Volcanoes and Tectonics

References:
- Encyclopedia of Volcanoes, pp. 89-114
- Volcanic Successions, pp. 445-467

Lithosphere
- Contains crust and mantle
- Defined by brittle behavior
- $T_{\text{max}} \sim 1350 \, ^\circ\text{C}$
- 100 to 150 km thick

Aesthenosphere
- Essential mantle material
- Moves by convection (flows)
- Source for most primary magmas

Plate Tectonics
- Few (7) large rigid plates
  - Several smaller ones
- Plate margins
  - Contact of two-plates
  - Triple junctions

Plate Movement
- Various rates and styles
- Explains most volcanism
Relationships Between Plates

- Convergence
  - Destructive margins
- Divergence
  - Constructive margins
- Transform
  - Lateral displacement

Relation of Volcanism to Plates

- Ocean ridge volcanoes
- Hot spots
- Continental rifts
- Convergent zones

Ocean Ridge Volcanism

- Push vs. pull models
- Adiabatic cooling
  - Compressed magma cools by expanding as it rises due to the reduction in pressure

Hot Spots

- Topographic swelling
- High heat flow
- Mantle plume mechanism
- Hawaiian sea mount chain
- Yellowstone trace
- Continental hot spots (stationary plates?)
  - Mid-Sahara
  - Antarctica

Relative volumes

- Ocean ridges 62% intrusive/extrusive (0.86:0.14)
- Arcs 26% (0.93:0.07)
- Hotspots 12% (0.86:0.12)

[Data from Fisher and Schmincke, 1984]
Continental Flood Basalts
- Colombia River Basalts (17-15 my)
- Deccan Traps (65 my)
  - Hot trail associated with drifting
- Parana, Brazil (breakup at 125 my)
  - Associated with rifting of SA from Africa
- Siberian Province (245 my)
- Wrangellia, B.C. (240 my)
- Drakensberg, South Africa (Precambrian)

The Wilson Cycle
- Continental break-up
- Formation of oceanic plates
- Convergence of continents
  - Passive and active margins
- Consumption of oceanic crust
- Collisional orogen

Continental Rifts
- Afar example
  - Red Sea
  - Gulf of Aden
  - African rift zone
- Mechanism
- Extension or thermal anomaly first?

Convergent zones
- Island arcs
  - Oceanic/oceanic crust
  - Oceanic/continental crust
- Continental Margins
  - Oceanic/continental crust
- Continent/Continent collisions
  - Himalayan Mts..

Convergent Plate Mechanisms
- Dipping Benioff zone
- Earthquakes down to 600 km depth
- Subducted slab
  - Dehydrates providing rising fluids
  - Heats as it goes down
- Overlying mantle wedge
  - Partially melted by rising fluids
Processes and Products

- Partial melting in slab and mantle wedge
- Fractional crystallization of magmas
- Assimilation of crustal material

Consequences

- Formation of large magma chambers
  - Calderas
  - Batholiths
- Chemically evolved products
- Andesites and rhyolites are common

Andes Volcanoes

- Segmentation
- Passive zones
- Subduction of Nazca and Cocos plates