

## Volcanoes and Tectonics

References:

*Encyclopedia of Volcanoes*, pp. 89-114

*Volcanic Successions*, pp. 445-467

## Lithosphere

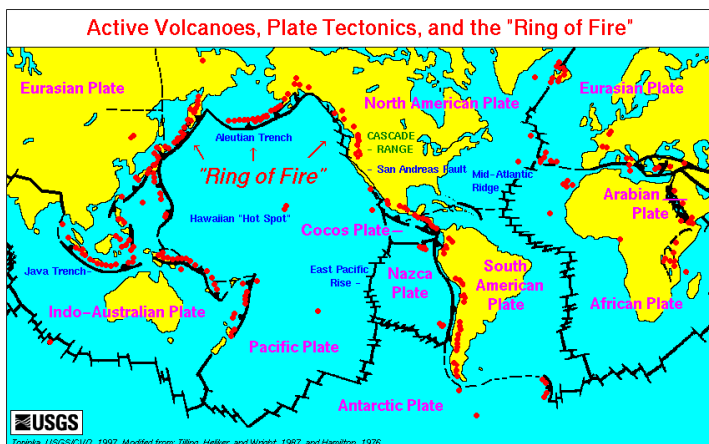
- Contains crust and mantle
- Defined by brittle behavior
- $T_{\max} \sim 1350 \text{ }^{\circ}\text{C}$
- 100 to 150 km thick

## 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

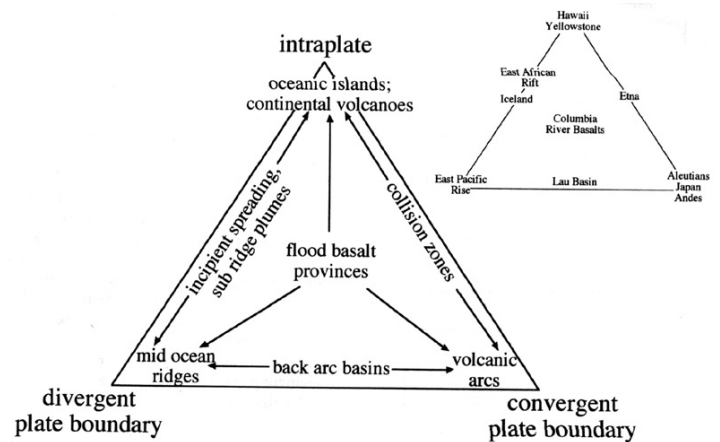


## Relationships Between Plates

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

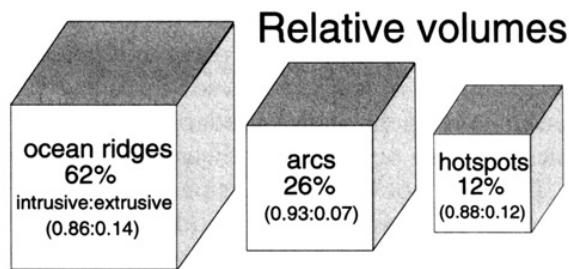
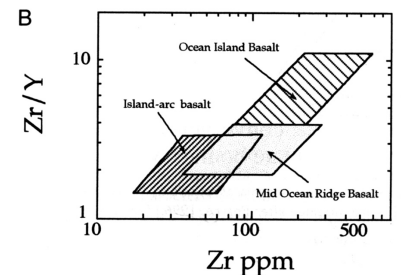
## Relation of Volcanism to Plates

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



## Elemental Discriminators

- Trace elements may be used to assess tectonic source
- Various element plots or ratio plots are used



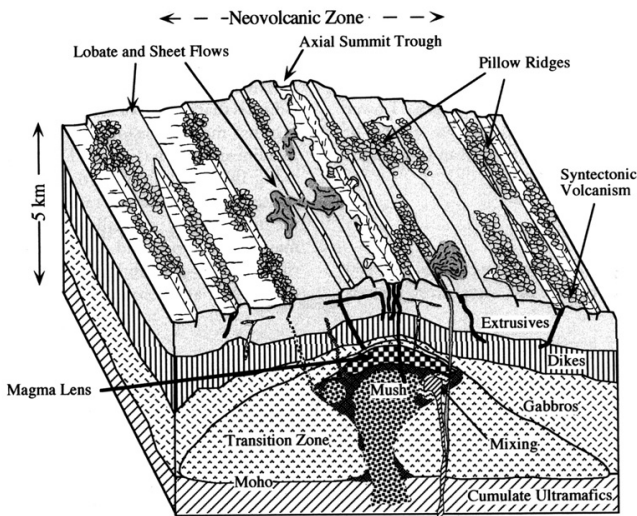
[Data from Fisher and Schmincke, 1984.]

