Jm0010

National University of Ireland, Galway
OLLSCOIL NA hÉIREANN, GAILLIMH

SUMMER EXAMINATIONS 1998

3rd Science

INTRODUCTION TO GEOPHYSICS IY 301

Dr. R.D. Barker
Prof. A. Brock
Dr. C. Brown

Time allowed: Three hours

Answer five questions, at least two from each Section.

SECTION A

1. Describe with the aid of diagrams the mechanical principles involved in the construction of a vertical component seismograph. How are these modified in a modern seismometer based upon Faraday's Law of electromagnetic induction?

   Sketch the appearance of a seismogram recorded by a vertical component seismometer immediately after the occurrence of a major earthquake 50km away. Label your axes carefully, mark the first arrivals of the different seismic waves and comment on the properties of the surface waves seen on the seismogram. State the velocities that you have assumed for the different seismic waves.

2. Sketch the paths of the seismic phases PP, sSP, PKiKP and ScS. Explain the notation. Describe how the PKP and PKIKP phases were used to infer the existence of a low-velocity outer core and an inner core respectively.

   Explain why an abrupt increase in P-wave velocity from 10kms^{-1} to 10.8kms^{-1} across the outer core - inner core boundary is good evidence for the existence of a solid inner core. Hence, estimate the S-wave velocity in the inner core.

contd./

3. State Euler's theorem for the movement of a plate on a spherical Earth. Describe how an Euler pole can be determined by (a) measuring spreading velocities at ridges and (b) using earthquake slip vectors at transform faults. How can the accuracy of the Euler pole position be checked using a Mercator projection?

   How much faster will a mid-ocean ridge spread at an angular distance of 60° from its Euler pole compared with its spreading velocity at 30° from its Euler pole?

4. Give an account of the evidence which suggests that there is considerable thermal and compositional heterogeneity in the mantle. What are the implications for models of mantle convection?

SECTION B

5. Describe the principle of isostasy and illustrate it by explaining qualitatively whether uplift or subsidence will result from the following events:

   (i) crustal stretching
   (ii) crustal shortening
   (iii) underplating
   (iv) delamination

   Choose one of the above cases and give the relevant isostatic balance equation for it. Use the equation to find an explicit solution for either uplift or subsidence. Define all your terms.

6. List the main assumptions made in palaeomagnetism and define the term palaeomagnetic pole. Describe how palaeomagnetic poles can be obtained from palaeo-inclination and palaeo-declination measurements.

   What is an apparent polar wander path. Outline the main results from global palaeomagnetic studies of Phanerozoic rocks.

contd./

7. Outline the evidence for the existence of reversals of the earth's magnetic field, and describe how the geomagnetic polarity time scale for the past three million years has been constructed. Sketch the general shape of the polarity time scale to three million years indicating the approximate ages of the main polarity changes.

Briefly describe the mechanism or mechanisms responsible for geomagnetic reversals, and make reference to recent research developments.

8. Describe how heat flow measurements are made at sea.

Marine heat flow data shows systematic variations with the age of the ocean floor and is fairly well described by the equation:

$$q = 510\ t^{-1/2}$$

where q is the heat flow in mWm^{-2} and t is the age in Ma. An equivalent formula for depth (in metres) is

$$d = 2600 + 365t^{1/2}$$

At what depth would you expect to find a heat flow of $102mWm^{-2}$?

Explain why both heat flow and depth are governed by a simple square root relationship, and sketch the underlying theory. At large values of t, the formulas overpredict depth and underestimate heat flow. Why is this so, and how is the theory modified to produce better predictions.