

Prentice Hall

# EARTH SCIENCE



**Tarbuck**

**♦ Lutgens**

Chapter

9

# Plate Tectonics

# 9.1 Continental Drift

## An Idea Before Its Time

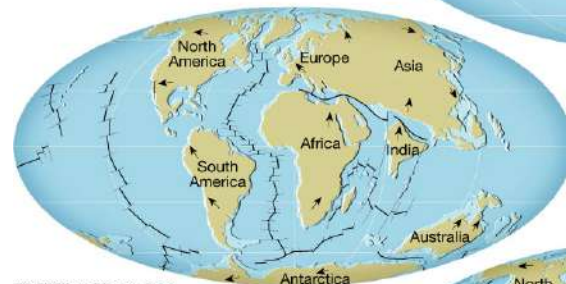
- ◆ Wegener's **continental drift** hypothesis stated that the continents had once been joined to form a single supercontinent.
- Wegener proposed that the supercontinent, **Pangaea**, began to break apart 200 million years ago and form the present landmasses.

# Breakup of Pangaea



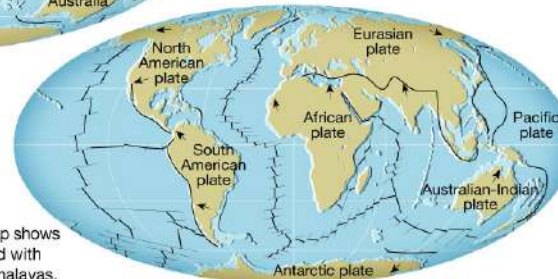
**250 Million Years Ago**  
Pangaea consisted of all the major continents.

**200 Million Years Ago** The rifting that eventually resulted in the Atlantic Ocean occurred over an extended period of time. The first rift developed between North America and Africa.



**100 Million Years Ago**  
Continued rifting of the southern landmasses sent India on a northward journey.

**50 Million Years Ago**  
Australia began to separate from Antarctica.



**Present** A modern map shows that India has collided with Asia, creating the Himalayas.

# 9.1 Continental Drift

## An Idea Before Its Time

### ◆ Evidence

- The Continental Puzzle
- Matching Fossils
  - Fossil evidence for continental drift includes several fossil organisms found on different landmasses.

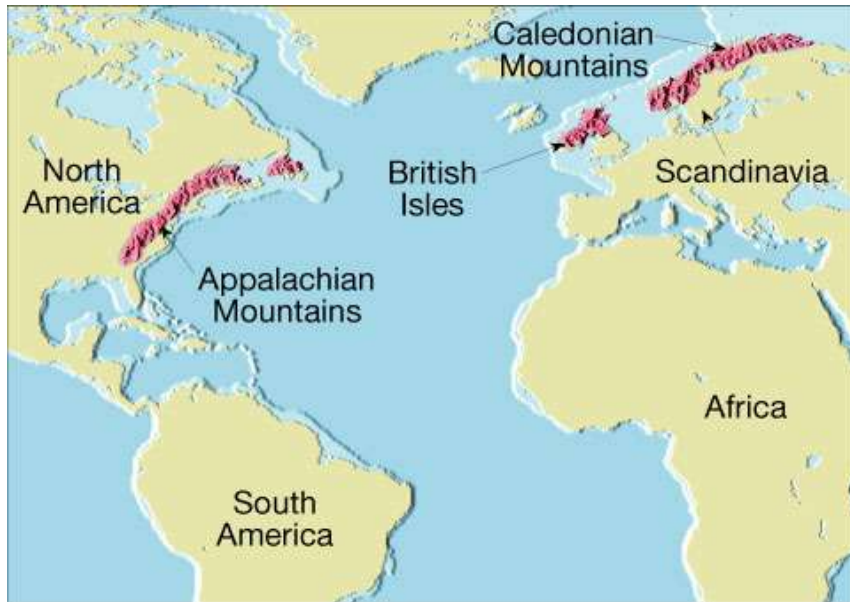
# 9.1 Continental Drift

## An Idea Before Its Time

### ◆ Evidence

- Rock Types and Structures
  - Rock evidence for continental exists in the form of several mountain belts that end at one coastline, only to reappear on a landmass across the ocean.
- Ancient Climates

# Matching Mountain Ranges





# Glacier Evidence





# 9.1 Continental Drift

## Rejecting the Hypothesis

### ◆ A New Theory Emerges

- Wegener could not provide an explanation of exactly what made the continents move. New technology lead to findings which then lead to a new theory called plate tectonics.

# 9.2 Plate Tectonics

## Earth's Major Roles

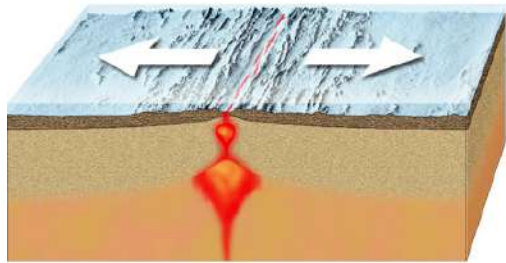
- ◆ According to the **plate tectonics** theory, the uppermost mantle, along with the overlying crust, behaves as a strong, rigid layer. This layer is known as the lithosphere.
  - A **plate** is one of numerous rigid sections of the lithosphere that move as a unit over the material of the asthenosphere.

# 9.2 Plate Tectonics

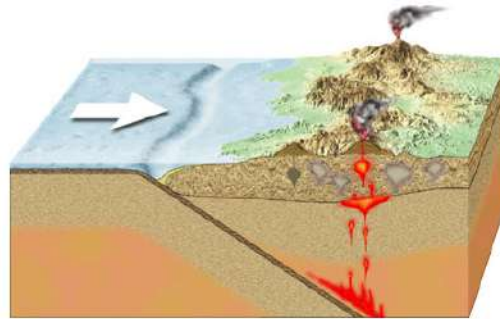
## Types of Plate Boundaries

- ◆ **Divergent boundaries** (also called spreading centers) are the place where two plates move apart.
- ◆ **Convergent boundaries** form where two plates move together.
- ◆ **Transform fault boundaries** are margins where two plates grind past each other without the production or destruction of the lithosphere.

