Plate Tectonics and Boundaries

June 2nd, 2021

Global Topography

Topography: how the Earth's crust is distributed into its major surface features

Scientist map the Earth's topography through the use of remote sensing, geographic information systems and other cartographic tools onto topographic maps, digital elevation models and digital terrain models.

The most noticeable topographic patterns on the Earth's surface are **relief** features: both continents and ocean basins

- Mountain chains
- High plateaus
- Ocean trenches

land forms

Mountain Chains

Plateaus

Ocean Trenches

Relief Features of the Continents

The two basic subdivisions of continental masses are:

1. **Active belts of mountain making (alpine chains)**
   - Characterized by high, rugged mountains
   - Built through two very different geologic processes:
     - **Volcanism** – accumulation of volcanic rocks by magma extrusion
     - **Tectonic activity** – the bending (folding) and breaking (faulting) of Earth's crust under internal Earth forces
       - Lithospheric plates collide

Relief Features of the Continents

2. **Inactive Belts:**
   - **Continental shields**
     - **low-lying** areas of old, inactive stable rocks igneous and metamorphic rock- resistant to weathering.
   - **Mountain roots:** remains of older mountain belts.
     - sedimentary rocks are shown with a brown line. The areas of oldest rock are circled in red dashed lines.

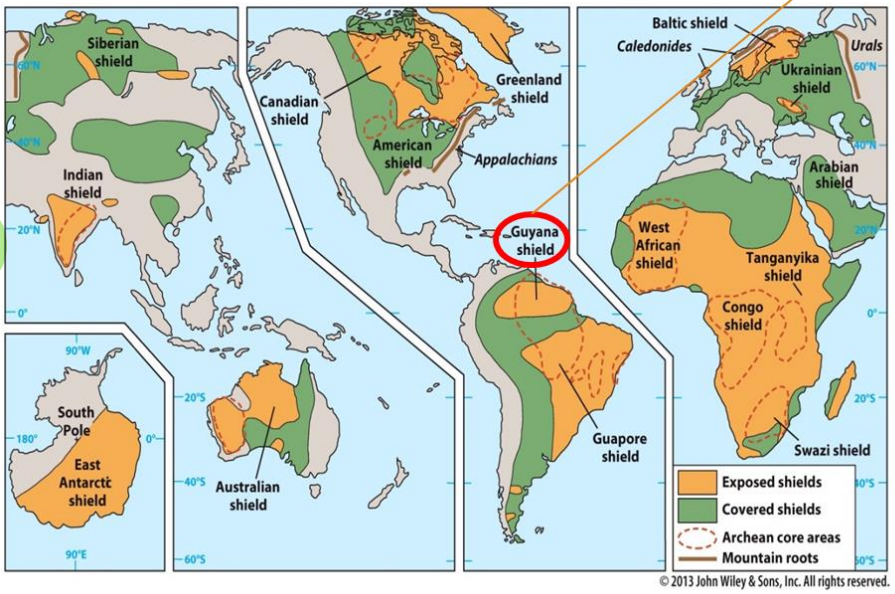


Figure 11.19 part 2

Configuration of the Continents

Alfred Wegener (1912) proposed that today's continents had broken apart from a single supercontinent named **Pangaea**.

The oceans he called: **Thalassa**

Although many doubted his ideas, a lot of evidence appeared in support of his observations and lead to the theory of ***continental drift*** in the geology community.

