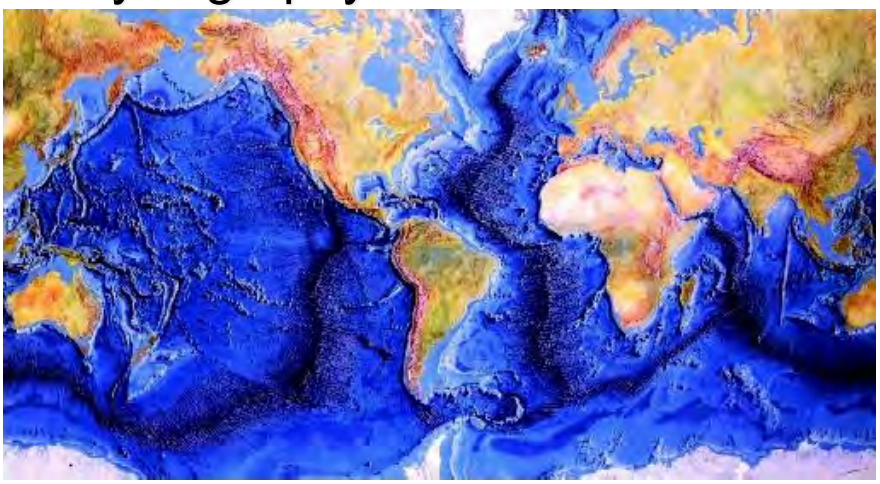
Lab 2: Isostasy, Bathymetry and the Physiography of the Ocean Floor



EPSS 15 Fall 2017

Ad art for NBC Radio, 1939

Archimedes

(c. 287 BCE – 212 BCE)

Greek mathematician, physicist and engineer

Archimedes' Principle:

"A rigid body which floats on a fluid will sink into the fluid until the weight of the displaced fluid exactly equals the weight of the rigid body".*

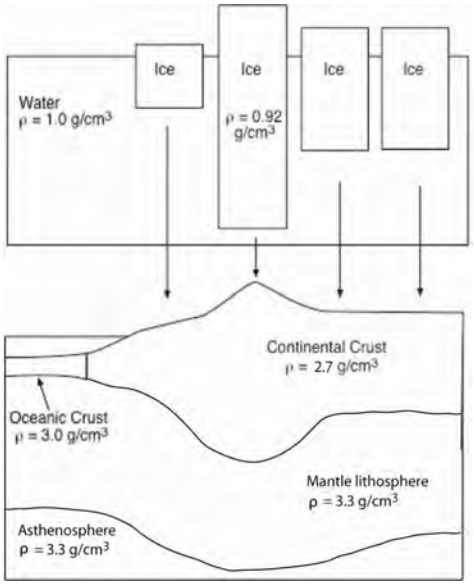
Or,

"A floating object will displace its weight in fluid"

* The acceleration of gravity is nearly constant near the Earth's surface, so for our purposes "weight" can be replaced by "mass"

Isostasy

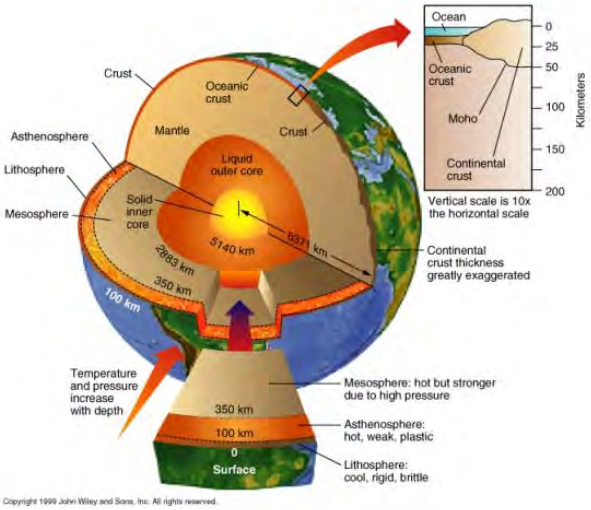
The theory of isostasy suggests that the earth consists of blocks of rigid lithosphere, which are "floating" in isostatic equilibrium on a plastic region of earth's mantle called the asthenosphere.



*Note that bottom figure is schematic and mantle lithosphere is much thicker than typical continental & oceanic crust.

