Ocean 201 week 4 Lecture 3: Plate Tectonics III (M.J. Mottl)

Text from slides

Tectonic Model

- Ultimate driving force: ***Convection of Earth's mantle***
- New crust is formed at MOR, spreads laterally "on conveyor belt".
- Oceanic plate subducts at trenches.
- Continents ride passively on the moving plates.

Driving Forces of Plate Tectonics
Immediate mechanism is more controversial: 4 possibilities . . .
1. Pushing from ridges➔ compressional stress in plate
2. Pulling by downgoing slab➔ tensional stress in plate
3. Gravity **sliding** from height of MOR to abyssal plain/trench
4. Dragging by convection cells acting on base of the plate

And the winner is . . .

- **Slab pull** is now considered the most viable mechanism
- *But some plates (S. American) have no subducting slab…*
- In such cases, mantle drag may provide the necessary force to move the plate along.

Implications for Oceanography

- Theory of plate tectonics has important implications for geochemical oceanography. It provides mechanisms for chemical interaction between deeper reservoirs in the Earth and those at the surface.

Implications for Oceanography: II

- Creation of oceanic and continental crust by differentiation from mantle ➔ manifested as volcanism at MOR and volcanic arcs
- Injection of primordial gases (3He) from Earth interior into oceans and atmosphere by volcanism

Implications for Oceanography: III

- Interaction of seawater with igneous oceanic crust (hydrothermal circulation) driven by heat of formation of new lithospheric plate
- Recycling of oceanic sediments and basalt back into mantle at subduction zones

Implications for Oceanography
Theory of plate tectonics also has important implications for biological and physical oceanography.
The change with time in the number, distribution, and configuration of continents and morphology of the ocean basins have likely affected various parameters…

Implications for Oceanography: IV

- Global patterns of ocean circulation (e.g., Kuroshio, Gulf Stream)
- Global sea level (as affected by MOR volume)

Implications for Oceanography: V

- Global climate: heat flux affects ocean T, volcanic ash blocks sun
- Distribution of organisms (land mass connections, paleolatitudes)

Phanerozoic Supercycles

- Large changes in volcanic activity over 600Ma
- Large sea level changes
- Climate change
- Large biological extinctions

Effect of Supercontinents (Pangaea, Penotia, Rodinia)

- They ride ***high*** relative to sea level because:
  - They were thickened by continent-continent collision as they accreted together.
  - They overlie thicker lithosphere.
  - They heat the underlying mantle

  and so become thermally elevated.

When continents are high and sea level is low, weathering is rapid:

$H_2O + CO_2 + CaSiO_3 = CaCO_3 + SiO_2 + H_2O$

- Rapid weathering lowers CO_2 in the atmosphere, cooling the climate.
- The 3 major ice ages of the past 600 million years all occurred when sea level and CO_2 were low.