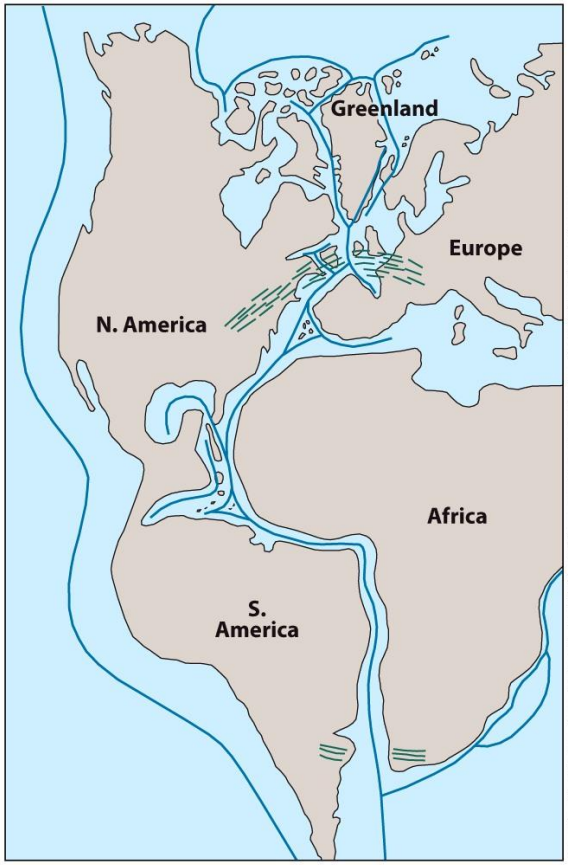


Figure 11.23

600 million years ago

500 million years ago

300 million years ago

200 million years ago

100 million years ago

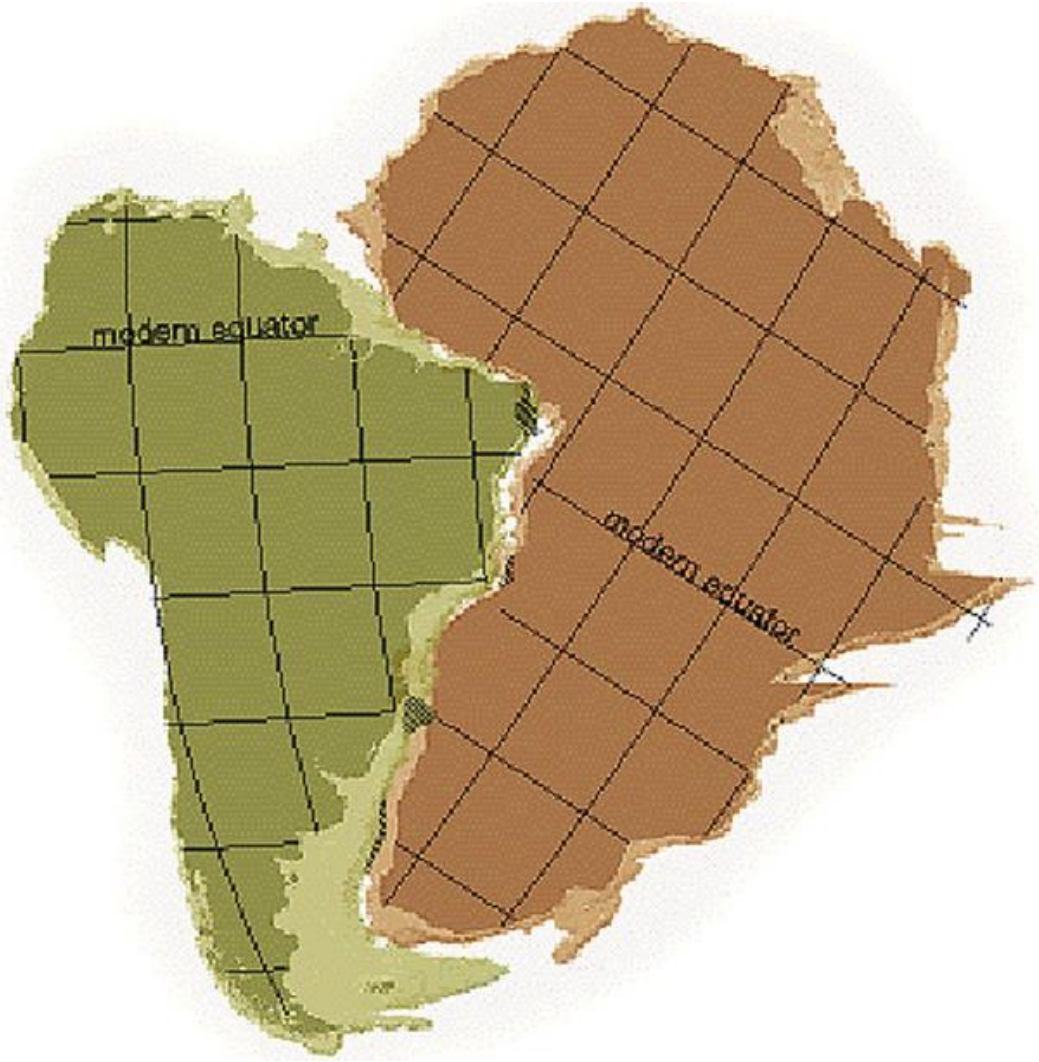
50 million years ago

Present

The Earth's lithospheric plates have twisted and turned, collided, and then broken apart to create the geography of the Earth as we know it today.

Evidence For Continental Drift

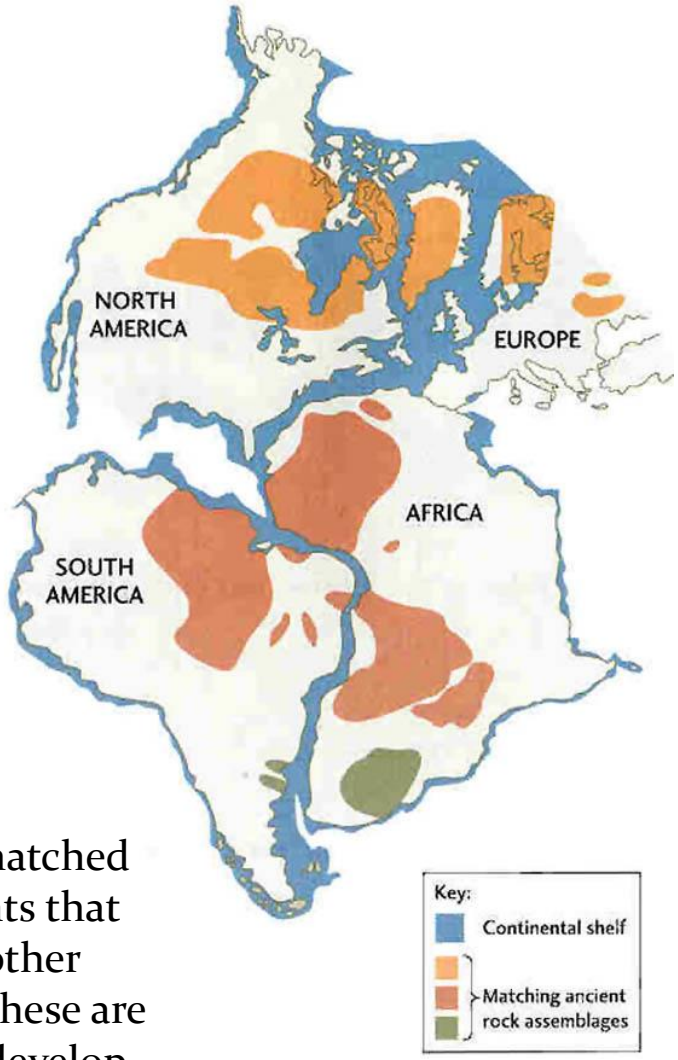
1. **The Jigsaw Fit Of The Continents:**
   - If the continents were brought back to together, they would fit back neatly.
   - There is a noticeable jigsaw fit between many of our continents - for example, between the East Coast of South America and the West Coast of Africa; suggesting continents were once assembled together.


modern equator
modern equator

Evidence for Continental Drift

2. **Geological Sequences:**

- Continents show evidence of matching geological sequences with **rocks of similar age, type, formation and structure occurring in different countries - e.g. the Appalachians (E USA) show a geological match with mountains in NW Europe** and if they were fitted together would form a single continuous mountain belt.
- There is evidence of glacial deposits in the Congo Basin, fossilized trees in Antarctica, and coral limestone in Greenland, all of which show that these climates (of these regions) were once quite different from what they are today.

