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Chapter 2: Earth Structure and Plate Tectonics

Answers to Study Problems

1) Estimate the thickness of oceanic lithosphere that is a) 5 million, b) 10 million, c) 20 million, and d) 50 million years old.

   Solution:

   Thickness (km) = 10 x sqrt(age in millions of years)
   a) Thickness = 10 x sqrt(5) = 22.4 km
   b) Thickness = 10 x sqrt(10) = 31.6 km
   c) Thickness = 10 x sqrt(20) = 44.7 km
   d) Thickness = 10 x sqrt(50) = 70.7 km

2) Given the results you obtained in the previous problem, how would you describe a plot of oceanic lithosphere thickness as a function of age of the lithosphere?

   Solution:

   The plot is not linear. The thickness increases more rapidly at younger ages than at older ages.

3) Near the Hawaiian Islands, the Pacific Plate is moving to the northwest at a speed of about 7 cm (~2.76 in) per year. How far will the Island of Oahu move in 30 million years? Give your answer in km and miles. Compare this with the distance between Los Angeles, CA and New York, NY.

   Solution:

   Distance (km) = (7 cm/yr) X (30,000,000 yr) x (1 km / 100,000 cm)
   = 2100 km
   Distance (mi) = (2100 km) x (1 mi / 1.609 km) = 1305 mi

   The distance between Los Angeles and New York is about 3944 km or 2451 mi. This is roughly twice the distance that Oahu would move.

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Chapter 2: Earth Structure and Plate Tectonics

Quick Review Questions

2.1 Earth's Interior

1. P-waves travel through solids, liquids, and gases. S-waves travel through solids.
2. Continental crust is composed largely of granite with an average density of 2.7 g/cm^3 and an average thickness of 40 km. Oceanic crust is composed largely of basalt with an average density of 2.9 g/cm^3 and an average thickness of 7 km.
3. The Moho is the boundary between the crust and the mantle. It is deeper under the continents because continental crust is generally thicker than oceanic crust.
4. (a) The crust and mantle are layers that differ from one another in chemical composition. (b) The lithosphere, asthenosphere, and mesosphere are layers that differ from one another in rigidity.
5. Because of isostatic equilibrium.
6. The outer core an inner core are similar because they have the same chemistry. The outer core and inner core are different because they are in different physical states. The outer core behaves like a liquid and the inner core is solid.

2.2 History of a Theory: Continental Drift

1. Wegener used a variety of different kinds of evidence in proposing his theory of drifting continents. These included the geographic fit of continents, and several different features that can be found on different continents now but that fit together when the continents are joined such as: patterns of fossil plants and animals; mountain ranges of similar age, structure, and composition; unusual sequences of rocks and rock units; and patterns of glaciation.
2. Pangaea included all modern land masses.
3. Laurasia included North America and Eurasia. Gondwanaland included Africa, South America, India, Australia, and Antarctica.
4. The primary objection was the lack of a plausible driving mechanism.

2.3 Evidence for a New Theory: Seafloor Spreading

1. Mantle convection cells are caused by heating of the mantle from below.

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2. In the Hess model, the plates are carried on top of mantle convection cells.
3. Earthquakes are not uniformly distributed around the globe. They concentrate along the edges of plates. They are generally shallow along divergent and transform boundaries and range from shallow to deep along convergent boundaries involving plate subduction. Heat flow is very high along divergent boundaries and decreases with increasing distance from them. The age of Earth's crust increases with increasing distance from divergent boundaries. The thickness of seafloor sediments increases with increasing distance from divergent boundaries.
4. Magnetic reversals occur when the polarity of Earth's magnetic field reverses. The polarity of Earth's magnetic field is recorded in seafloor rocks as they cool. When a magnetic reversal occurs, the event is recorded in the rocks.
5. The patterns of magnetic reversals in seafloor rocks are characterized by roughly linear bands of high and low magnetic intensity in the rocks that are parallel to the spreading center.

2.4 Plate Tectonics

1. This is a mechanical exercise for the students.
2. Divergent boundaries where plates move away from each other. Convergent boundaries where plates move toward each other. Transform boundaries where plates slide past each other.
3. Most divergent plate boundaries are found in the ocean basins.
4. A transform fault is the active portion of a fracture zone. Transform faults are located between segments of ridge crest. Transform faults are plate boundaries.
5. Most transform faults join two segments of divergent boundaries.
6. A Wadati-Benioff zone is a zone of earthquake activity that descends into Earth's interior. They are associated with ocean trenches and subducting oceanic lithosphere.
7. Oceanic lithosphere is denser and heavier than continental lithosphere.
8. A passive continental margin is not a plate boundary. An active continental margin is a plate boundary. Active continental margins often have oceanic trenches are transform faults.

2.5 Motion of the Plates

1. The average rate of seafloor spreading is about 5 cm (2 in) per year.
2. In the convection model of plate motion the plates ride on top of large convection cells in the mantle. This model is driven by heat and gravity.
3. In the ridge-push, slab-pull model of plate motion the plates slide down the sides of mid-ocean ridges (pushing on the rest of the plate). As they move away from the ridges they cool, thicken, and increase in density. Eventually they are pulled into the

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mantle at ocean trenches by the weight of their leading edges. This model is driven by gravity.

4. A hotspot is a persistent rising plume of hot mantle material that remains stationary for long periods of time.
5. Hotspots create volcanoes at Earth's surface. As a plate moves over the hotspot, a chain of extinct volcanoes will be created marking both the direction of plate movement and the speed of the plate.

2.6 History of the Continents

1. The Panthalassa Ocean was a massive ocean that included most of Earth's seawater. The Tethys Sea was a much smaller body of water occupying an indentation in Pangaea between what would eventually become present-day Australia and Asia.
2. Panthalassa eventually became the present-day Pacific Ocean.
3. The Wilson cycle is a description of the stages in the creation and destruction of an ocean basin. An initial continent is broken apart by rifting, creating a young, shallow, ocean basin. Continued rifting widens the ocean basin and seafloor eventually becomes old enough to subduct. Subduction hastens closing of the ocean basin and eventually continental collision eradicates the ocean entirely.

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