Answer Key

Answers to Study Questions

1. Seismic waves reflect off the boundaries between layers of differing densities; some of this energy returns to the Earth's surface, where it is recorded on a seismogram.

2. Depth to a seismic reflecting surface may be determined from the amount of time needed for a seismic wave to travel down to the boundary, reflect from the surface of the boundary, and travel back to the surface as recorded on the seismogram.

3. In seismic refraction, some of the energy passes through a rock boundary, but the wave bends as its speed and direction change in the new medium. The new velocity depends on the velocity of the medium. *Seismic reflection* is the energy that does not pass into the new medium, being reflected back into the original medium instead.

4. The depth to a rock boundary may be determined using seismic refraction. After a shock such as an earthquake or nuclear explosion, both a direct wave and a refracted wave move from the focus of the shock to the surface. Stations relatively close to the epicentre receive the direct wave first, followed by the refracted wave. However, at some point (called the transformation point), the refracted wave overtakes the direct wave, so at stations farther away from the epicentre, the refracted wave reaches the receiving station first. The distance of the transformation point from the epicentre depends on the depth of the boundary between the two rock layers. Therefore, if the transformation distance is known, the depth of the rock boundary can be calculated.

5. The pressure increase that takes place with depth causes a gradual increase in the velocity of a seismic wave as it goes deeper. With each increase in velocity, small changes occur in the direction of the wave, which results in a curved pathway.

6. Oceanic crust is thinner than continental crust: oceanic crust = 7 km, while continental crust = 30-50 km. The oceanic crust is composed of basaltic rocks, whereas the continental crust is composed of granitic rocks. Seismic P waves travel faster through basaltic rocks and oceanic crust than through granitic rocks and the continental crust.

7. The *Moho* is the boundary between the crust and the mantle.

8. Two lines of evidence suggest that mantle rock is ultramafic. First, P waves travel faster in the mantle than in the crust, suggesting that the two are composed of different types of rock; and second, ultramafic mantle rocks have been found at the Earth's surface.

9. The *lithosphere* consists of the Earth's crust and the uppermost portion of the mantle. It is up to 125 km thick.

10. Seismic waves travel more slowly in the asthenosphere than in the lithosphere. Movement is slower because the rocks in the asthenosphere are closer to their melting point, and may, in fact, be partially melted.

11. If the rocks of the asthenosphere are near their melting point, the asthenosphere may represent a zone in which magma is likely to be generated. Also, the rocks may have relatively little strength. Therefore, they may be likely to flow, possibly acting as a lubricant between the crust and the core.

12. The layers detected in the mantle by seismic techniques may reflect changes in mineralogy caused by the pressure increase with depth.

13. As P waves hit the Earth's core, their refraction creates a shadow zone, a region between 103° and 142° from the epicentre of an earthquake, where P waves are not detected. The presence of this shadow zone indicates that the P waves are being deflected around the core.

14. S waves cannot travel through liquids; therefore, the fact that S waves do not travel through the core implies that at least the outer part of the core is liquid.

    The way in which P waves are refracted suggests that the core has two parts: a liquid outer core and a solid inner core.

15. The Earth's core is thought to be composed of iron, with a minor amount of silicon, sulphur, or nickel. This theory of core composition is based on density calculations involving the overall density of the Earth and the densities of crustal and mantle rocks. It is also supported by the composition of meteorites that are thought to be remnants of the basic material that created our solar system.

16. Three basic types of meteorites:

    - *stones:* made up mostly of plagioclase and Fe-Mg silicates. Most stones contain round silicate grains called chondrules, and are referred to as chondrites.
    - *stone-irons:* made up of silicate minerals and nickel-iron alloy in approximately equal amounts.

- *irons:* principally iron-nickel alloy, with small amounts of other minerals.

17. A *carbonaceous chondrite* is a chondrite composed mostly of serpentine or pyroxene, that contains up to five per cent organic molecules, including carbon, hydrocarbon compounds, and amino acids. Carbonaceous chondrites are believed to have the same composition as the original material from which the solar system was formed.

18. *Isostacy* is the balance between adjacent blocks of brittle crust floating on the plastic upper mantle. If weight is added to a column of rock, the column sinks into the upper mantle to adjust to the added weight. If weight is removed from a column of rock, the column rises. In either the case the adjustment is called *isostatic adjustment*.

19. No. As material is eroded from a mountain, the weight of the crust is reduced. The crust rises by isostatic adjustment to compensate for the loss of weight. Therefore, part of the elevation lost through erosion is regained by isostatic adjustment.

20. *Crustal rebound* is the rise of the crust through isostatic adjustment after removal of glacial ice.

21. A gravity meter measures the gravitational attraction between the Earth and a mass within the gravity meter. Dense rocks pull strongly on the mass inside the meter; less dense material pulls less strongly. Hence, the gravity meter can be used to distinguish the densities of rock bodies within a local area.

22. Positive gravity anomalies might occur where tectonic forces are holding a region up out of isostatic equilibrium or where local concentrations of dense rock, such as metal ore, occur.

    Negative gravity anomalies occur where tectonic forces are holding a region down out of isostatic equilibrium (e.g., oceanic trenches) or over regions of low density rocks, such as salt domes.

23. It is thought that the Earth's magnetic field is created by electric currents within the slowly circulating, liquid part of the core.

24. Compare your drawings to Figure 17.18 in the textbook.

25. Rocks that contain iron compounds can record the polarity of the Earth's magnetic field. Magnetite crystals in a cooling lava align to point towards the north magnetic pole. When the magma solidifies, the magnetite crystals preserve the record of the Earth's magnetic field. In sedimentary rock, iron-containing minerals record the Earth's magnetism either at the time of deposition of the sediment or at the time the mineral was precipitated during alteration of the rock.

26. Small magnetic anomalies generally indicate variations in rock type. Positive magnetic anomalies may indicate the presence of a body of magnetic ore, the intrusion of a large dike of gabbro into granite, or the presence of a granitic basement lying buried by sediments. Negative magnetic anomalies may indicate the presence of a down-dropped fault block in igneous rock (e.g., a graben filled in with sediment).

27. A *geothermal gradient* is the temperature increase with depth into the Earth from a particular location. The average geothermal gradient near the Earth's surface is 25°C/km.

28. The temperature at the boundary between the inner and outer core of the Earth is about 6600° C. The inner core is still solid at this temperature because it is under great pressure, which increases the melting temperature.

29. High heat flow can be caused by

    - the presence of a magma body or still-cooling pluton near the Earth's surface.
    - an old igneous body.
    - the rise of warm mantle rock beneath abnormally thin crust.

30. Heat flow through the continents is expected to be high because of the high concentration of radioactive material in continental crust. Heat flow under the ocean may be unexpectedly high because hot mantle rock rises slowly by convection under parts of the ocean.