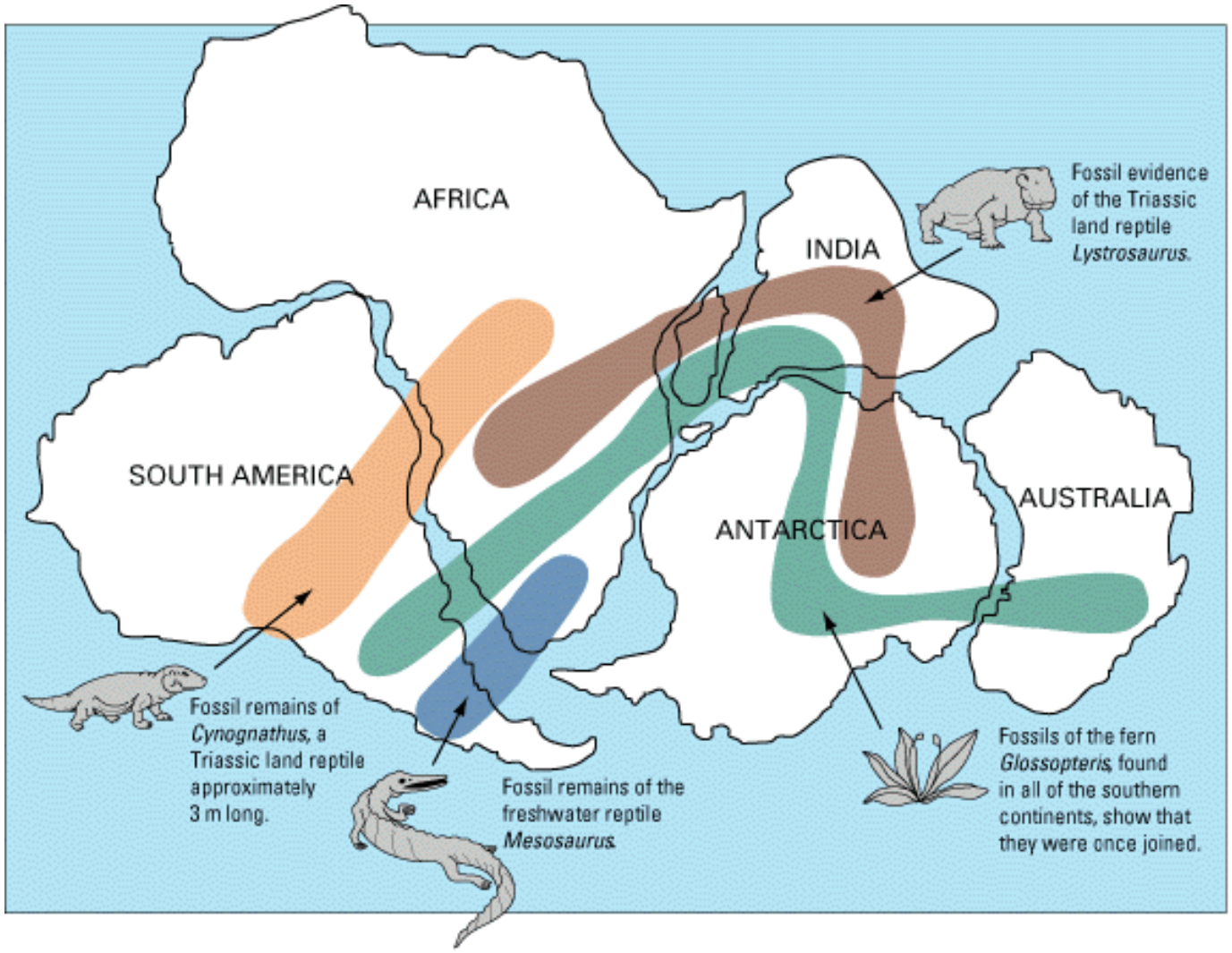


Rocks in West Africa can be matched with those in Brazil. Continents that drift from one ***latitude*** to another experience climate changes. These are reflected in the rocks, which develop under the different climates.

Evidence for Continental Drift

3. **Plant / Animal Fossils:**

- A number of identical fossils have been found distributed across the southern continents, again suggesting that they were once joined.
- Plant Fossils, such as **Glossopteris** (a tree) have been found in South America, Africa, India and Australia.
- **Coal bands** (for mature tropical hot weather and vegetation) areas of high altitude, there are deposits of coal remnants of tropical vegetation, areas where we find coal, tropical vegetation existed there.


AFRICA
INDIA
SOUTH AMERICA
AUSTRALIA
ANTARCTICA
Fossil evidence of the Triassic land reptile *Lystrosaurus*.
Fossil remains of *Cynognathus*, a Triassic land reptile approximately 3 m long.
Fossil remains of the freshwater reptile *Mesosaurus*.
Fossils of the fern *Glossopteris*, found in all of the southern continents, show that they were once joined.

So what's driving these movements…?

Plate Tectonics

Theory describing our current understanding of how lithospheric plates move

Tektonikos – **Greek** for building or construction

- Evidence suggests that the rates of separation between or convergence of plates are on the order of 1 to 2 (as much as 5 to 10 cm) per year.
- It is believed that over Earth's history the union of continents have occurred and then subsequent breakup; a repeating process.

Plate Tectonics

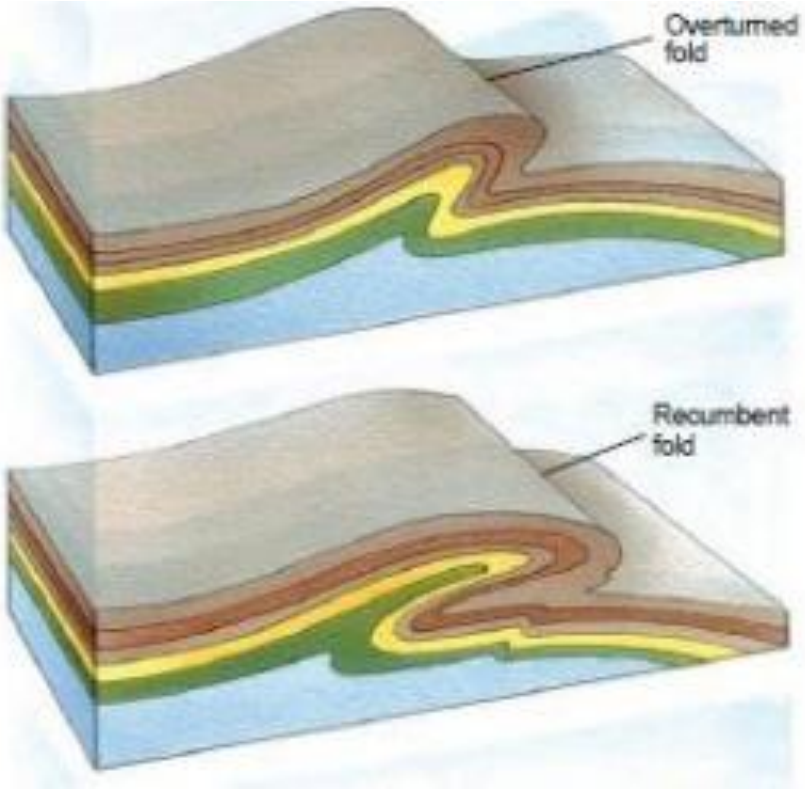
Tectonic processes – extension and compression**.**