## Ocean Ridge Volcanism

- Push vs. pull models
- Adiabatic cooling
  - Compressed magma cools by expanding as it rises due to the reduction in pressure
- Ophiolites
  - Represent ancient ridge sequences
- Regular stratigraphy
  - Sediments, pillow lavas, sheeted dikes, cumulates, mantle

## Model for Ocean Ridge Magmas

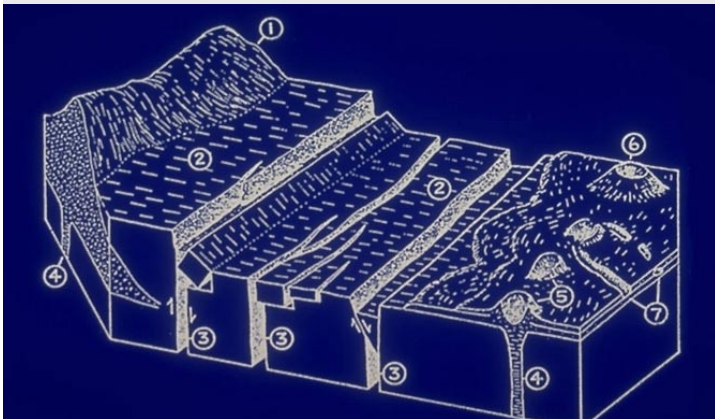
- Pillow lava at ocean floor
- Axial magma chamber
- Cumulates form at chamber margin
- Ultramafic cumulates at base
- Tectonized hartzburgites in sheared zone
- Mantle below



## Iceland, A Special Case!

- Three surface rift zones
- Dike systems - Krafla
- Fissure flood basalts - Laki
- Central andesites volcanoes - Hekla
- Calderas - Askja
- Fractionated products
  - andesite stratovolcanoes & local rhyolites
- Subglacial volcanoes

## Major Features of Icelandic Rift Zone



## Hot Spots

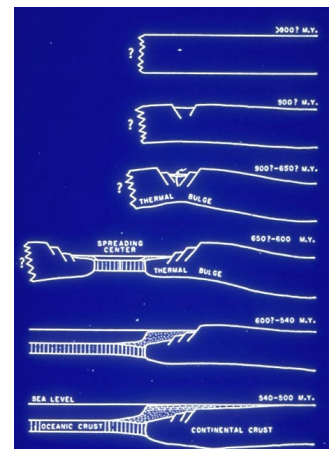
- Topographic swelling
- High heat flow
- Mantle plume mechanism
- Hawaiian sea mount chain
- Yellowstone trace
- Continental hot spots (stationary plates?)
  - Mid-Sahara
  - Antarctica

## 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)

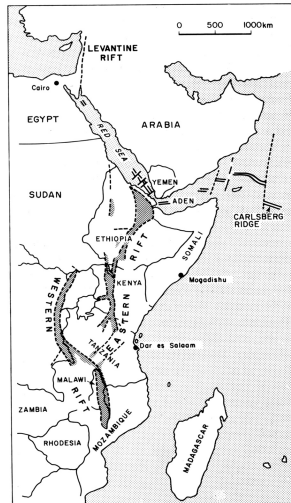
## The Wilson Cycle

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



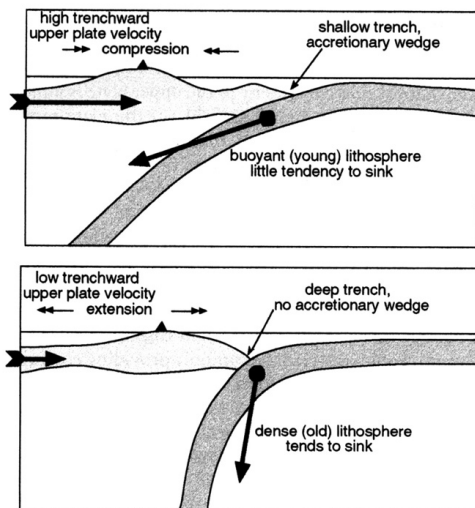
## Continental Rifts

- A far 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..

