Calc-alkali Volcanics

Winter Chapters 16 & 17

Calc-alkaline Volcanic Rocks

- Petrography
- Processes
- Field relations
- Volcanic arcs
- Petrogenesis

Petrography

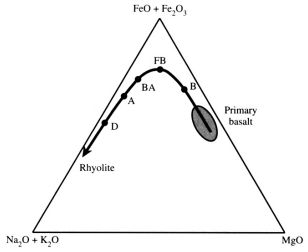
- Fabric
- Classification
- Alteration

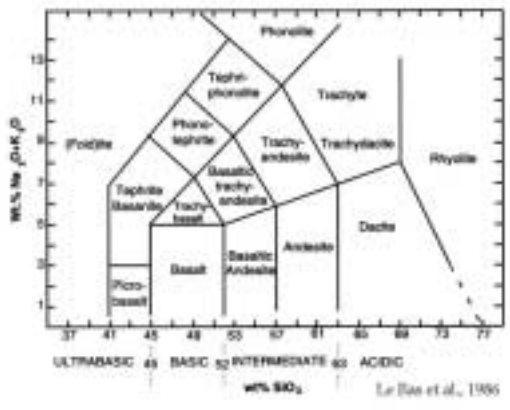
Fabric

- Aphanitic
  - Rapid cooling
  - Loss of volatiles
- Glassy (vitric)
  - Chilling of viscous magma
- Clastic
  - Fragmented due to rapid, violent eruption

Compositional Classification

- Rhyolite
- Rhyodacite
- Dacite
- Andesite
- Latite
- Basalt





Textural Classification (glassy silicic types)

- Obsidian
- Perlite
- Pumice
- Vitrophyre

Volcaniclastic Classification

- Epiclastic
  - Transport by a hydrologic system
  - Volcanic sandstone, shale, etc
  - Greywacke
  - Lahar

Pyroclastic Classification

- Components
  - Vitric, crystal, lithic
- Size
  - Ash, lapilli, blocks & bombs
- Types
  - Tuff
  - Welded tuff
  - Breccia

Alteration

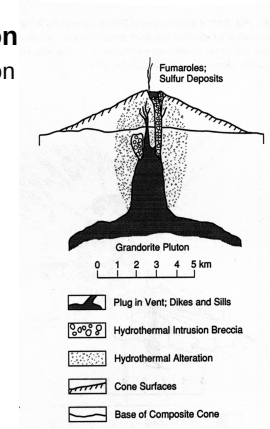
- Deuteric alteration
  - Occurs as materials cool after emplacement
- Hydrous minerals may decompose
  - Due to reduction in pressure
  - Fe-Ti dusty rims on reddish pseudomorphs

Hydrothermal alteration

- Forms due to circulation of hot ground water

Propylitic alteration

- Formation of hydrous minerals
- Chlorite, amphibole, epidote, prehnite
- Associated with some ore bodies



Extrusive Processes

- Lava flows and domes
  - Thicker and shorter than for basalts
  - Due to higher viscosity
- Mono Domes
- Dacite lava flows

Pyroclastic Processes

- Eruptive column
- Pyroclastic fall
- Pyroclastic flow
- Pyroclastic surge

Ash-flow Sheets

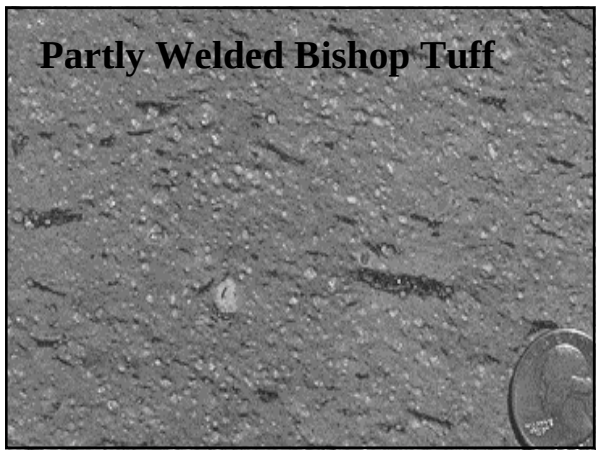
- Flow units
- Cooling units
- Welded tuffs