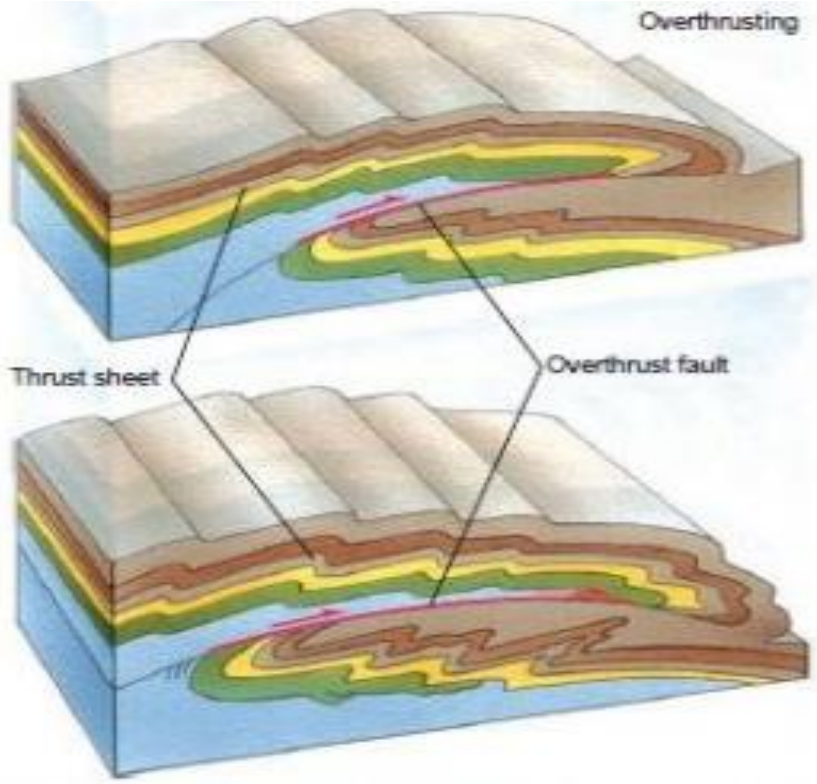
Extension

- Occurs when oceanic plates are pulled apart or when a continental plate breaks up into fragments.

Compression "squeezing together" or "crushing"

- At converging plate boundaries.
- Results in alpine mountain chain; Strata tightly compressed into wave-like *folds*.
- Overthrust faults: Faulted slices of rock move over the underlying rock on fault surfaces.


Overturned fold
Recumbent fold


Overthrusting
Thrust sheet
Overthrust fault

Basic Mechanisms Of Movement

Driving forces – the **Asthenosphere** is not rigid (***plastic – remember Jello?***), and its currents of molten rocks drag along the continents at the top.

Not only continents move, but the entire ***Lithosphere***.

The Lithosphere is broken up into ***Plates*** that are in motion.

Continents are parts of plates and move as a part of the overall movement of plates.

Lithospheric Plates

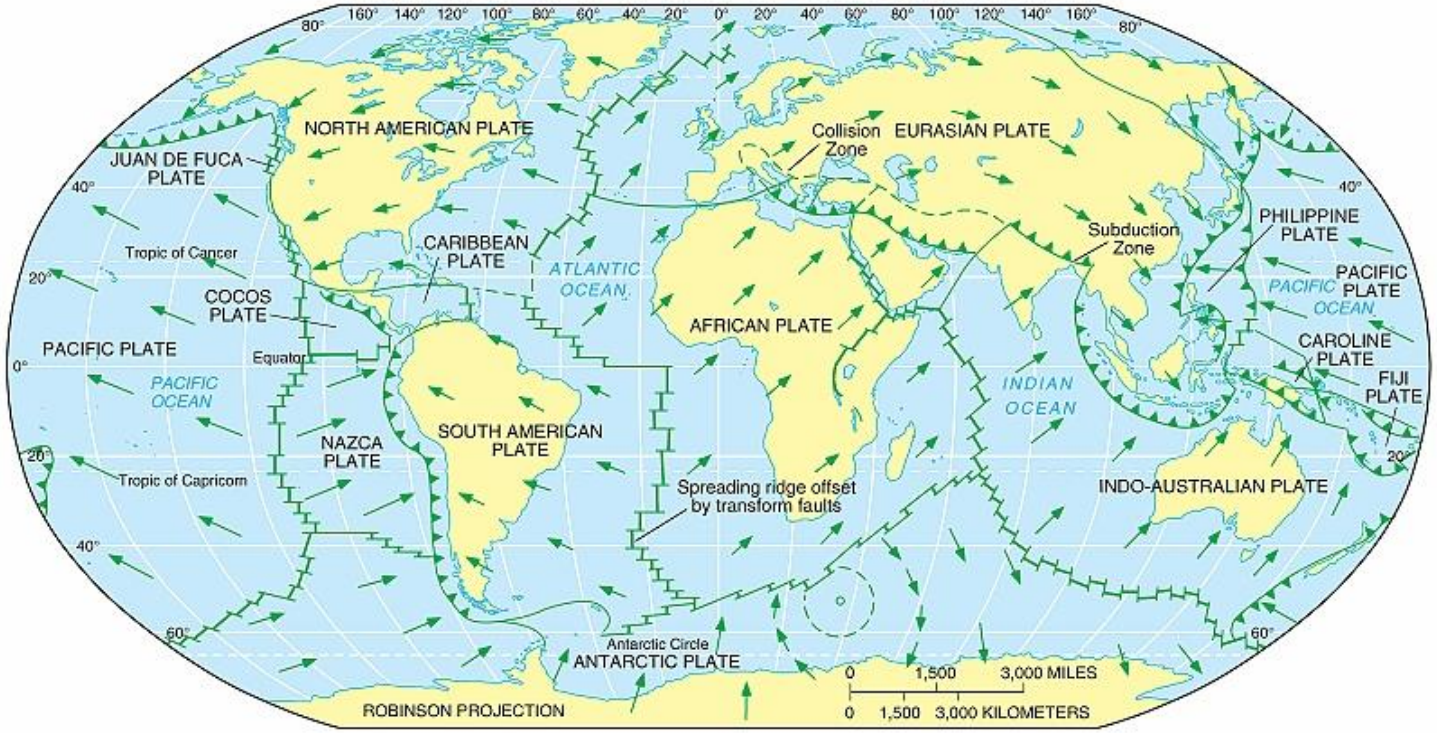


Plate Boundaries

- **Divergent Boundaries**: when two plates are moving apart from each other – these are called Divergent boundaries or ***Spreading.***

- **Convergent Boundaries**: this is where plates collide.

