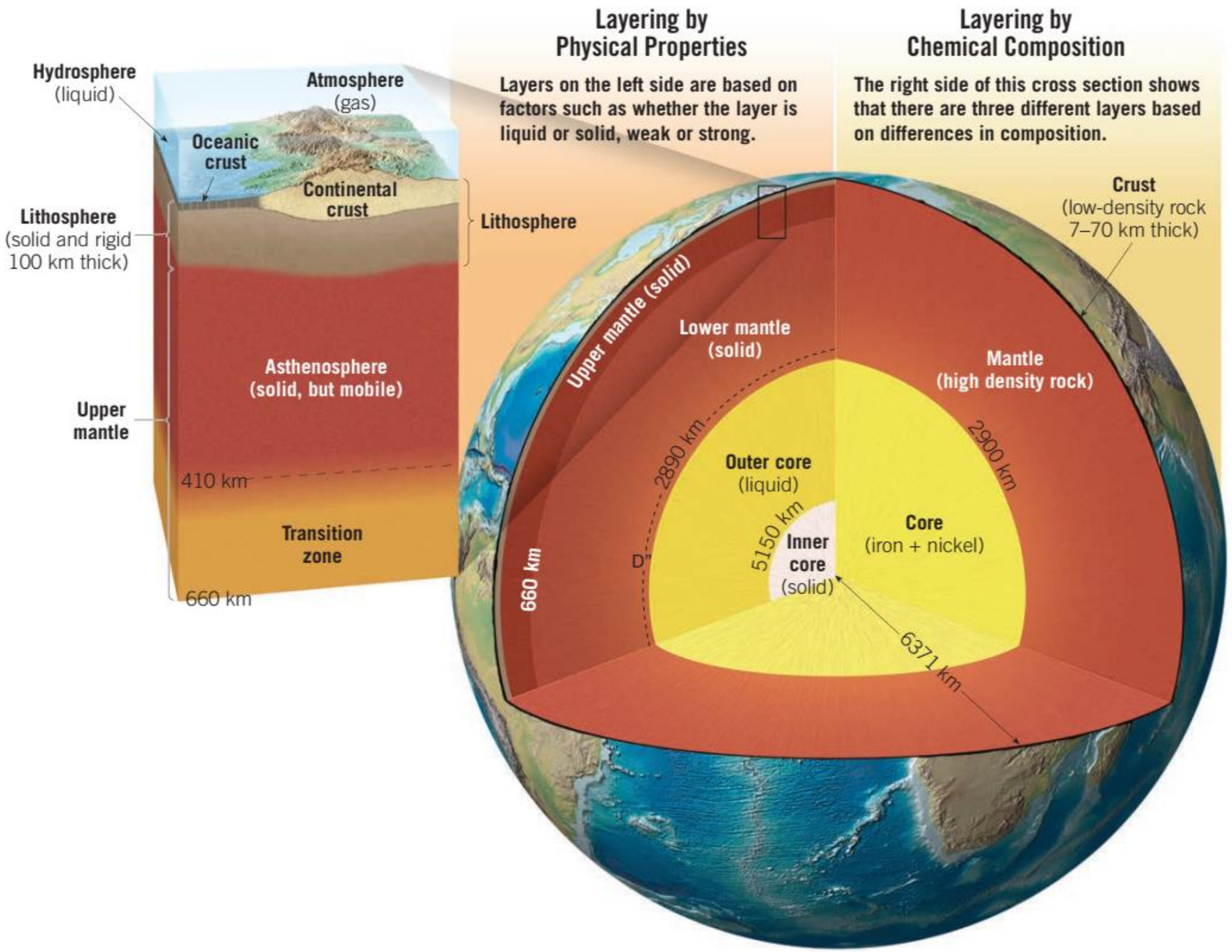
Earth and Planetary Sciences (ES1101)

(Interior of the Earth)

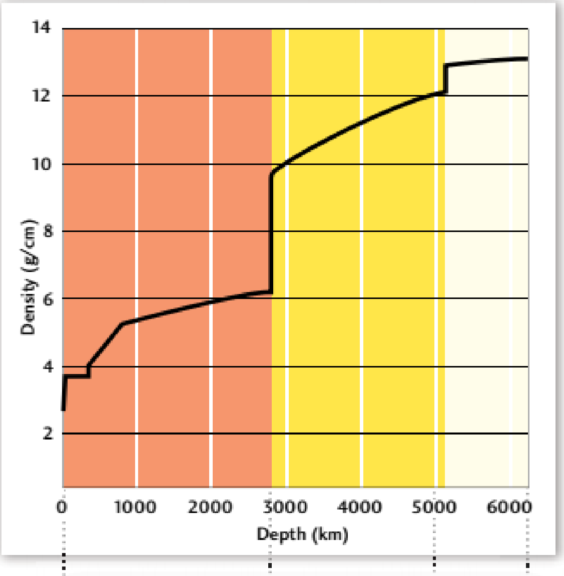
(Autumn 2021 by Gaurav Shukla)

Book: **1) Understanding Earth by Grotzinger & Jordan (Textbook)**
2) Earth: An introduction to Physical Geology by Tarbuck & Lutgens
3) The Solid Earth: An introduction to global geophysics by Fowler

Internal Structure of the Earth



Internal Structure of the Earth



Chemical Composition of Earth's Major Layers

By the mid-twentieth century, geologists had discovered all of Earth's major layers—crust, mantle, outer core, and inner core—plus a number of more subtle features in its interior. They found, for example, that the mantle itself is layered into an *upper mantle* and a *lower mantle*, separated by a *transition zone* where the rock density increases in a series of steps. These density steps are not caused by changes in the rock's chemical composition, but rather by changes in the compactness of its constituent minerals due to the increasing pressure with depth. The two largest density jumps in the transition zone are located at depths of about 410 km and 660 km, but they are smaller than the density increases across the Moho and core-mantle boundaries, which *are* due to changes in chemical composition (Figure 1.12).

