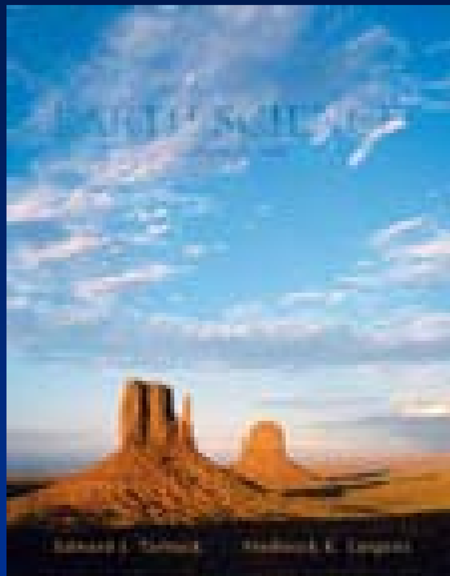


Lecture Outlines PowerPoint

Chapter 8

Earth Science, 12e

Tarbuck/Lutgens

Earth Science, 12e

Earthquakes and Earth's Interior

Chapter 8

Earthquakes

- General features
  - Vibration of Earth produced by the rapid release of energy
  - Associated with movements along faults
    - Explained by the plate tectonics theory
    - Mechanism for earthquakes was first explained by H. Reid
      - Rocks “spring back” – a phenomenon called elastic rebound
      - Vibrations (earthquakes) occur as rock elastically returns to its original shape

Elastic rebound

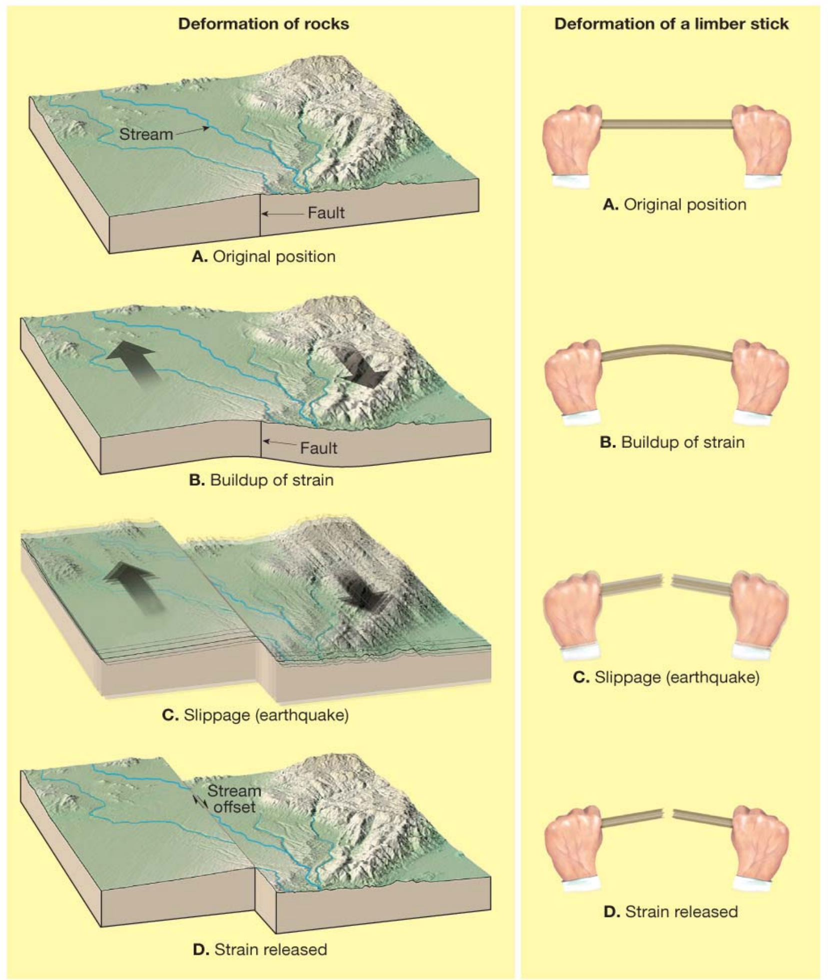


Figure 8.5

Earthquakes

- General features
  - Earthquakes are often preceded by foreshocks and followed by aftershocks

Earthquakes

- Earthquake waves
  - Study of earthquake waves is called seismology
  - Earthquake recording instrument (seismograph)
    - Records movement of Earth
    - Record is called a seismogram
  - Types of earthquake waves
    - Surface waves
      - Complex motion
      - Slowest velocity of all waves

