Introduction

• Earth's lithosphere is divided into mobile plates.
• Plate tectonics describes the distribution and motion of the plates.
• The theory of plate tectonics grew out of earlier hypotheses and observations collected during exploration of the rocks of the ocean floor.
You will recall from a previous chapter that there are three major layers (crust, mantle, and core) within the earth that are identified on the basis of their different compositions (Fig. 1).

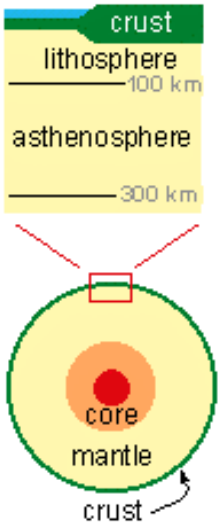


Figure 1. The outermost part of Earth is divided into two mechanical layers, the lithosphere and asthenosphere.

The uppermost mantle and crust can be subdivided vertically into two layers with contrasting mechanical (physical) properties. The outer layer, the **lithosphere**, is composed of the crust and uppermost mantle and forms a rigid outer shell down to a depth of approximately 100 km (63 miles). The underlying **asthenosphere** is composed of partially melted rocks in the upper mantle that acts in a plastic manner on long time scales. The asthenosphere extends from about 100 to 300 km (63-189 miles) depth. The theory of plate tectonics proposes that the lithosphere is divided into a series of plates that fit together like the pieces of a jigsaw puzzle.

Continental Drift

• **Alfred Wegener** First proposed continental drift hypothesis in 1915.
• He noted that opposing coastlines were similar on opposite sides of the Atlantic Ocean, mountains belts matched when continents were reassembled, fossils matched between different continents.
• Published the Origin of Continents and Oceans.

The concept of continental drift was proposed by Alfred Wegener. Wegener suggested that the earth's continents once formed a single super-continent landmass that he named Pangaea (Fig. 2). He suggested that Pangaea split apart into its constituent continents about 200 million years ago and the continents "drifted" to their current positions.