Morphology

- Controlled by topography
- Fill depressions
- Even upper surface
- Valley ponded deposits
- Veneer deposits
- Multiple lobes and fans
- Lateral levees

Welded Tuff

- Degree of welding
  - Non-welded
  - Partially welded
  - Densely welded
- Density is a good index
- Welding (density) profiles



Welding Profiles

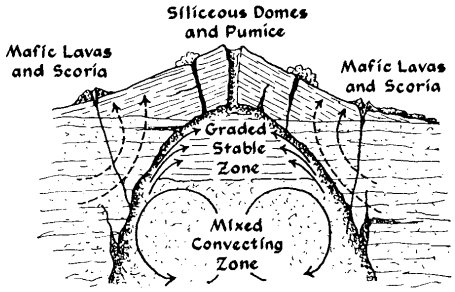
- Density plotted vs. elevation
  - $\rho = 1.0$ at base and top
  - ρ = maximum value near center
- Erosion easily removes upper part
- Welding = f(temperature, Pressure)

Secondary Mineralization

- Vitrophyre
- Devitrification
- Lithophysae
- Vapor-phase crystallization
- Zeolitization

Compositional Zoning

- Initial eruptions
  - Crystal-poor rhyolites
  - Crystal-rich latites or dacites
- Related to zoned magma chambers
  - Highly-evolved upper parts
  - More primitive lower parts
- Evidence in banded pumice



Calderas

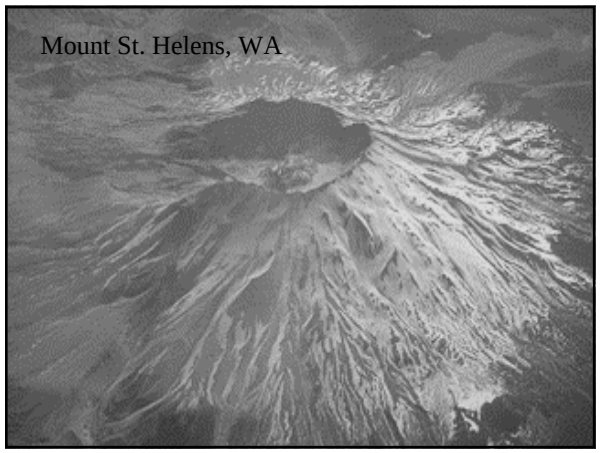
- Cauldron subsidence
- Resurgent calderas
- Caldera complexes
- Origin of silicic calderas
- Active calderas

Caldera Characteristics

- Simple circular form
- Diameter > 2 km
- V of collapse = V of tephra
- Steep walls
- Collapse megabreccia
- Generally a lake

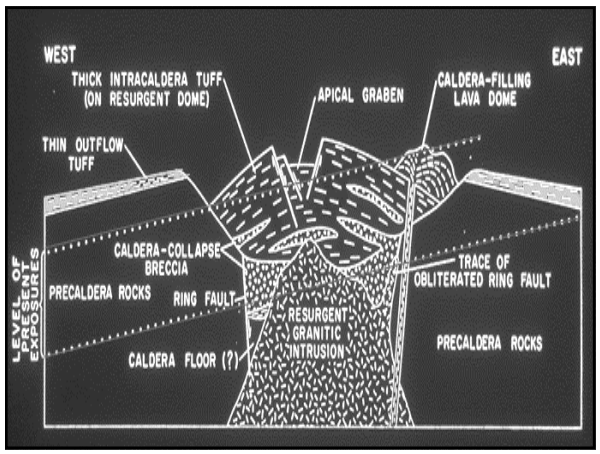
Sector Collapse Scarps

- Horseshoe shape
- Open towards debris apron
- Gravitational mechanism
- Associated with andesite cones
- Van Bemmelen model
- Mount St. Helens