Transform boundaries

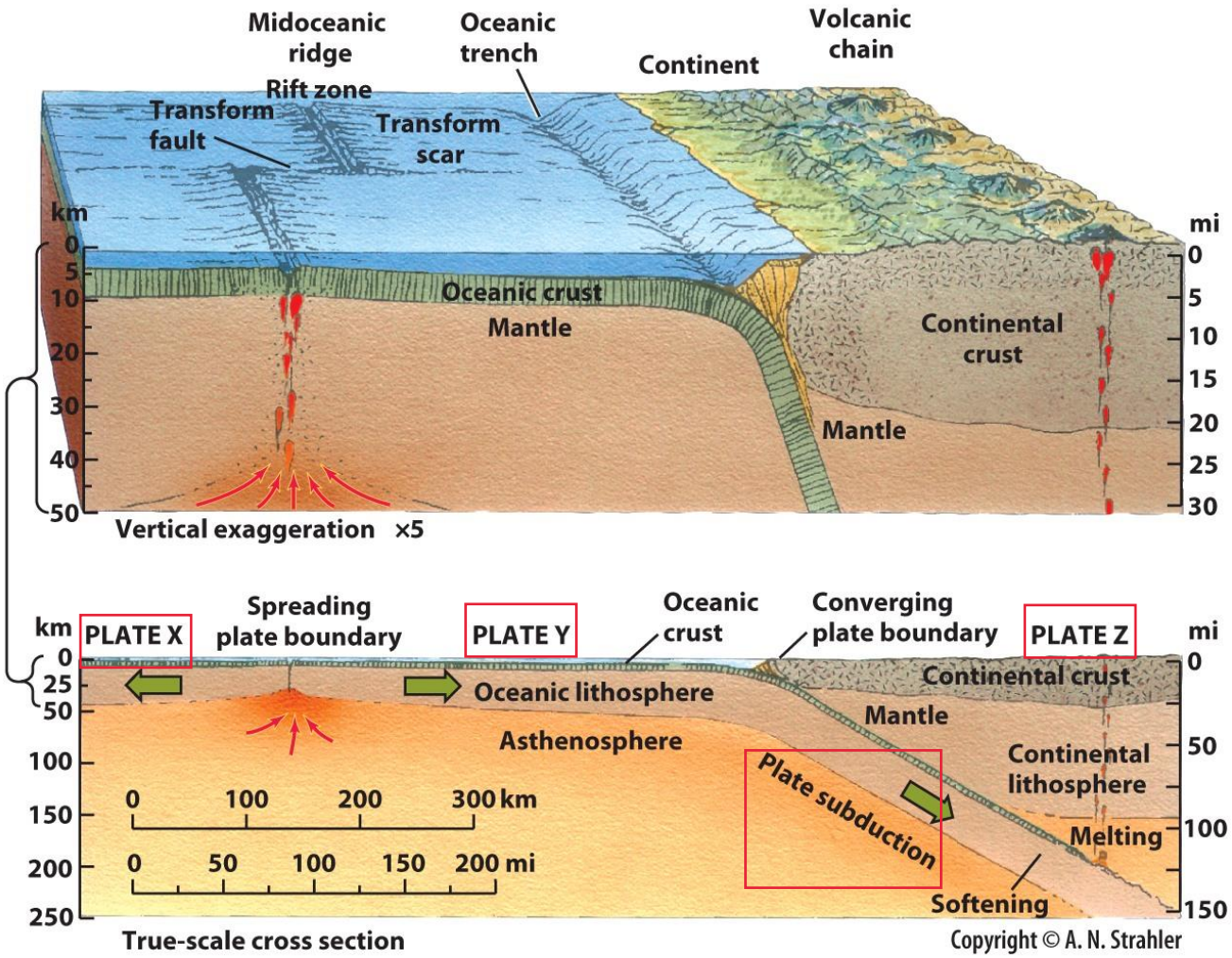


Figure 11.28 part 1

Plate Tectonics

Plate Boundaries

Oceanic plate moving to the right, away from a **spreading** boundary at an axial rift at the left.

Converging boundary: the plate is subducting under a continental plate.

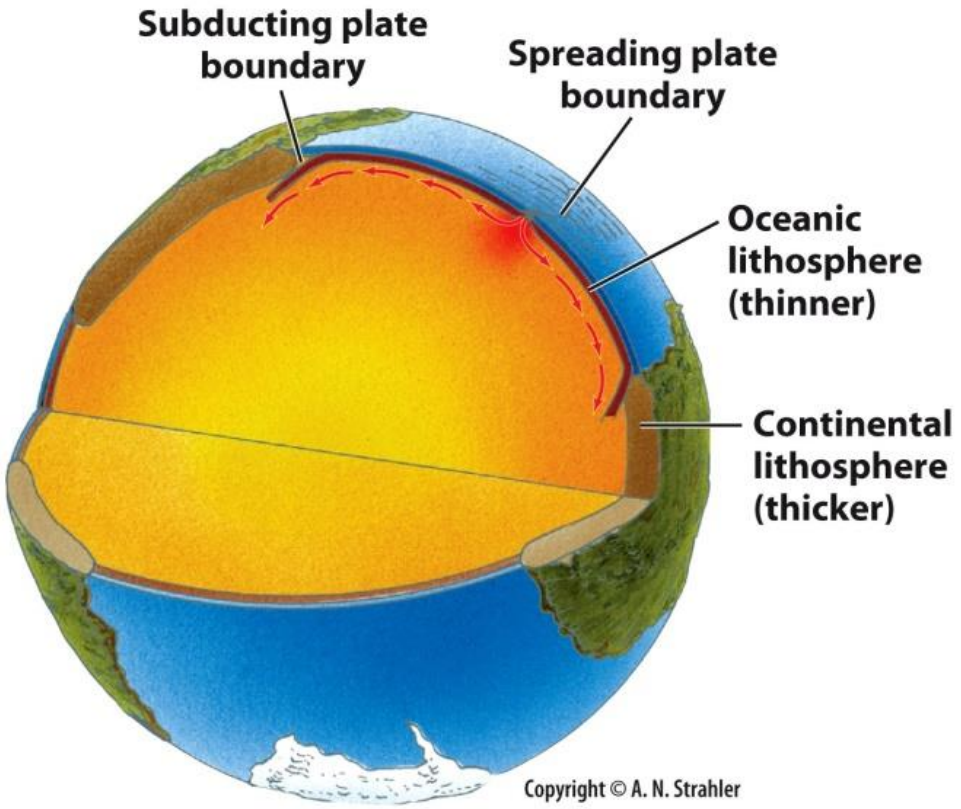
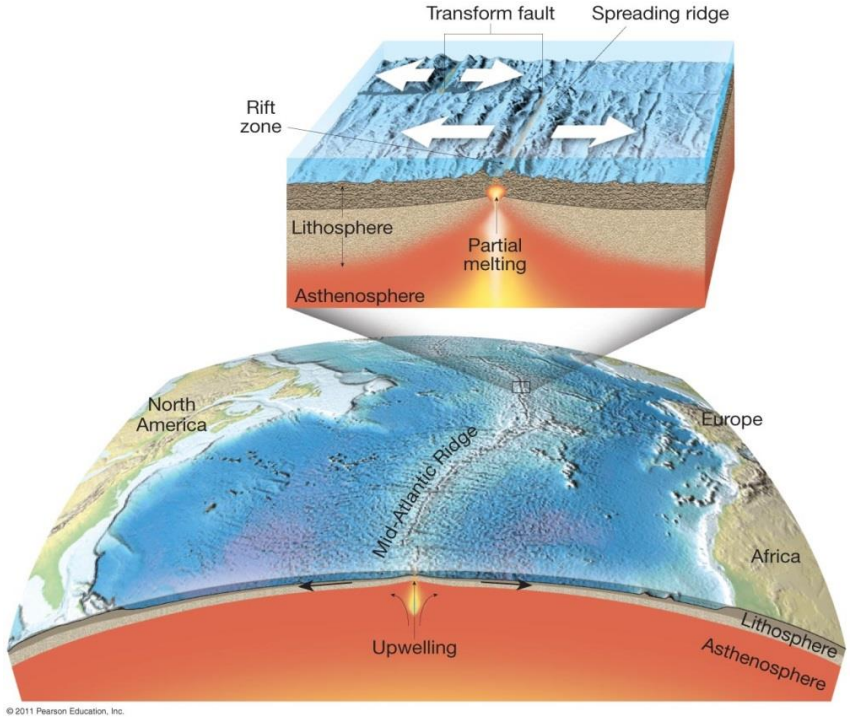


