GX1150

National University of Ireland, Galway
OLLSCOIL NA hÉIREANN, GAILLIMH

SUMMER EXAMINATIONS 1999

3rd Science

INTRODUCTION TO GEOPHYSICS IY 301

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Time allowed: Three hours

Answer five questions, at least two from each Section.

SECTION A

1. A P-ray is incident upon an interface between two media that propagate seismic waves with different speeds and have different densities. Explain, with the help of diagrams, the phenomenon of mode conversion. State the generalised form of Snell's Law that predicts the directions of the transmitted and reflected rays.

   Illustrate the results of Zoeppritz equations for the variations in reflected and transmitted P-ray amplitudes for different angles of incidence of the P-ray. Comment on their significance for seismic reflection surveys.

   The speeds of P and S waves in a medium are:

   $$V_p = \sqrt{\frac{k + (4/3)\mu}{\rho}} \qquad V_s = \sqrt{\frac{\mu}{\rho}}$$

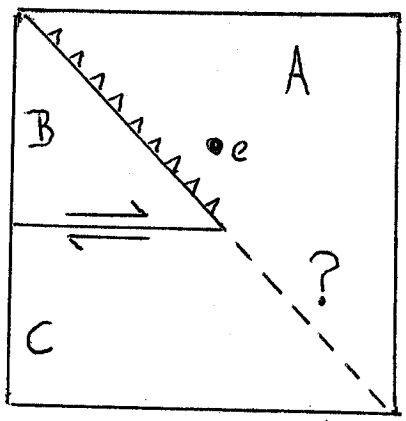
   If the bulk modulus is 5/3 times the rigidity modulus, what is the V_p/V_s ratio?

2. Explain with the help of a diagram what happens when seismic rays are incident upon (i) a low velocity zone in the upper mantle and (ii) a sudden increase in velocity in the mantle. Sketch the travel time versus epicentral angle curves for both cases. Why do these low velocity zones and velocity increases occur in the upper mantle? Do they occur everywhere?

   Calculate an approximate speed in rocks just above the upper mantle-lower mantle boundary for a ray that grazes the boundary. Assume the ray parameter is 570s, the boundary is at a depth of 670km and Earth's radius is 6370km. Comment on whether it is a P or S wave.

3. Define the following terms: ridge, transform fault, subduction zone and triple junction. Illustrate three types of triple junction that are dynamically stable.

The diagram below shows a 3-plate system in which B is being subducted beneath A with a speed of 28mm/year in the north-east direction. If the relative speed of B with respect to C is 40mm/year, use a velocity space diagram to identify the unknown boundary between A and C. Label this diagram carefully.



Comment on the evolution of the triple junction and the change in tectonic environment at the point e.

4. Explain how the relative importance of the different forces associated with plate motion can be assessed. Pay particular attention to the ridge push, slab pull, slab resistance and mantle drag forces, and mention any others which may be relevant.

Summarise the seismological evidence for whole mantle circulation of material.

SECTION B

5. Gravity at the equator is slightly less than that at the pole due in part to the acceleration arising from the earth's rotation. Estimate the magnitude of the rotational acceleration at the equator, given that the earth's radius is approximately 6400km.

The earth's rotation also has an effect on the earth's shape. Explain how this arises, and indicate, without giving the full mathematical detail, how the effect is calculated. The resulting shape is called the spheroid. A related surface is called the geoid. Distinguish carefully between these two surfaces.

6. Describe the McKenzie model for sedimentary basin formation, and give examples of it's application.

   A region of crust of thickness 30km and density 2700 kgm^{-3} with its surface close to sea level is stretched by a factor of two under strong extensional forces. Given that the density of the underlying mantle is 3300 kgm^{-3}, find the depth of the resulting ocean. Give your assumptions and explain the calculation. You may assume that the density of the water is 1000 kgm^{-3}.

7. With the help of a diagram, define the magnetic elements X, Y, Z, H, F, D and I, and give expressions for D and I in terms of X, Y and Z.

   The earth's magnetic field exhibits time variations on a variety of time scales. Briefly describe the nature of the following styles of variation, stating in each case, the characteristic times involved: diurnal variation, secular variation, reversals, apparent polar wander.

8. What simple observation tells us that the earth must be losing heat? Outline the principal mechanisms by which the earth looses heat, and list the main sources of heat production. By considering the balance between heat loss and heat production, attempt an answer to the question "is the earth cooling?"