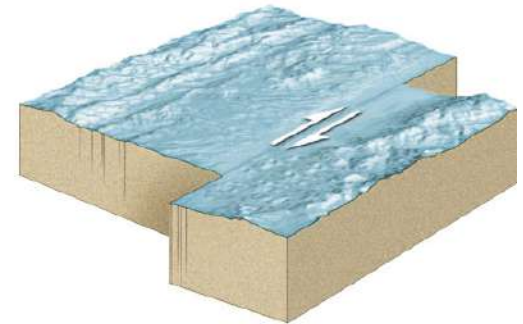
# Three Types of Plate Boundaries



Divergent boundary



Convergent boundary



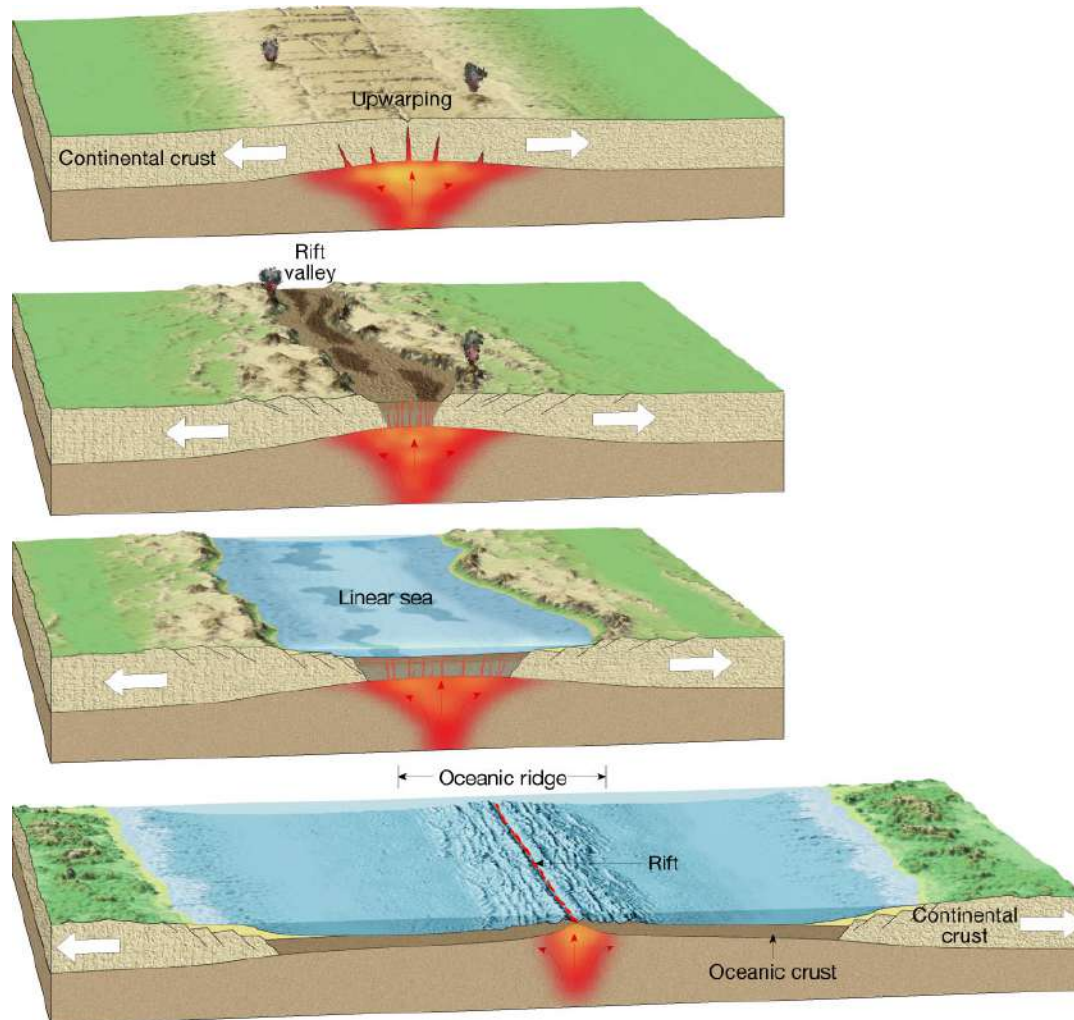
Transform fault boundary

# 9.3 Actions at Plate Boundaries

## Divergent Boundaries

- ◆ Oceanic Ridges and Seafloor Spreading
  - **Oceanic ridges** are continuous elevated zones on the floor of all major ocean basins. The rifts at the crest of ridges represent divergent plate boundaries.
  - **Rift valleys** are deep faulted structures found along the axes of divergent plate boundaries. They can develop on the seafloor or on land.
  - **Seafloor spreading** produces new oceanic lithosphere.