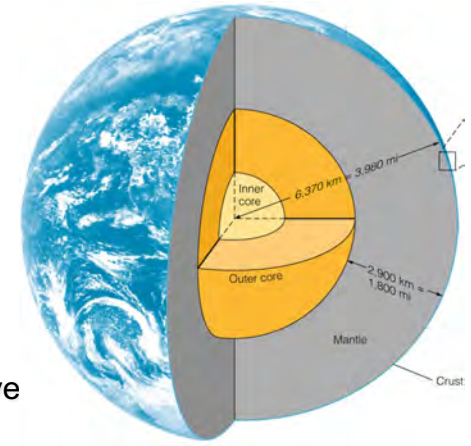
Earth's Interior Structure

- The Earth is roughly a layered sphere with the most dense layers in the center and the least dense layers at the surface
- Can be subdivided by chemical composition and physical properties



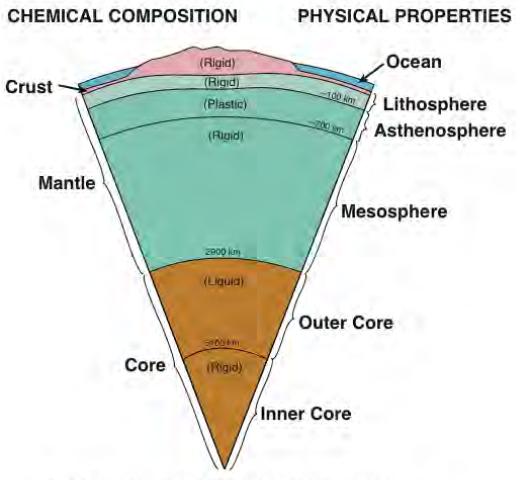
Chemical Composition

- Crust - low density rock
  1) continental (granite)
  thickness: ~ 30 - 70 km
  density = 2.7 g/cm^3
  2) oceanic (basalt)
  thickness ~ 5 - 8 km thick
  density = 3.0 g/cm^3
- Mantle - higher density material below crust and above outer core ~ 3.3 g/cm^3
- Core - most dense layer composed primarily of iron



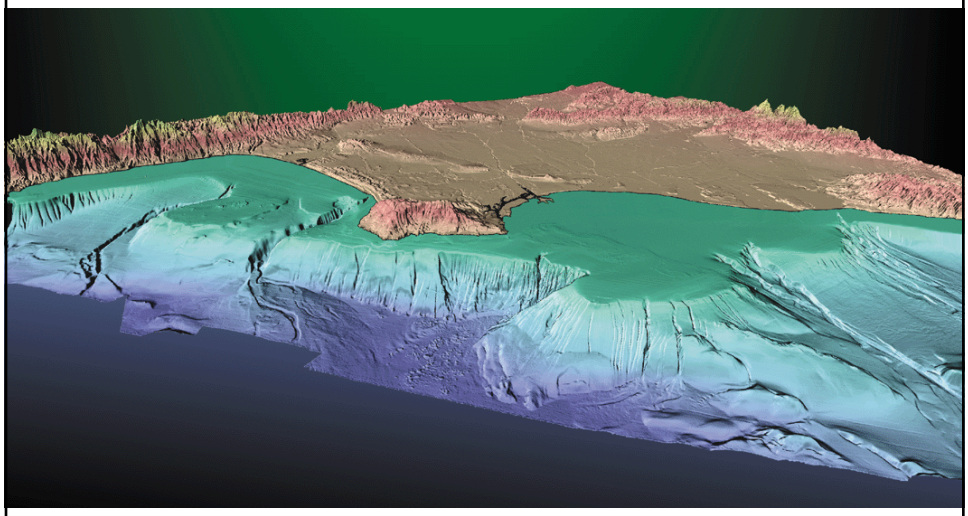
Physical Properties

- Lithosphere
  cool, rigid outer layer (crust and upper mantle) ~100 km thick
- Asthenosphere
  plastic part of the mantle below lithosphere (upper mantle)
  ~ 600 km thick
- Mesosphere
  plastic, but stronger than the asthenosphere (middle and lower mantle)
- Inner and outer core
  inner is solid, outer is liquid



SCHEMATIC DRAWING OF A SECTION OF EARTH'S INTERIOR. Note that the dimensions of the crust and lithosphere are greatly exaggerated.