Seismograph

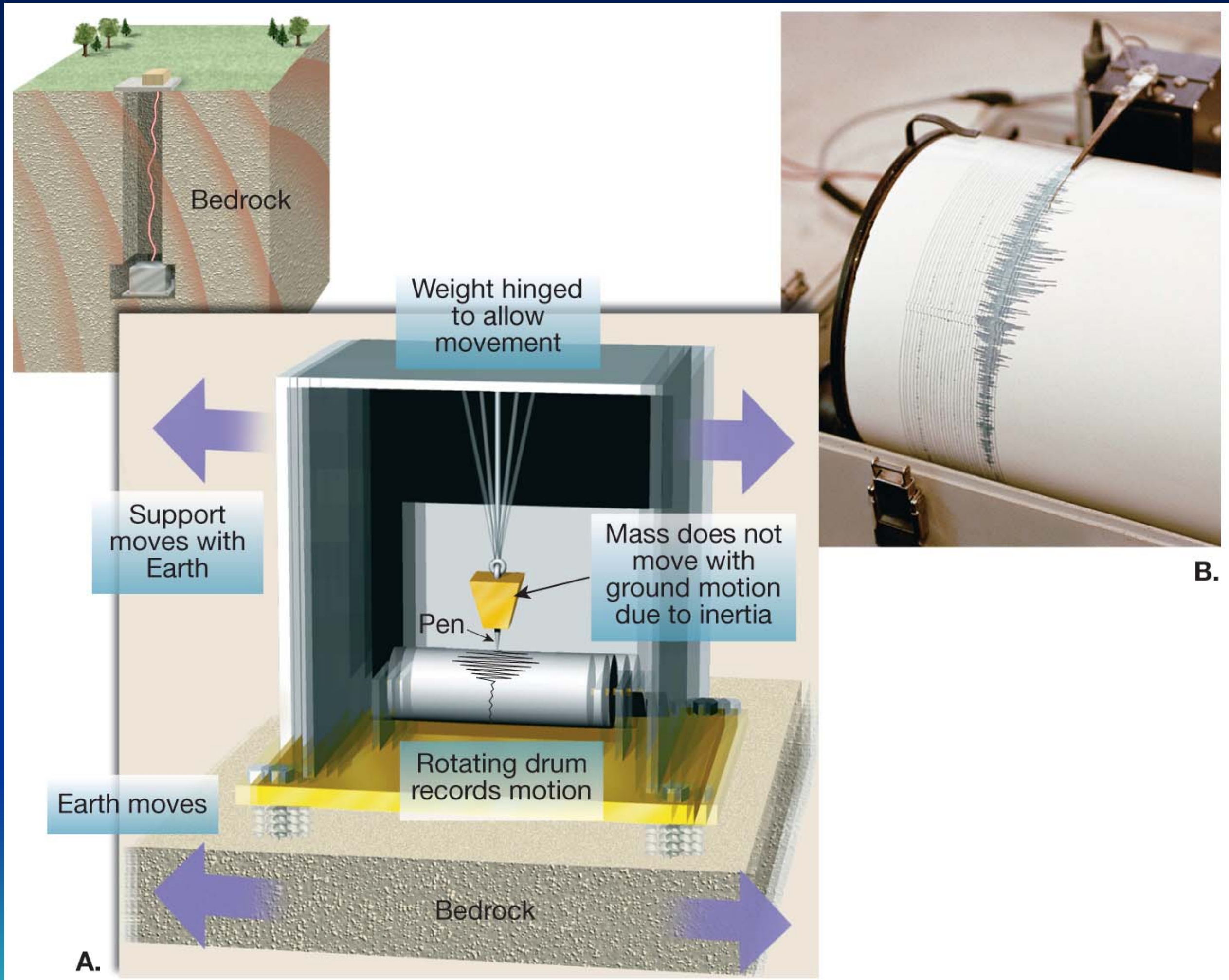


Figure 8.7

A seismogram records wave amplitude vs. time

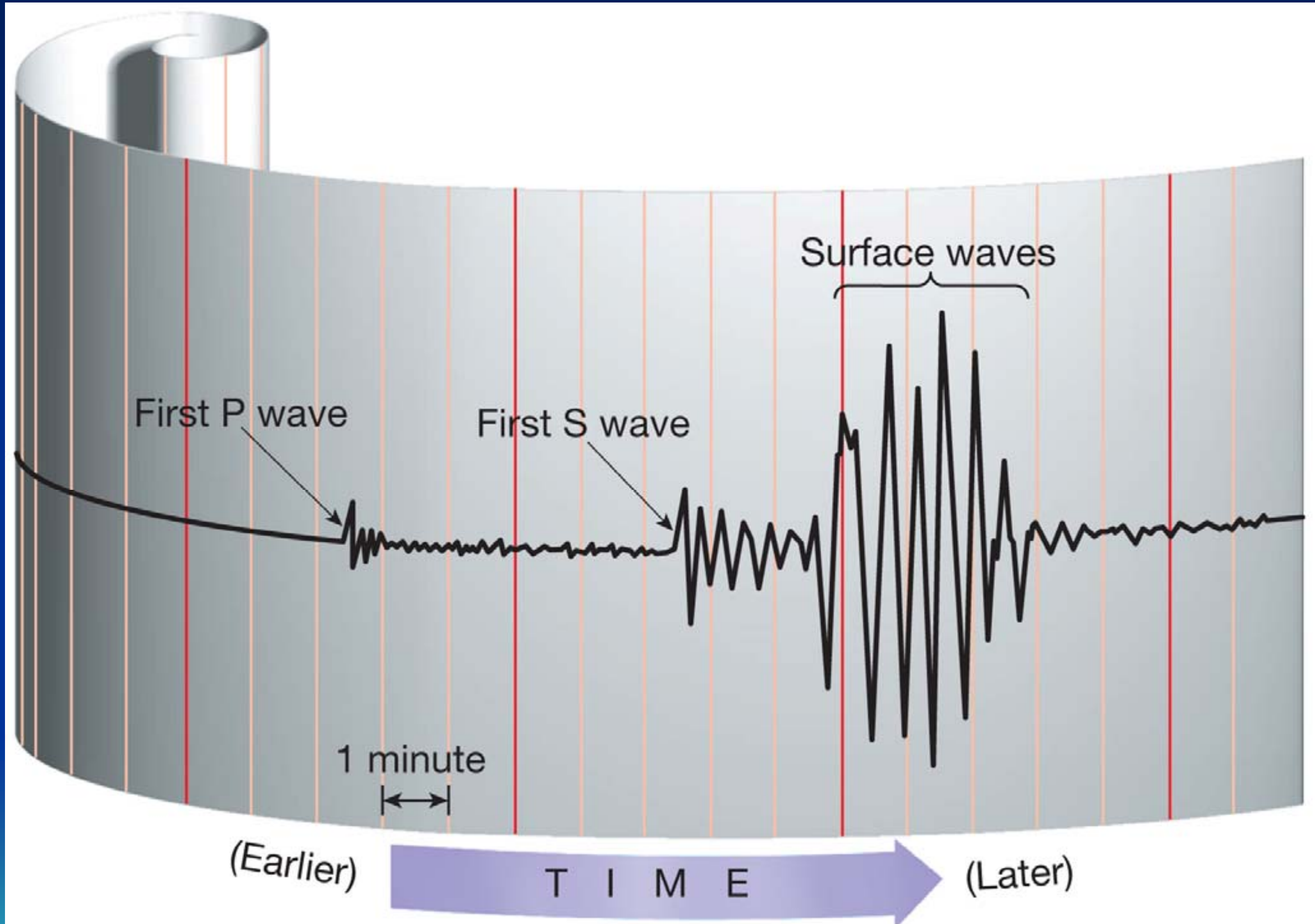


Figure 8.8

Surface waves

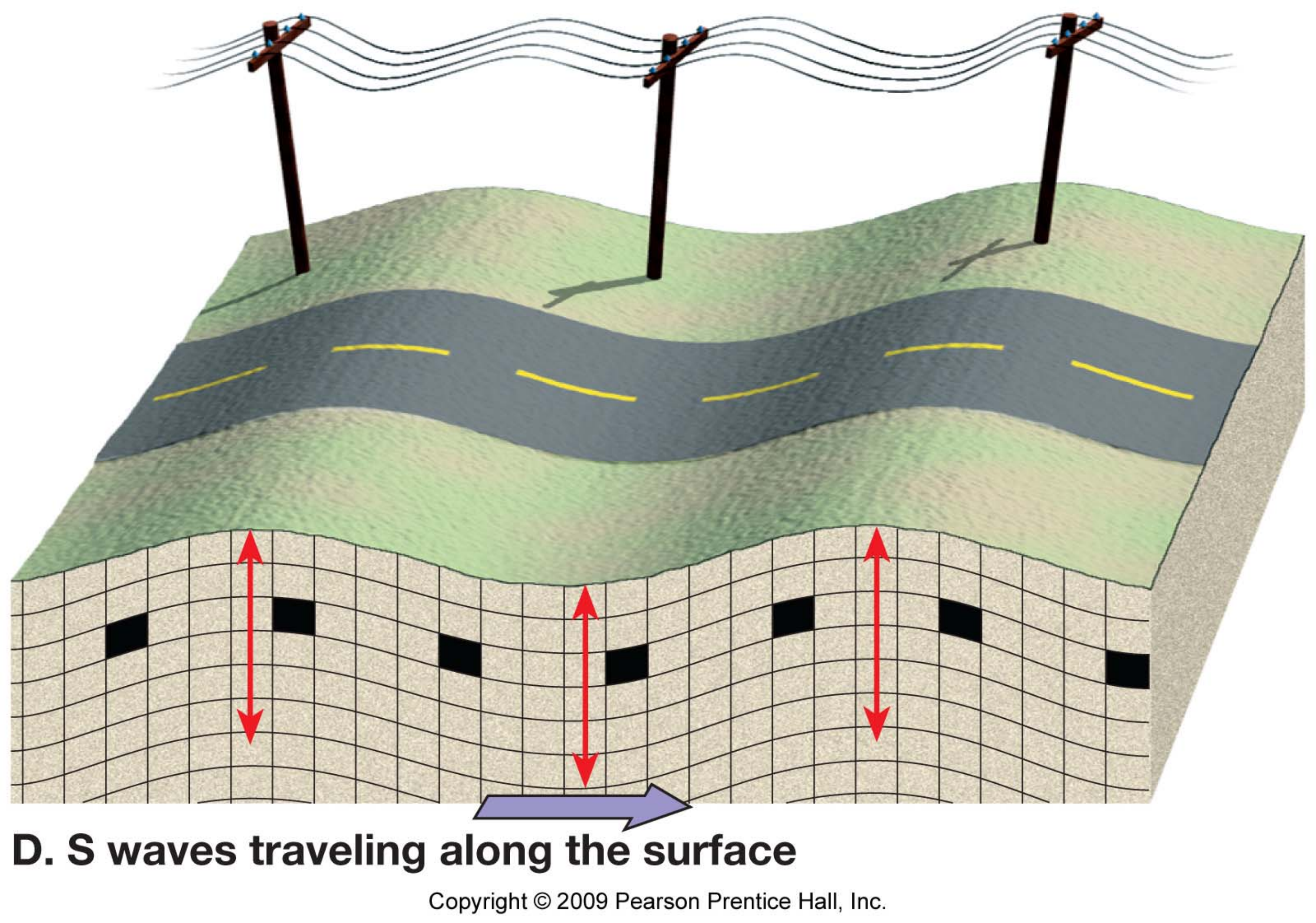
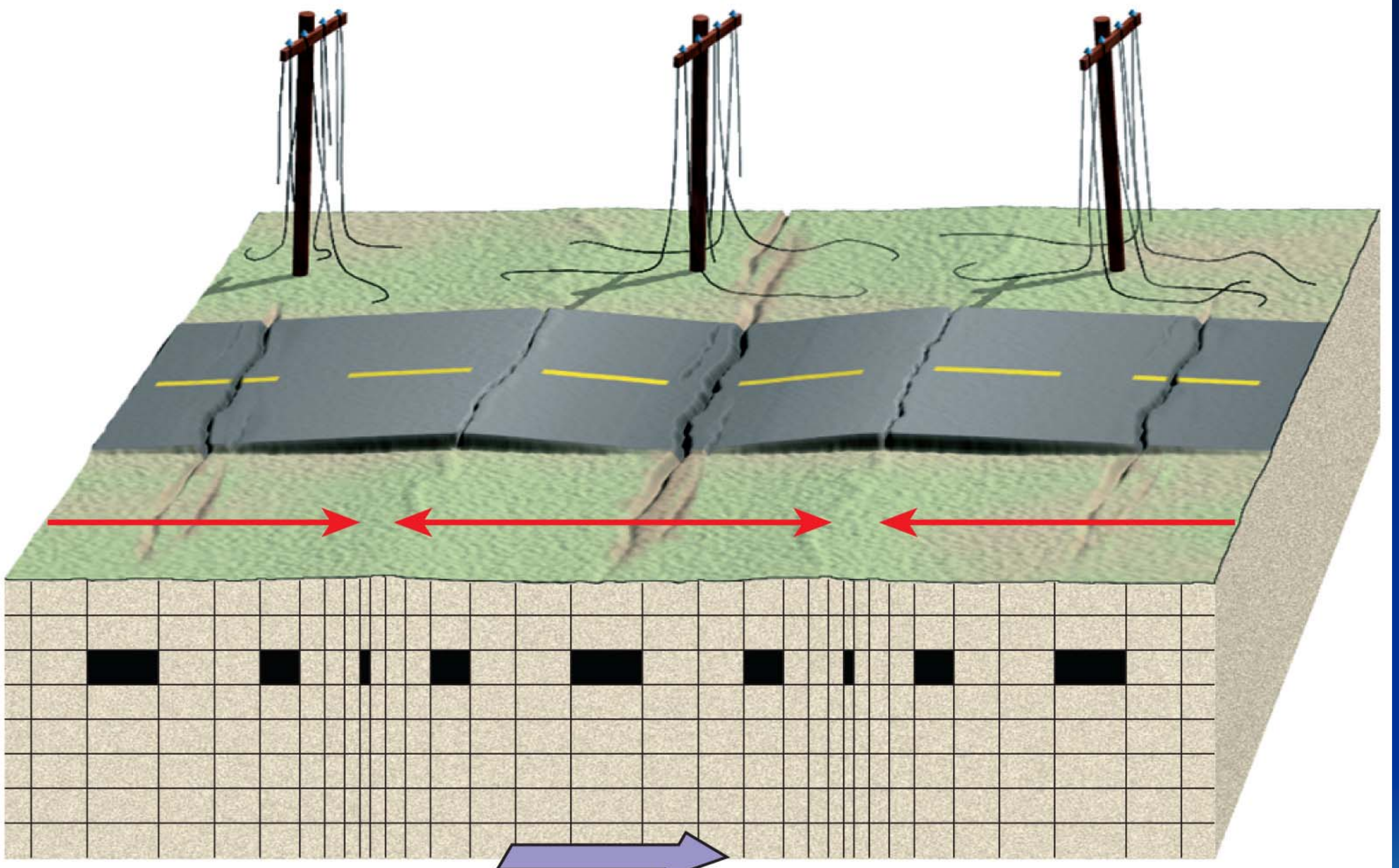


Figure 8.9 D

Earthquakes

- Earthquake waves
  - Types of earthquake waves
    - Body waves
      - Primary (P) waves
        - Push–pull (compressional) motion
        - Travel through solids, liquids, and gases
        - Greatest velocity of all earthquake waves

Primary (P) waves



B. P waves traveling along the surface

Figure 8.9 B

Earthquakes

- Earthquake waves
  - Types of earthquake waves
    - Body waves
      - Secondary (S) waves
        - “Shake” motion
        - Travel only through solids
        - Slower velocity than P waves

Earthquakes

- Locating an earthquake
  - Focus – the place within Earth where earthquake waves originate
  - Epicenter
    - Point on the surface, directly above the focus
    - Located using the difference in the arrival times between P and S wave recordings, which are related to distance

