GX 1350

National University of Ireland, Galway
OLLSCOIL NA hÉIREANN, GAILLIMH

WINTER EXAMINATIONS 2002

3rd SCIENCE
INTRODUCTION TO GEOPHYSICS IY301
Prof. B.P.J. Williams
Dr. C. Ebinger
Dr. C. Brown

Time allowed: Three hours.
Answer five questions.
Allow about 35 minutes for each question.

Q.1 Define equipotential surface and distinguish between the geoid and spheroid. Explain, without giving the full mathematical details, how the shape of the Earth is approximately an ellipsoid of revolution whose gravity field varies as a function of latitude.

Explain the corrections to gravity observations in a mountainous area before they can be used to infer the sub-surface density distribution. Sketch the shape of a complete Bouguer anomaly profile over (1) a buried granite and (2) a high mountain plateau. Comment on the sketches.

Q.2 The magnetic field changes with time over a wide range of timescales. Sketch the variations to be expected at a scale of 24 hours. Sketch the variation in magnetic declination and inclination for Hawaiian lavas erupted over the last 5 thousand years.

Summarise the main features of the Geomagnetic Polarity Time Scale (GPTS) over the last 5 million years. Explain how the GPTS can be used to estimate the age of oceanic crust. State your assumptions.

Q.3 Starting from the law of radioactive decay, derive the relationship between half-life and decay constant. How many atoms of the radioactive parent are left after 7 half-lives?

Describe the radioactive decay mechanisms associated with the Potassium-Argon dating method, Explain how the ages of lavas can be estimated by measuring the amounts of potassium and argon. State the main assumptions.

Briefly state why the method cannot be used to date the age of meteorites.

Q.4 What simple observations show that the Earth must be losing heat from its interior? Discuss the evidence and give an explanation for the variation of heat flow over oceanic crust. Explain why the heat flow is particularly variable near a mid-ocean ridge.

Compare and contrast the heat flow variation with age over oceanic crust and continental crust. Explain why the average heat flow in continents is larger than in oceans when thermal equilibrium has been reached.

Q.5 Sketch the travel-time versus distance curves along a 250km reversed seismic refraction profile over continental crust with a dipping Moho. Explain the concepts of critical distance, cross-over distance, apparent velocity, intercept time and reciprocal time. State why it is necessary to have a profile of this length for continental crust yet it is sufficient to have a profile 80km long for oceanic crust?

Estimate the depth of the Moho beneath each shot point if the P-wave velocities in the crust and mantle are 6.0 and 8.0 km s^{-1} respectively and the two intercept times are both equal to 8.8s.

Q.6 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 core and inner core. Why are there two PKP arrivals recorded at a seismological observatory at an epicentral angle of 150° from an earthquake?

Explain why an abrupt increase in P-wave velocity from 10 to 10.8 km s^{-1} across the outer core – inner core boundary is evidence for the existence of a solid inner core.

Q.7 Describe how the first P-wave motions recorded by seismometers on the Earth's surface can be used to infer the type of movement on a fault after an earthquake has occurred. Illustrate your answer for a north-south striking fault dipping down to the east if it is a) a normal fault and b) a thrust fault. Sketch the focal spheres.

Summarise the typical fault plane solutions that occur for earthquakes in a Wadati-Benioff zone. Explain why some subducted oceanic plates are associated with earthquakes that are predominately due to down dip tension while other subducted oceanic plates have earthquakes predominately due to down dip compression.

Q.8 Summarise the major tectonic processes that occur at a creative plate boundary (e.g. Mid-Atlantic Ridge) and a conservative plate boundary (e.g. Dead Sea Rift).

Give a brief plate tectonic explanation of the fault plane solutions for earthquakes occurring along fracture zones offsetting segments of a mid-ocean ridge. Explain the existence of fracture zones in oceanic crust that persist for long distances beyond mid-ocean ridge segments.