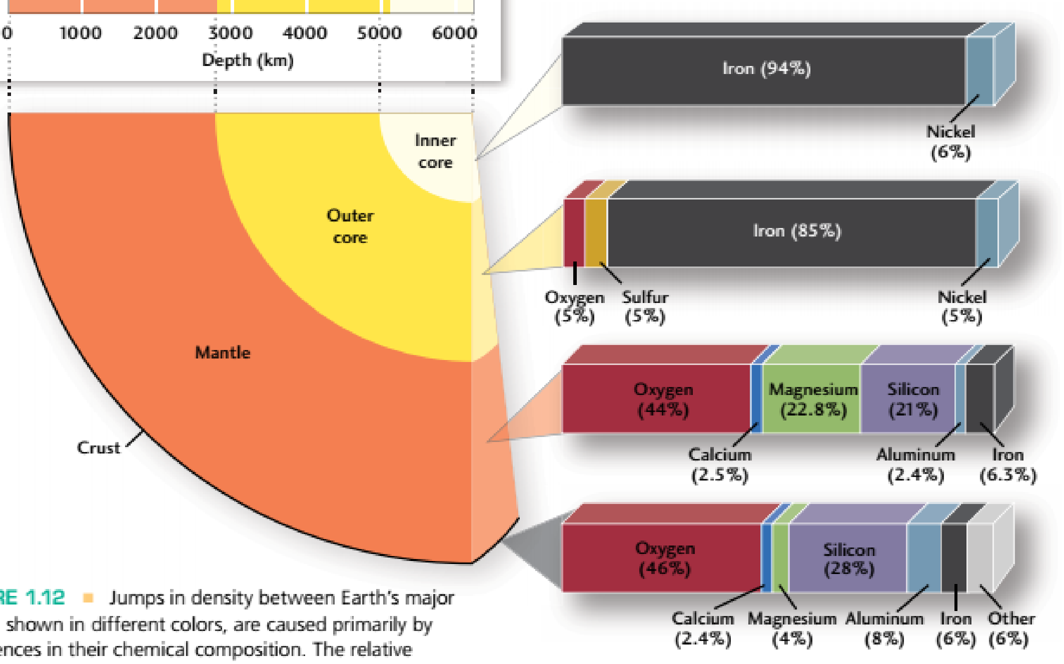


FIGURE 1.12 ■ Jumps in density between Earth's major layers, shown in different colors, are caused primarily by differences in their chemical composition. The relative amounts of the main elements are depicted in the bars on the right.

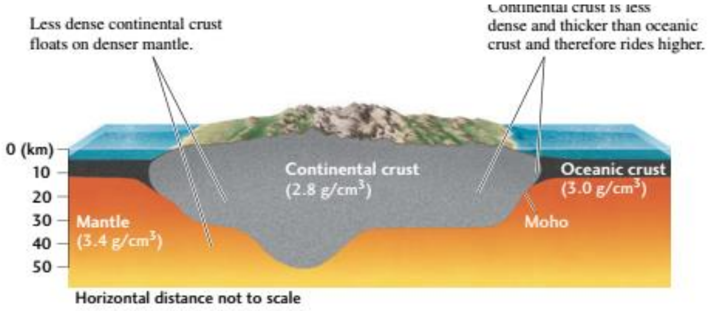


FIGURE 1.11 ■ Because crustal rocks are less dense than mantle rocks, Earth's crust floats on the mantle. Continental crust is thicker and has a lower density than oceanic crust, which causes it to ride higher, explaining the difference in elevation between continents and the deep seafloor.

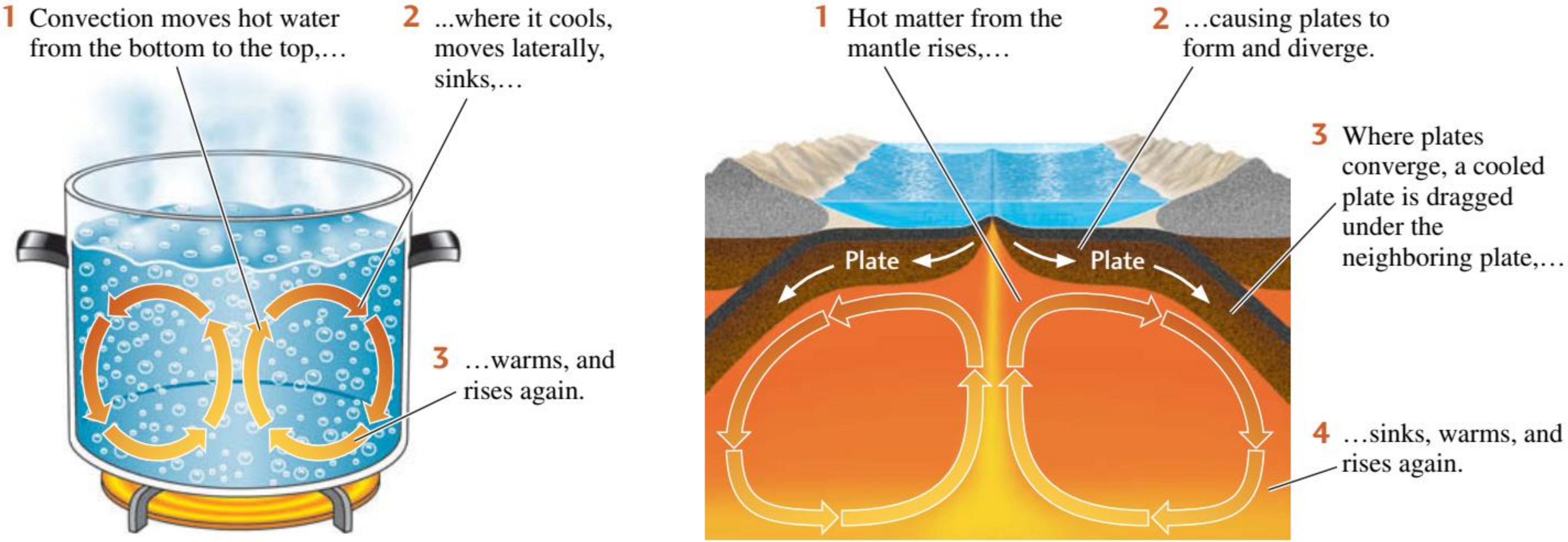


FIGURE 1.16 ■ Convection in Earth's mantle can be compared to the pattern of movement in a pot of boiling water. Both processes carry heat upward through the movement of matter.