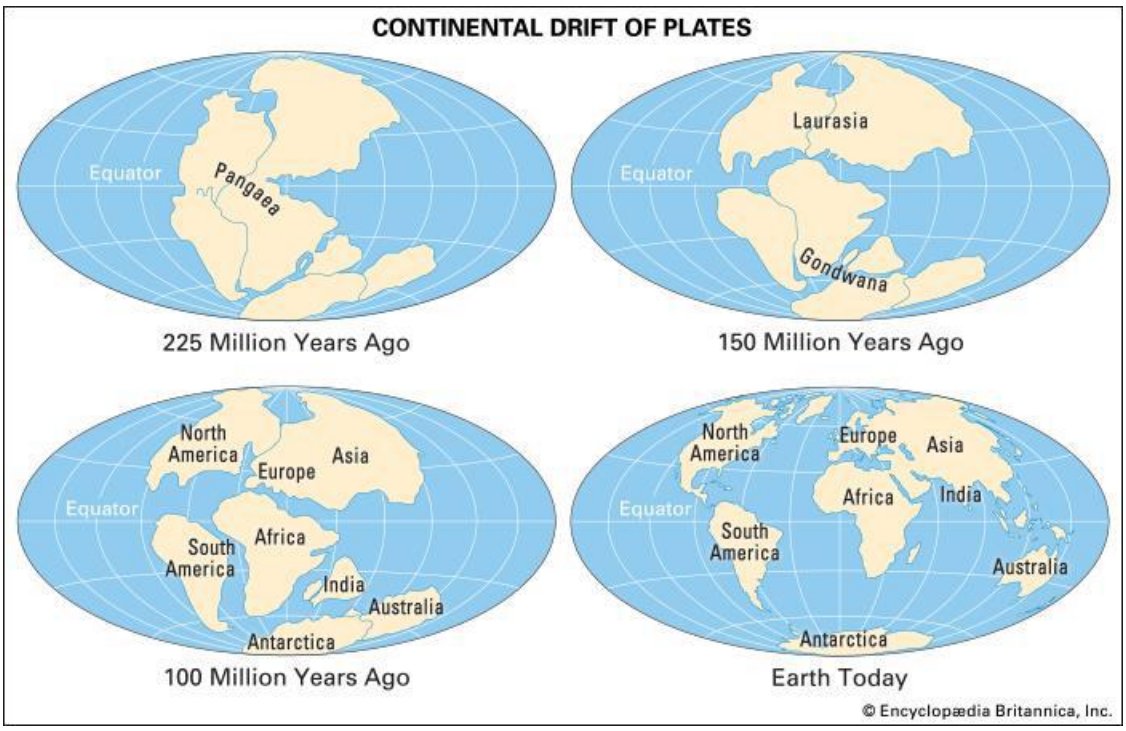


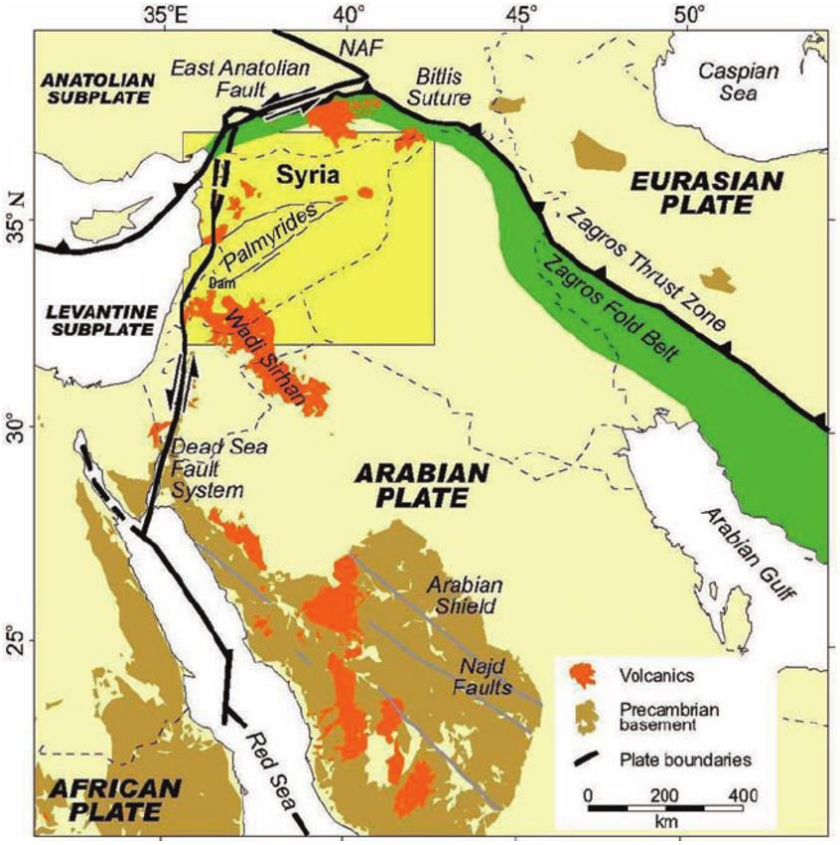
Figure 2. A reconstruction of the supercontinent Pangaea.

Plate Tectonics

• Earth's lithosphere is divided into a series of major and minor mobile plates.
• Plates move at rates of centimeters per year.
• Plates may be composed of continental and/or oceanic lithosphere.
• The destruction of oceanic lithosphere below oceanic trenches explains the occurrence of earthquakes and volcanoes adjacent to trenches.

The theory of plate tectonics proposes that the lithosphere is divided into eight major plates (North American, South American, Pacific, Nazca, Eurasian, African, Antarctic, and Indian-Australian) and several smaller plates (e.g., Arabian, Scotia, Juan de Fuca) that fit together like the pieces of a jigsaw puzzle (Fig. 3). The largest plate is the Pacific plate. These plates are mobile, moving in constant, slow motion measured in rates of centimeters per year. The movements of plates over millions of years resulted in the opening and closure of oceans and the formation and disassembly of continents. The theory links Earth's internal processes to the distribution of continents and oceans; it is the big picture view of how Earth works.

Figure 4. Distribution of tectonic plates with type of plate boundary.



The Arabian Plate

Earth's major plates

•Plates move relative to each other at a very slow but continuous rate.
-About 5 centimeters (2 inches) per year
-Cooler, denser slabs of oceanic lithosphere descend into the mantle.

Today satellite technology is used to determine the current rates of plate motion. Satellites anchored in space can record tiny movements of fixed sites on Earth, thus constraining the motions of plates (Fig. 5).