# Spreading Center



# 9.3 Actions at Plate Boundaries

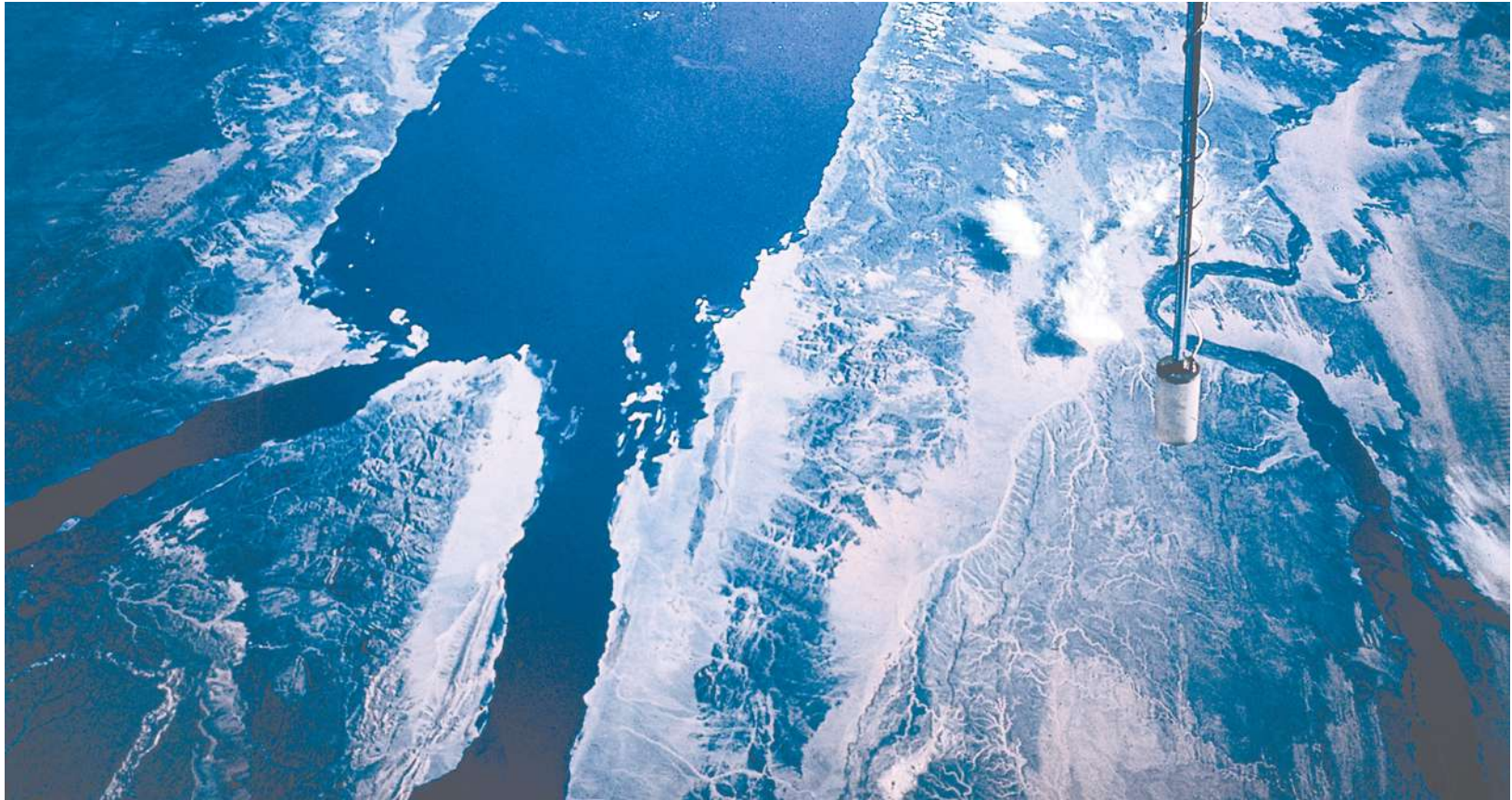
## Divergent Boundaries

### ◆ Continental Rifts

- When spreading centers develop within a continent, the landmass may split into two or more smaller segments, forming a rift.