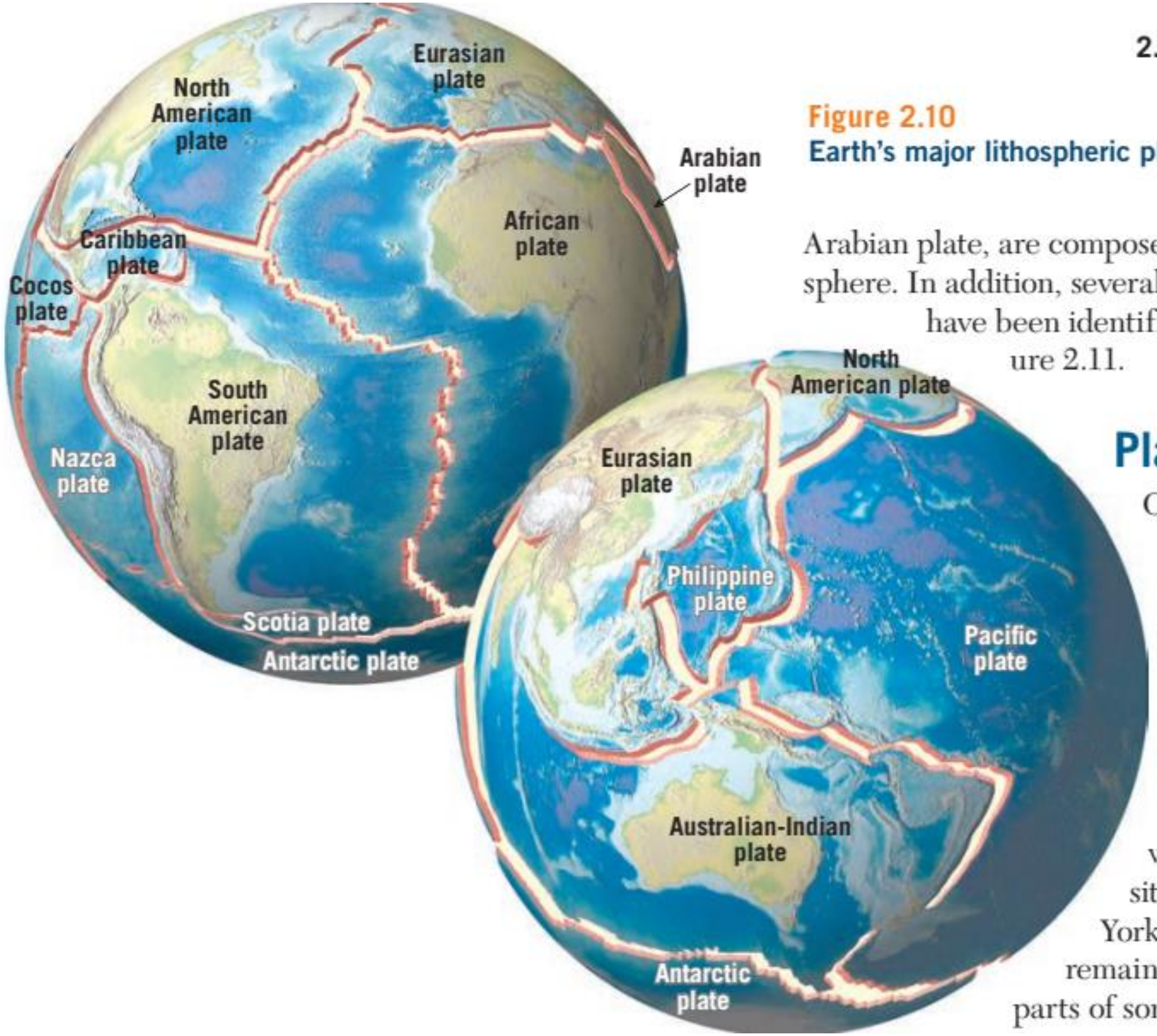
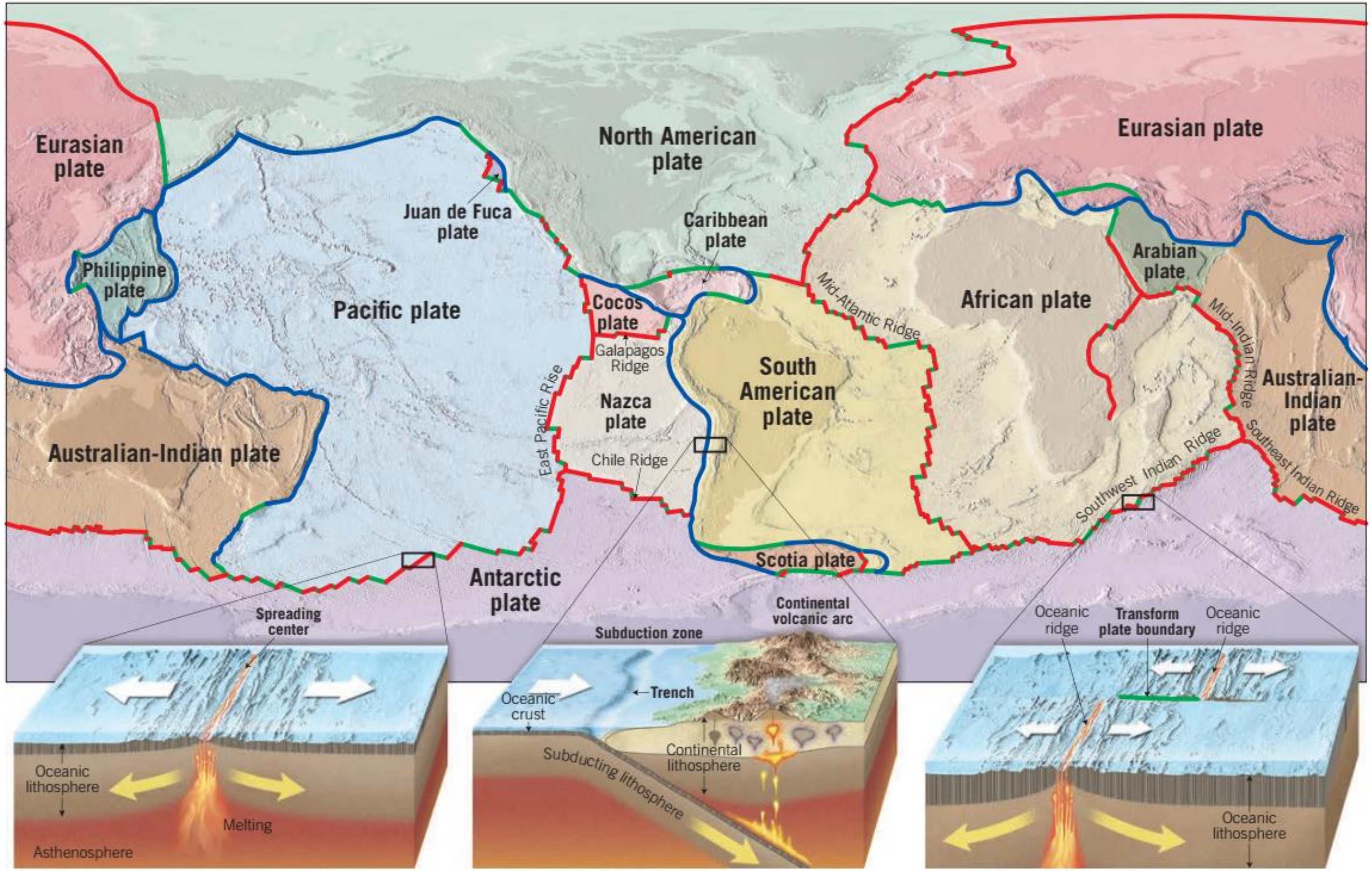


