Chapter 9: Plates and Plate Boundaries

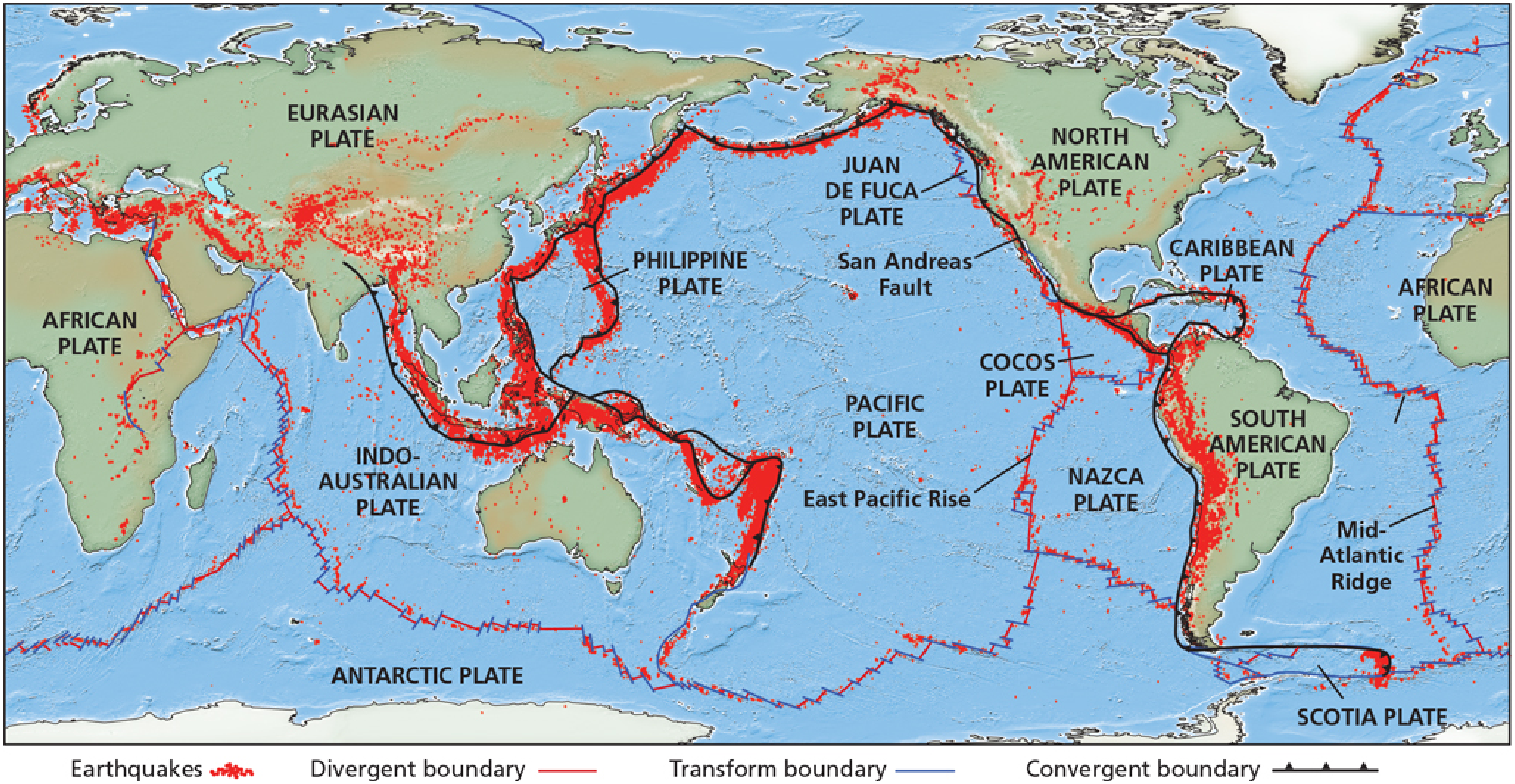

Fig. 9.11

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OBJECTIVES

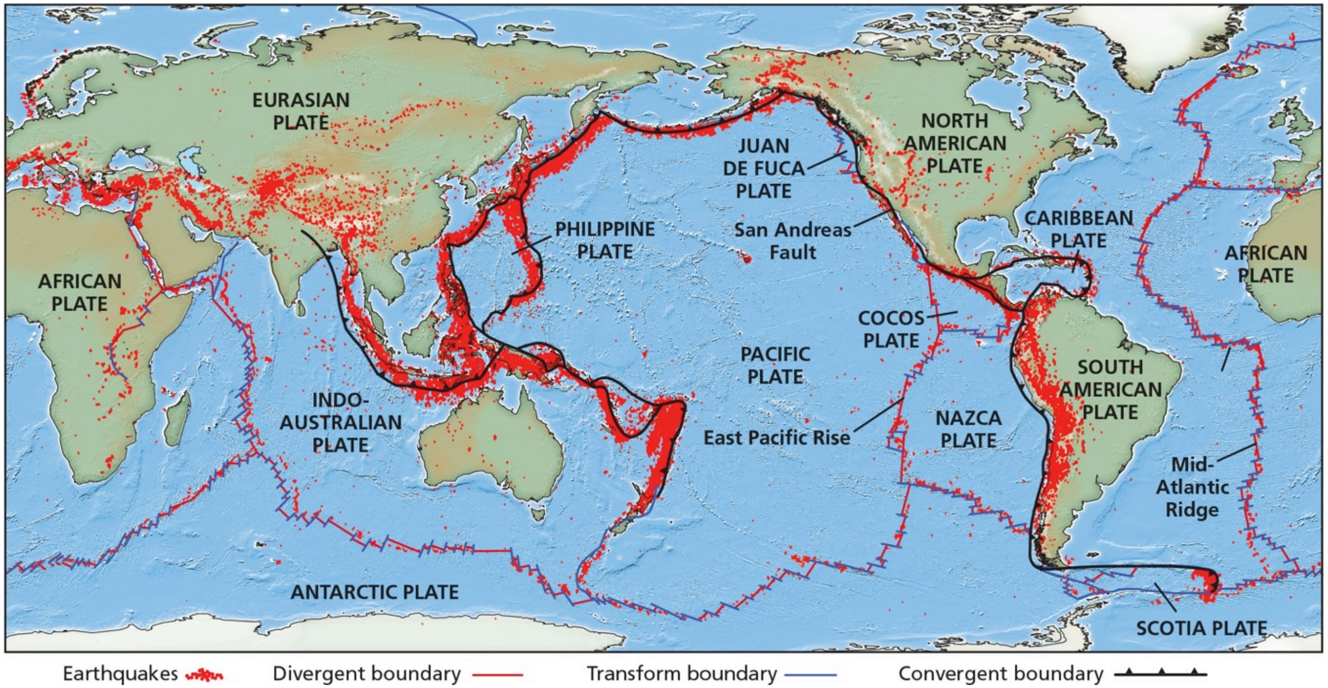
- Identify the physical and chemical divisions in Earth's outer layers.
- Understand that the lithospheric plates are buoyant and that this buoyancy controls the relationship between crustal elevation, crustal thickness, and crustal density.
- Compare and contrast the three types of plate boundaries and describe the three main ways boundaries interact: spreading apart, coming together, and sliding past one another.
- Describe the processes that occur at divergent boundaries and explain how new ocean floor is created.

OBJECTIVES

- Describe the processes that occur at convergent boundaries and explain how crust is recycled and continents are built.
- Describe the motion along transform boundaries and compare and contrast the two principal types of transform faults.
- Describe the enigmatic volcanic regions known as hotspots and explain how they can be used to track the movement of plates.
- Compare and contrast the three types of force that may propel plates.