# Red Sea

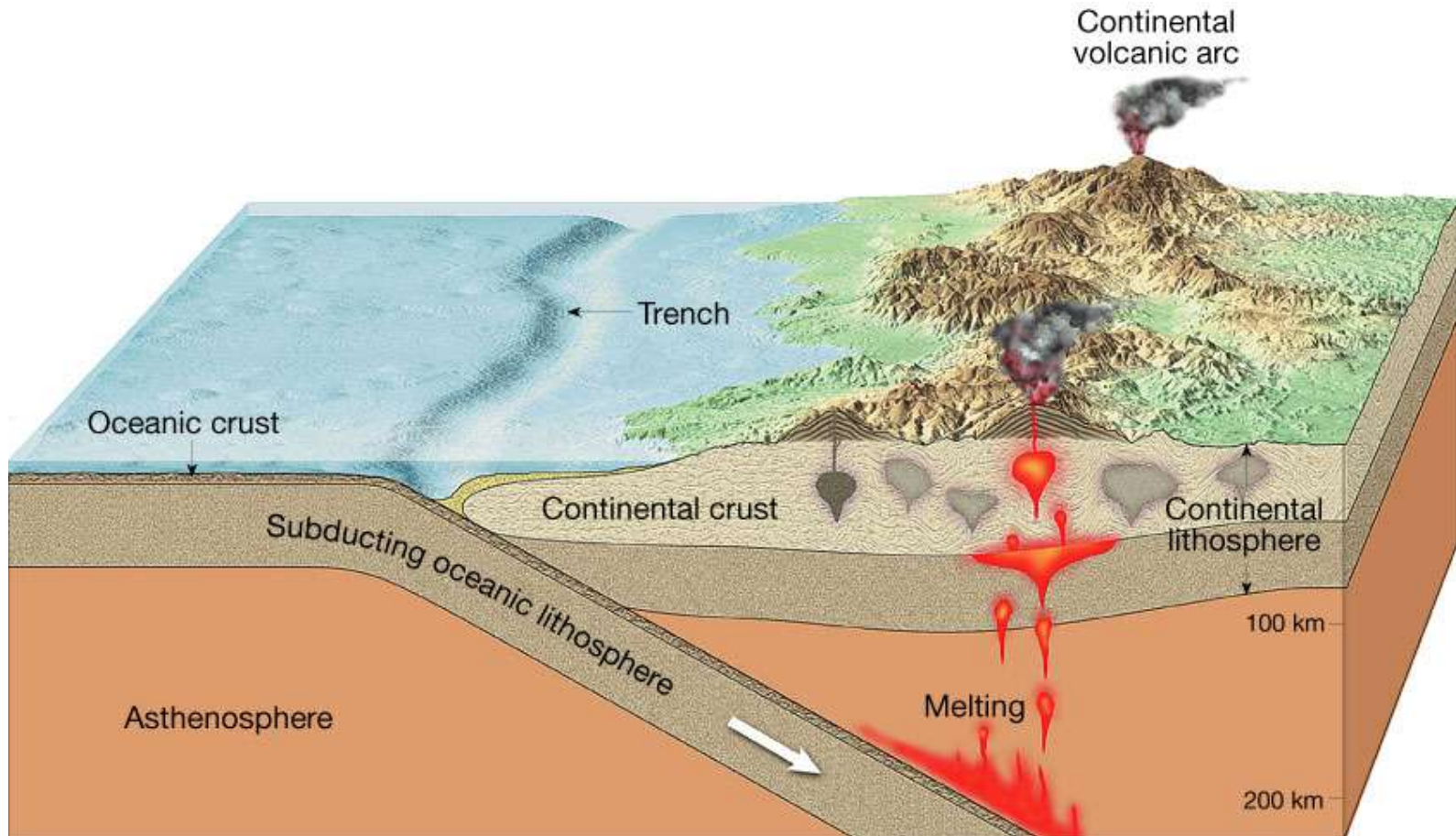


# 9.3 Actions at Plate Boundaries

## Convergent Boundaries

- ◆ A **subduction zone** occurs when one oceanic plate is forced down into the mantle beneath a second plate.
- ◆ **Oceanic-Continental**
  - Denser oceanic slab sinks into the asthenosphere.
  - Pockets of magma develop and rise.
  - **Continental volcanic arcs** form in part by volcanic activity caused by the subduction of oceanic lithosphere beneath a continent.
  - Examples include the Andes, Cascades, and the Sierra Nevadas.

# Oceanic-Continental Convergent Boundary





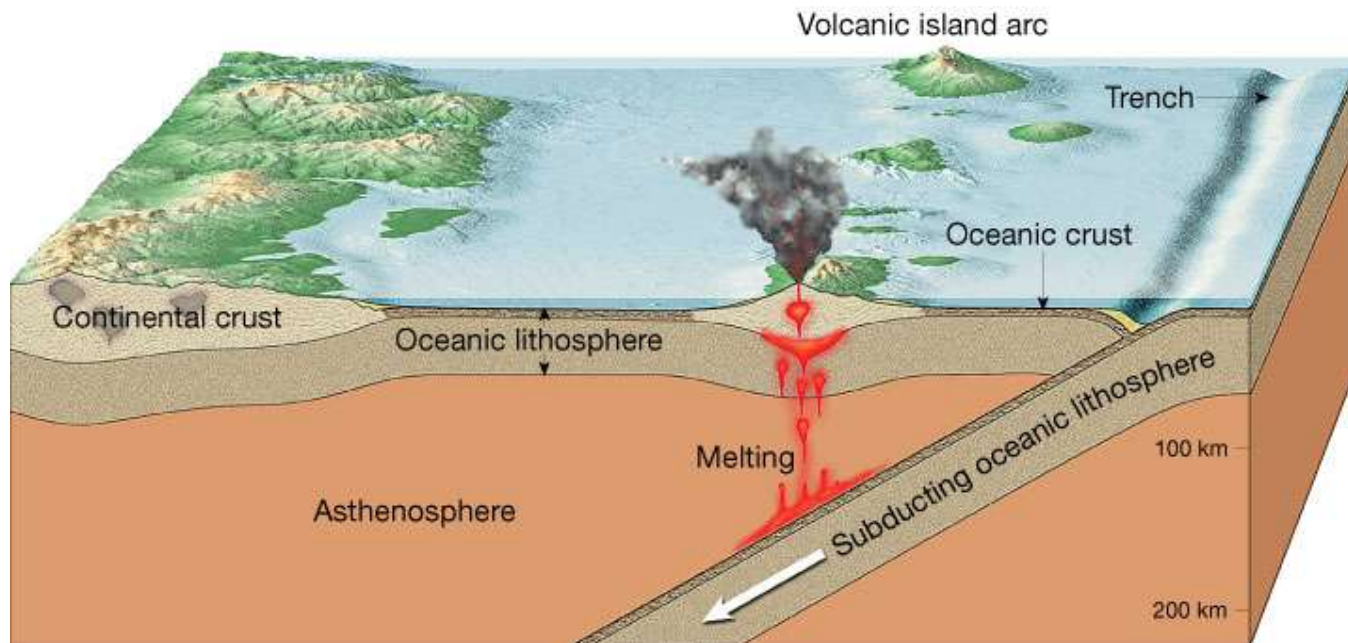
# 9.3 Actions at Plate Boundaries

## Convergent Boundaries

### ◆ Oceanic-Oceanic

- Two oceanic slabs converge and one descends beneath the other.
- This kind of boundary often forms volcanoes on the ocean floor.
- **Volcanic island arcs** form as volcanoes emerge from the sea.
- Examples include the Aleutian, Mariana, and Tonga islands.