Figure 2.10
Earth's major lithospheric plates

Arabian plate, are composed mostly of oceanic lithosphere. In addition, several smaller plates (*microplates*) have been identified but are not shown in Figure 2.11.

Plate Movement

One of the main tenets of the plate tectonics theory is that plates move as somewhat rigid units relative to all other plates. As plates move, the distance between two locations on different plates, such as New York and London, gradually changes, whereas the distance between sites on the same plate—New York and Denver, for example—remains relatively constant. However, parts of some plates are comparatively



A. Divergent plate boundary
B. Convergent plate boundary
C. Transform plate boundary

Exploring the Earth's interior

- **Earthquake seismology:** A principal technique to investigate the interior of the Earth.

- **Geothermal gradient:** Exploring the various heat sources and understanding the thermal variations inside the Earth.

- **Pressure gradient:** Pressure variation within the Earth.

- **Constituents of Earth Materials:** Study of minerals and melts, Phase changes of minerals with pressure and their correlations with seismically observed layers of the Earth.

- **Continental Drift and Plate tectonics**

Earthquake Seismology

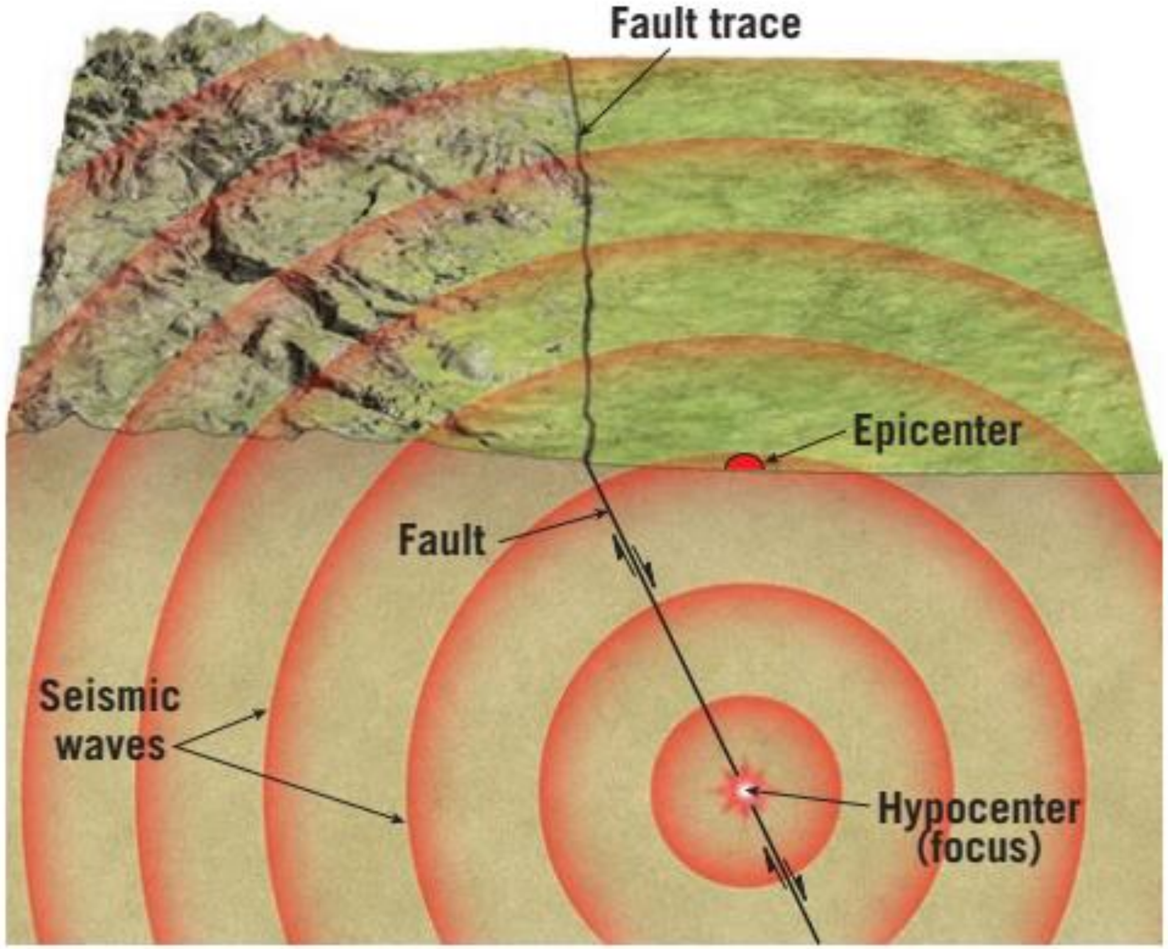
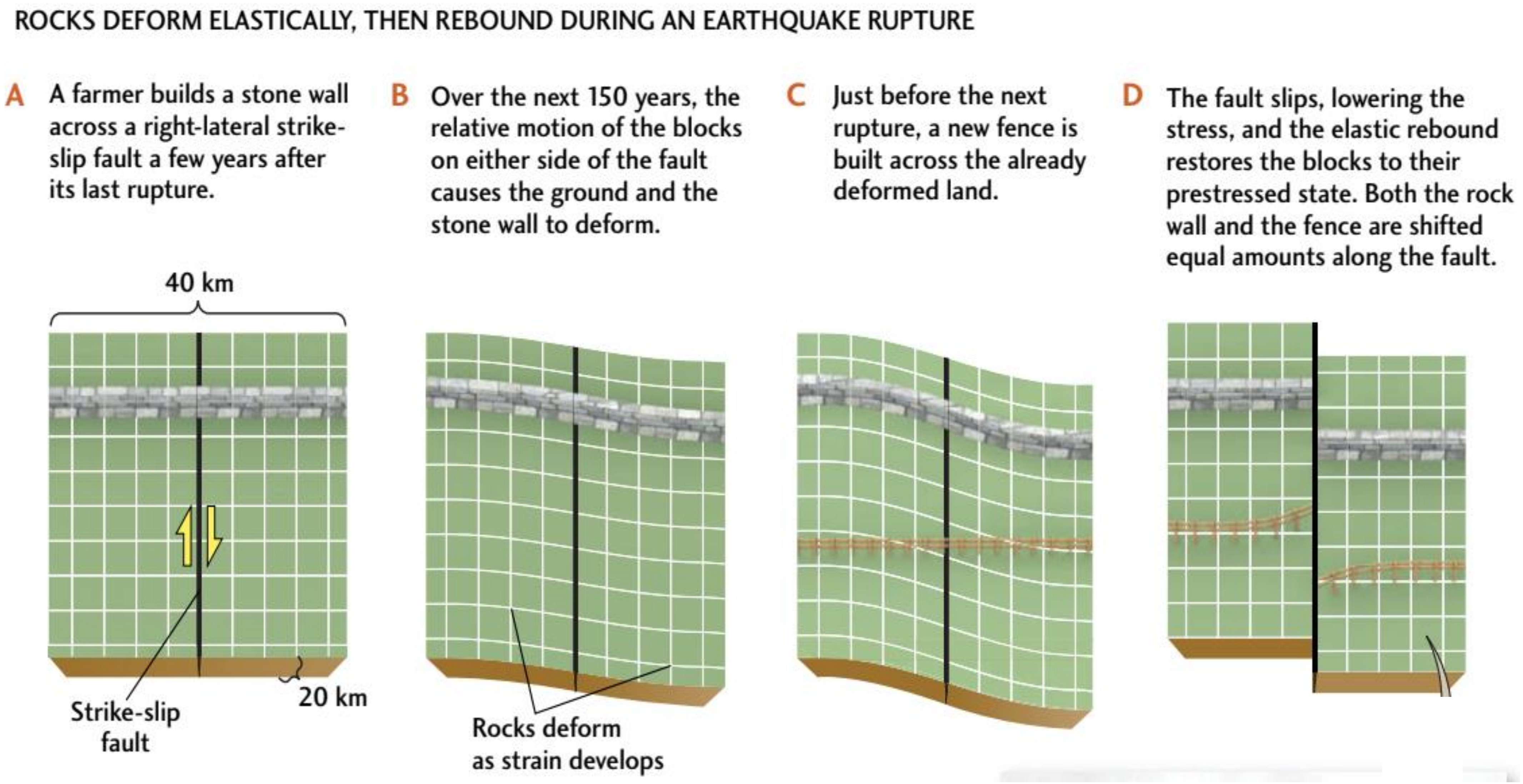


Figure 11.2
Earthquakes hypocenter and epicenter The *hypocenter* is the zone at depth where the initial displacement occurs. The *epicenter* is the surface location directly above the hypocenter.

