NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

MAPH 5238 GRAVITY AND MAGNETIC EXPLORATION METHODS

MSc GEOPHYSICS PART I: MAY 2006 *DURATION: 4 hours*

ANSWER ALL FIVE QUESTIONS

Constants: Universal Gravitational constatnt, $G = 6.67x10^{-11} Nm^2 kg^{-2}$

1. (a) Define the following quantities and give their SI units:

   (i) dipole moment
   (ii) magnetization
   (iii) magnetic succeptibility [6]

   (b) Calculate the induced magnetic dipole moment of a homogeneous sphere of pyrrhotite with diameter 20 m ; succeptibility 1.5 SI units, at a place where the Earth's field is 32 000nT. [4]

   (c) Draw a diagram of the general anomaly observed over a magnetized body of an arbitrary shape and comment briefly on the anomaly characteristics. [5]

   (d) A rock specimen has a succeptibility of 10^{-2} (SI), and a remanence of 1 A m^{-1}. In a field of strength 30000 nT what will its Konigsberger ratio be? Comment on this value. [5]

2. (a) Describe the origin of the Earth's magnetic field. Define and show the vector relationship between the elements of this field. [6]

   (b) From first principles derive expressions for the vertical and the horizontal components of the magnetic anomaly due to a magnetized rod of length L, polarized along its axis and placed nearly horizontally at depth z below the surface. Show graphically the components of the anomaly and comment briefly. [9]

   (c) Outline one method for qualitative interpretation of magnetic anomalies. [5]

3. (a) Write a short essay on the planning and execution of a ground magnetic survey for mineral deposits. Discuss quantitatively the choice of survey parameters including line orientation and spacing; the required corrections to

the field data, etc. in order to ensure that the resultant total field map is an accurate representation of the anomalous field. [11]

(b) Explain the principle and mode of operation of the optically pumped magnetometer. Include a diagram in your answer.
Is it a suitable instrument for ground magnetic surveys and why? [9]

4. (a) A large sedimentary basin produces a maximum negative anomaly of 1000 g.u. at its center. The sediments are estimated to be 8 km thick from seismic data. Calculate the average density contrast of the sediments with respect to the basement complex. [5]

(b) Write down an expression for the gravitational potential at an observation point on the earth's surface due to an arbitrary shaped sub-surface body of density contrast $\Delta\rho$. [4]

(c) Show that the gravity effect at point P(x,y) due to an infinite vertical material line (mass per unit length μ) is given by:

$$\Delta g = G\,\mu / r \qquad [7]$$

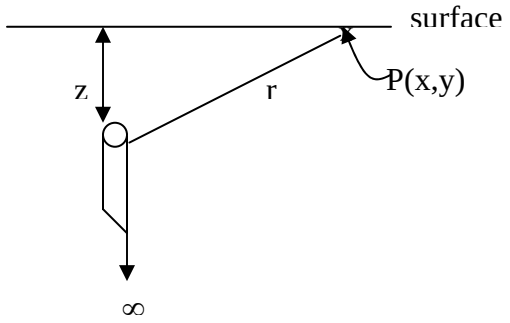

Fig 1.

(d) Write down the expressions for the higher vertical derivatives of the gravitational potential at the same point. [4]

5. (a) Draw a diagram and explain the principle of operation of La Coste – Romberg gravity meter. How do we control the sensitivity and the accuracy of this instrument? [8]

(b) A gravity survey has been conducted in a search for a massive sulphide ore body in a region of fairly flat terrain. List the required data reduction procedures in order to produce a Bouguer anomaly map over the suspected mineral deposit. Write down the expression for the Bouguer anomaly. [7]

(c) The Excess mass of the causative body of a gravity anomaly Δg , relative to its surrounding rocks, is given by

$$\Delta M = (2\pi G)^{-1} \iint_{A} \Delta g(x,y)\, dxdy$$

where x and y are in m, and Δg is in mGal.

Define all terms in the above equation and explain how can we use the excessive mass to interpret the results of a gravity survey. [5]

= END OF EXAM PAPER =