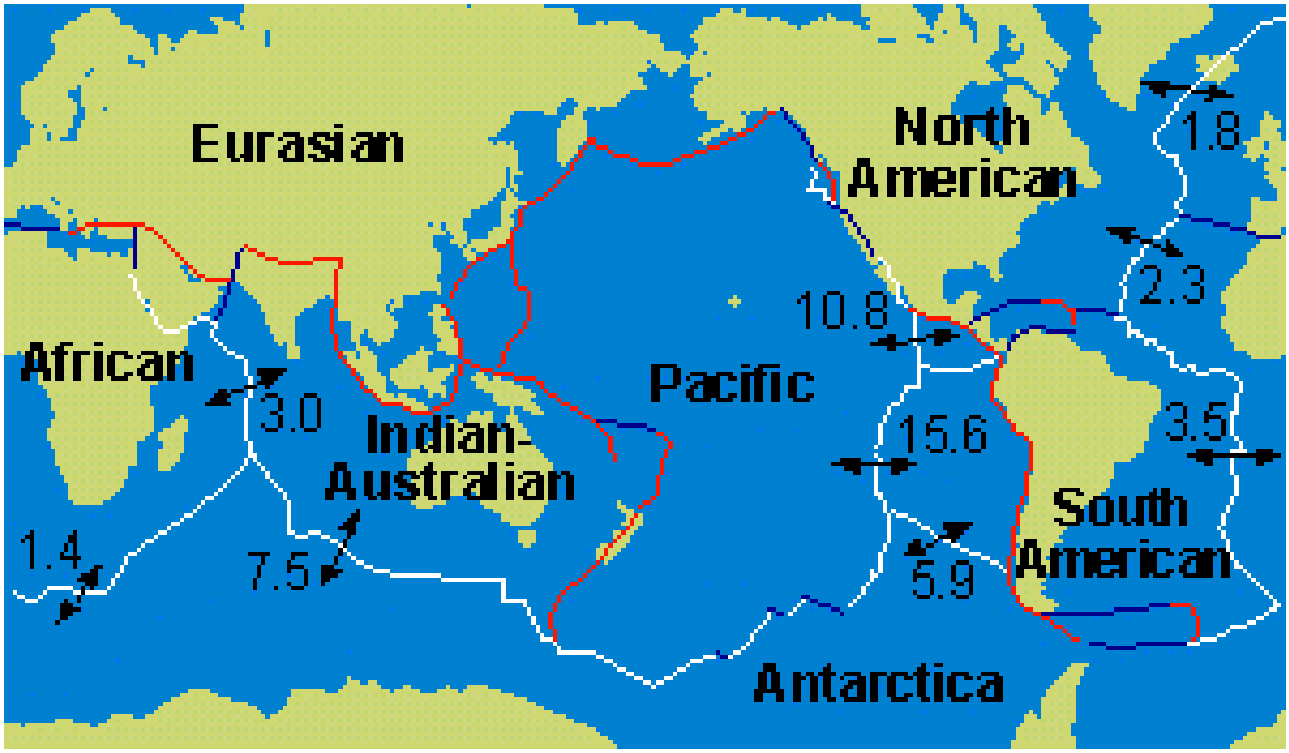


Figure 5. Directions and rates of plate motions (centimeters per year) along oceanic ridge systems. Spreading rates in the Pacific Ocean are nearly five times faster than in the Atlantic.

Types of plate boundaries:

1. Divergent plate boundaries.
2. Convergent plate boundaries.
3. Transform fault boundaries.

Divergent Plate Boundaries

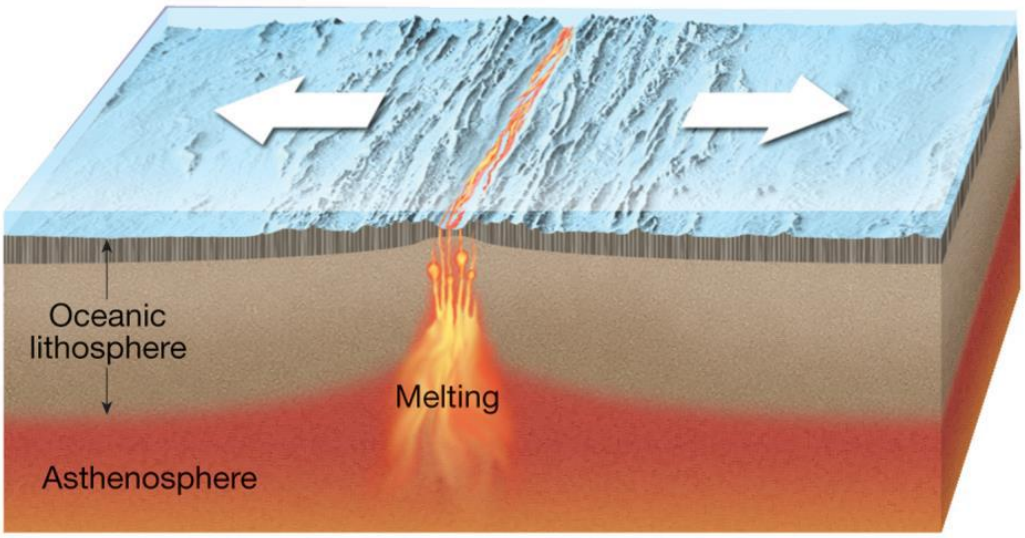
-Most are located along the crests of oceanic ridges.

-Divergent boundaries begin by splitting apart segments of continental crust along rift valleys.

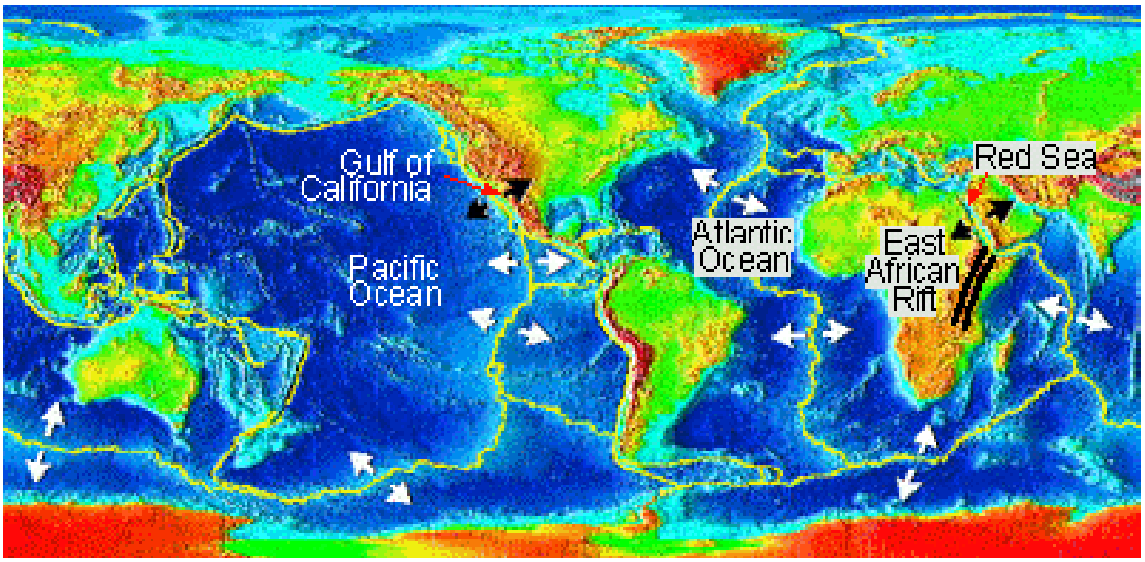
-Narrow oceans represent youthful divergent boundaries and wide oceans are indications of a long-lived ocean basin.