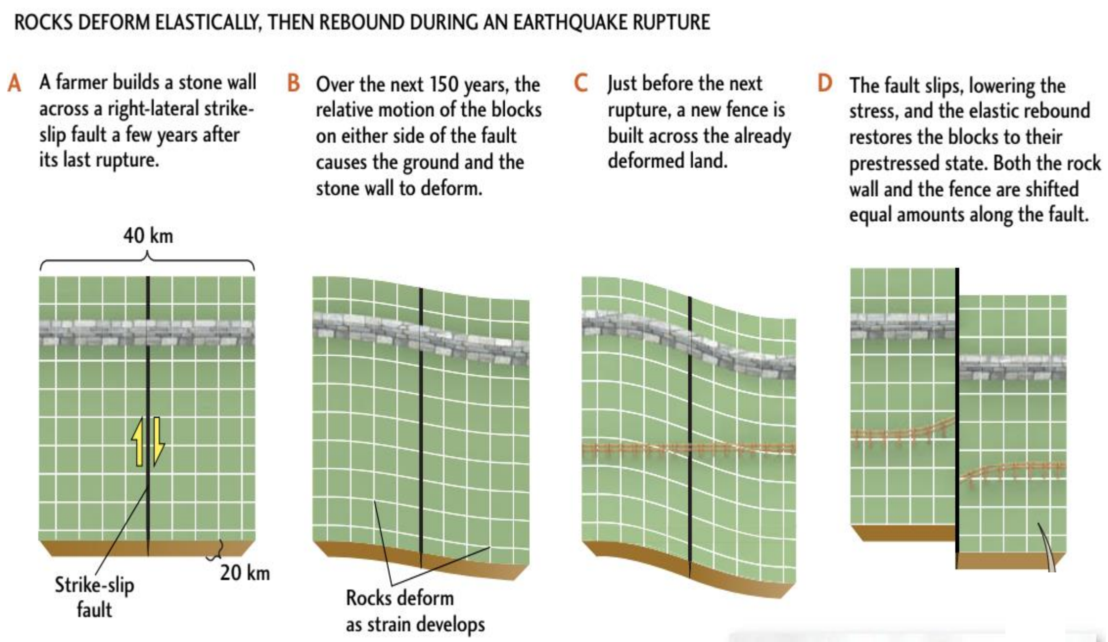
Earthquake Seismology

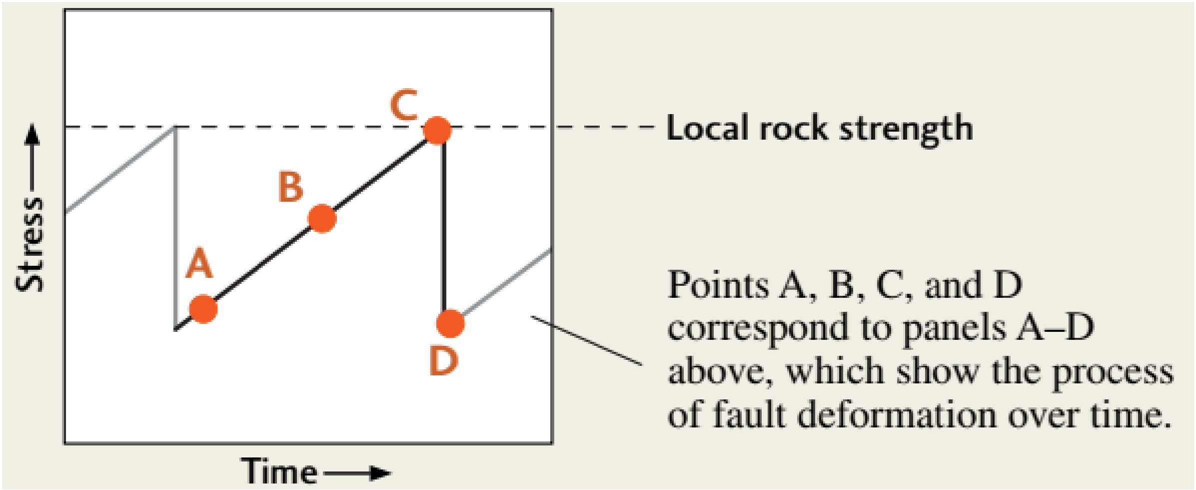
FIGURE 7.7 ■ View of the San Andreas fault, showing the northwestward movement of the Pacific Plate with respect to the North American Plate. The map shows a formation of volcanic rocks 23 million years old that has been displaced by 315 km. The fault runs from top to bottom (dashed line) near the middle of the photograph. Note the offset of the stream (Wallace Creek) by 130 m as it crosses the fault. [University of Washington Libraries, Special Collections, John Shelton Collection, KCN7-23.]

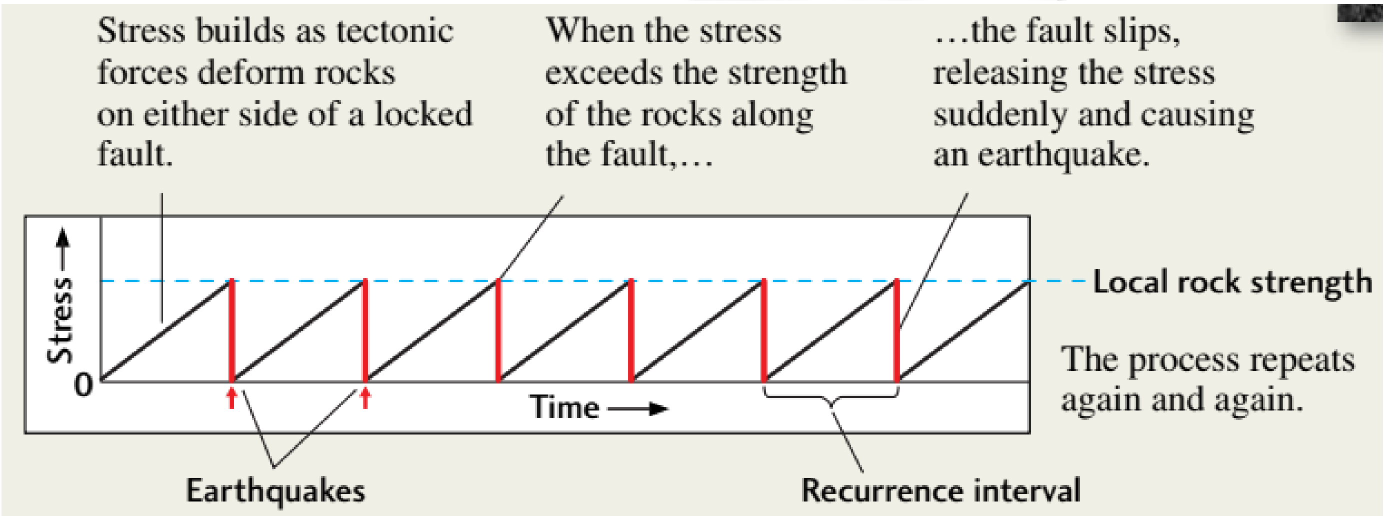
Earthquake Seismology: Elastic Rebound Theory