Earthquake focus and epicenter

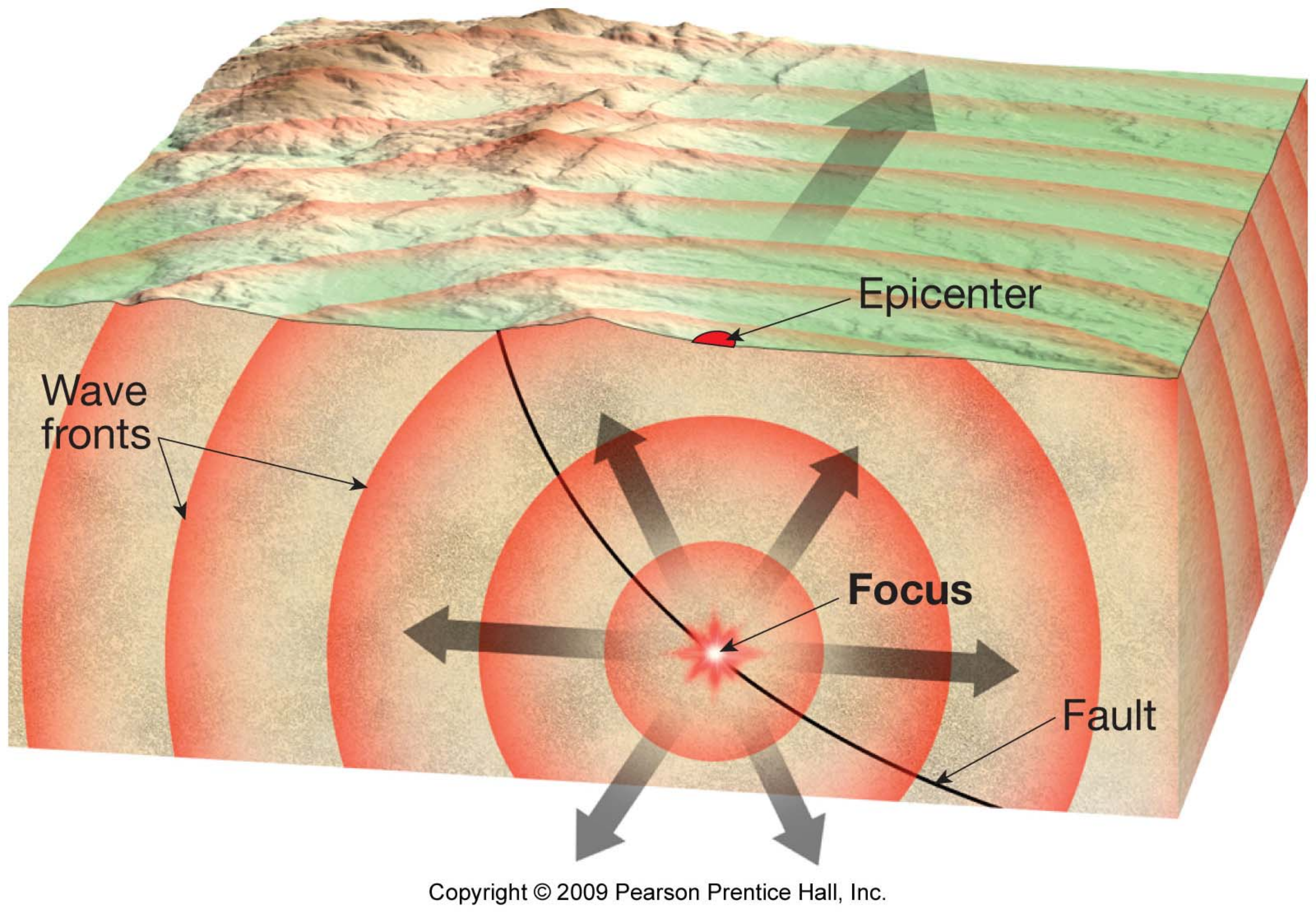
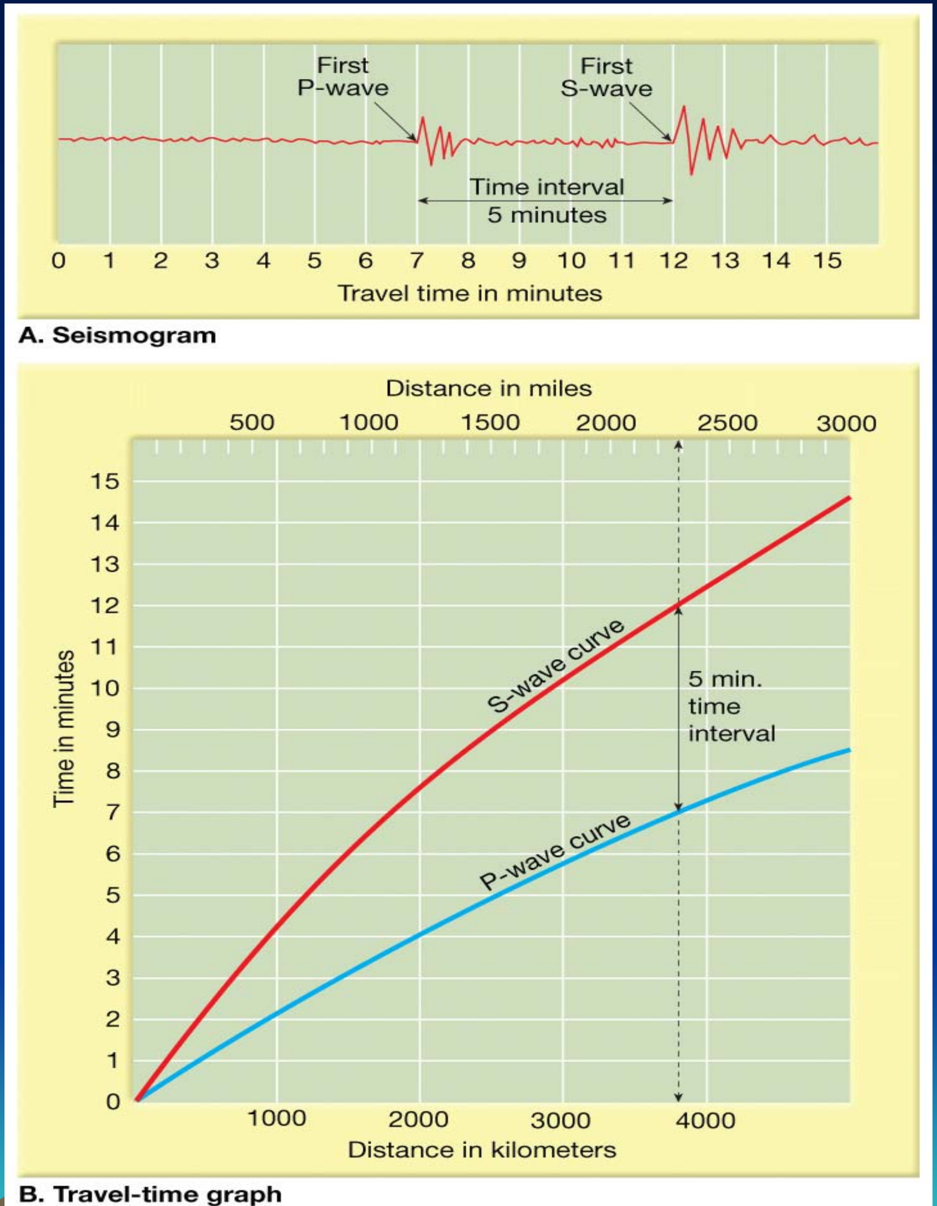


Figure 8.2

Earthquakes

- Locating an earthquake
  - Epicenter
    - Three station recordings are needed to locate an epicenter
      - Circle equal to the epicenter distance is drawn around each station
      - Point where three circles intersect is the epicenter