# Oceanic-Oceanic Convergent Boundary



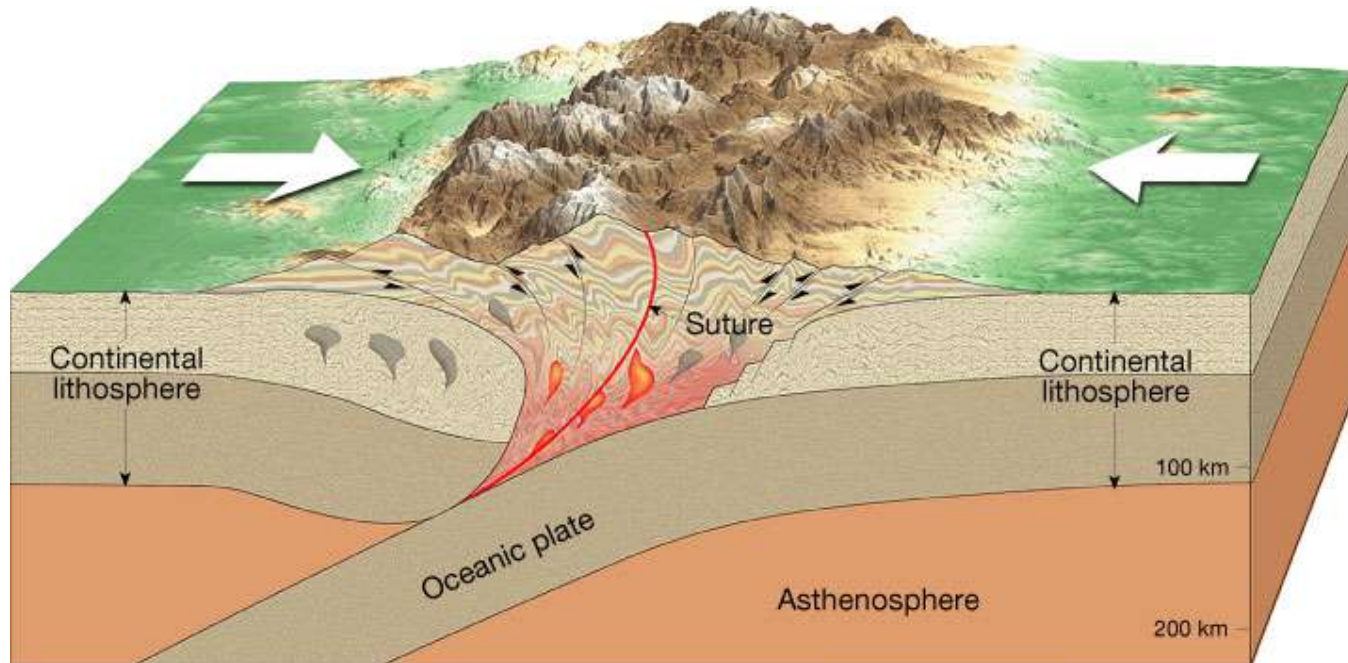
# 9.3 Actions at Plate Boundaries

## Convergent Boundaries

### ◆ Continental-Continental

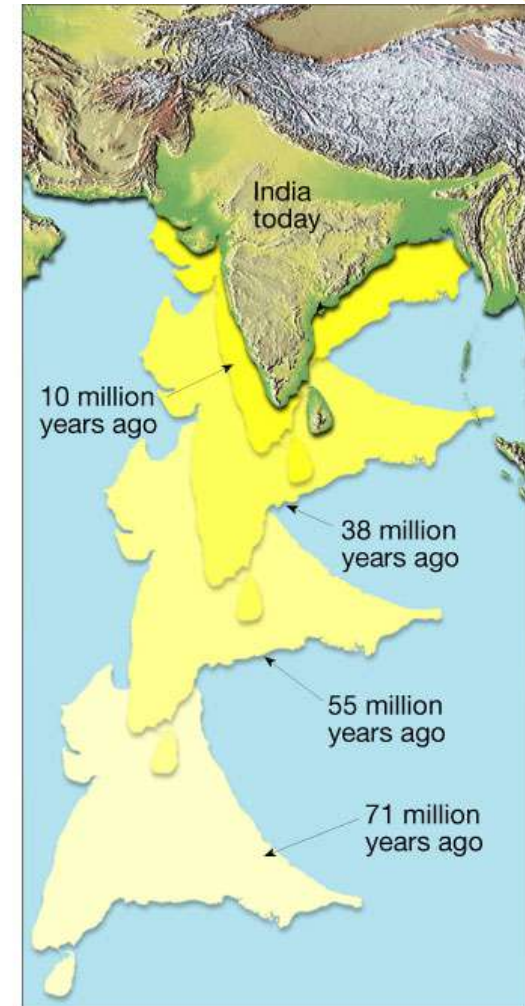
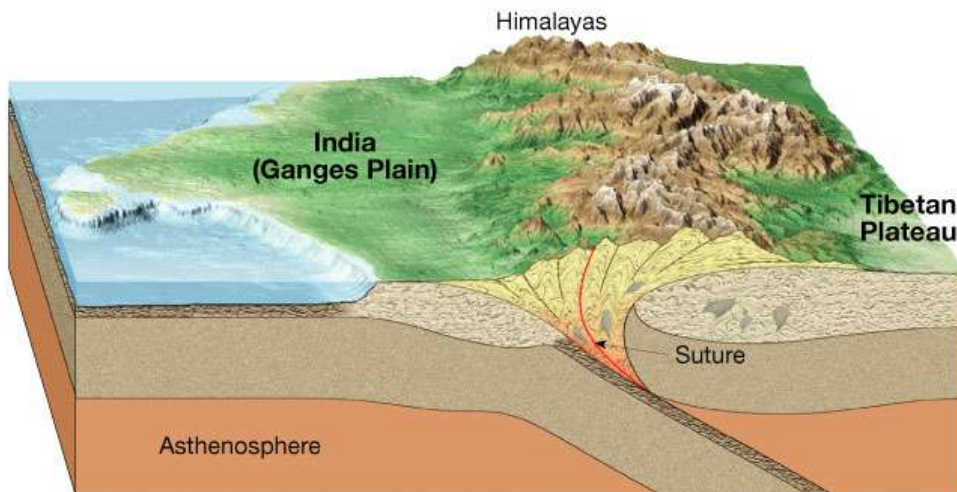
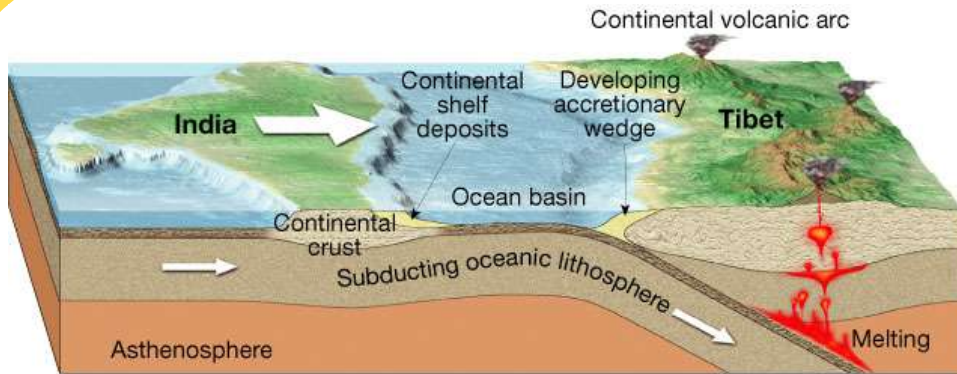
- When subducting plates contain continental material, two continents collide.
- This kind of boundary can produce new mountain ranges, such as the Himalayas.

