

Ocean 201 week 3 Lecture 2: Seafloor Spreading (M.J. Mottl)

Text from slides

Revival of Continental Drift Theory

Wegener's theory was revived in the 1950's based on paleomagnetic evidence for "Polar Wandering".

Earth's Magnetic Field

Earth's magnetic field simulates a bar magnet, but it is caused by convection of liquid Fe in Earth's outer core: the *Geodynamo*.

A moving electrical conductor induces a magnetic field.

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.

Apparent Polar Wander Paths

- Rocks from different continents gave different paths! Divergence increased with age of rocks.
- Geomagnetic poles had apparently "wandered" systematically with time.
- Magnetic poles have never been more the 20° from geographic poles of rotation; rest of apparent wander results from ***motion of continents!***

Seafloor Spreading: I,II

- First suggested by Arthur Holmes (1931) based on concepts of continental drift and convection cells within the mantle.
- Suggested by characteristics of **mid-ocean ridge**:
 - Topography is elevated.
 - Structure: **axial valley** formed by normal faulting, implying tension and extension

Mid-Ocean Ridges

- Heat flow is high.
- Seismicity is shallow (<70 km below MOR).
- Sediment is absent or thin.

Global Seismicity (Earthquakes)

Seafloor Spreading: III

Formally proposed by Dietz (1961) and Hess (1962):

- Convection cells: Mantle upwells under mid-ocean ridge (MOR).
- New oceanic crust is formed at MOR, then spreads laterally as if on conveyor belt.
- Oceanic crust is dragged down at trenches (compression, mountain ranges and volcanic arcs).
- Continents ride passively between sites of upwelling and downwelling.

Seafloor Spreading: IV

- Confirmed for some by Vine and Matthews (1963): the *“tape recorder”* model

Magnetic polarity reversals* were first observed by Brunhes (1906) on land.

*North magnetic pole becomes South magnetic pole and South becomes North!

Seafloor Spreading: V

- Confirmed for most geologists by DSDP (1970's): age of seafloor (crust) increases regularly with distance from the ridge axis:
a major prediction of seafloor spreading hypothesis!

Sediment also thickens.

Volume of Ocean Basins

- Ridges are elevated because lithospheric plate is young and hot at the spreading center → thicker!
- As it cools (slowly with time) it contracts, causing depth of seafloor to increase linearly with square root of the crustal age (only to ~80 Ma).
- Fast spreading means larger ridge volume → reduces volume of ocean basins
→ increases sea level
→ causes flooding of continents (on time scale of million yrs)
→ *large sea level change!*