A travel-time graph

Figure 8.10

The epicenter is located using three or more seismic stations

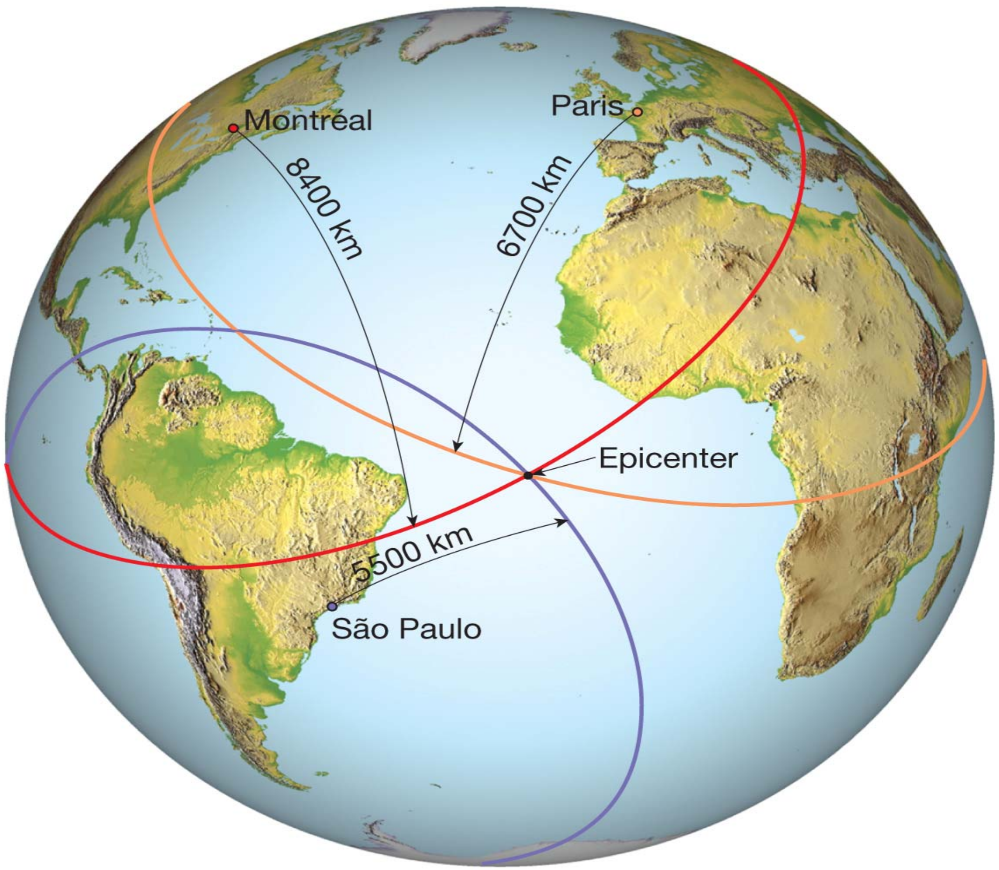


Figure 8.11

Earthquakes

- Locating an earthquake
  - Earthquake zones are closely correlated with plate boundaries
    - Circum-Pacific belt
    - Oceanic ridge system

Magnitude 5 or greater earthquakes over 10 years

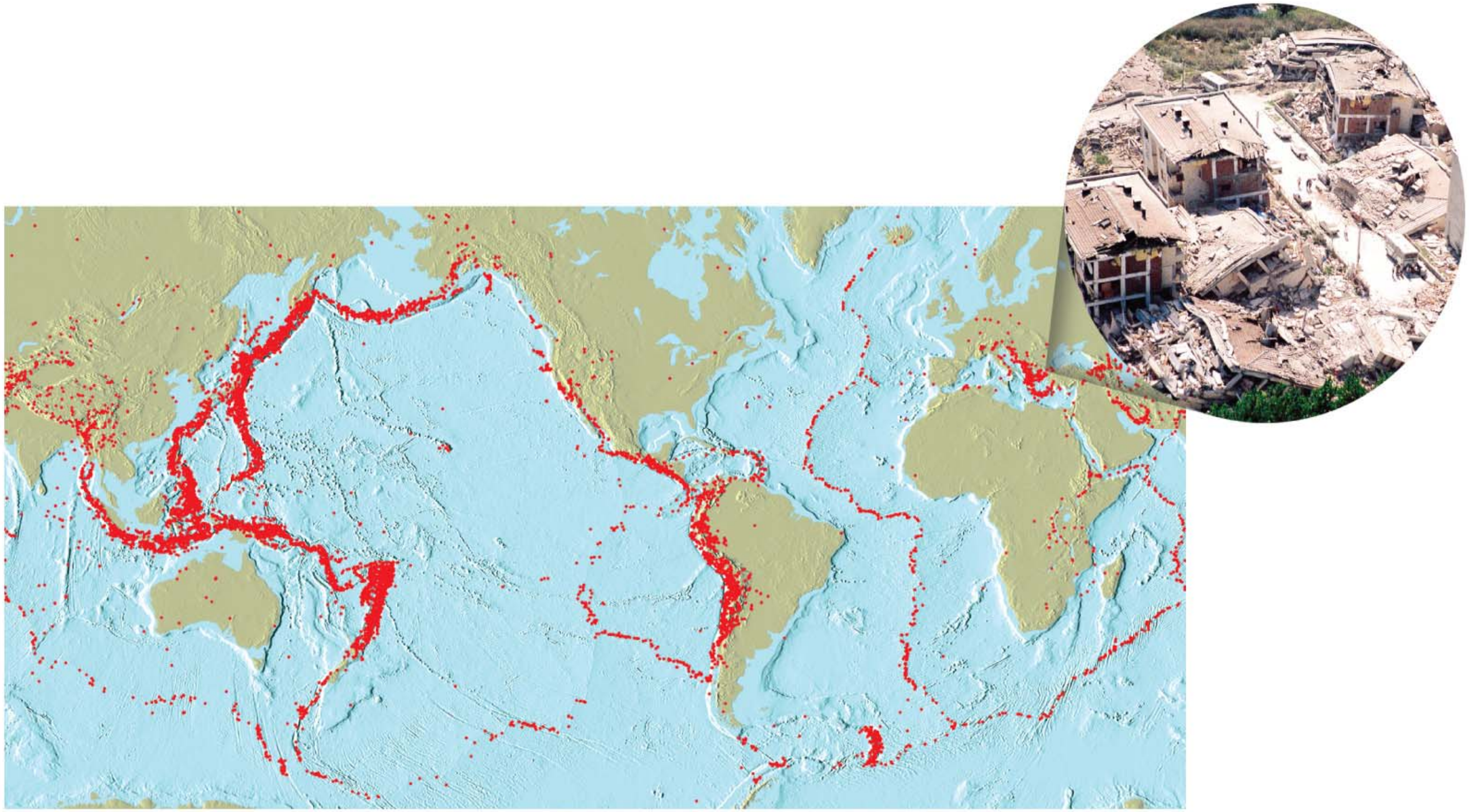


Figure 8.12

Earthquakes

- Earthquake intensity and magnitude
  - Intensity
    - A measure of the degree of earthquake shaking at a given locale based on the amount of damage
    - Most often measured by the Modified Mercalli Intensity Scale
  - Magnitude
    - Concept introduced by Charles Richter in 1935

Earthquakes

- Earthquake intensity and magnitude
  - Magnitude
    - Often measured using the Richter scale
      - Based on the amplitude of the largest seismic wave
      - Each unit of Richter magnitude equates to roughly a 32-fold energy increase
      - Does not estimate adequately the size of very large earthquakes

Earthquakes

- Earthquake intensity and magnitude
  - Magnitude
    - Moment magnitude scale
      - Measures very large earthquakes
      - Derived from the amount of displacement that occurs along a fault zone

Earthquakes

- Earthquake destruction
  - Factors that determine structural damage
    - Intensity of the earthquake
    - Duration of the vibrations
    - Nature of the material upon which the structure rests
    - The design of the structure

Earthquakes

- Earthquake destruction
  - Destruction results from
    - Ground shaking
    - Liquefaction of the ground
      - Saturated material turns fluid
      - Underground objects may float to surface
    - Tsunami, or seismic sea waves
    - Landslides and ground subsidence
    - Fires

