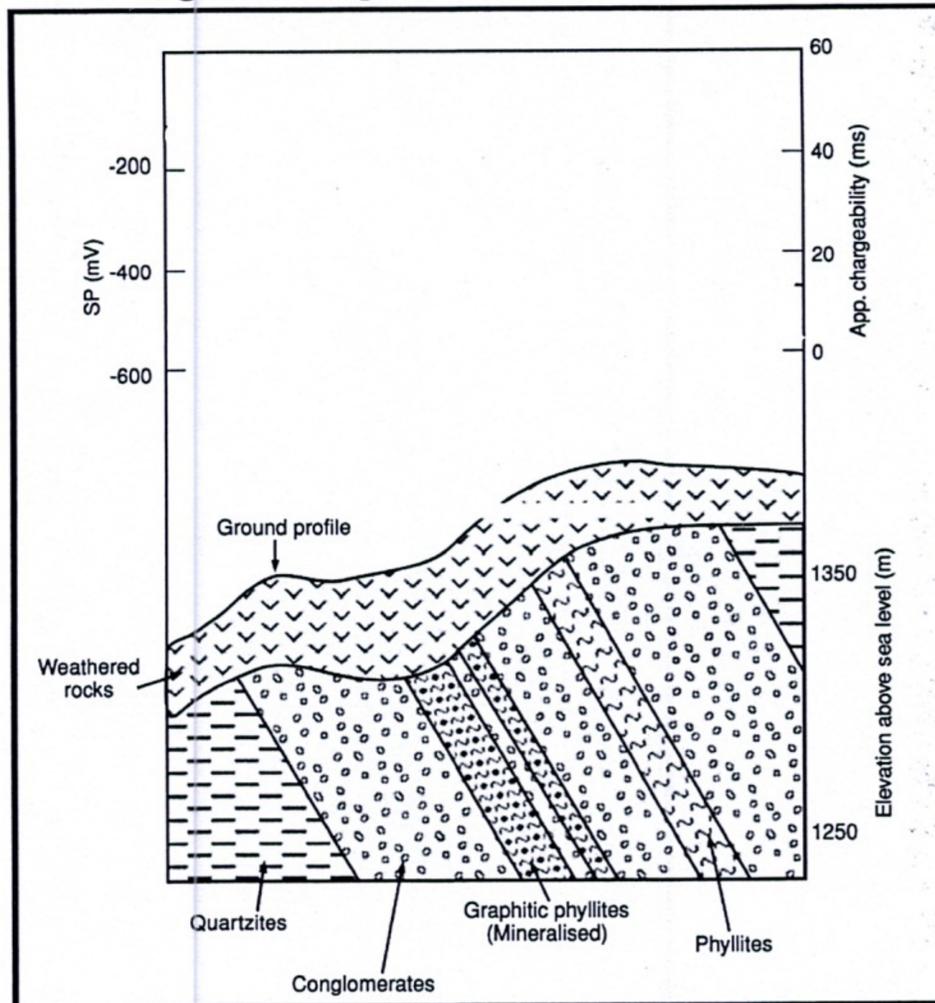- one caused by electrokinetic processes due to the flow of water in permeable disintegrated conglomerates.

Figure 2. Geological structures and mineralisation.

(c) Compare and contrast the operation of *telluric* and *magneto-telluric* methods in exploration of natural resources. [4]

End of Examination Paper: 2024

Ground profile

Weathered rocks

Quartzites

Conglomerates

Graphitic phyllites (Mineralised)

Phyllites