Plates and Plate Boundaries: An Overview

- Plate motion creates and destroy ocean basins, forms mountain belts, and moves continents.



- Plates interact along plate boundaries: splitting apart, colliding, or sliding past each other.

Fig. 9.11

Plates on Earth's Surface

- Earth's outer layers can be subdivided in terms of
  - Chemical properties (crust, mantle, core)
  - Physical properties (lithosphere, asthenosphere)
- **Lithosphere**
  - Rigid, outermost layer
  - Makes up plates
  - Crust plus uppermost mantle
- **Asthenosphere**
  - Weak, ductile layer
  - Moves slowly (convects)
  - Lower part of the upper mantle

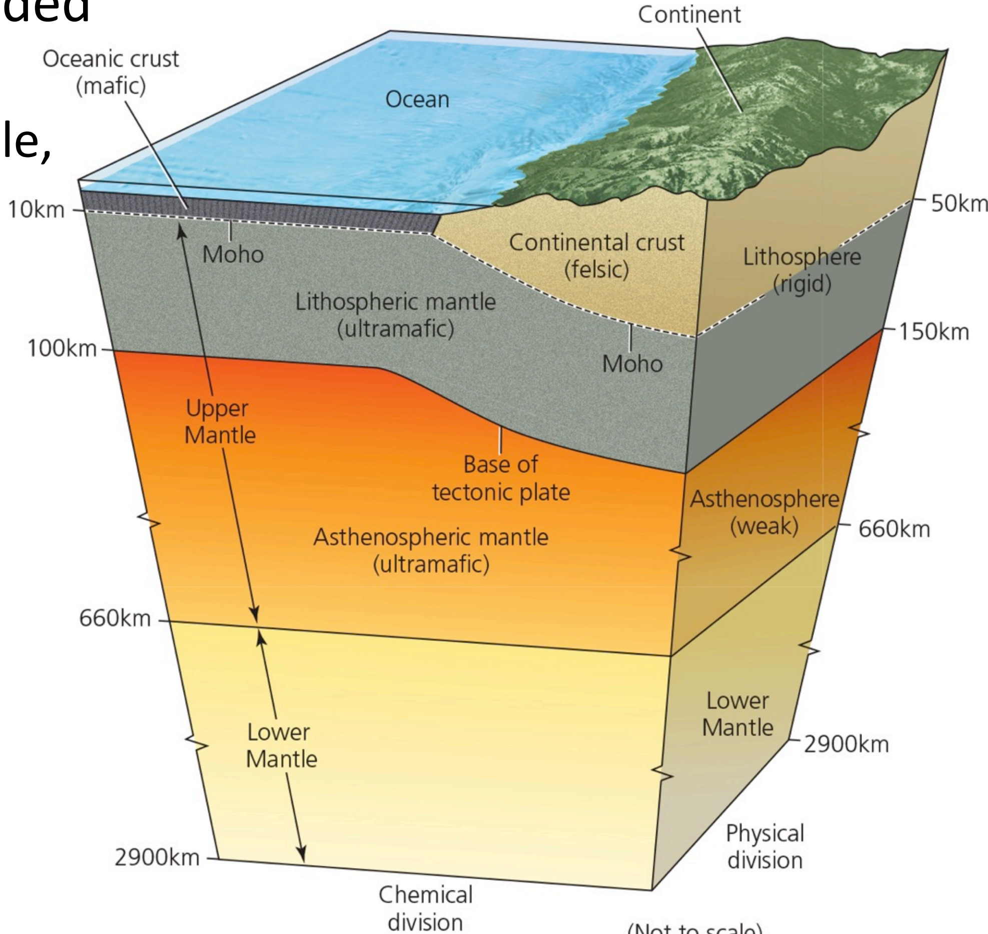
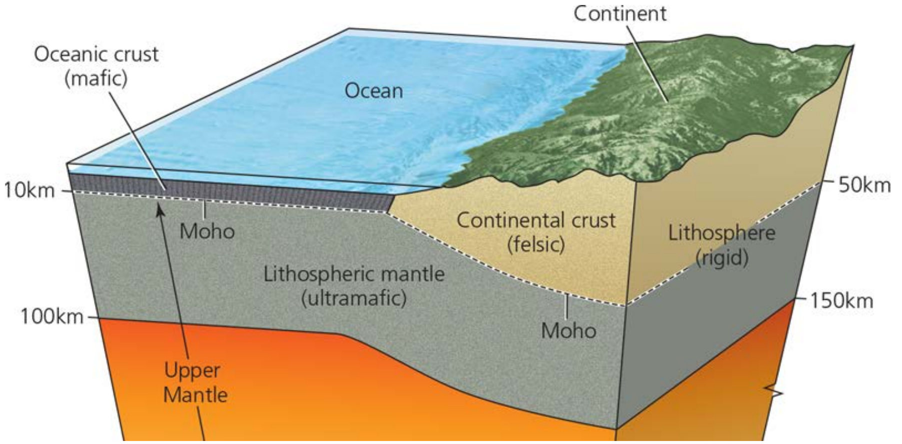


Fig. 9.1

Layers of the Lithosphere

- **Continental Crust**
  - Granitic composition
  - Least dense layer
  - Averages 35 km; as thick as 80 km
- **Oceanic Crust**
  - Basalt overlain by sediments
  - Denser than continental crust
  - Thinner than continental crust, averaging 7 km
- **Upper (Lithospheric) Mantle**
  - Ultramafic rock
  - Denser than crust
  - Cool and rigid; part of the lithosphere
- **Moho** *(Mohorovičić Discontinuity)*
  - The sharp boundary between the crust and upper mantle



Plates and Isostasy

- The base of the crust has a shape that mirrors the overlying shape of Earth's surface.
- **Buoyancy:** lithosphere "floats" on the asthenosphere below.
  - High crust areas must be supported by deep crustal "roots" that project into the mantle.
  - Continental crust is lighter and so rides higher on Earth's surface; denser oceanic crust rides lower.

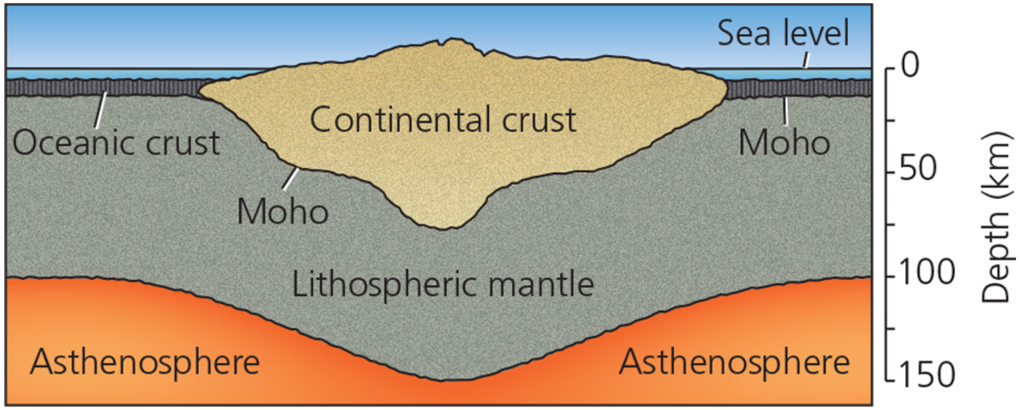
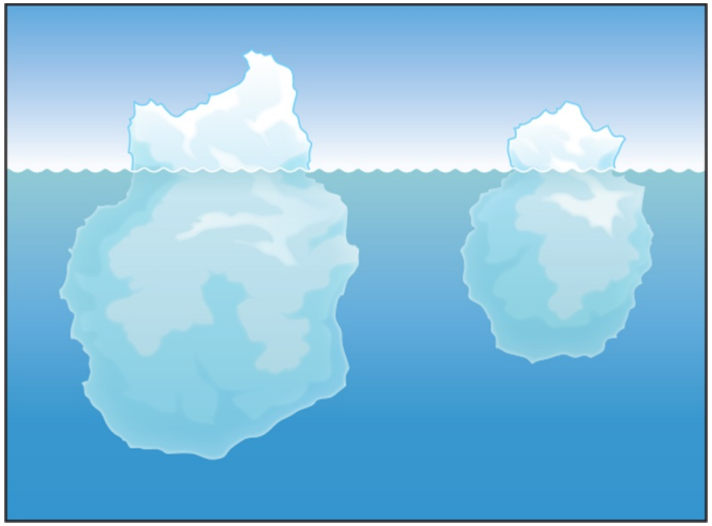