Damage caused by the 1964 earthquake in Alaska

Figure 8.16

Damage from the 1964 Anchorage, Alaska, earthquake

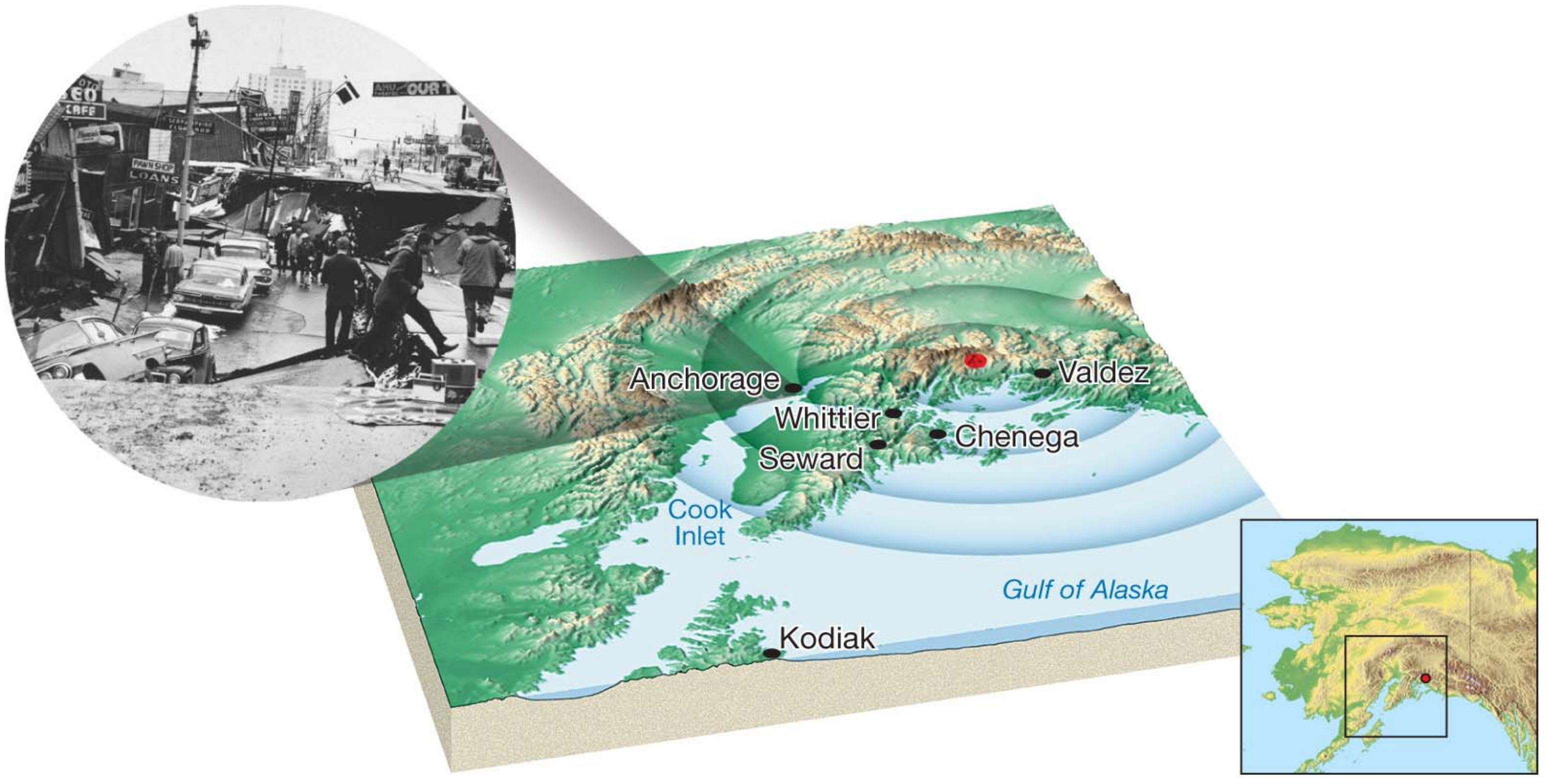


Figure 8.15

Formation of a tsunami

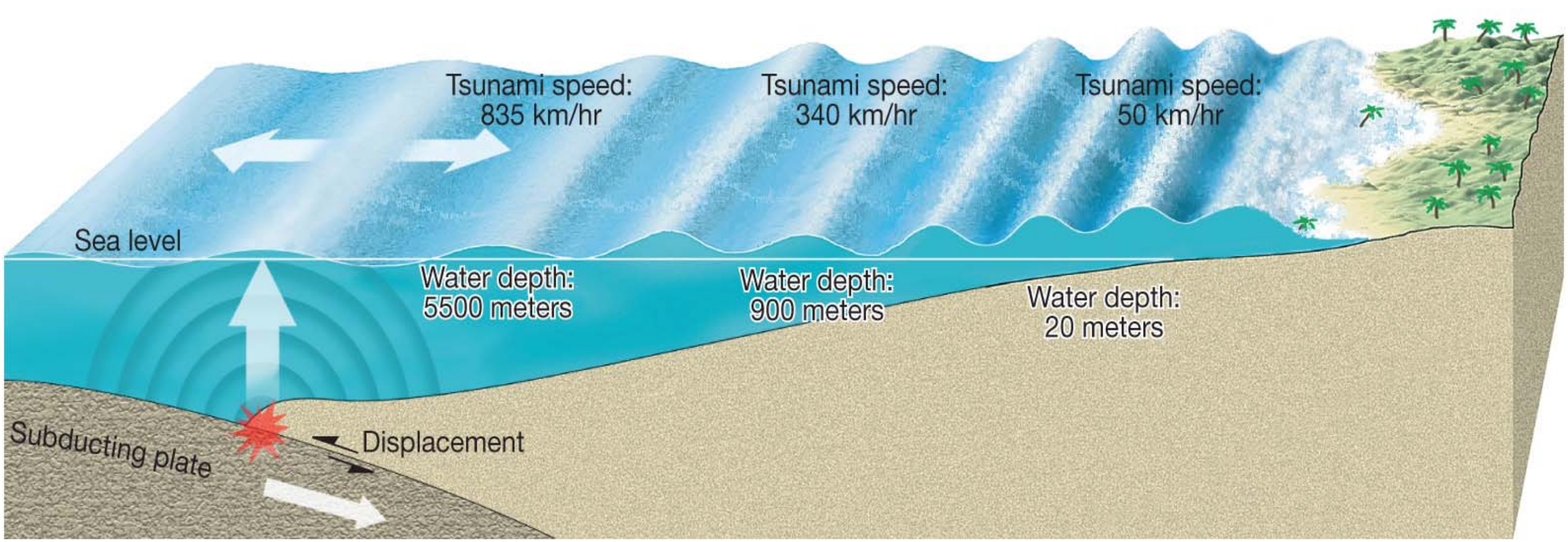


Figure 8.19

Tsunami travel times to Honolulu

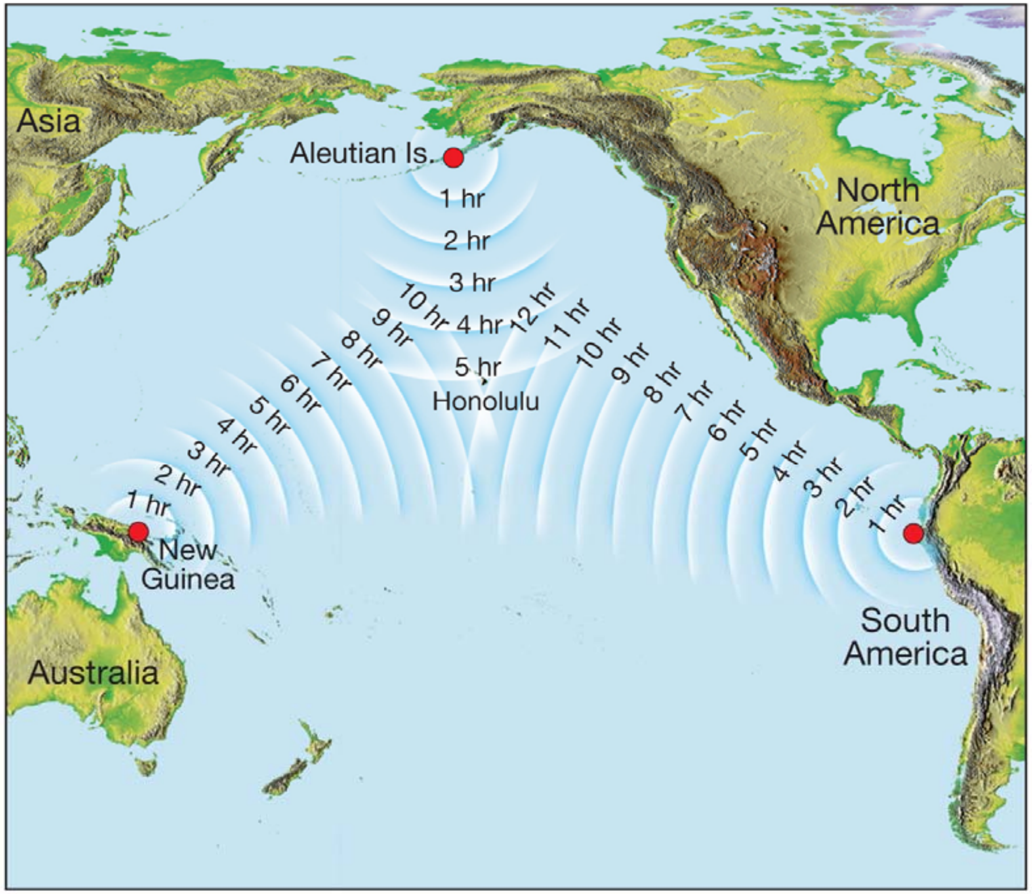


Figure 8.21

Earthquakes

- Earthquake prediction
  - Short-range – no reliable method yet devised for short-range prediction
  - Long-range forecasts
    - Premise is that earthquakes are repetitive
    - Region is given a probability of a quake

Earth's layered structure

- Most of our knowledge of Earth's interior comes from the study of P and S earthquake waves
  - Travel times of P and S waves through Earth vary depending on the properties of the materials
  - S waves travel only through solids

Possible seismic paths through the Earth

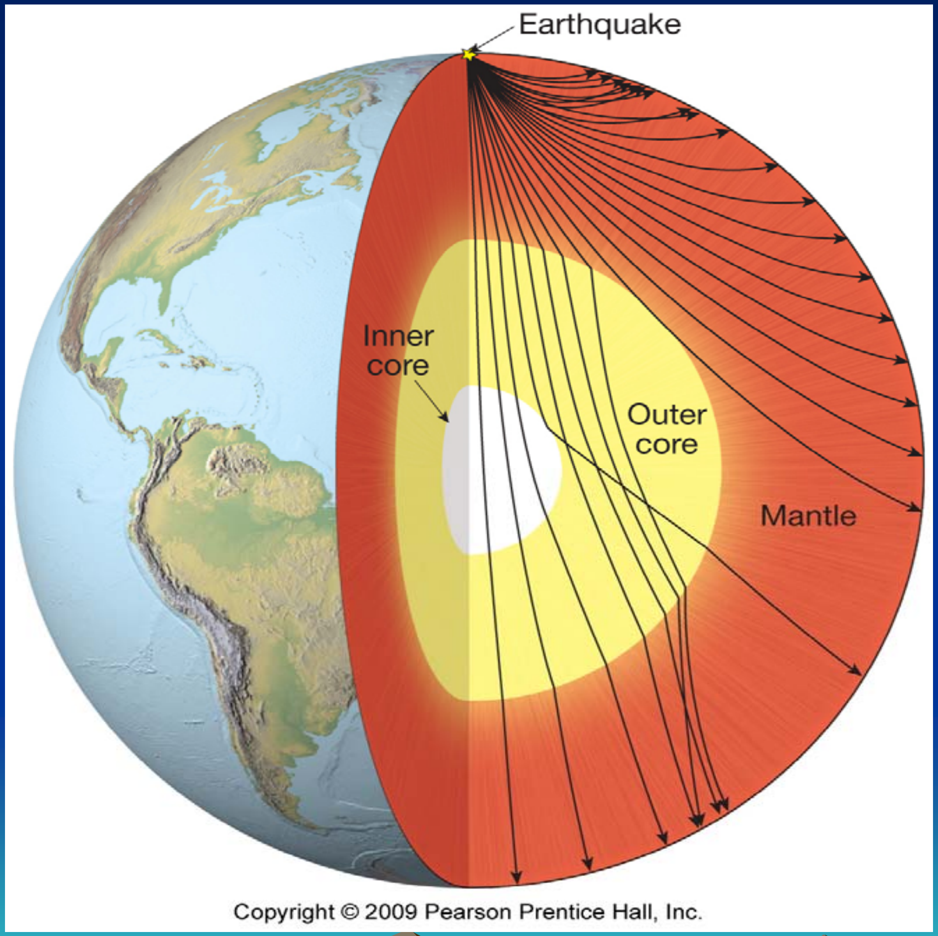


Figure 8.26

Earth's internal structure

- Layers based on physical properties
  - Crust
    - Thin, rocky outer layer
    - Varies in thickness
      - Roughly 7 km (5 miles) in oceanic regions
      - Continental crust averages 35–40 km (25 miles)
      - Exceeds 70 km (40 miles) in some mountainous regions

Earth's internal structure

- Layers based on physical properties
  - Crust
    - Continental crust
      - Upper crust composed of granitic rocks
      - Lower crust is more akin to basalt
      - Average density is about 2.7 g/cm^3
      - Up to 4 billion years old

Earth's internal structure