Figure 11.28 part 2

Plate Tectonics

- **Plate boundaries:** Divergent boundaries
  - Plates move away from each other
  - Asthenosphere wells up in the plate opening
  - Represented by a midocean ridge
  - Associated with shallow-focus earthquakes and volcanic activity
  - Constructive
  - Continental rift valley, proto-ocean



Divergence

1. **Continental**:
   - the moving apart of these plates cause the middle to fall in, creating a ***Rift Valley*** e.g. Great Rift Valley of Africa.

Divergence

2. **Oceanic**:
   - when plates move apart on the ocean floor, the upwelling magma spreads out forming mountain ranges - Volcanic Mountain Ranges which are called ***mid-Ocean ranges***.
   - As the magma erupts, there is violent volcanic activity and frequent earthquakes. The result is the formation of new "crust" or new Lithosphere as it gets into the ocean and cools.
     - E.g. Iceland and mid-Atlantic ridge.

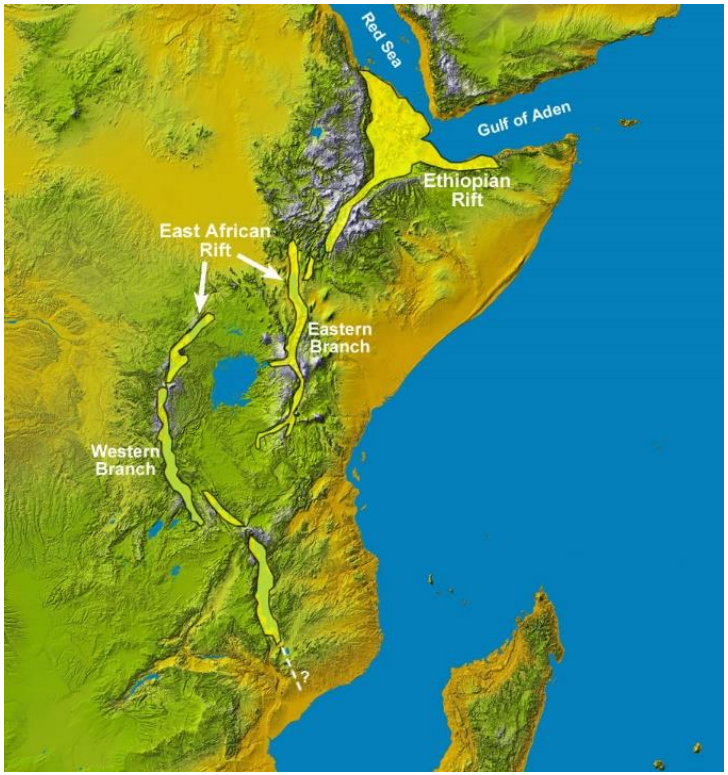


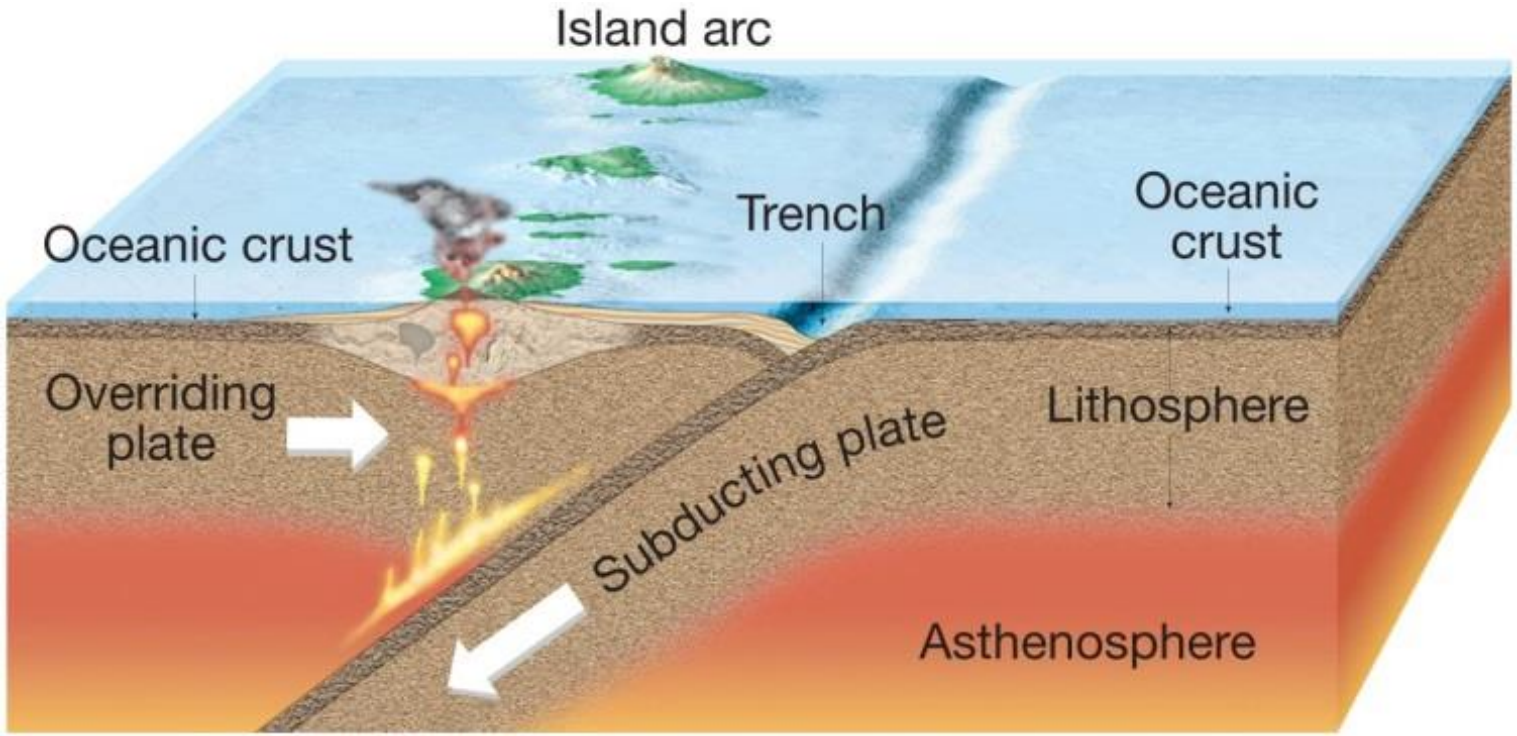
Plate Tectonics

- **Convergent boundaries**
  - Collisions between plates
  - Destructive
  - Three primary collisions:
    1. Oceanic-oceanic
    2. Oceanic-continental
    3. Continental-Continental