Fig. 9.2

Plates and Isostasy

- **Isostasy:** balance reached by the lithosphere as it floats upon the asthenosphere.
  - Depends on lithosphere volume and density
  - Balance = **isostatic equilibrium**
- Decrease in thickness or density causes **isostatic rebound**.



Floating icebergs demonstrate the concept of isostasy. These two icebergs float in such a way that the same proportion of each iceberg is above the water line.

Fig. 9.6

Plates and Isostasy

Isostasy and Ice Sheets: Continental ice sheets illustrate isostatic depression and rebound.

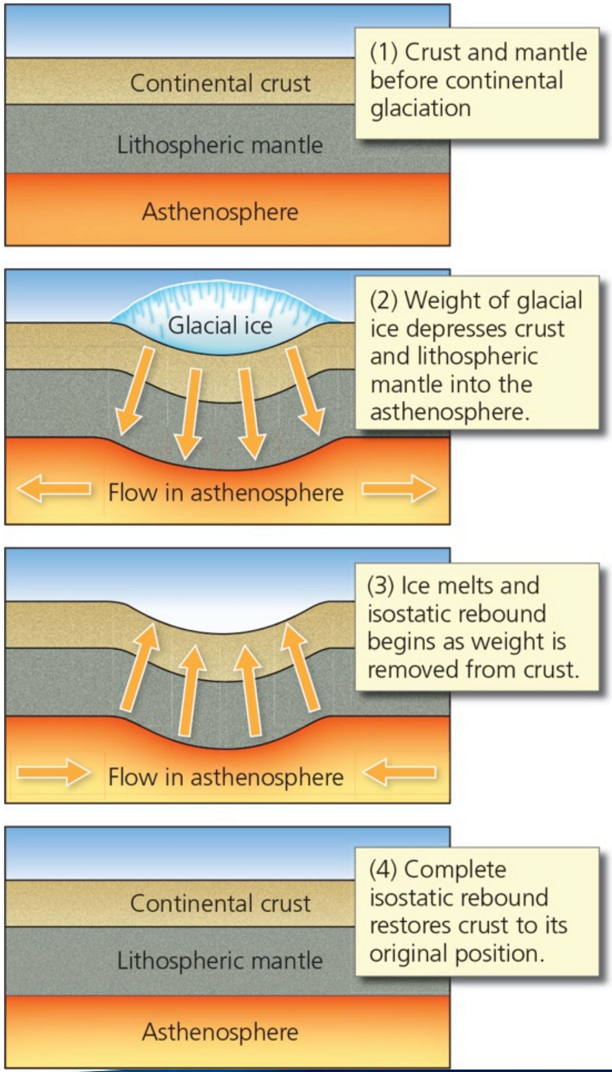
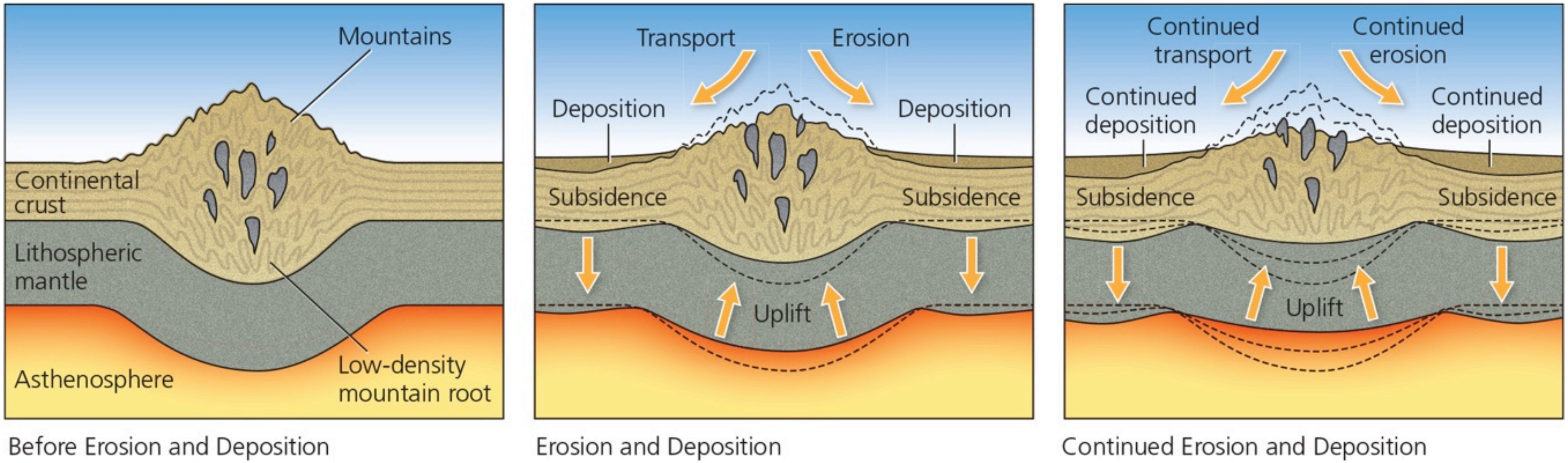


Fig 9.7

Plates and Isostasy



- Erosion in mountainous regions causes uplift of the mountain root (isostatic rebound).
- Deposition of sediment causes subsidence of the crust and rest of the lithosphere.

Fig. 9.8

Plate Boundaries

- Three Types of Motion: **extension**, **compression**, and **shear**

- **Divergent** Plate Boundaries
  - Plates move apart (extension)
  - New lithosphere is formed (*constructive* plate margins)

- **Convergent** Plate Boundaries
  - Plates collide
  - Lithosphere can be destroyed (*destructive* plate margins)

- **Transform** Plate Boundaries
  - Plates slide past each other
  - link other plate boundaries (*conservative* plate margins)