Continental Margins

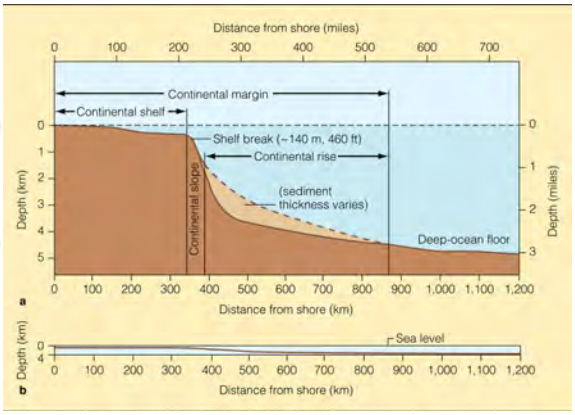


(the Los Angeles / Orange County coast)

Continental Margins cont'd

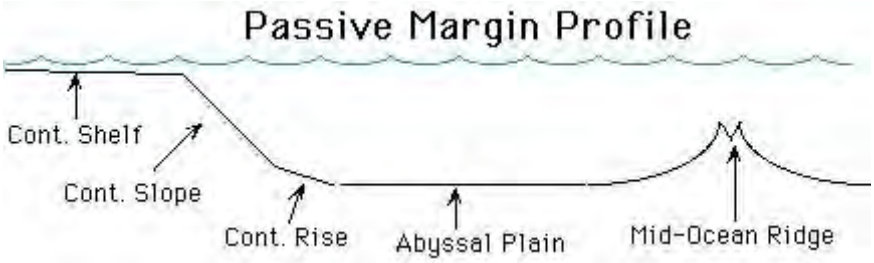
- Continental shelf: gently sloping depositional surface extending from the shoreline to the continental slope
- Continental slope: relatively steep surface seaward of the continental shelf
- Continental rise: gently sloping depositional surface at the base of the continental slope

Shelf break: at ~140 m depth separates the shelf and slope

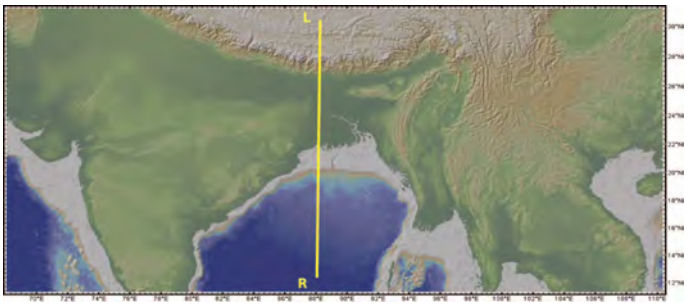


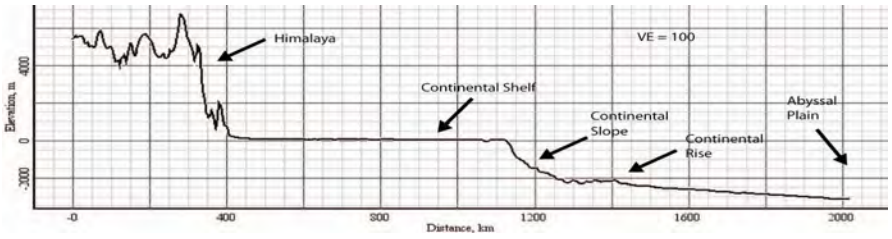
Passive (Atlantic-style) Margins

- Typically found in Atlantic Ocean
  - Continental Shelf has gentle slope ~ 0.1°
  - Continental Slope is steep ~ 4 °
  - Continental Rise has a gentle slope ~ 0.2°
- No plate boundary
- Low degree of tectonic activity (volcanoes, earthquakes)