Convergence

1. **Oceanic –Oceanic**:
   - One plate will be pushed below the other into the Asthenosphere. This is called a ***subduction zone***. Subduction results in undersea trench formation.
     - Creating a deep **Oceanic Trench**, Deep and shallow earthquakes
   - Since the Asthenosphere is very hot, the plate that is pushed downwards will melt its way through the plate that is not submerged giving rise to a volcanic island.
   - E.g. the string of volcanic islands or island arcs seen in the West Indies (Caribbean sea).

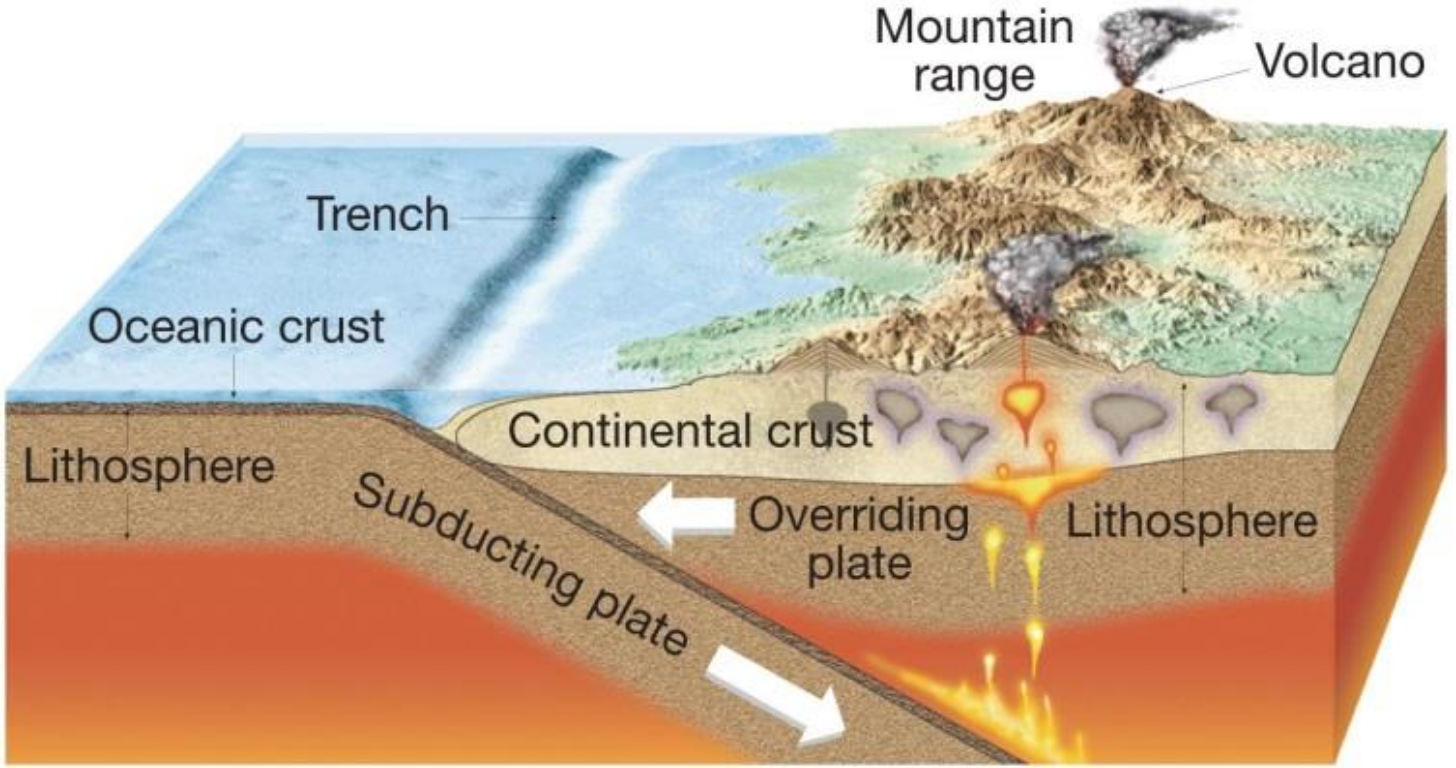
Oceanic-Oceanic



Convergence

2. **Oceanic – Continental**:
   - When an **Oceanic plate and a Continental plate collide**, the Continental plate rides up over the edge of the heavier (denser) oceanic plate, and the rocks along the edge of the Oceanic plate are absorbed into the mantle.
   - In these zones of subduction, the Oceanic plate is bent down into the mantle as the continental plate 'rides' up over it.
   - Trenches are formed
     - e.g., the Java Trench, which in time fill up with sediments derived through erosion of the continent.
   - Volcanic activity, often of great intensity, is a characteristic feature of these regions.
     - e.g., West Side of South America, very deep oceans and Mountains - Andes, Cascade ranges.

