GX1152

National University of Ireland, Galway
OLLSCOIL NA hÉIREANN, GAILLIMH

SUMMER EXAMINATIONS 1999

MSc Examination

Applied Geophysics

Paper One

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Time allowed : Three hours

Answer Question 1, and any **three** of the remaining six.

1A Select the answer or answers which you believe to be correct.

(a) The magnetising force in Am^{-2} at the earth's equator is:
(i) 30 (ii) 300 (iii) 3000 (iv) 30,000

(b) The magnetic poles are where:
(i) $D = 0$ (ii) $D = \pm 180$ (iii) $I = 0$ (iv) $I = \pm 90$

(c) The free air gravity gradient in gravity units per metre is
(i) +1.119 (ii) -1.119 (iii) +1.967 (iv) -3.086

(d) If $\underline{\phi} = -\text{grad}\Psi + \text{curl}\underline{A}$, and $\text{curl}\underline{A}$ is solenoidal,
(i) $\text{curl}\underline{\phi} = \text{curl}(\text{grad}\Psi)$ (ii) $\Delta\Psi = -\text{div}\phi$
(iii) $\text{curl}\underline{A} = 0$ (iv) $\text{grad}\underline{\phi} = 0$

(e) The depth to the top of an ensemble of magnetic sources,
(i) is proportional to the maximum amplitude of the power spectrum of the magnetic anomalies
(ii) is proportional to the slope of the power spectrum
(iii) is independent of the width of the magnetic anomalies
(iv) none of the above statements is true

1B Write short notes on the following topics:

(a) Koenigsberger's ratio

(b) Pseudo-gravity anomalies

(c) Talwani's method for calculating 2D gravity anomalies over bodies with polygonal cross-sections

(d) Total mass calculation

(e) The difference between the geoid and the spheroid

2. Outline the mathematical arguments that allow the gravitational potential variations above the Earth's surface to be represented by a Fourier transform by considering:

(i) Laplace's Equation, (ii) D'Alembert's method of separation of variables, and

(iii) The principle of superposition for harmonic functions

The Fourier transform so obtained contains a term that decays exponentially with height above the surface. By referring to a profile of discrete gravity values $\partial g(kL)$ for $k = 0, 1 \ldots N$, define and illustrate the concept of upward continuation.

State two reasons for upward continuing gravity data.

[You do not need to give precise mathematical details, but you should define any symbols used in your answer].

3. When the radius, R, of an infinitely long, vertical cylinder is much less than the depth, z, to its top, the gravity anomaly as a function of distance, x, from the cylinder axis can be approximated by:

$$\partial g(x) \sim \frac{\pi R^2 \rho G}{(x^2 + z^2)^{1/2}}$$

Show how the depth to the top of the cylinder is $\sqrt{2}x_o$, where x_o is the distance at which the second horizontal derivative is zero. Illustrate your answer.

Estimate the maximum gravity anomaly over a disused, water-filled mine shaft with R=3m and z=10m. Estimate the maximum anomaly if the water level in the shaft drops by 5m.

State briefly the precautions you would need to take in order to monitor such small variations in gravity due to the variable height of the water column.

{Assume $G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$}

4. High-resolution aeromagnetic data have been collected over a shallow marine environment consisting of sediments deposited within a half-graben in igneous basement. A single seismic reflection profile perpendicular to the strike of the half-graben shows that its rifted margin is characterised by en-echelon normal faulting. The seismic data and several exploratory boreholes suggest that some of the basement faults have been re-activated after the deposition of sediments.

Describe how you would process and model the aeromagnetic data to obtain all information relevant to hydrocarbon exploration. Pay particular attention to wavenumber-domain filtering, fault mapping and the magnetic modelling procedure.

5. The relevant physical property in the gravity method is density. Describe how the density and porosity of rock samples can be determined, and explain the difference between saturated density, bulk density, and grain density.

List and describe briefly, other sources of density information which the geophysicist might use.

Discuss the importance of density in gravity modelling and assess its relevance to the non-uniqueness problem.

6. Describe the construction and mode of operation of
either the proton precessison magnetism or the fluxgate magnetometer

How might such an instrument be used in a land survey covering an area of a few square kilometers, paying attention to field procedures and corrections?

Land magnetic surveying at station spacings of less than 10m often uses magnetic gradiometers. Describe a typical gradiometer and list its advantages and disadvantages.

7. In 1998, the Society of Exploration Geophysicists devoted a special section of its journal The Leading Edge to gravity and magnetic methods in oil and gas exploration. Describe how potential field methods can help hydrocarbon exploration and speculate why they have become popular again.