Earthquake Seismology: Elastic Rebound Theory







- Based on elastic rebound theory it seems one can predict future Earthquakes nicely? The answer is NO because of in reality the pattern is irregular (see the next slide)

Earthquake Seismology: Elastic rebound theory

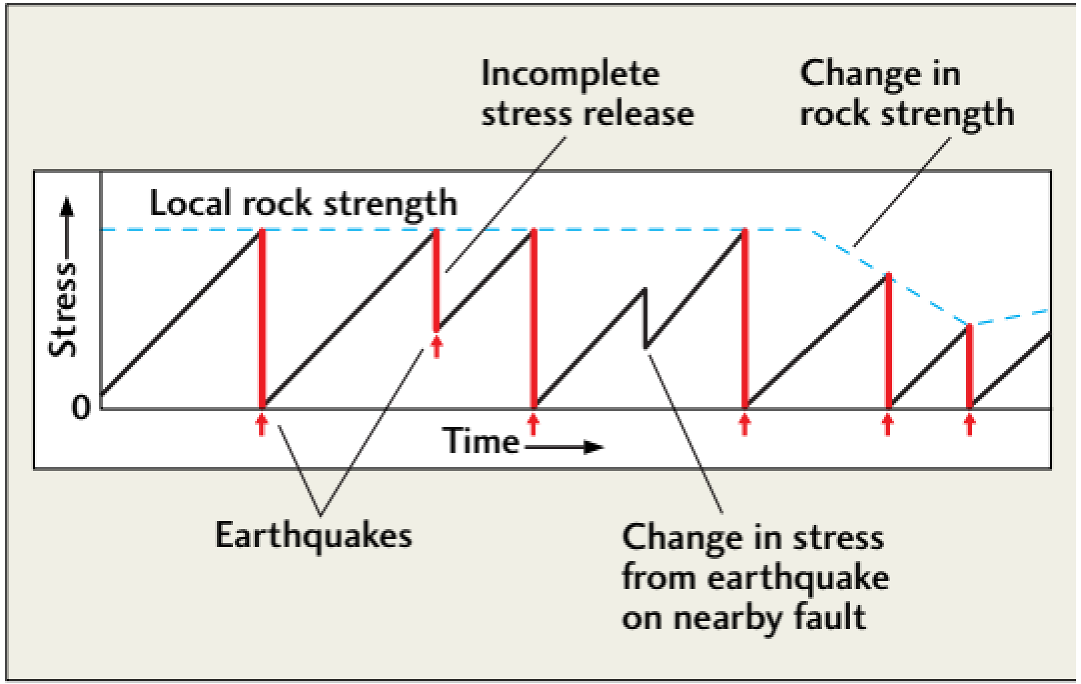


FIGURE 13.4 ■ Irregularities in the earthquake cycle can be caused by incomplete stress release, changes in stress caused by earthquakes on nearby faults, and local variations in rock strength.

