Sea-Floor Spreading, Subduction, & Plate Boundaries

Lecture 21

Alfred Wegener’s Evidence for Continental Drift

1. Continental “Fit”
2. Similar Rocks, Ages
3. Similar Fossils
4. Widespread Glaciation

Pangaea = Gondwanaland + Laurasia

Source: http://vishnu.glg.nau.edu/tech/Penn.jpg
Alfred Wegener’s Evidence for Continental Drifts Was NOT Accepted in USA.

Problem: No Mechanism for Continents to Plow Through Oceanic Crust

Answer lies on & in the Sea Floor - Ch. 18 + 19 in Text
Know these mega-scale Landforms
• Continental Shelf
• Continental Slope
• Continental Rise
• Abyssal Plain
• Mid-Ocean Ridge (~ Mid-Ocean Rise)
• Trench

Know differences between Oceanic Crust and Continental Crust

Ocean Basin Bathymetry
See Figures 18.5 to 18.16 in Plummer & Others 10th ed.

Ocean Basin Bathymetry
See Figures 18.5, 18.15 in Plummer & Others 10th ed.
Cold War
More Submarine Science
Magnetic Anomalies in Ocean Basin

Deep Sea Drilling Project (DSDP)
Studied Geology of Ocean Basins
Continental Record = Incomplete
Deep Ocean Basin Record Was Thought to be More Complete

Glomar Challenger
Harry Hess
Magnetic Anomalies: Atlantic Ocean South of Iceland
New Ocean Crust Created at Mid-Ocean Ridges: Spread Centers

DSDP Surprise Finding:
Ocean Basins are <200,000,000 y Old
Much Younger than the Continents
Very Young Sediments at the Mid Ocean Ridges
Birth of an Ocean Basin?

Spreading at the Red Sea: Break-Up of Asia and Africa

Note a “Failed” Arm of Rifting in East Africa

Problem:

If New Crust is Created at Mid-Ocean Ridges,

Where is Old Crust Consumed to Balance the New Crust?
Where is Old Crust Consumed to Balance the New Crust?

Answer Lies in Deep-Focus Earthquakes.

Earthquakes Occur in Brittle (Elastic) Lithosphere

Lithosphere

Asthenosphere

Distribution of All Earthquakes (Deep and Shallow Focus)
Subduction Zones: Ocean-Ocean Margin

Subduction Zones: Ocean-Continent Margin

Deep-Focus Quakes Only in Subduction Zones
Isotherms in Subduction Zones

Japan Trench & Volcanic Arc

Back-Arc and Fore-Arc “Basins”
See Figure 19.35 in Plummer & Others 9th ed.
Subduction Zones & Volcanoes

Spread Centers Feed Subduction Zones

Missing Mechanisms for Continental Drift: Sea Floor Spreading & Subduction

Continents are Passive “Boats”
How Are Mountains Built?

First a Brief Review of Sea Floor Spreading

Break-Up of a Continent and Origin of an Ocean Basin

Missing Mechanisms for Continental Drift: Sea Floor Spreading & Subduction

Continents are Passive "Boats"
Orogeny (Mountain Building) in the Himalayas

Continental Lithosphere Will NOT Flush Down Subduction Zones
Orogeny - Mountain Building - Sediment Supply
Orogeny - Mountain Building - Glaciation

Plate Margins:
- Spread Centers (Mid-Ocean Ridges)
- Subduction Zones (Trenches)
- Transform Faults
Transform Faults & Fracture Zones

San Andreas Fault: Right-Lateral Transform Fault

Left-Lateral Offset!!
Why?: Fault is Produced by Offset, vs. Offset Produced by Fault
Transform Faults: Three Causal Scenarios

Plate Motion on a Sphere

Plate Motion on a Sphere Requires Transform Faults Because of Different Rates of Motion
What *Drives* Plate Tectonics?

1. Convection Cells in Mantle
2. Sinking of Cool, Dense Plates
3. Mantle Plumes - Hot Spots
Mantle Plumes

Large scale degassing
\( \text{H}_2\text{O} + \text{CO}_2 \)

Lava plateau
2000 km diameter
60 km thick

Super plume
Rising plume
Mantle
Upper mantle plume
Crust

670 km discontinuity

Depth (km)

Mantle Plumes Under Continents

Flood basalts
on uplift

Hot spot

Mantle plume
Mantle
Known “Hot Spots”

Hawaiian Islands

Numbers = Age of Rock in Millions of Years
Sinking of Cool, Dense Plates

Seamounts

Hot spot

Mantle plume

Volcanoes Surrounded by Fringing Coral Reefs

Atolls: Submerged Volcanos Support Reefs Only in Warm Clear Seas Tuamoto Islands

NASA