

Chapter 3: Plate Tectonics

Continental Drift: Alfred Wegener (1880-1930) – *The Origin of Continents and Oceans*

The continents have drifted apart over time (due to similarity of the coastlines of South America and Africa).

->Others noticed the similarity of the continents in the past.

Evidence:

- 1) Fit of the continents
- 2) Distribution of Fossils on southern hemisphere continents
 - a. Plant collection: Gondwanan Succession
 - b. Animals: Mesosaurus, Lystrosaurus
- 3) Glaciation
- 4) Paleoenvironments
- 5) Matching rock types across the Atlantic Ocean

How come his theory was not accepted by the scientific community?

Wegener Vindicated

Wegener's work was more accepted in Europe than in America, mostly due to Arthur Holmes.

Arthur Holmes (1920s)

->Suggested continental drift occurred as the new crust grew between the continents (essentially seafloor spreading) and was destroyed by sinking back into the earth in marine trenches (aka subduction)-interestingly enough, he was correct, but at that time, we did not have the technology to prove it all

Nothing like a good war or two to help us develop new technology that would be utilized in the scientific world. The development of the magnetometer that could measure seafloor magnetism in rocks would lead to the following research:

Harry Hess (1960)

->Sea-floor Spreading and "geopoetry"

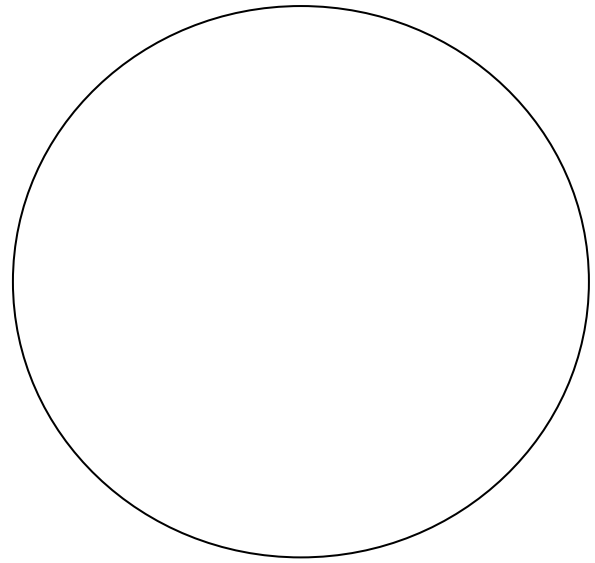
Vine, Matthews and Morley (1963)

->Paleomagnetism studies of the seafloor: Positive and Negative Anomalies

Geophysical Contributions

Shadow Zones (1920s)

- 1) P Wave Shadow Zone (Inge Lehmann)
- 2) S Wave Shadow Zone (Richard Oldham)



Kiyoo Wadati (1927) and Hugo Benioff

->Studied distribution of earthquakes along what would be later identified as plate boundaries

Sykes, Oliver and Isacks (1960s): described subduction zones and coined that term

Plate Tectonics

The “plate” idea actually came from Vening Meinesz (1920s), who described plates as broad regions of structurally diverse crust, such as the Caribbean Plate that he studied while working for the US Navy.

J. Tuzo Wilson revived Meinesz’s work in the 1960s, and combined with his own work on Transform Faults, coined the term PLATE TECTONICS for the whole theory.

Now there are about a half dozen or so major plates plus a bunch of little ones.

Plate Boundary

Forces

Locations and Mass Balance

Divergent

Plate Boundary

Forces

Locations and Mass Balance

Convergent

Transform

What Causes All of this Restlessness?

Compositional View		Geophysical View
Earth's Structure		
1) Crust (compositional)	Oceanic	Continental
Average thickness	7 km	30-50 km (thickest under mountains)
Seismic P Waves	7 km/s	6 km/s (higher in lower crust)
Density	3.0 g/cm ³	2.7 g/cm ³
Probable Composition	Basalt underlain by Gabbro	Granite and other plutonic igneous rocks, met or sed. cover

Moho - separates crust from the mantle

We also have **samples** of both types of crust.

2) Mantle

a. Lithosphere - crust and upper mantle (**geophysical term**)

- Lithos - strong, hard, brittle
- averages 70 km beneath oceans, may be 125-150 km beneath continents
- seismic waves v generally increases with depth
- low velocity zone ---> marks boundary of Asthenosphere

b. Asthenosphere - low velocity zone (**geophysical term**)

- rocks are close to melting point - which is controlled by T and P
- may be partially molten - crystal and liquid slush
- makes them weaker - can be deformed in a ductile manner

c. Lower Mantle (**compositional**) also called Mesosphere (**geophysical**)

-400 km - concentric layers at these depths

-670 km - deepest quakes

* These layers are probably “pressure collapse” layers

We also have samples of mantle rocks in the form of Ophiolites.

How do ophiolites form?

The Dance of the Continents

Seafloor Spreading and Subduction have recycled the ocean crust many times. How many?

New crust: 1.1 mi² per year (2.8km/yr)

Total Ocean: 120 million mi² (310 million km²)

Formation time average: 110 million years, thus at least 20 global ocean floors have been recycled

Wilson Cycle: Stages in the Tectonic Birth and Death of Oceans

- 1) Embryonic (Rift Valleys of East Africa)
- 2) Youthful (Gulf of CA, Red Sea)
- 3) Mature (Atlantic Ocean)
- 4) Declining (Pacific Ocean)
- 5) Terminal (Mediterranean Sea)

What causes a supercontinent to break and start the whole process?

Thermotectonic Arch

->Form Divergent Boundaries with Passive Margins

Supercontinents form about every 400-500 million years.

Most recent: Pangea, before that Rodinia

Plate Tectonics and the Rock Cycle

Hot Spots: Hawaii

Plate Tectonics and the Human Environment

The origin of natural resources are tied to plate movements.

->1 out of 10 people lives on a convergent boundary. Convergent Boundaries are typically rich farmlands and rich in ore materials associated with volcanics.

->Passive Margins are also favorites of folks too. Flood plains are rich in supplies, and are not prone to earthquakes or volcanism, but prone to floods...

→ Mature Passive Margins are rich in petroleum (due to folding and faulting)

Case Studies

3.1 Exotic Terranes-the making of the west coast

3.2 Visions of How the Earth Works