-Interactions along convergent boundaries involve the collision of pairs of plates where oceanic lithosphere is often destroyed at subduction zones.

Ocean ridges and subduction zones are boundaries between plates of lithosphere. A gap is created when oceanic lithosphere separates along the oceanic ridge. The gap is filled by magma that rises from the asthenosphere. The magma cools and solidifies to create new oceanic lithosphere.



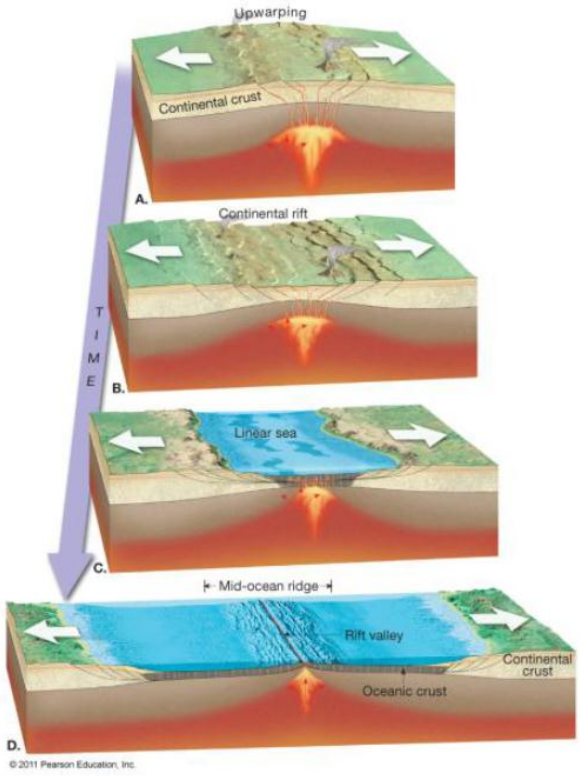
A. Divergent boundary

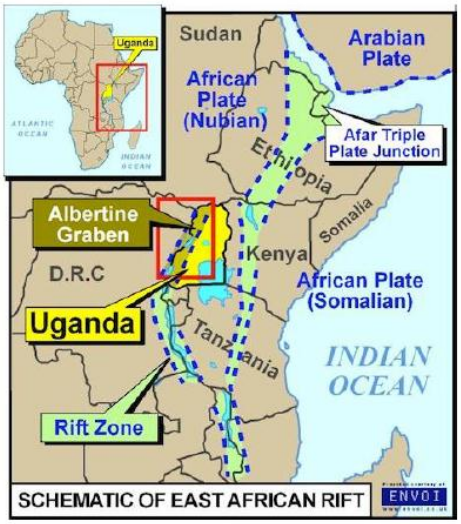


Locations of divergent plate boundaries and sense of plate motion indicated by arrows. Map courtesy of NOAA National Geophysical Data Center.