# Continental-Continental Convergent Boundary





# Collision of India and Asia

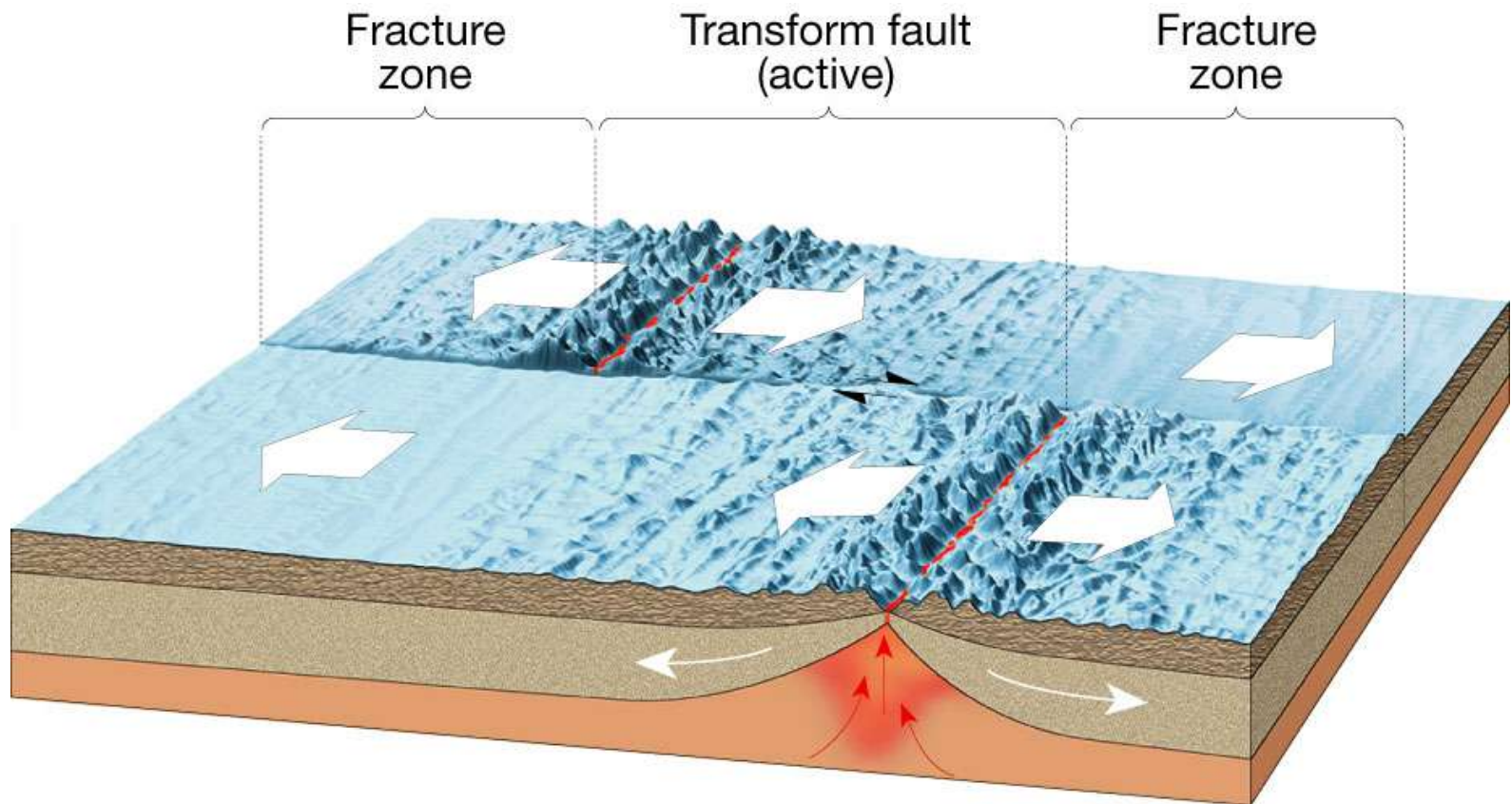


# 9.3 Actions at Plate Boundaries

## Transform Fault Boundaries

- ◆ At a transform fault boundary, plates grind past each other without destroying the lithosphere.
- ◆ Transform faults
  - Most join two segments of a mid-ocean ridge.
  - At the time of formation, they roughly parallel the direction of plate movement.
  - They aid the movement of oceanic crustal material.