Passive Margins: Example

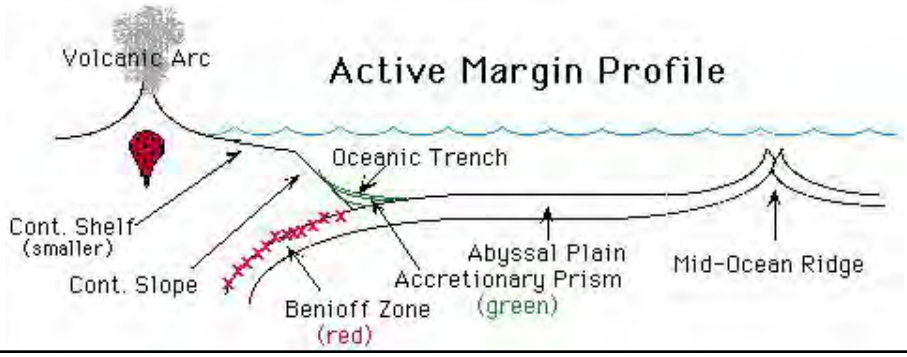




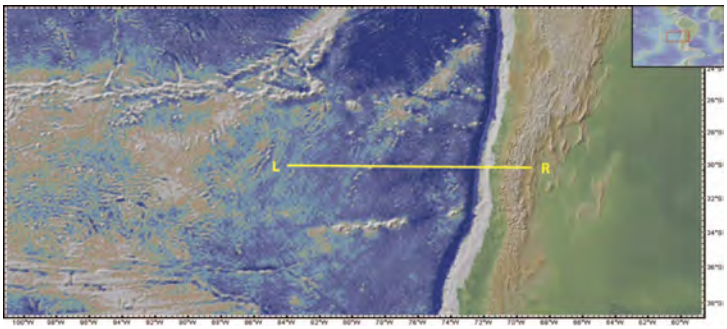
Data from Marine Geoscience Data System, accessed through GeoMapApp 2.6.0
Ryan, W. B. F., S.M. Carbotte, J. Coplan, S. O'Hara, A. Melkonian, R. Arko, R.A. Weissel, V. Ferrini, A. Goodwillie, F. Nitsche, J. Bonczkowski, and R. Zemsky (2009), Global Multi-Resolution Topography (GMRT) synthesis data set, *Geochem. Geophys. Geosyst.*, 10, Q03014, doi:10.1029/2008GC002332.

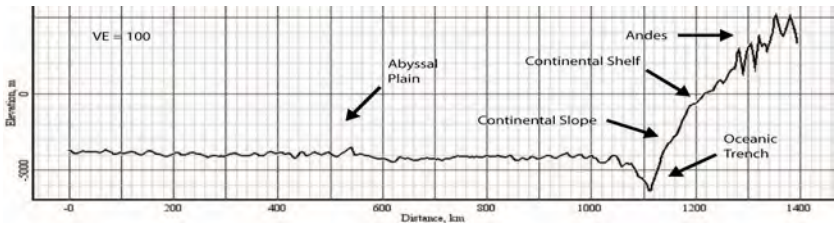
Active (Pacific-style) Margins

- Typically found in Pacific ocean
  - Continental Shelf is narrow
  - Continental Slope transforms abruptly to trench
  - Continental Rise is absent
- High degree of tectonic activity



Active Margins: Example





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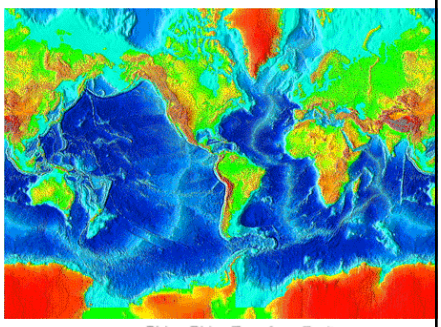
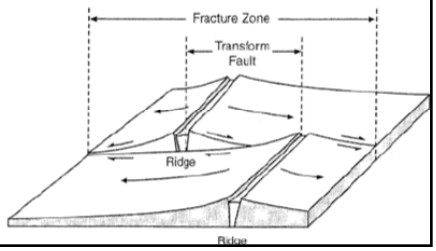
Mid-Ocean Ridge and Rise System

- Ocean floor mountain chains:
  - total length: ~ 75,000 km
  - width: 500 -1500 km
  - rugged slope with a central rift
- Divergent plate boundaries; ridge crests are offset by perpendicular fractures

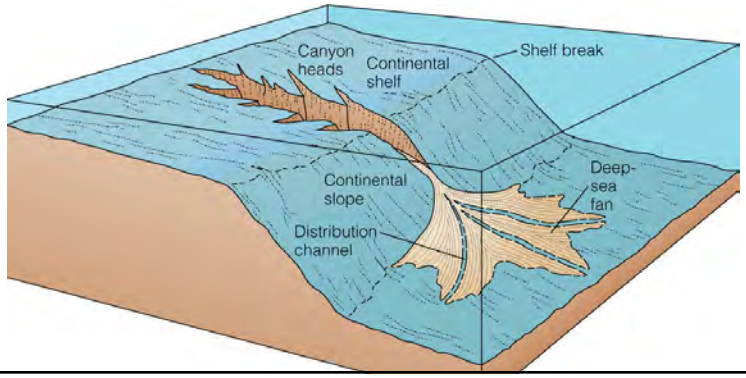


Ridge-Ridge Transform Fault



Submarine Canyons and Fans

- Canyons cut through the shelf and slope
- Rivers may deliver sediments to the head of the canyons
- Sediments episodically flow out as turbidity currents
- Fan-shaped sediment deposits merge to form the continental rise which in turn merges with the abyssal plain



Abyssal Plains

- Flat or very gently sloping areas of the deep ocean floor.
- Among the Earth's flattest and smoothest regions (and the least explored)
- Cover approximately 40% of the ocean floor