

## Ocean 201 week 4 Lecture 2: Plate Tectonics II (M.J. Mottl)

Text from slides

### Theory of Plate Tectonics: II

- Entire surface of Earth consists of a small number of thin (70-120 km thick) rigid plates that correspond to the *lithosphere*.
- Driven by convection in the mantle, *lithospheric plates* move continuously over the Earth's surface, riding on the *asthenosphere*.
- Plates interact with one another along three types of boundaries.
- Interactions of plates produce most of the tectonic activity of the Earth.

### Earth's Lithosphere = Plates

Crust is only the outer part of the lithosphere; most of the lithosphere is upper mantle.

Oceanic crust ~ 6 km thick

Continental crust ~ 35 km

Lithosphere ~100 km

### Structure of Continents

- Continental crust has formed throughout Earth's history by chemical differentiation at subduction zones.
  - **Oceanic crust:** *dry melting* of mantle at MOR → *basalt*
  - **Continental crust:** *wet melting* in subduction zones  
→ *andesite* of volcanic arcs

Subducted H<sub>2</sub>O is from the oceans, in seafloor sediment and weathered oceanic crust.

H<sub>2</sub>O comes off subducted plate as it heats, rises into mantle of plate above, and lowers its melting temperature.

### Structure of Continents

Continental crust exists on Earth because we have

- Liquid water oceans
- Subduction
- Venus lacks liquid H<sub>2</sub>O and subduction zones  
→ no continental crust

Hypsometric curves: Elevation of the solid surface of Earth vs. Venus

### Structure of Continents

Oldest oceanic crust ~ 170 million years

Oldest continental crust = 3.96 billion years (in Canada)

What do the continents tell us about Earth history?

***Cratons vs. mobile belts***

### Terranes and Structure of Continents

- Continental crust is too thick and buoyant to subduct.
- When continental fragment or island arc collides with continent it "sticks".

## Terranes and Structure of Continents

- Fragments of cont. crust incorporated into larger cont. masses are called *terranes*.
- Younger terranes are parts of *mobile belts*.
- Older now stable parts (*cratons*) appear to have accreted as terranes in the more distant past.

## Terrane Structure of N. America

- North America age distribution illustrates *terrane* accretion.
- Oldest material is N. central *craton* (2.3-3.8 Ga).
- Material is progressively younger “seaward”.
- Youngest material is found in currently active *mobile belts*.

## The Supercontinent Cycle

### Changing Continent Configurations

#### Seafloor Spreading: VI

The residual magnetism of oceanic crustal basalt produces magnetic stripes on the ocean floor that correlate with magnetic pole reversals. These stripes can be dated.

Progressively closing ocean basins along these stripes reveals the history of continental motions during the past ~200 million years.

Earth’s magnetic field is toroidal, or “donut-shaped”.

A freely moving magnet lies horizontal at the equator, vertical at the poles, and points toward the “North” pole.

### **Paleomagnetism in Rocks**

- Magnetic minerals in rocks align with Earth’s magnetic field when rocks solidify.
- Magnetic alignment is “frozen in” and retained if rock is not subsequently heated.
- Can use paleomagnetism of ancient rocks to determine:
  - direction and polarity of magnetic field
  - paleolatitude of rock
  - apparent position of N and S magnetic poles.

### Scotese Videos

1. 0-200 Ma: breakup of Pangaea
  - constructed by closing magnetic stripes.
2. 0-750 Ma: 3 supercontinents: Pangaea, Penotia, Rodinia
  - constructed using paleomagnetic data from continents and lots of geologic data.

### Shows:

- continents aggregating and rifting apart.
- Continents move continuously, whether apart or together.
- Continents also rotate, whether apart or together.
- changes in sealevel and continental submergence.
- collision of India with Asia ~50 million years ago