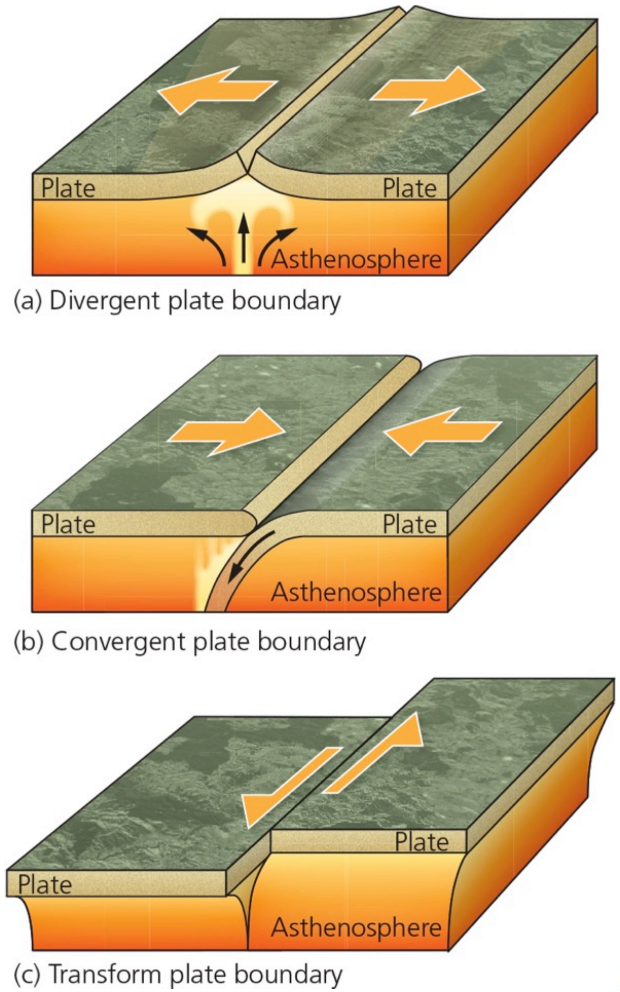


Fig. 9.10

Divergent Boundaries: Creating Oceans

- Continental Rifting and Ocean Formation
  - Plates start to separate.
  - Rising magma stretches and thins crust.
  - Mantle pressure lowers and forms more magma.
  - In early stages of rifting, the continent settles along faults.
  - Settling fault blocks form a steep-walled **rift valley**.

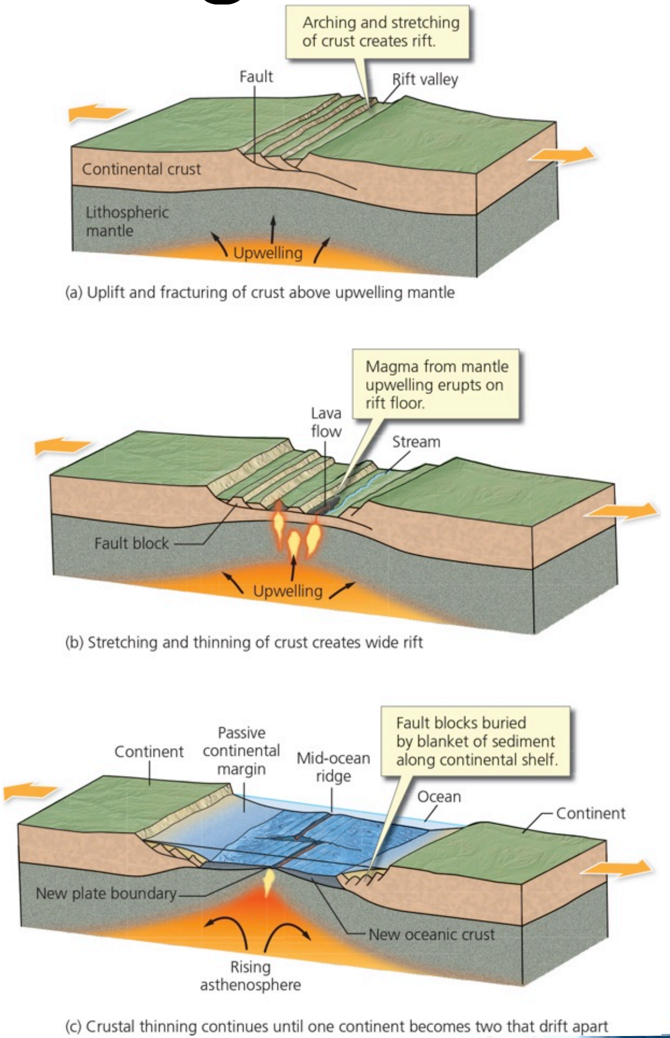


Fig. 9.12

Mid-Ocean Ridges and Ocean Opening

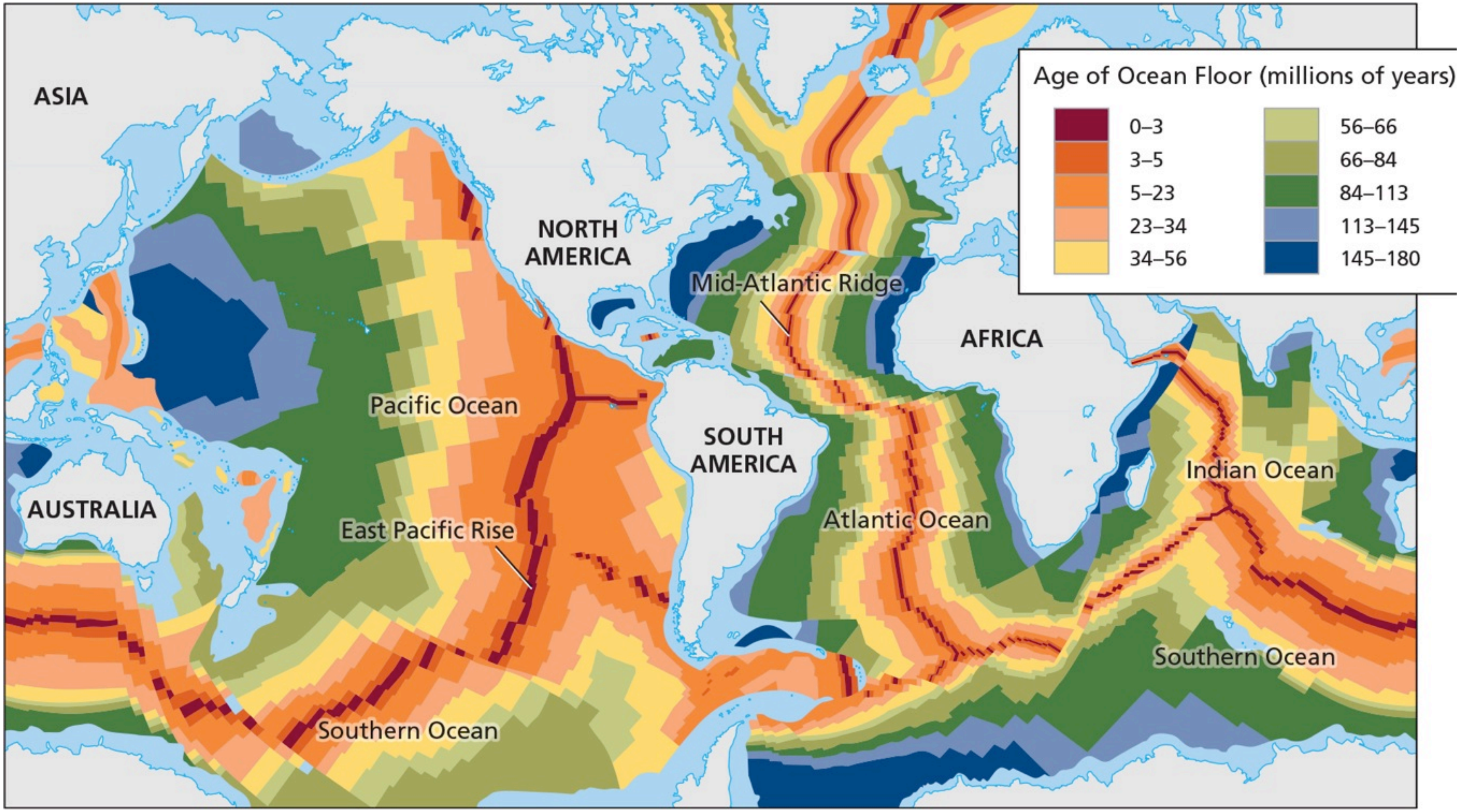
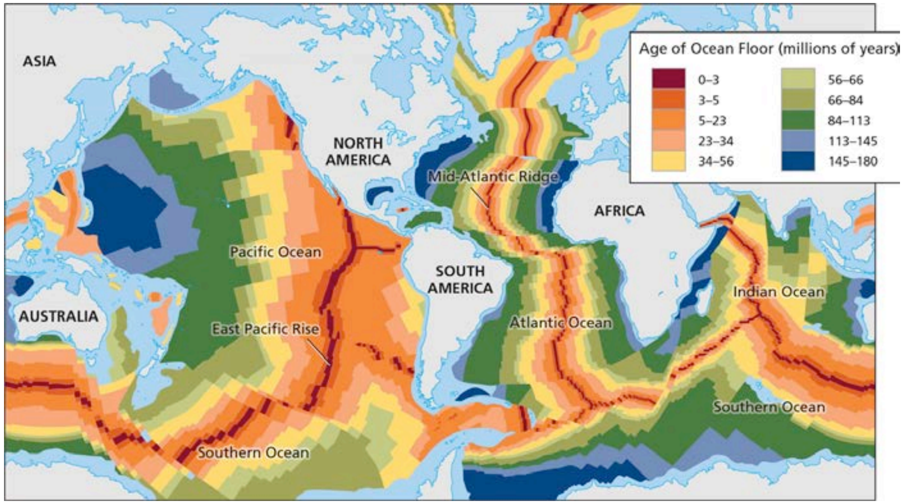