# Transform Fault Boundary



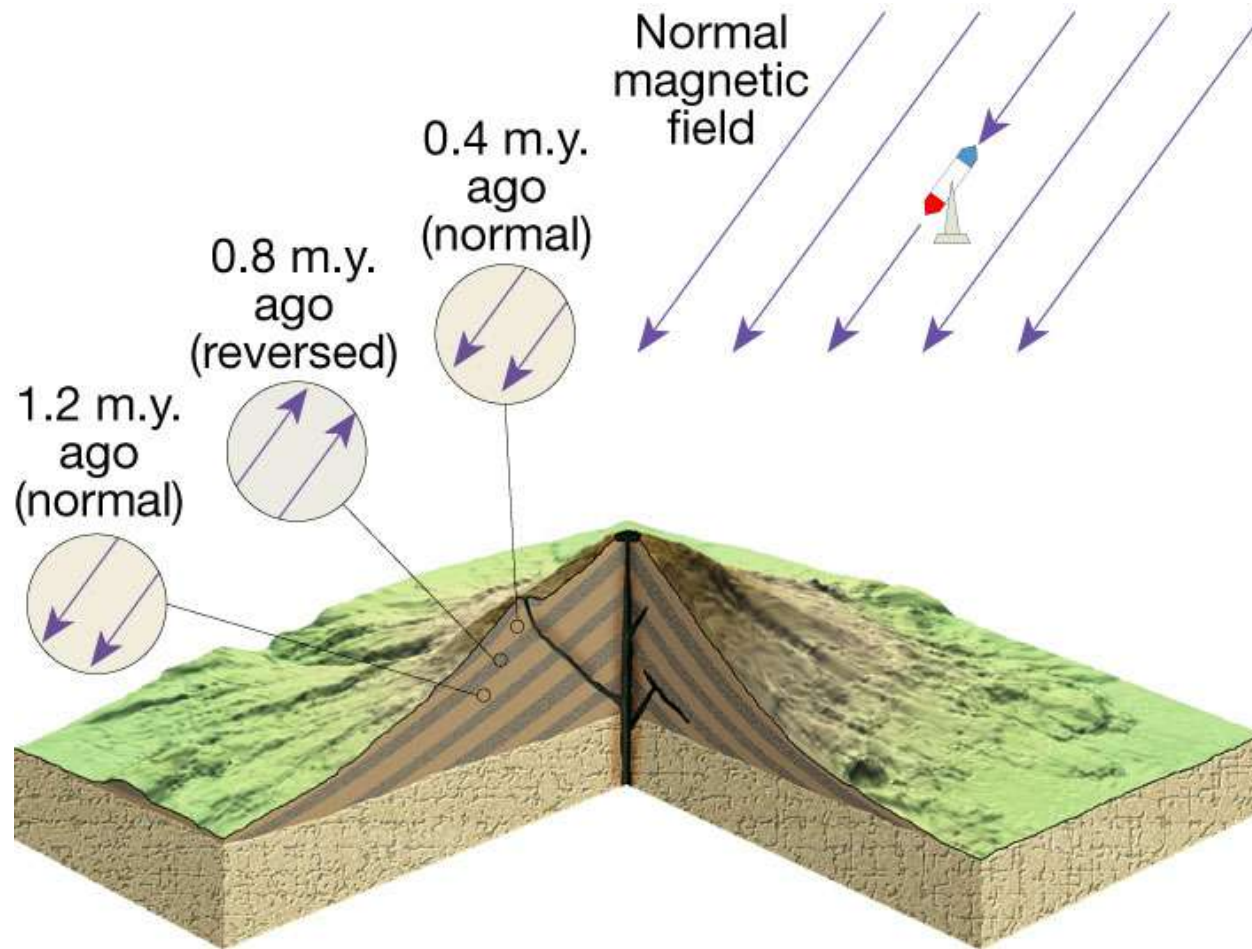
# 9.4 Testing Plate Tectonics

## Evidence for Plate Tectonics

- ◆ **Paleomagnetism** is the natural remnant magnetism in rock bodies; this permanent magnetization acquired by rock can be used to determine the location of the magnetic poles at the time the rock became magnetized.
  - **Normal polarity**—when rocks show the same magnetism as the present magnetism field
  - **Reverse polarity**—when rocks show the opposite magnetism as the present magnetism field



# Paleomagnetism Preserved in Lava Flows

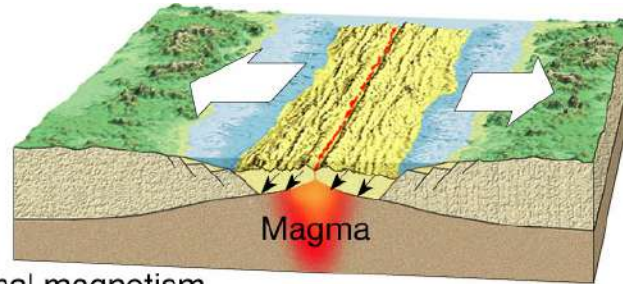


# 9.4 Testing Plate Tectonics

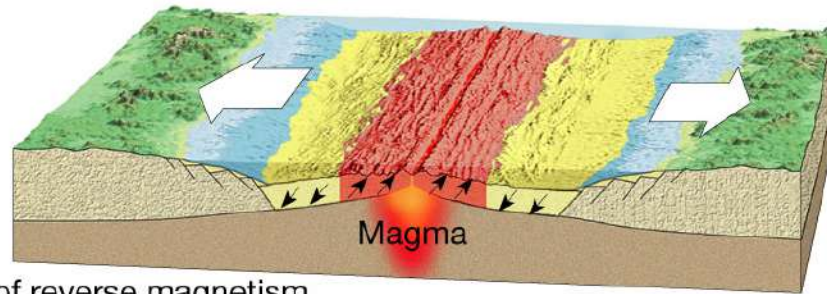
## Evidence for Plate Tectonics

- ◆ The discovery of strips of alternating polarity, which lie as mirror images across the ocean ridges, is among the strongest evidence of seafloor spreading.

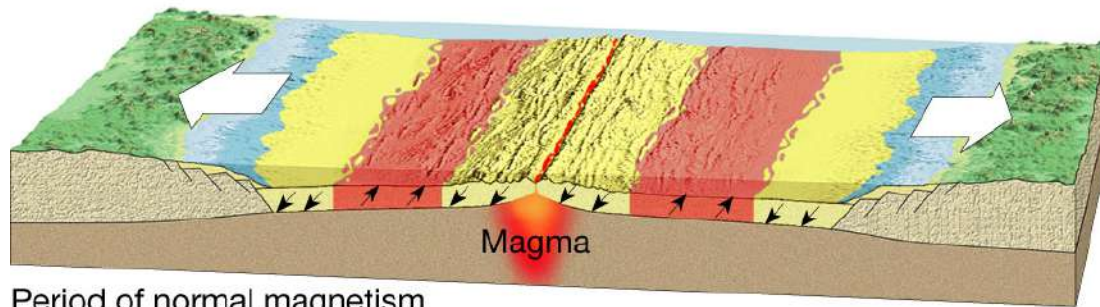
# Polarity of the Ocean Crust



Period of normal magnetism



Period of reverse magnetism



Period of normal magnetism



# 9.4 Testing Plate Tectonics

## Evidence for Plate Tectonics

### ◆ Earthquake Patterns

- Scientists found a close link between deep-focus earthquakes and ocean trenches.
- The absence of deep-focus earthquakes along the oceanic ridge system was shown to be consistent with the new theory.

