

Natural Disasters

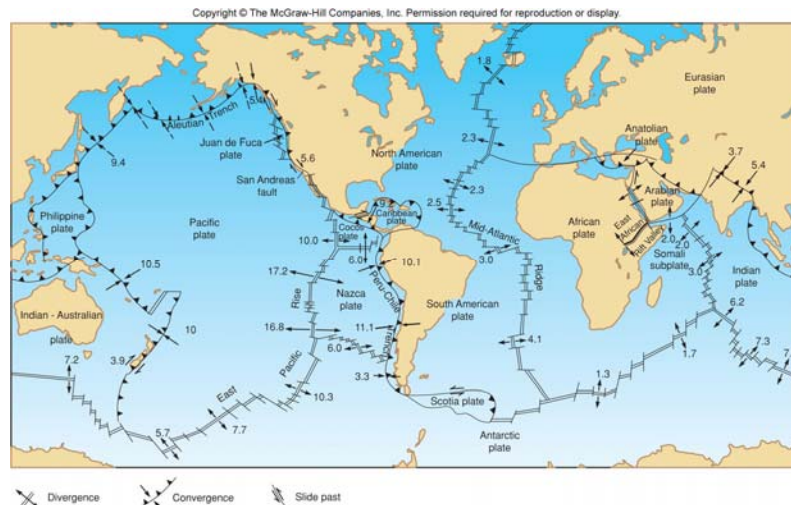
Lecture 11

Ch 2 – Internal Energy and Plate Tectonics

Text Source Today:
Chapter 2 (p. 36-48)

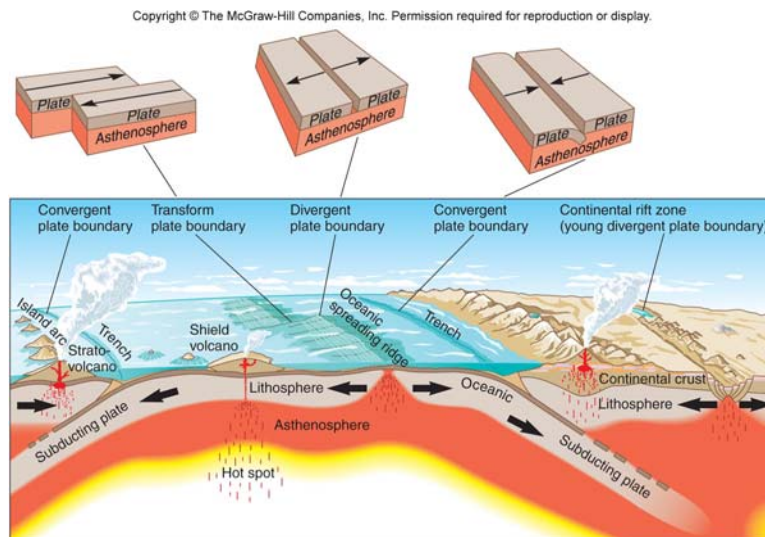
2.1: Ch. 2 – Internal Energy and Plate Tectonics

- **Francis Bacon, 1620:** noted the **“fit”** of South America and Africa and suggested that, at one time, **they were joined**.
- **Eduard Suess, late 1800s:** presented evidence of an ancient southern supercontinent, **“Gondwanaland”**, comprised of South America, Africa, Antarctica, Australia, India and New Zealand, which later **split apart**.
- ◆ **Alfred Wegener, 1915:** published his book, *“The Origin of Continents and Oceans”*, on **continental drift**, presenting evidence of **similar rocks, fossils and geologic structures** on opposite sides of the Atlantic Ocean. He proposed that all the continents were once joined into one supercontinent: **Pangaea**.
- However, **Wegener** could not explain **how** the continents **split apart and moved in continental drift**. He was mocked!
- ◆ **In the mid-1960s:** evidence abounded on **sea-floor spreading** and that the **lithosphere** was broken into **plates** that decoupled from the **asthenosphere** and moved laterally; the relatively **small, low-density continents**, set within the oceanic crust, were seen to be carried along as “incidental passengers.” (Fig. 2.14)



- ♦ The “indisputable” evidence of **sea-floor spreading**:
 - map of **earthquake epicenters** (deep EQs at subduction zones) and **volcanic activity outline tectonic plates**
 - **ages of ocean floor**; young at ridges/old at trenches
 - **depth of sediment** increases away from ridges/rises toward the trenches
 - **ocean floor depths** increase away from ridges toward trenches, due to cooling and contraction (inc. age), and isostatic downwarping due to increased sediment weight
 - **magnetization (reversal) patterns** on the seafloors

- ♦ Plate Tectonics: a **unified theory of continental drift and sea-floor spreading**. (**Wegener** was posthumously proclaimed the “*Plate Tectonic King*” amongst geologists!) (Fig. 2.27)



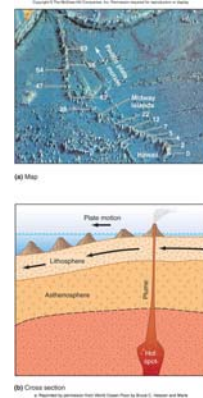
- **Lithosphere** is made up of **oceanic crust or continental crust** which is **fused to the rigid upper mantle** at the MOHO. Earth's surface is broken up into many **lithospheric plates**.