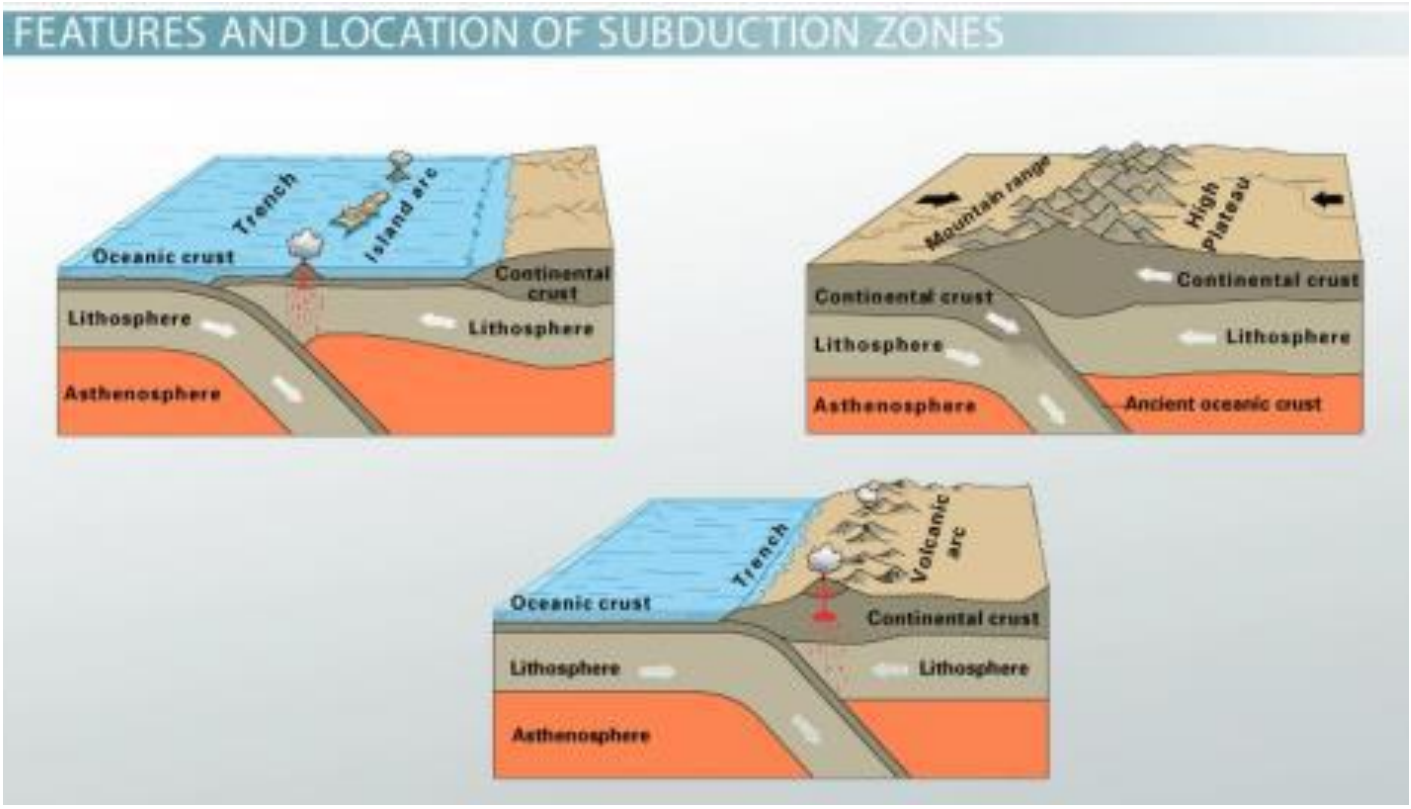
Continental rifting

•Splits landmasses into two or more smaller segments along a continental rift
•Examples include:
–East African Rift Valleys
–Rhine Valley in Northern Europe
•Produced by extensional forces





•Older portions of oceanic plates are returned to the mantle at these destructive plate margins.
•Surface expression of the descending plate is an ocean trench.
•Also called subduction zones
•Average angle of subduction = 45degrees.



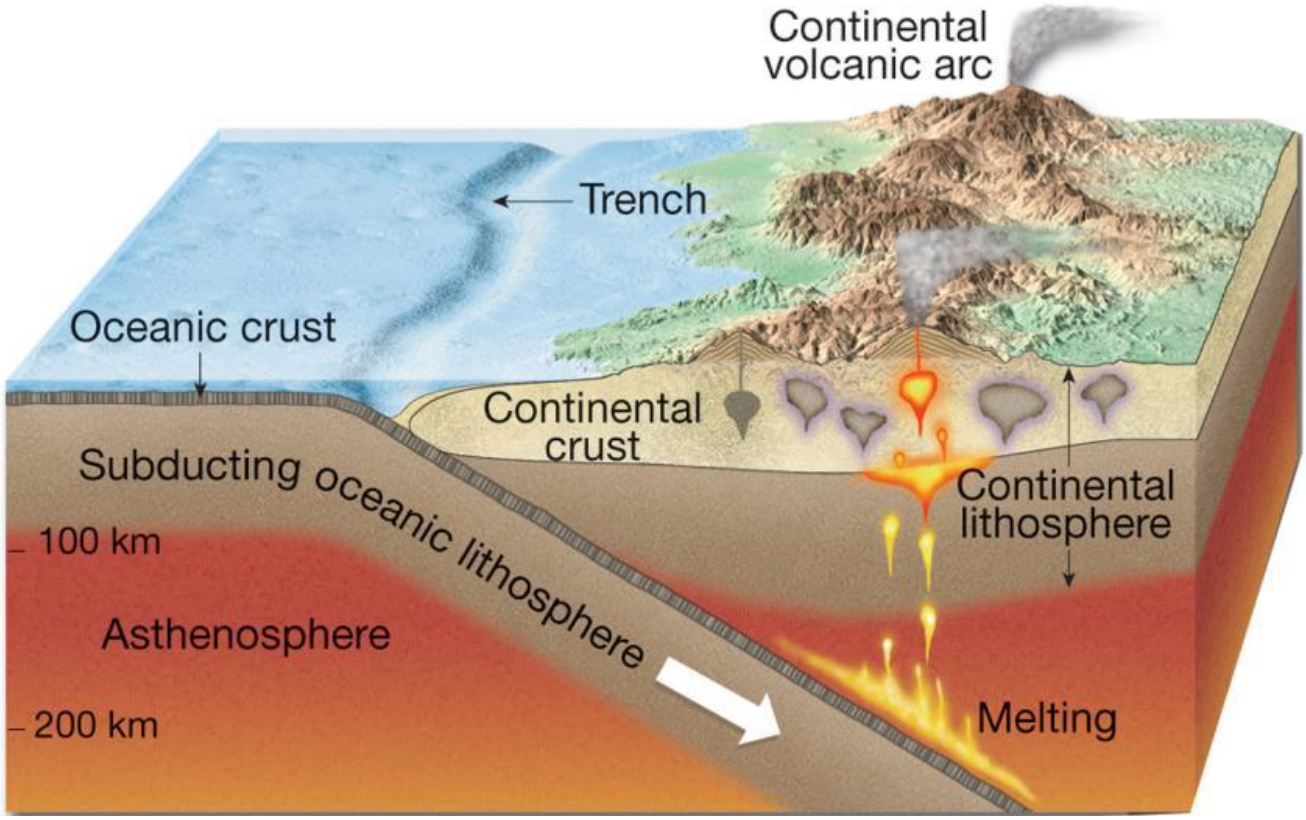
Types of convergent boundaries:

1. Oceanic–continental convergence

–The denser oceanic slab sinks into the asthenosphere.