Fig. 9.14

Mid-Ocean Ridges and Ocean Opening

- Mid-ocean ridges are produced by extension and separation.

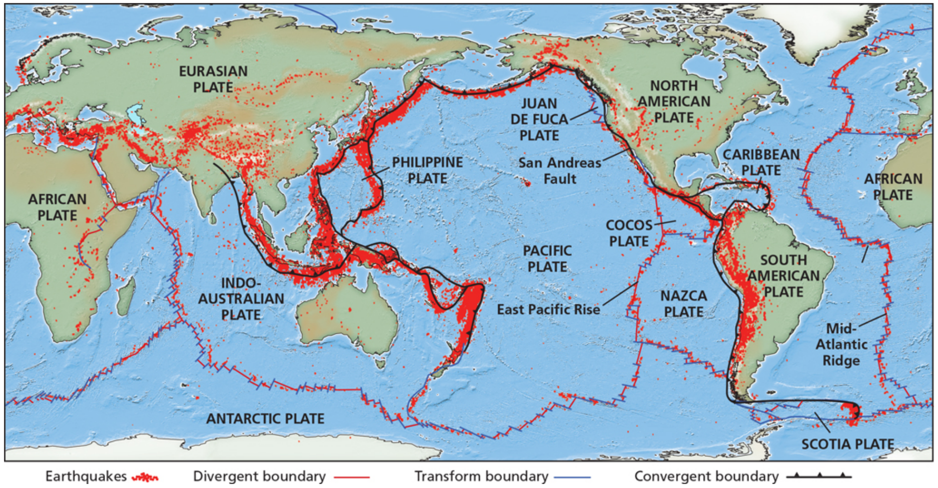


- Are found in all the world's major oceans.
- Form an interconnected system 65,000 kilometers long.
- With seafloor spreading, the crust moves away from mid-ocean ridges to form the flat, abyssal plain of the deep ocean.

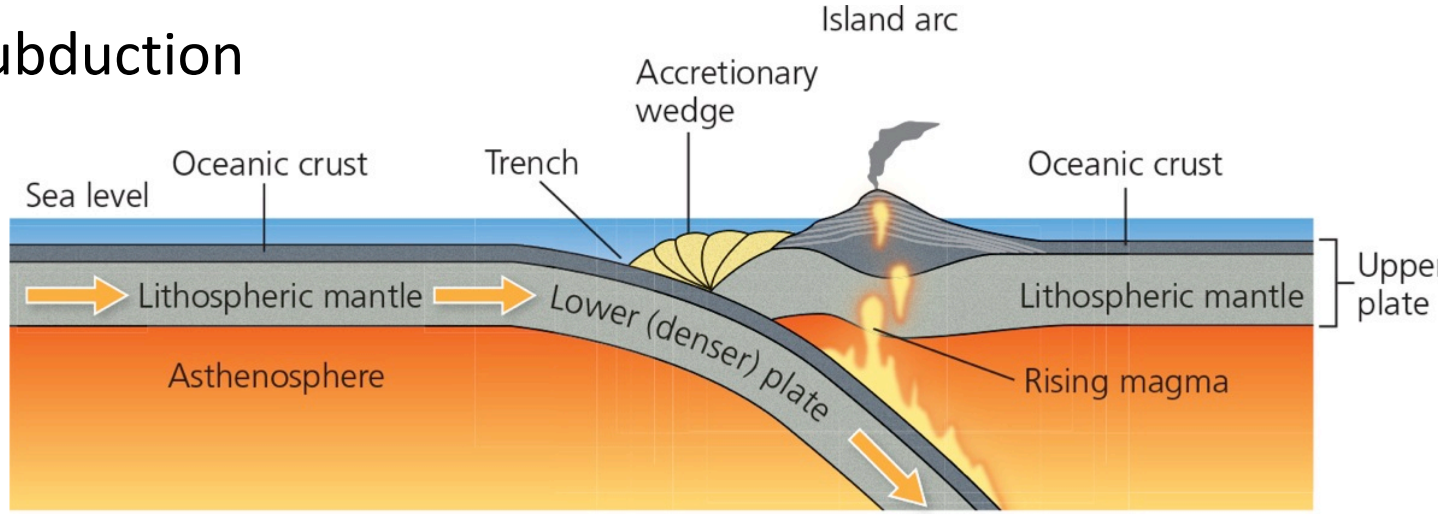
Convergent Boundaries

- The creation of lithosphere is balanced by the destruction of lithosphere (subduction).

- Three Types of Convergent Plate Boundaries
  - Ocean-Ocean
    - Deep ocean trenches
    - Island arc volcanoes
  - Ocean-Continent
    - Deep ocean trenches
    - Continental arc volcanoes
  - Continent-Continent
    - Fold and thrust mountain belts