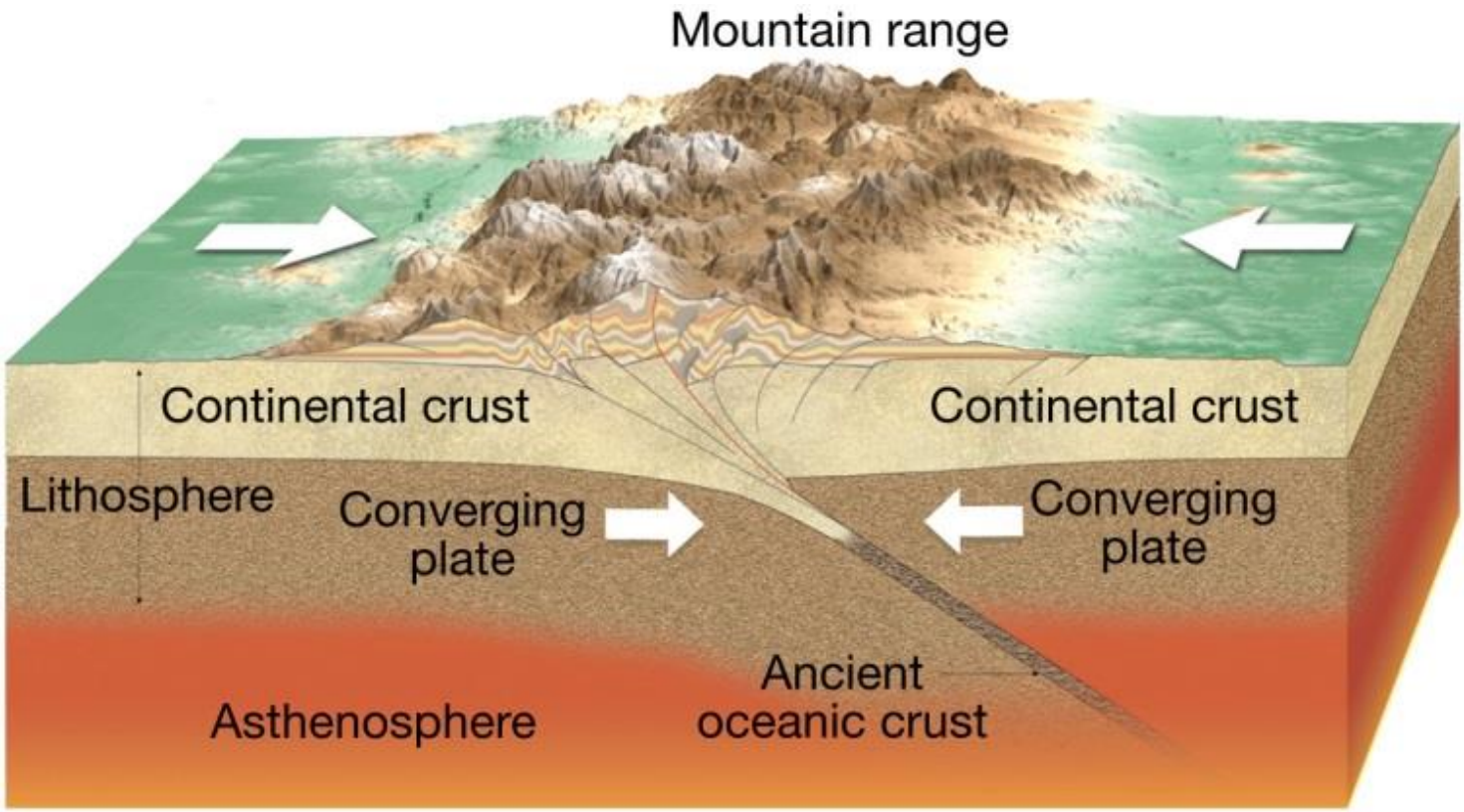
Oceanic-Continental



Convergence

3. **Continental – Continental**: when two continental plates approach each other, **neither sink** because they are of the same density.
   - Instead, **they collide**, their edges are fractured, and the sediment of their continental margins is folded to produce vast Mountain ranges.
     - e.g., the Himalayas, Alpes, Tibetan Plateau.

Continental-Continental



Earth's Topographic Regions

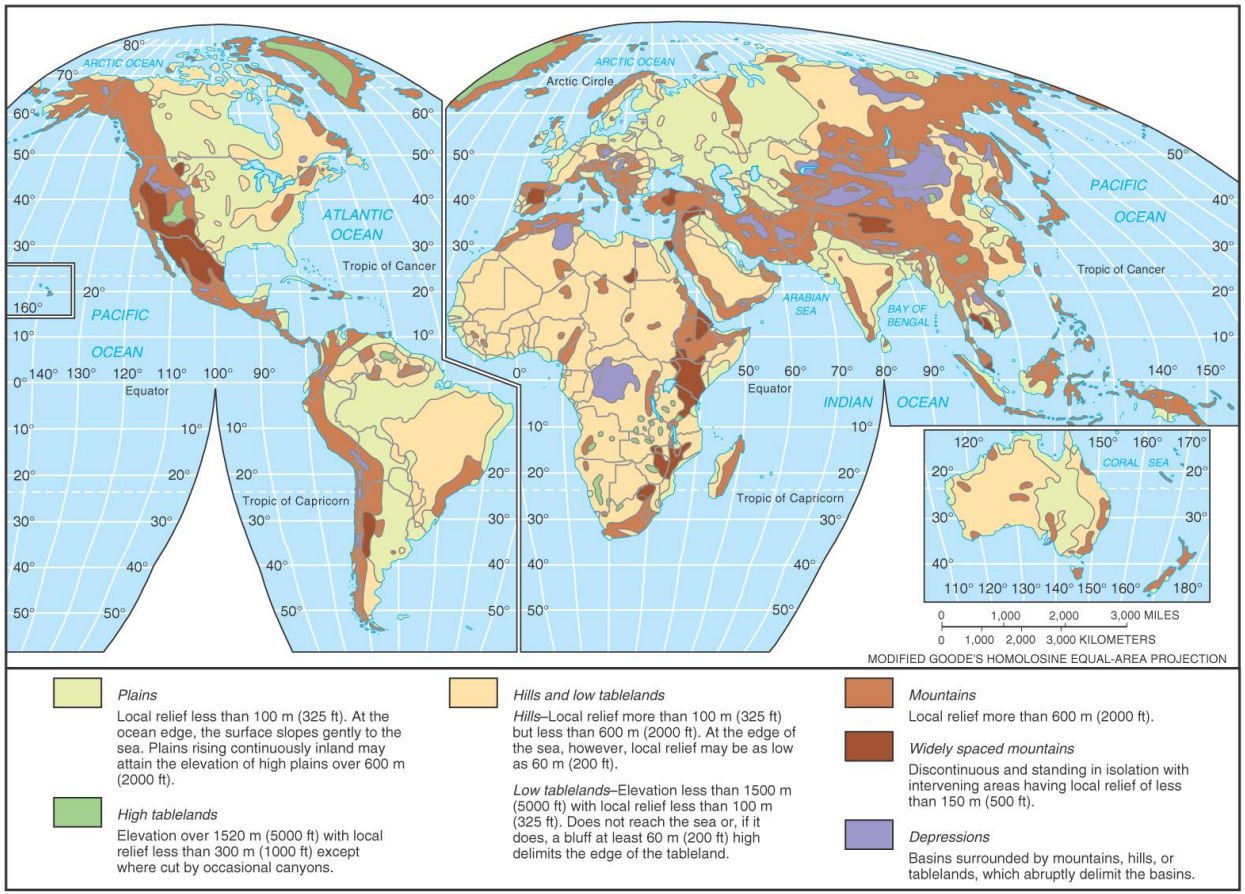


Plate Tectonics

- **Transform boundaries**
  - Two boundaries slip past each other laterally
  - Transform faults
  - Neither creates nor destroys crust
  - **Commonly produce shallow focus earthquakes**
  - San Andreas fault

Summary:

- Active and inactive belts; **active driven by volcanism and Tectonism**
- Plate tectonics attempts to explain the movement of lithospheric plates
- The movement of plates *determines the type of topographic features* we see on the continents and in the oceans.