–Along the descending plate, partial melting of mantle rock generates magma.

–The resulting volcanic mountain chain is called a continental volcanic arc. (The Andes and the Cascades are examples.)

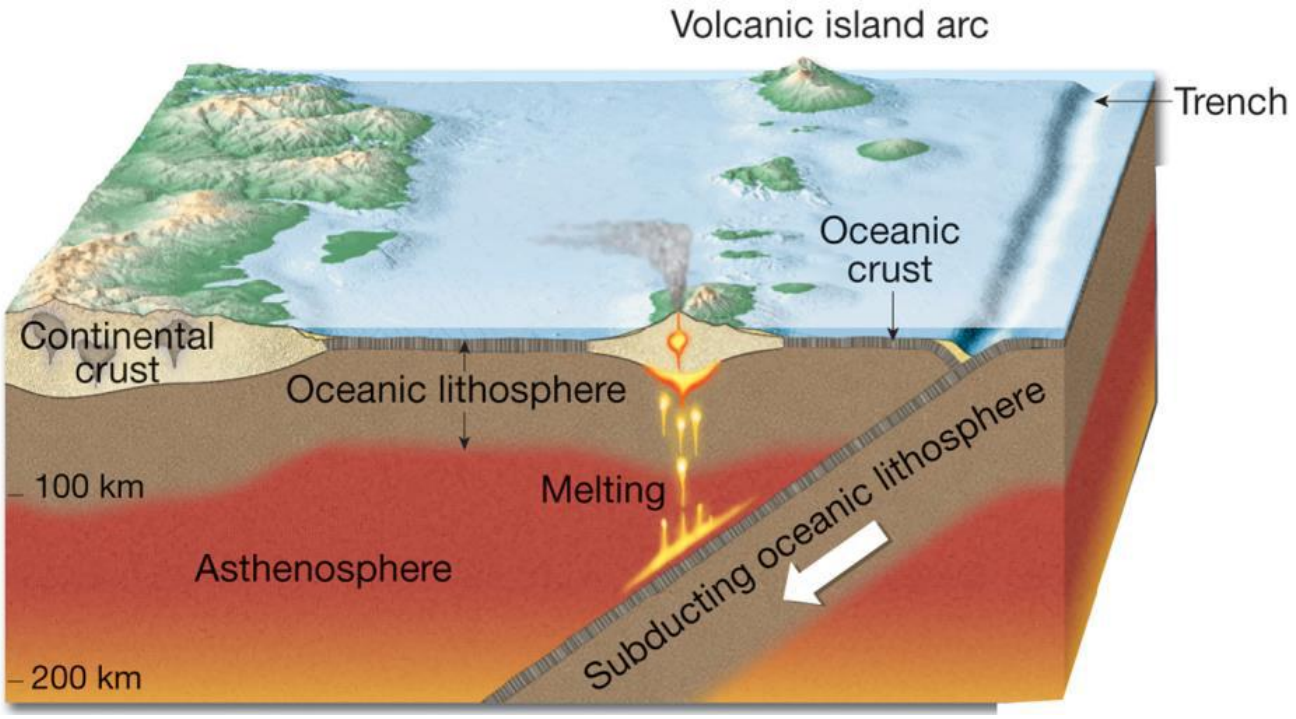


2. Oceanic–oceanic convergence

–When two oceanic slabs converge, one descends beneath the other.

–Often forms volcanoes on the ocean floor

–If the volcanoes emerge as islands, a volcanic island arcis formed. (Japan, the Aleutian islands, and the Tonga islands are examples.)