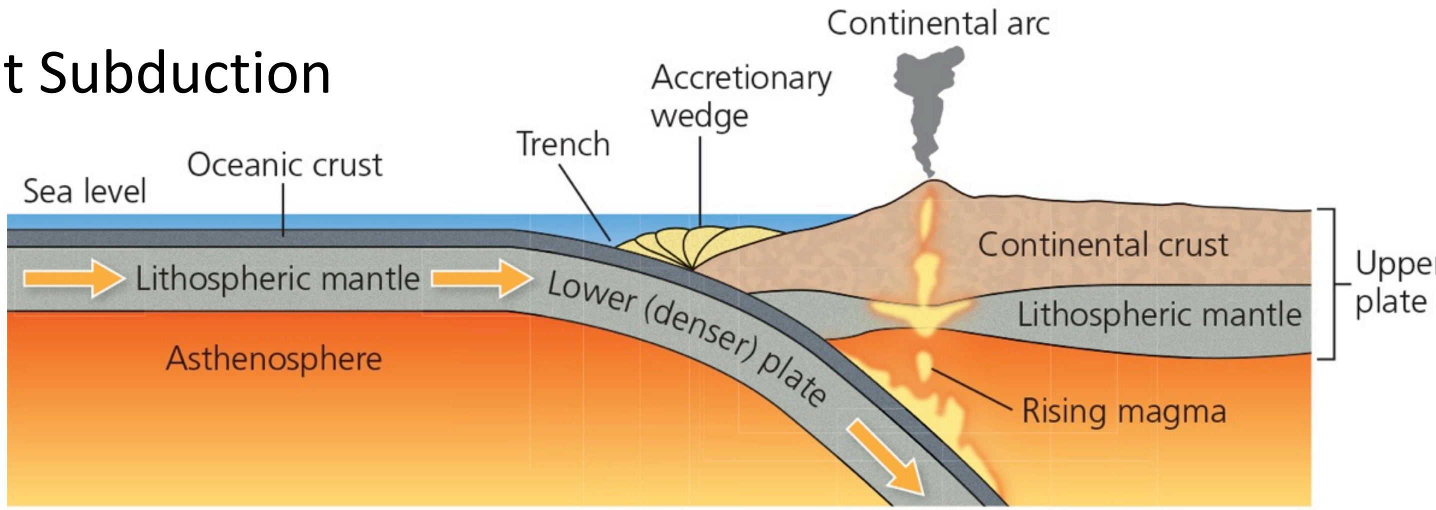


Ocean-Ocean Subduction



(a) Ocean-ocean convergence

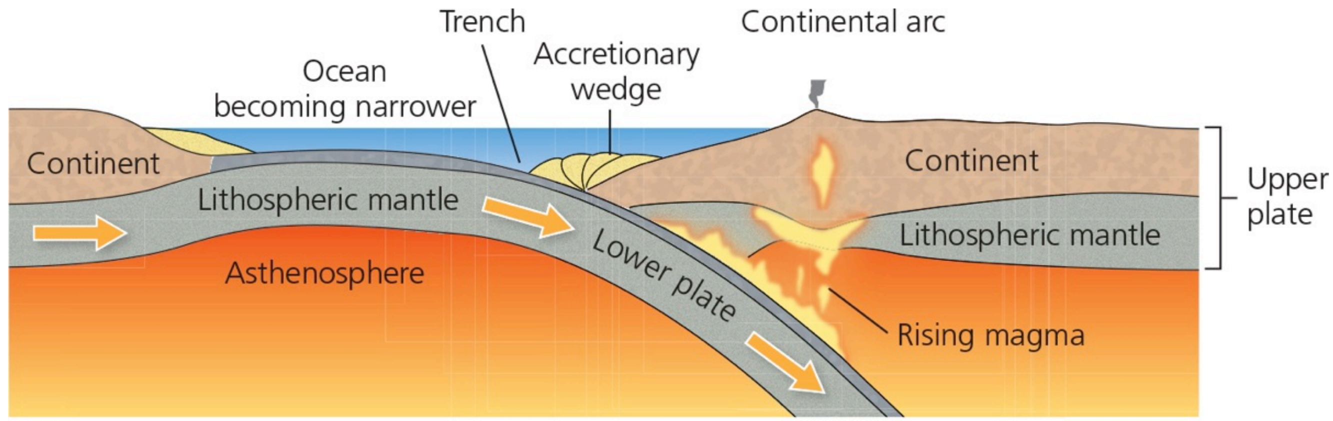
Ocean-Continent Subduction



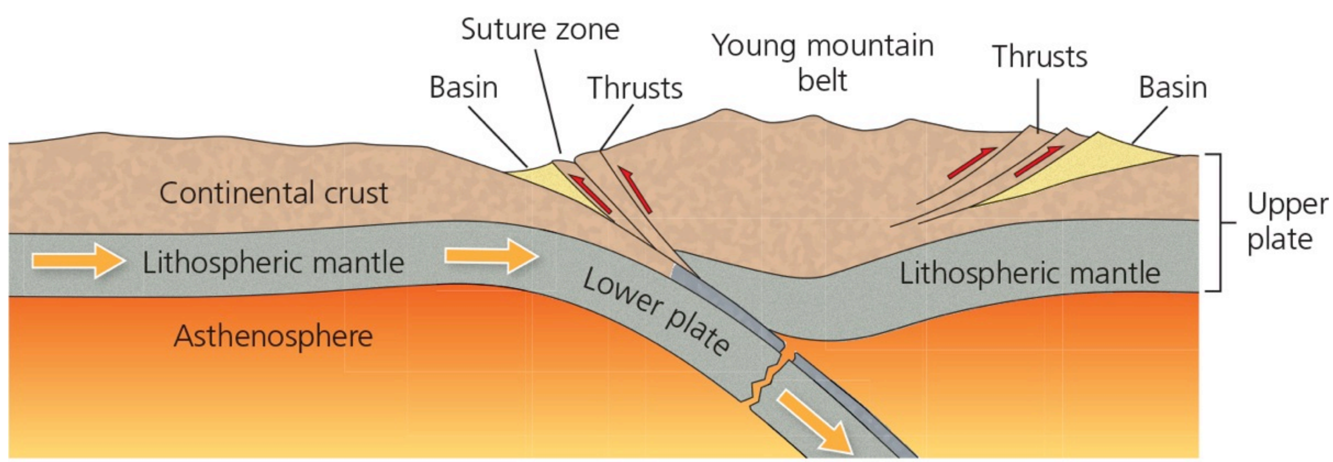
(b) Ocean-continent convergence

Fig. 9.16

Continent Convergence to Continental Collision



(a) Continent-continent convergence



(b) Continent-continent collision

Fig. 9.17

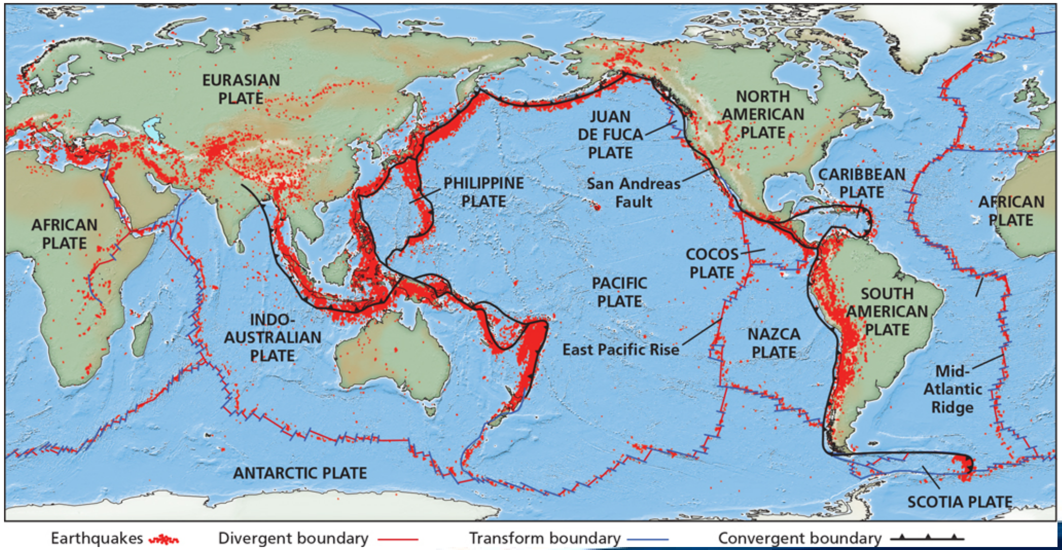
Transform Boundaries

- Plates slide past each other along transform faults.