# 9.4 Testing Plate Tectonics

## Evidence for Plate Tectonics

### ◆ Ocean Drilling

- The data on the ages of seafloor sediment confirmed what the seafloor spreading hypothesis predicted.
- The youngest oceanic crust is at the ridge crest, and the oldest oceanic crust is at the continental margins.

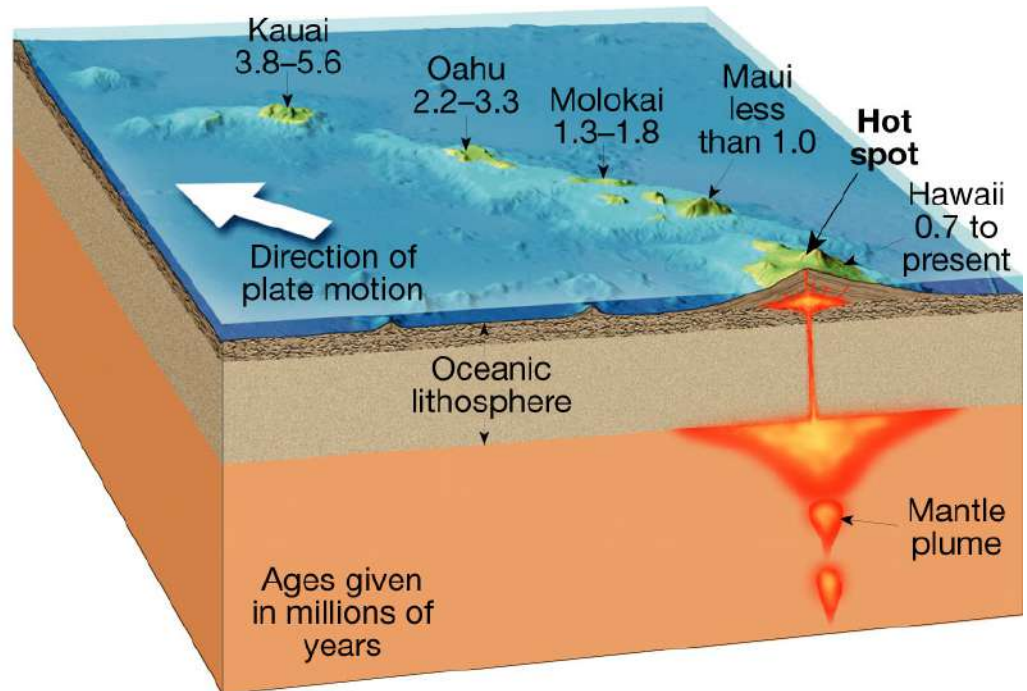
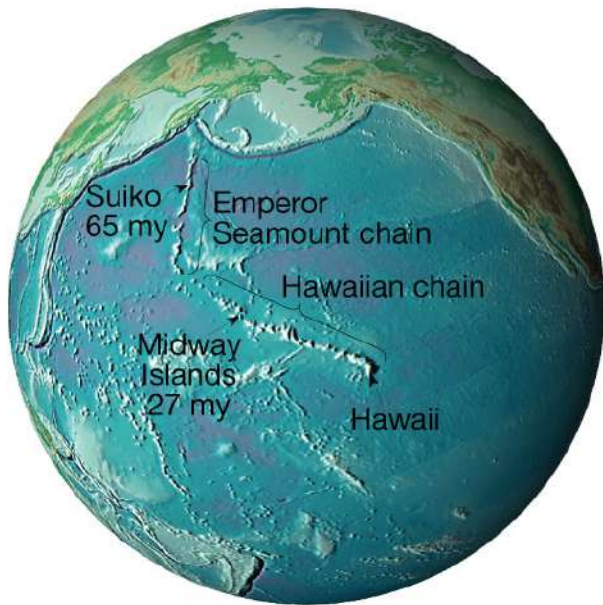
# 9.4 Testing Plate Tectonics

## Evidence for Plate Tectonics

### ◆ Hot Spots

- A **hot spot** is a concentration of heat in the mantle capable of producing magma, which rises to Earth's surface; The Pacific plate moves over a hot spot, producing the Hawaiian Islands.
- Hot spot evidence supports that the plates move over the Earth's surface.

# Hot Spot



# 9.5 Mechanisms of Plate Motion

## Causes of Plate Motion

- ◆ Scientists generally agree that convection occurring in the mantle is the basic driving force for plate movement.
- **Convective flow** is the motion of matter resulting from changes in temperature.

# 9.5 Mechanisms of Plate Motion

## Causes of Plate Motion

### ◆ Slab-Pull and Ridge-Push

- **Slab-pull** is a mechanism that contributes to plate motion in which cool, dense oceanic crust sinks into the mantle and “pulls” the trailing lithosphere along. It is thought to be the primary downward arm of convective flow in the mantle.
- **Ridge-push** causes oceanic lithosphere to slide down the sides of the oceanic ridge under the pull of gravity. It may contribute to plate motion.

# 9.5 Mechanisms of Plate Motion

## Causes of Plate Motion

### ◆ Mantle Convection

- **Mantle plumes** are masses of hotter-than-normal mantle material that ascend toward the surface, where they may lead to igneous activity.
- The unequal distribution of heat within Earth causes the thermal convection in the mantle that ultimately drives plate motion.



# Mantle Convection Models