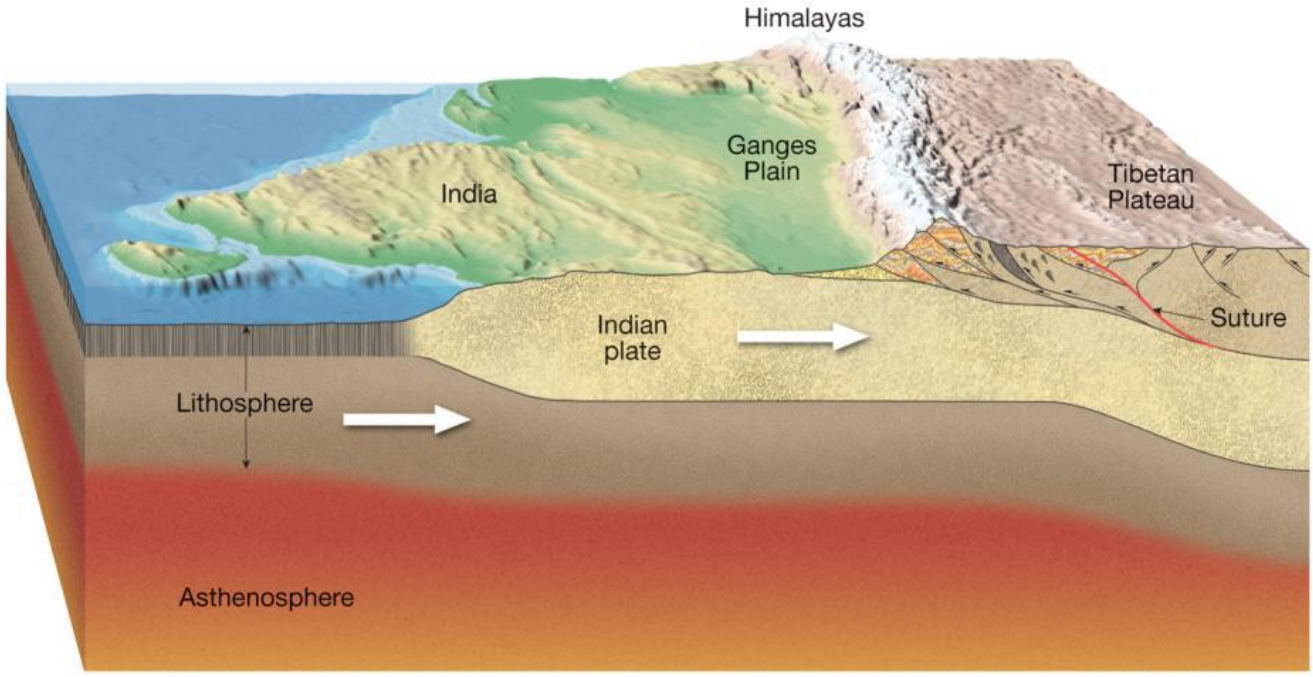


3. Continental–continental convergence

–Continued subduction can bring two continents together.

–Less dense, buoyant continental lithosphere does not subduct.

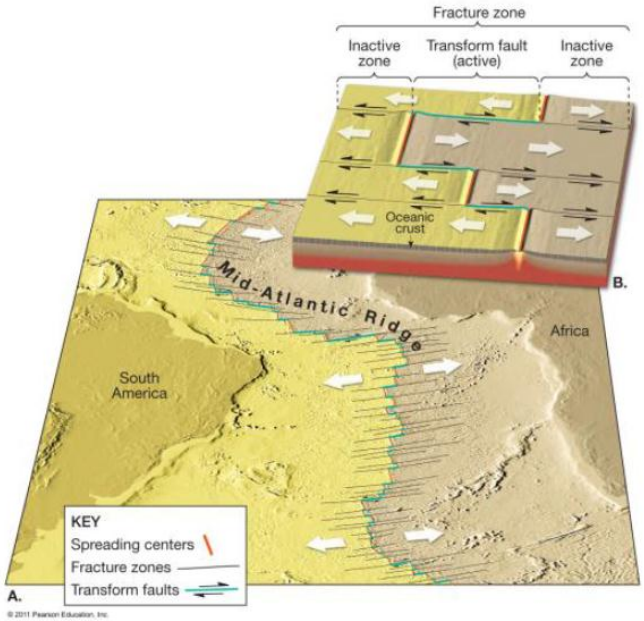
–The resulting collision produces mountains.(The Himalayas, the Alps, and the Appalachians are examples.)



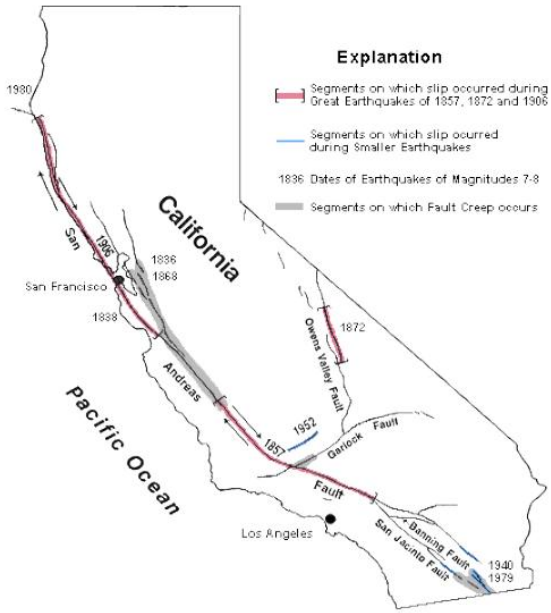
Transform Fault Boundaries

•Plates slide past one another and no new lithosphere is created or destroyed.
•Transform faults
•Most join two segments of a mid-ocean ridge along breaks in the oceanic crust known as fracture zones.
•A few (the San Andreas Fault and the Alpine Fault of New Zealand) cut through continental crust.