- Transform faults link other boundaries:
  - Two segments of a mid-ocean ridge
  - An ocean ridge and a subduction zone
  - Two subduction zones

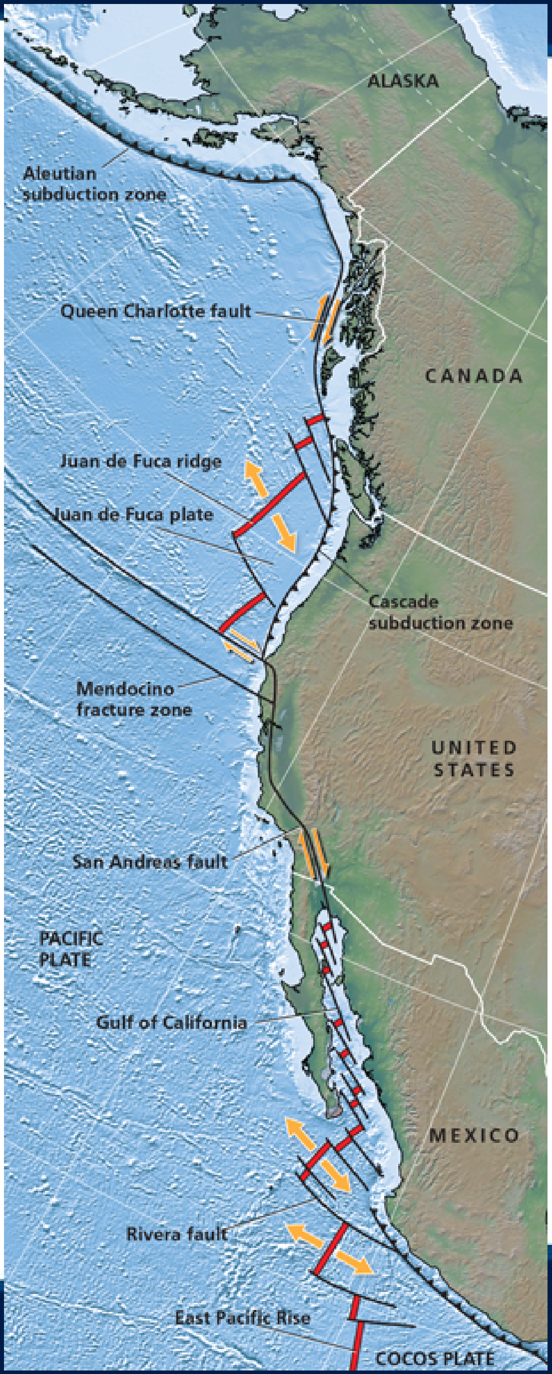
- Underwater in oceanic lithosphere

- On land in continental lithosphere

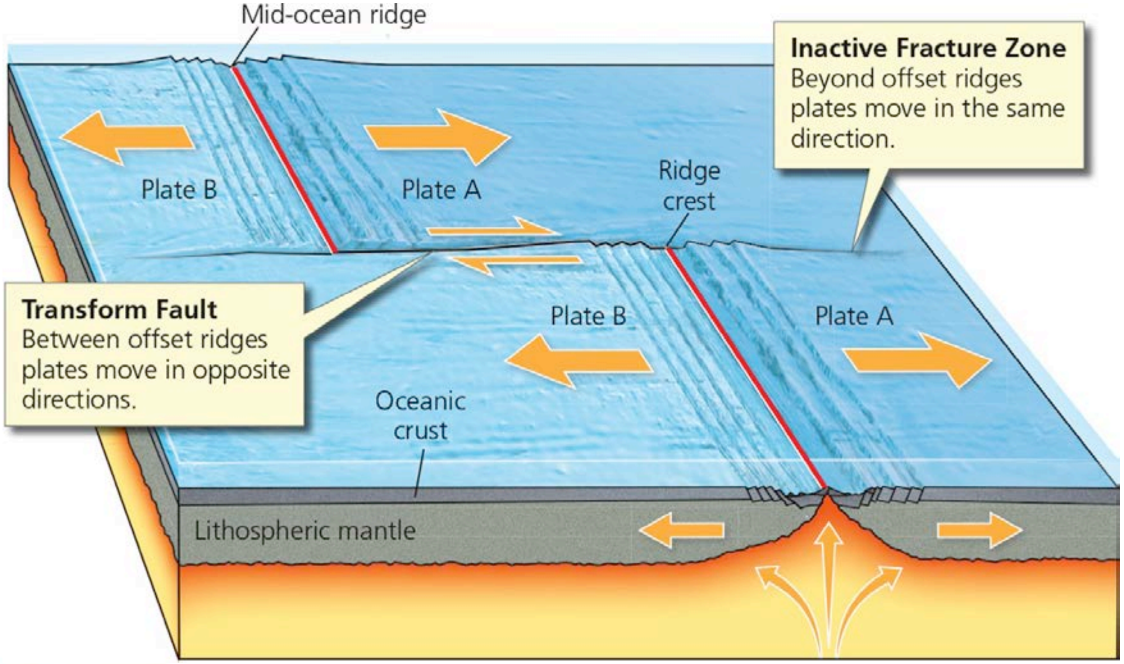


Transform Boundaries

Transform boundary in continental lithosphere between mid-ocean ridge segments



Transform boundary in oceanic lithosphere between mid-ocean ridge segments



Figs. 9.26, 9.28

Hotspots

- **Hotspots** are small, isolated areas of higher-than-average heat associated with volcanoes.
  - Found on continents and in oceans
  - Most located far from plate boundaries
  - May be a result of **mantle plumes**, areas of upwelling of heat.
  - Provide evidence of the movement of tectonic plates
  - May play a role in continental rifting