- Layers based on physical properties
  - Crust
    - Oceanic Crust
      - Basaltic composition
      - Density about 3.0 g/cm^3
      - Younger (180 million years or less) than the continental crust

Earth's internal structure

- Layers based on physical properties
  - Mantle
    - Below crust to a depth of 2,900 kilometers (1,800 miles)
    - Composition of the uppermost mantle is the igneous rock peridotite (changes at greater depths)

Earth's internal structure

- Layers based on physical properties
  - Outer Core
    - Below mantle
    - A sphere having a radius of 3,486 km (2,161 miles)
    - Composed of an iron–nickel alloy
    - Average density of nearly 11 g/cm^3

Earth's internal structure

- Layers based on physical properties
  - Lithosphere
    - Crust and uppermost mantle (about 100 km thick)
    - Cool, rigid, solid
  - Asthenosphere
    - Beneath the lithosphere
    - Upper mantle
    - To a depth of about 660 kilometers
    - Soft, weak layer that is easily deformed

Earth's internal structure

- Layers based on physical properties
  - Mesosphere (or lower mantle)
    - 660–2,900 km
    - More rigid layer
    - Rocks are very hot and capable of gradual flow
  - Outer Core
    - Liquid layer
    - 2,270 km (1,410 miles) thick
    - Convective flow of metallic iron within generates Earth's magnetic field

Earth's internal structure

- Layers based on physical properties
  - Inner Core
    - Sphere with a radius of 1,216 km (754 miles)
    - Behaves like a solid