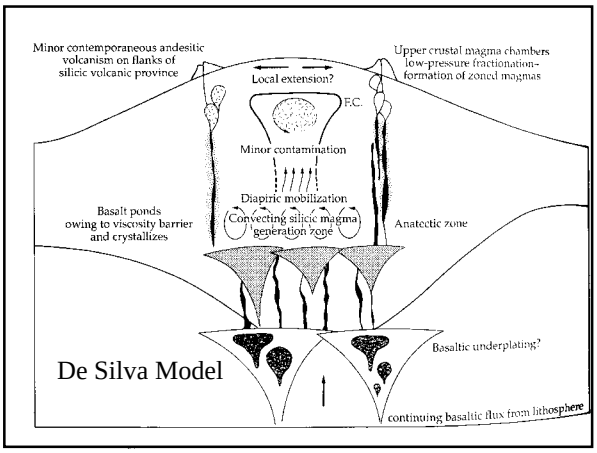
Silicic Caldera Complexes

- Large calderas are only in continental crust
- Basaltic under plating plays a role
- Silicic magmas rise towards the surface



Silicic Caldera Magmas

- Mixed magmas are evidence
- Marginal basaltic eruptions
- Zoned magma chambers
- Sequential tapping of evolving magma



De Silva Model

Large Composite Volcanoes

- Generally polygenetic
- Simple cones
- Composite cones
- Compound volcanoes
- Volcano complexes

Simple Stratocones

- Single summit vent
- Small crater (<200 m diameter)
- Radial symmetry
- Slopes > 40^{o} near summit

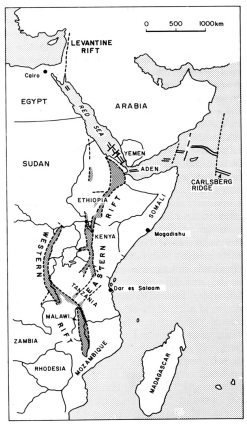
Simple Stratocones

- Concave profiles
- Height of a volcano is limited
- May grow to 3000 m
- Mass eruption rate is a control

Popocatepetl, Mexico

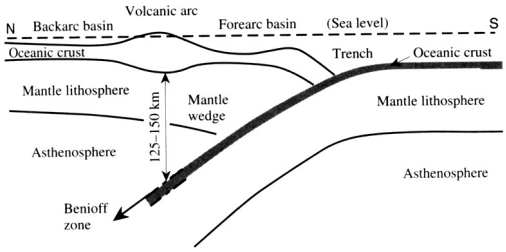
Continental Rifts

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



Convergent Zone Island Arcs

- Oceanic/oceanic crust
  - Mariana Islands
- Oceanic/continental crust
  - Andes Mountains

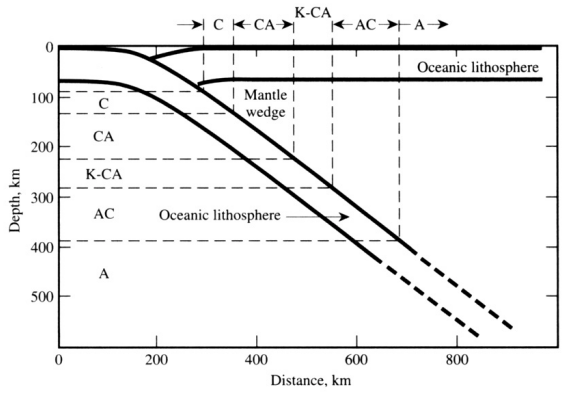


Convergent Zones

- Continental margins
  - Oceanic/continental crust
- Continent/continent collisions
  - Himalayan Mts.

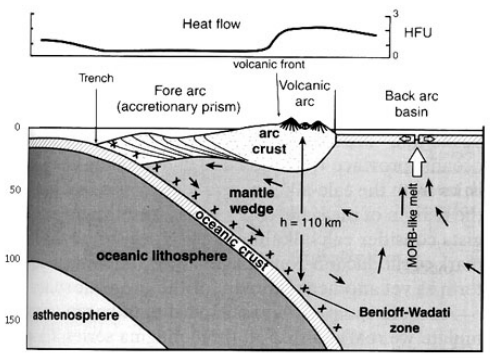
Convergent Plate Mechanisms

- 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

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



Gill, 1981

Products

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

Arc Volcanic Petrogenesis

- Diverse and felsic magmas on continental crust
  - Suggest involvement of continental sial
- Basalt and andesite magmas on oceanic plates
  - Imply mantle derived magmas

Prominent Models

- Partial melting of the lower continental crust
- Partial melting of the subducting oceanic slab
- Melting of Peridotite in the mantle wedge