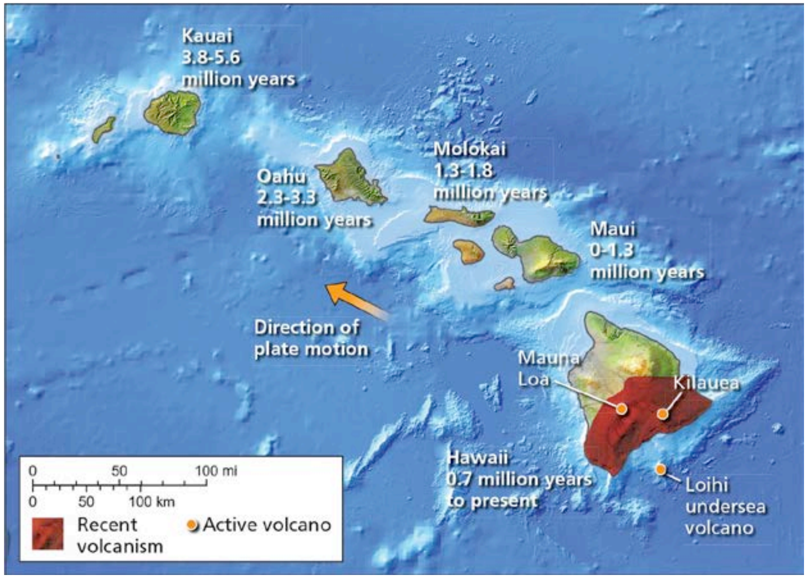


Fig. 9.38

Hotspot Tracks

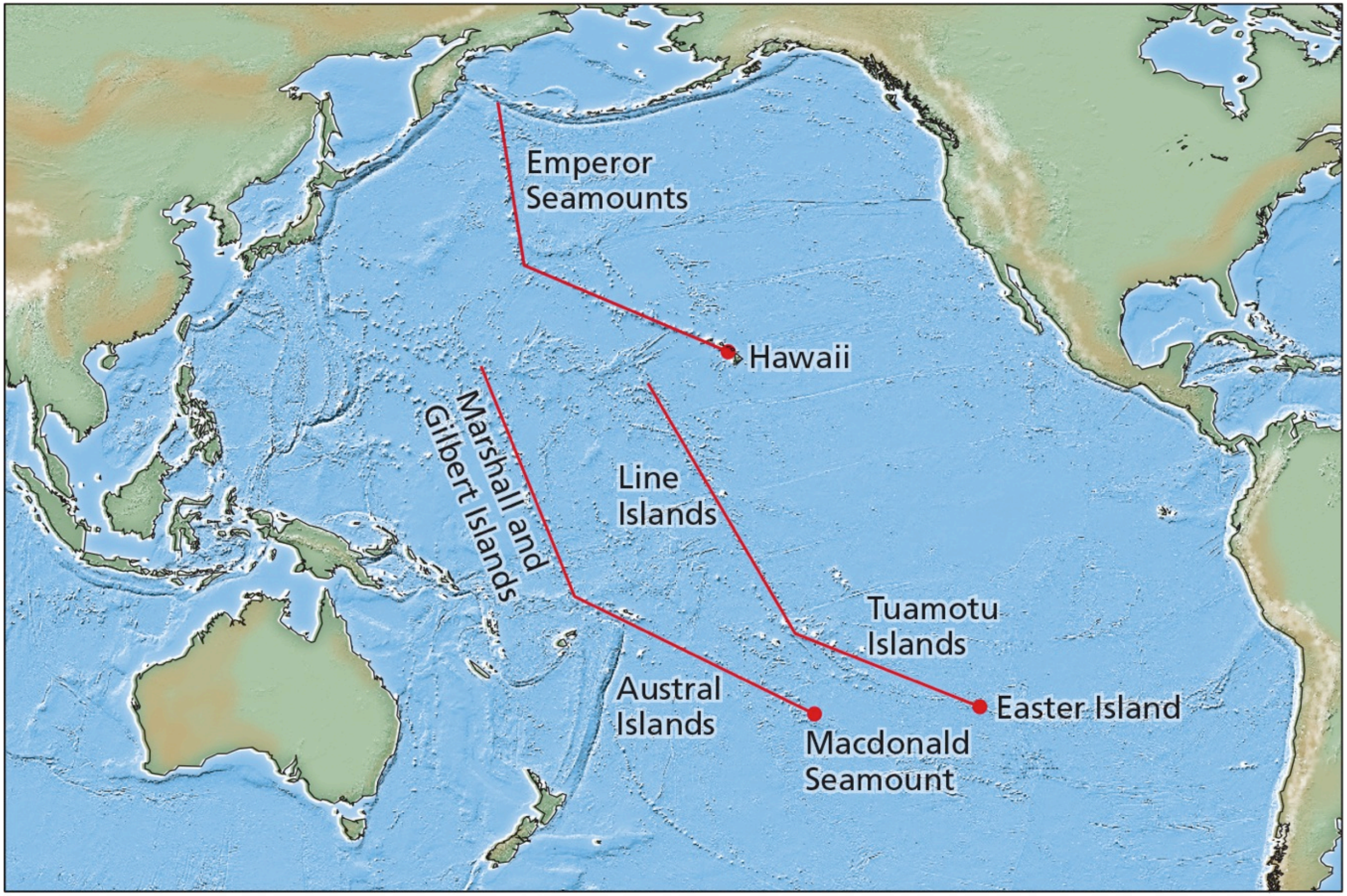


Fig. 9.39

Plate-Driving Mechanisms

- Plate motion is thought to be driven by cooling of Earth's interior by **convection**.

- Plates may be propelled by three types of force:
  - **Slab Pull:** the weight of the subducting slab pulls the rest of the plate behind it.
  - **Ridge Push:** the plate slides downslope toward a trench from the ridge crest.
  - **Mantle Drag:** the plates are carried by convection currents of the hot ductile rock of the asthenosphere below it.

Plate-Driving Mechanisms

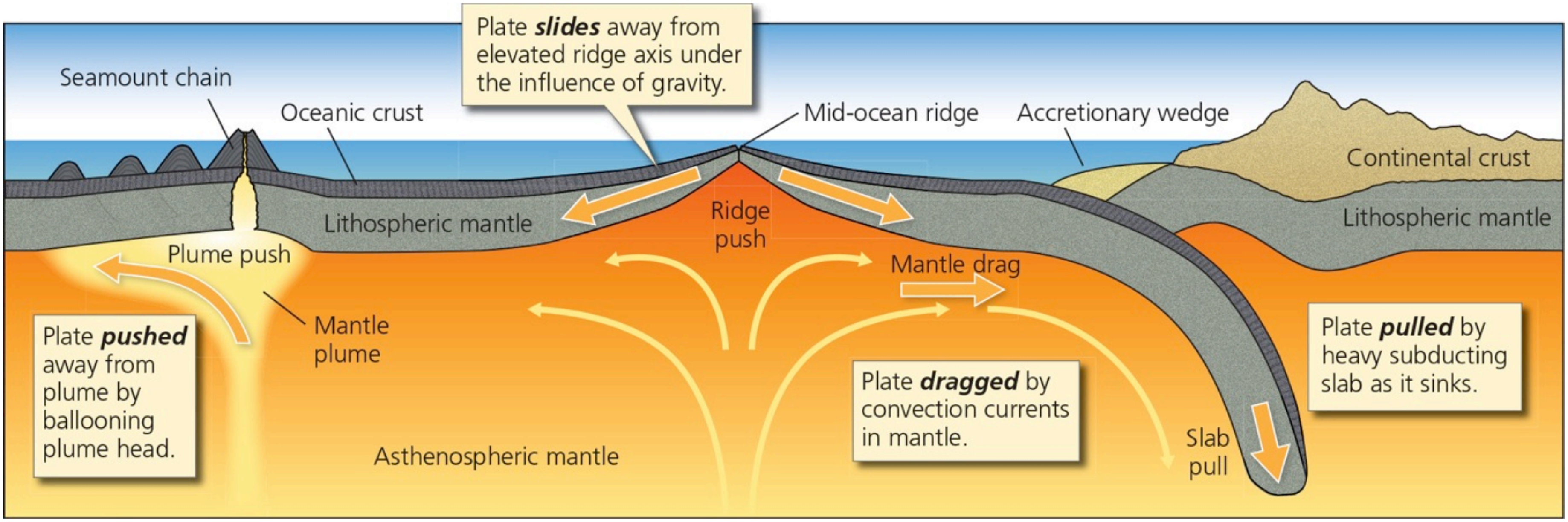


Fig 9.44

SUMMARY

- Earth's outer layers consist of a rigid lithosphere and a weaker asthenosphere below.
- The lithosphere is broken into tectonic plates that move slowly over the surface.
- Plates are balanced by buoyancy and isostasy and move in response to the flow of heat from Earth's interior.
- Plates move relative to each other through extension, compression, and shear.

SUMMARY

- Plate boundaries are classified as divergent (extensional), convergent (compressional), and transform (shear).
- Major surface features and geologic processes occur along plate boundaries.
- Hotspots are solitary areas of volcanism that can be far from plate boundaries and not caused by plate motion.
- Plates are thought to be driven by convection currents in the lithosphere and by gravitational pull of subducting slabs and along ridge crests.