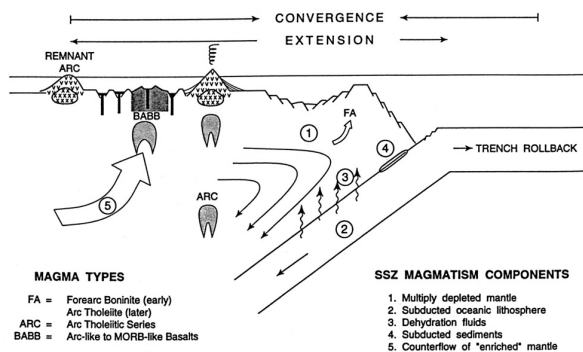


## Convergent Plate Mechanisms

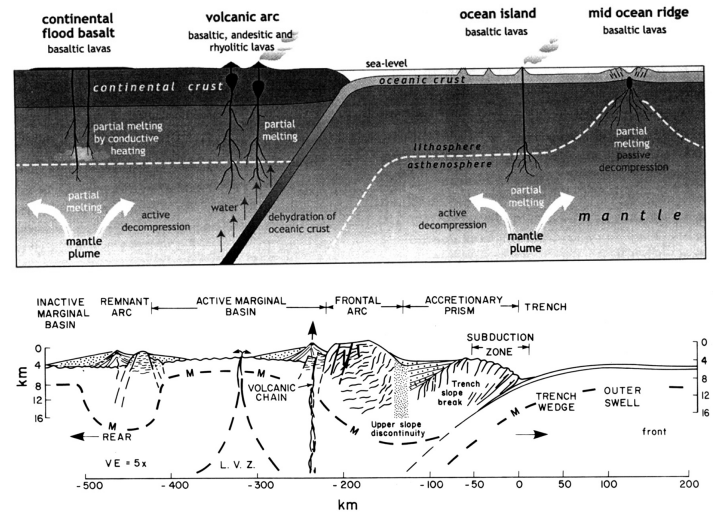
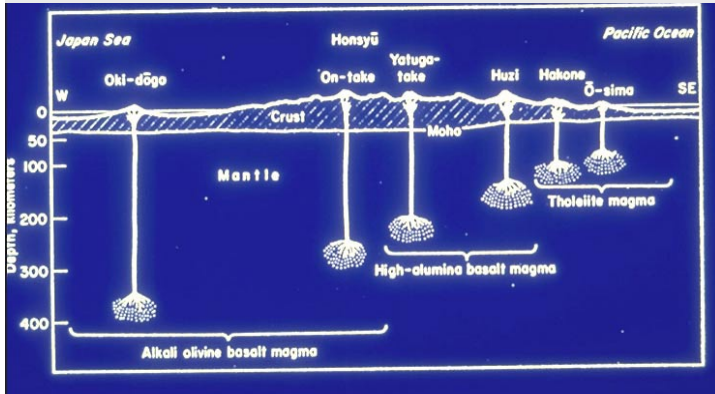
- Dipping Benioff zone
- Earthquakes down to 600 km depth
- Subducted slab
  - Dehydrates providing rising fluids
  - Heats as it goes down
- Overlying mantle wedge
  - Partially melted by rising fluids

## Processes and Products

- Partial melting in slab and mantle wedge
- Fractional crystallization of magmas
- Assimilation of crustal material
- Formation of large magma chambers
  - Calderas
  - Batholiths
- Chemically evolved products
- Andesites and rhyolites are common



## Depth to Source, Japan Arc



## Andes Volcanoes

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



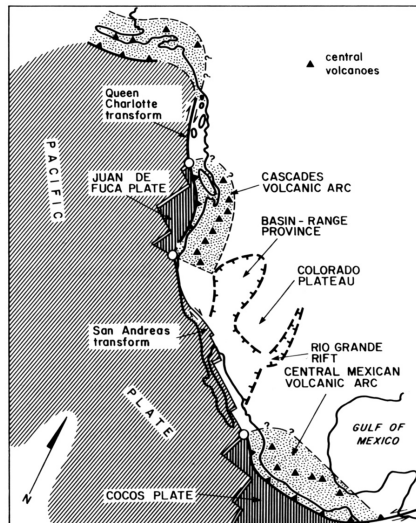
## Tectonic Reconstruction of Western USA

- Impingement of triple junction ~25 myBP
- Development of San Andreas Fault
- Distributed spreading behind the transform



## Tectonic and Volcanic Elements

- Limited subduction with volcanic arcs
- Large transform (San Andreas)
- Distributed spreading in Basin and Range
- Missing Farralon Plate



## Major Basins

- Basin and Range
- Great Valley
- Snake River Plain
- Rio Grande Rift
- Pacific NW