- **Asthenosphere** is the **upper mantle** that is partially melted due to high heat and pressure; it is **ductile and “plastic-like”**.

- **Convection cells** in the mantle force molten pure basalt magma up through the oceanic lithospheric plates at the **spreading ridges and rises** (a divergent plate boundary).

- ◆ The oceanic crust is forced laterally away from the **spreading centers toward the subduction zones (i.e., trenches)**, where the **denser (older, colder)** oceanic crust goes beneath the **less-dense (younger, warmer)** plate into the mantle and is melted and “re-cycled” (eventually returned to the convection cell). An entire ocean floor is replaced about every **200 million years**.

- **Hot spots** are places where a buoyant plume of **pure basalt magma** moves upward through a crack in a lithospheric plate (oceanic or continental), creating **shield volcanoes**. If in the ocean, the “on-off” nature of hot spots can create a **linear series of volcanic islands/seamounts** (e.g., the Hawaii-Midway-Emperor Seamount Chain). (Fig. 2.23)



- ◆ **Divergent (pulling apart) plate boundaries:**

- **oceanic spreading ridges/rises** (e.g., mid-Atlantic ridge)
- **continental rift valley** (e.g., East African Rift Valley)

- ◆ **Convergent (colliding) plate boundaries:**

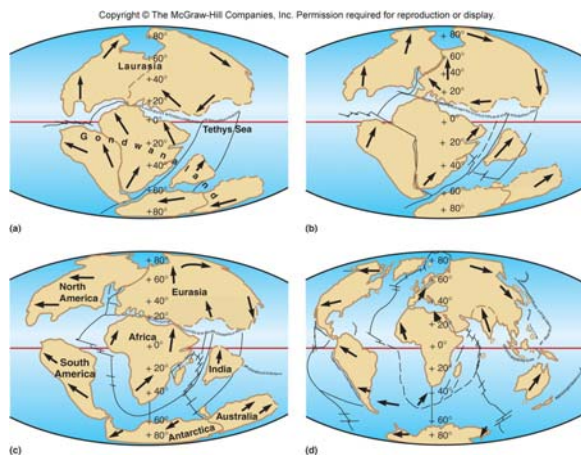
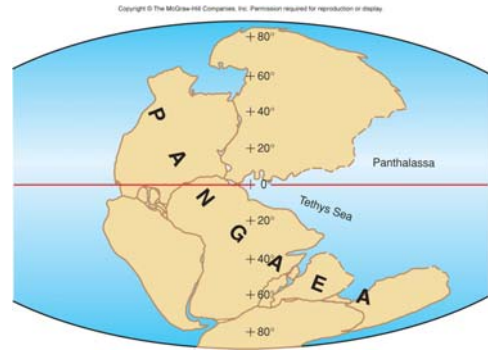
- **ocean-ocean** (e.g., island arc system; Mariana Trench)
- **ocean-continent** (e.g., volcanic arc system; Cascadia)
- **continent-continent** (e.g., mountains; Himalayas)

- ◆ **Transform (slide-past) plate boundaries:**

- **transform fault** (e.g., San Andreas Fault)

♦ Continental Drift:

About **220 million years ago**, all the continents were joined into one supercontinent named **Pangaea**. The northern land was named **Laurasia** and a southern land, **Gondwanaland**. There was one massive ocean named **Panthalassa** and one sea, **Tethys Sea**.



- (a) **at 180 million years ago, Pangaea began breaking up**, as Laurasia separated from Gondwanaland, and South America-Africa and India broke away from Antarctica-Australia.

- (b) **at 135 million years ago, sea floor spreading** had begun

opening up the Atlantic Ocean, **India began its journey** northward toward Asia, and the South Atlantic was a narrow sea, similar to the Red Sea of today.

- (c) **at 65 million years ago, sea floor spreading had opened** the South Atlantic Ocean and connected it to the North Atlantic, Africa came into contact with Europe (cutting off the west end of Tethys to form the **Mediterranean Sea** and creating the **Alps**). North America and Eurasia were still connected, as were Antarctica and Australia. **India** was just crossing the equator.

- (d) **present day; during** the past 65 million years, nearly **half** the present ocean floor was created; **India collided into Asia creating the Himalayas**. Much of the sediment of Tethys Sea was **uplifted** from the Himalayas to the Alps! North America broke away from Europe. Australia moved far from Antarctica.