TRANSFORM FAULT BOUNDARIES



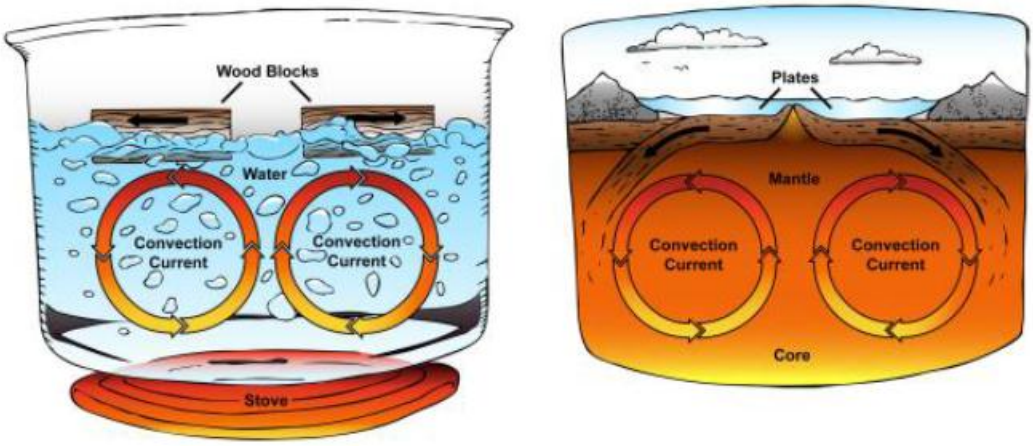
MID-OCEANIC RIDGE

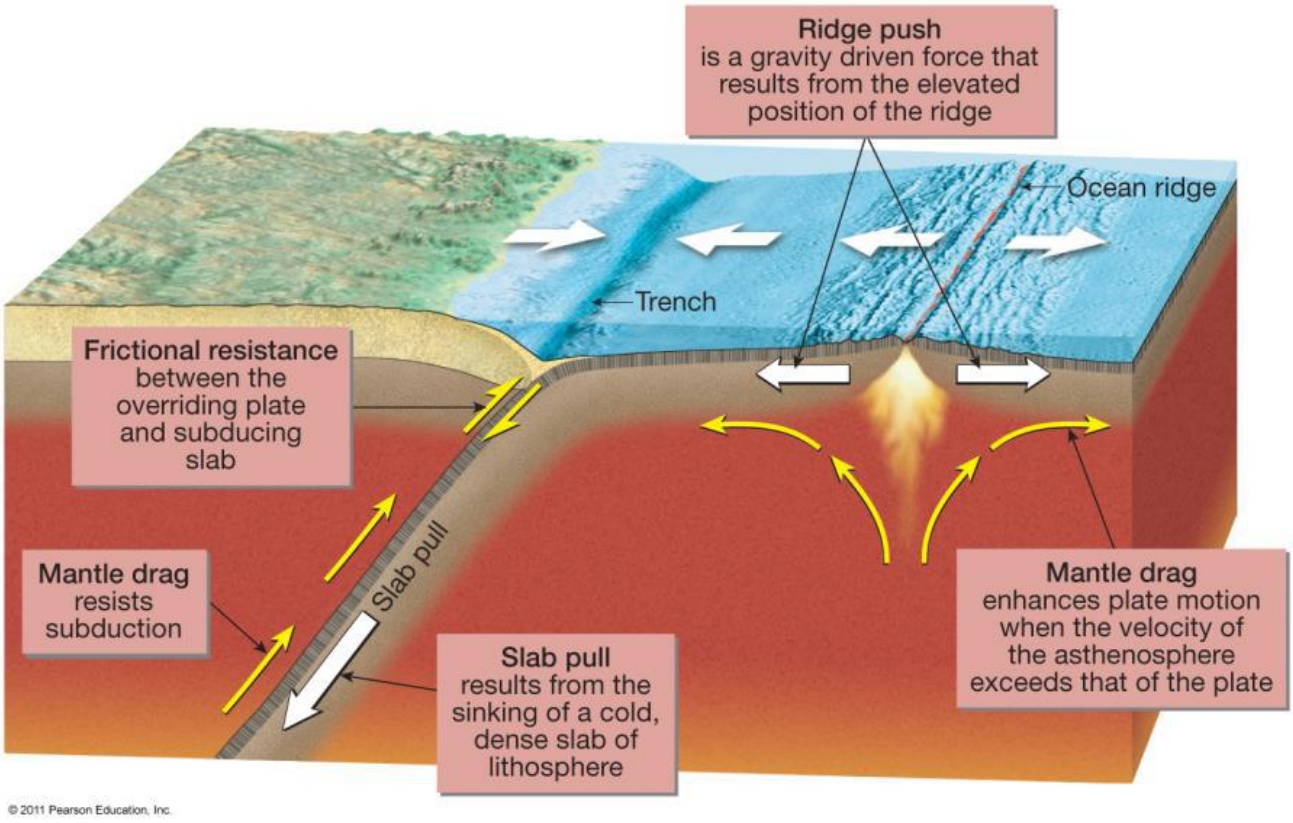


SAN ANDREAS FAULT

What drives plate motions?

•Researchers agree that convective flow in the mantle is the basic driving force of plate tectonics.
•Forces that drive plate motion:
•Slab-pull
•Ridge push





Importance of plate tectonics

The theory provides explanations for:

1. Earth's major surface processes
2. Distribution of earthquakes, volcanoes, and mountains
3. Distribution of ancient organisms and mineral deposits