Views of Earth's layered structure

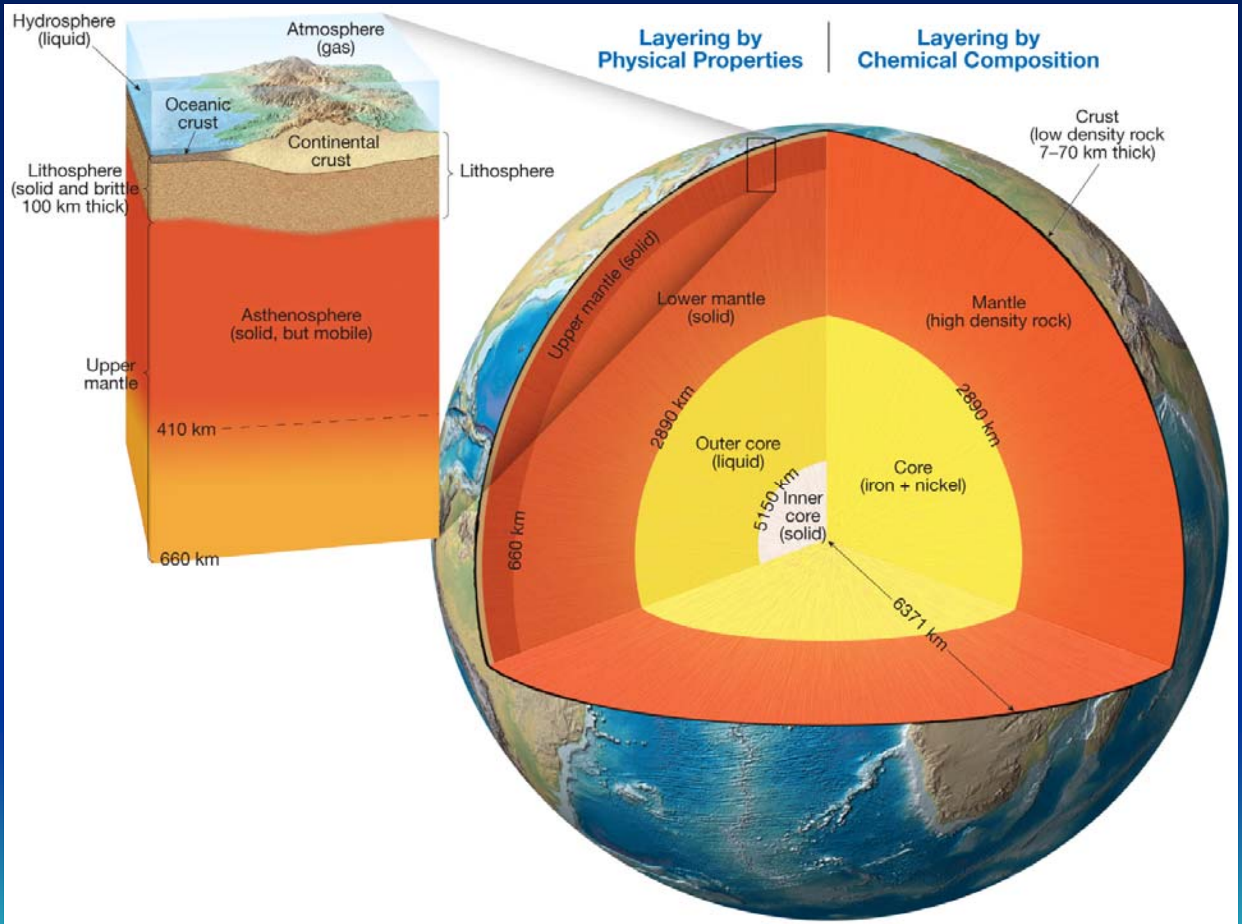


Figure 8.25

Earth’s layered structure

❖ Discovering Earth’s major layers
- Discovered using changes in seismic wave velocity
- Mohorovicic discontinuity
  - Velocity of seismic waves increases abruptly below 50 km of depth
  - Separates crust from underlying mantle

Earth's layered structure

- Discovering Earth's major layers
  - Shadow zone
    - Absence of P waves from about 105 degrees to 140 degrees around the globe from an earthquake
    - Explained if Earth contained a core composed of materials unlike the overlying mantle

S-wave shadow zones

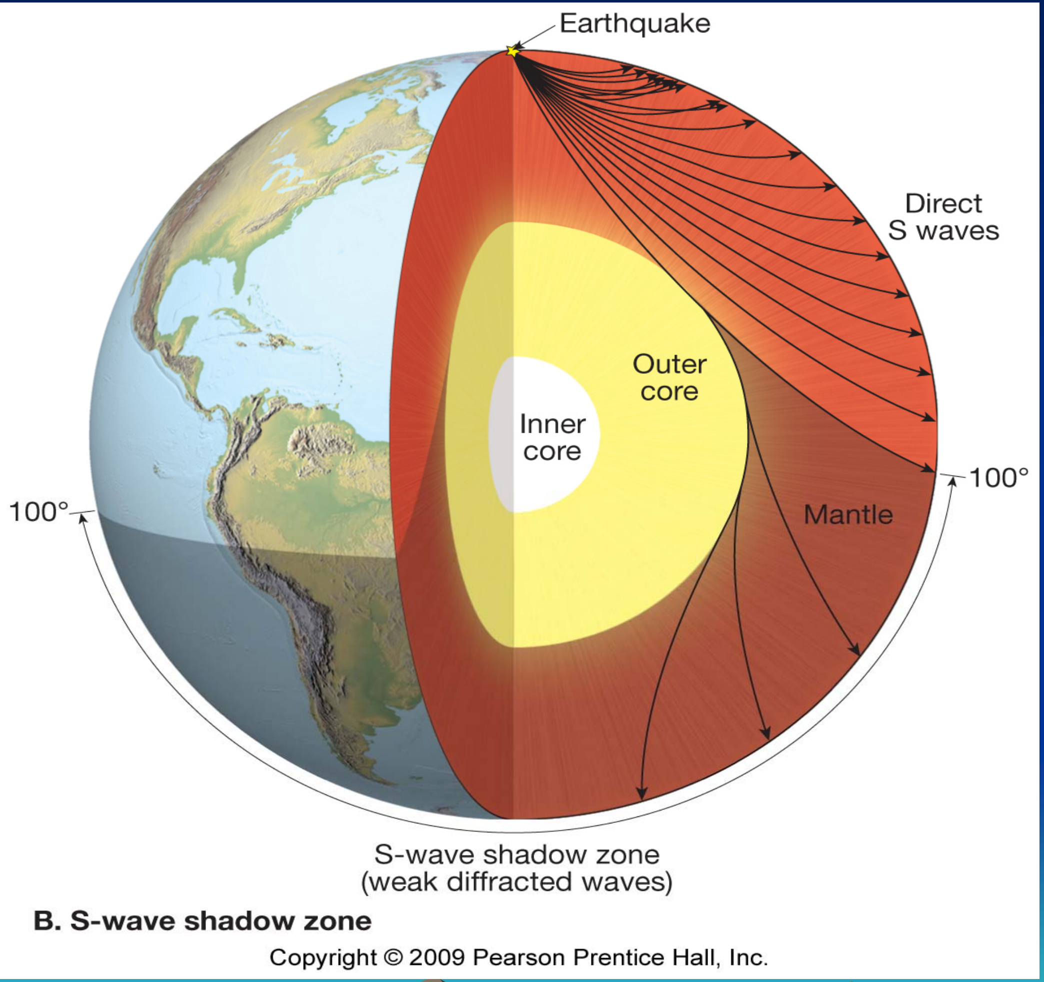


Figure 8.28 B

Earth's layered structure

- Discovering Earth's major layers
  - Inner core
    - Discovered in 1936 by noting a new region of seismic reflection within the core
    - Size was calculated in the 1960s using echoes from seismic waves generated during underground nuclear tests

End of Chapter 8