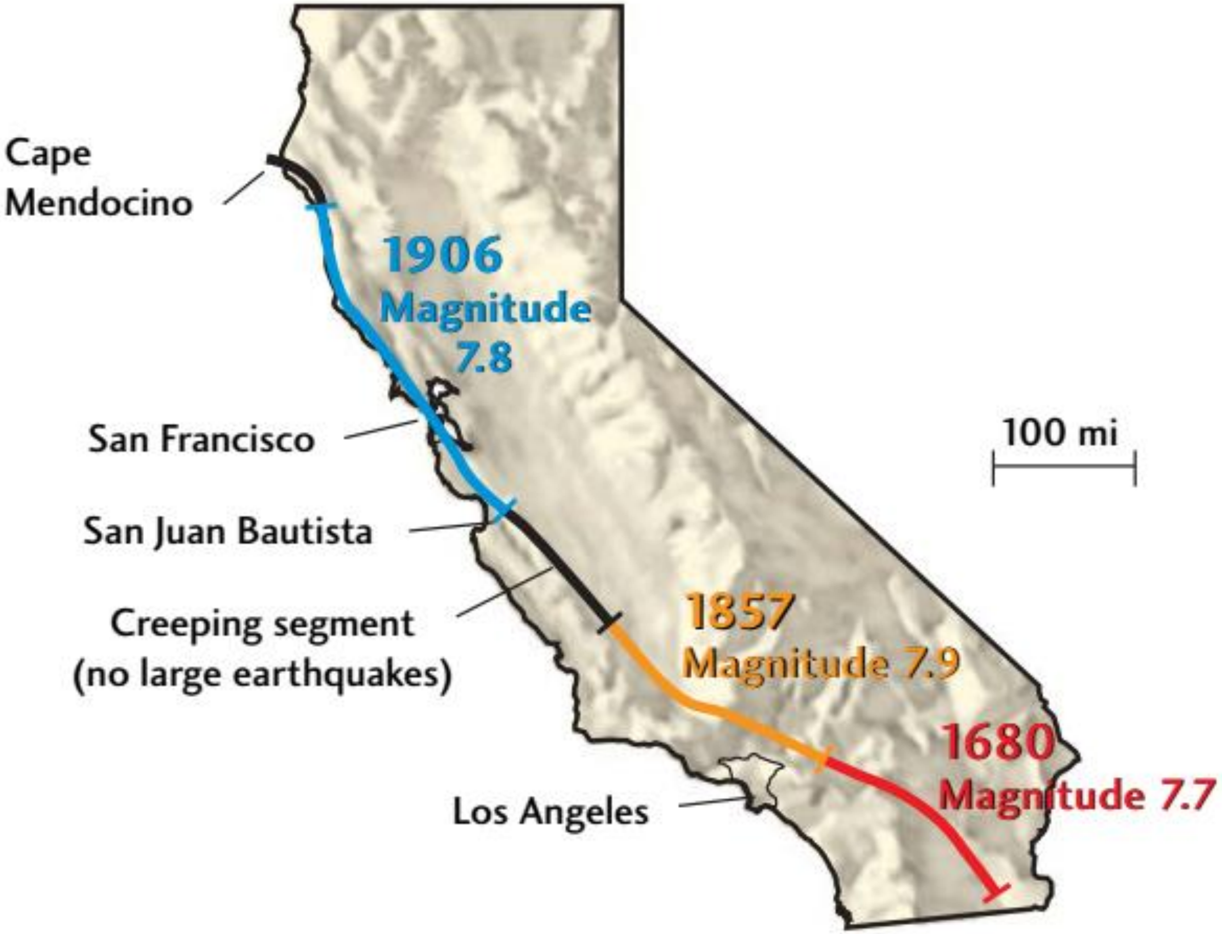
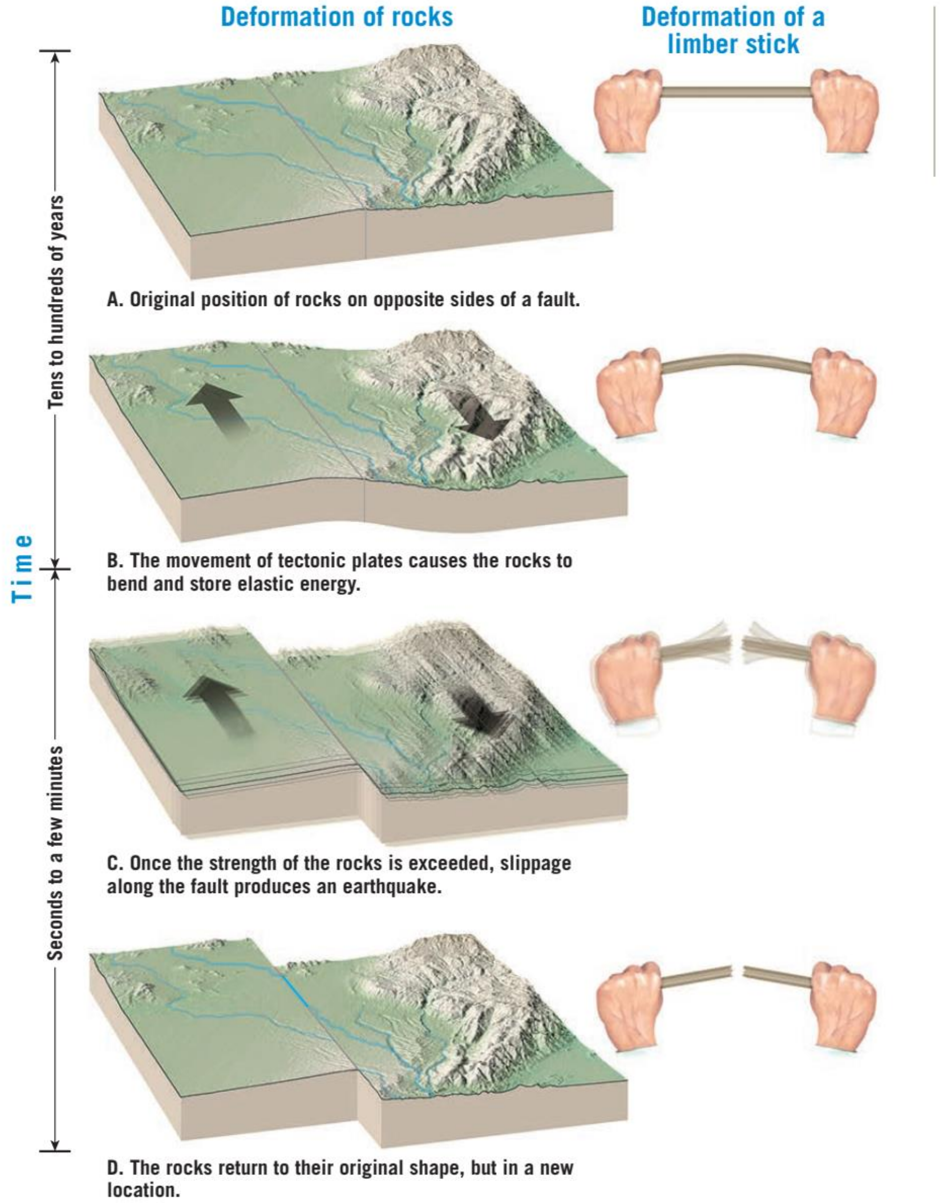


FIGURE 13.2 ■ Map of California, showing the segments of the San Andreas fault that ruptured in 1680, 1857, and 1906. [Southern California Earthquake Center.]

Earthquake Seismology: Fault slipping progression



Earthquake Seismology: Fault slipping progression