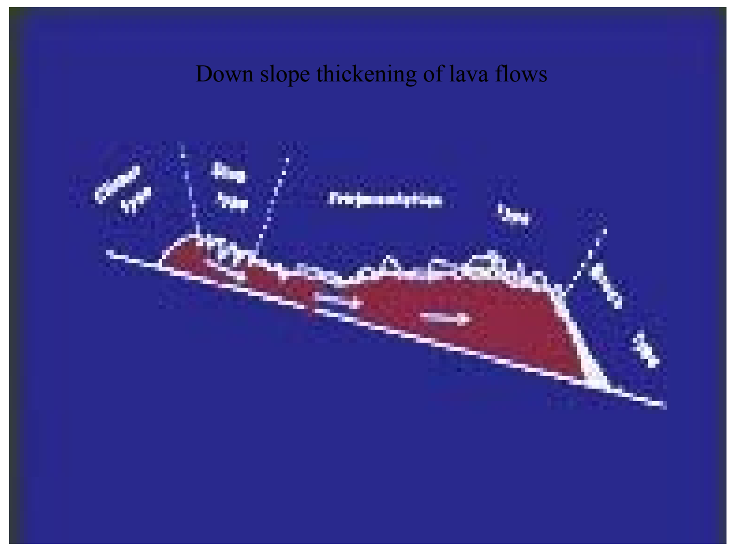
Petrography of Basaltic Rocks

- Fabric
- Classification
- Alteration

Field Relations - Basaltic Rocks

- **Intrusions**
  - **Dikes, sills, plugs, necks**
- **Extrusions**
  - **Lava flows (pahoehoe, aa aa)**
  - **Shield volcanoes**
  - **Scoria cones**
  - **Tuff rings**
  - **Hyaloclastites**


1983 lava, Etna




1970 lava, Hekla

Pahoehoe Flows

- **Very fluid lavas**
- **Smooth surface skin**
- **Ropy textures, surface pleats**
- **Flow moves as growing bubbles or buds**
- **Sometimes a gap at the top of the bud**
- **Shelly pahoehoe**

Pahoehoe lava, Cerro Pinacate

Mount Etna, Italy

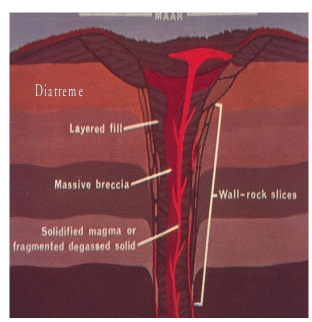
Scoria Cones

- Simplest and commonest volcanic form
- Characterized by three parameters
  - Height, width, crater width
- Standard initial slope of 30°
- Conical shape
- Occur in several environments
- McGetchin model of cone growth
- Erosion is systematic

Sunset Crater, Arizona

Diatremes

- Breccia pipes
- Kimberlite
- Contains diamonds
- Ultramafic magmas
- Mixture of rocks
- Driven by deep CO_2

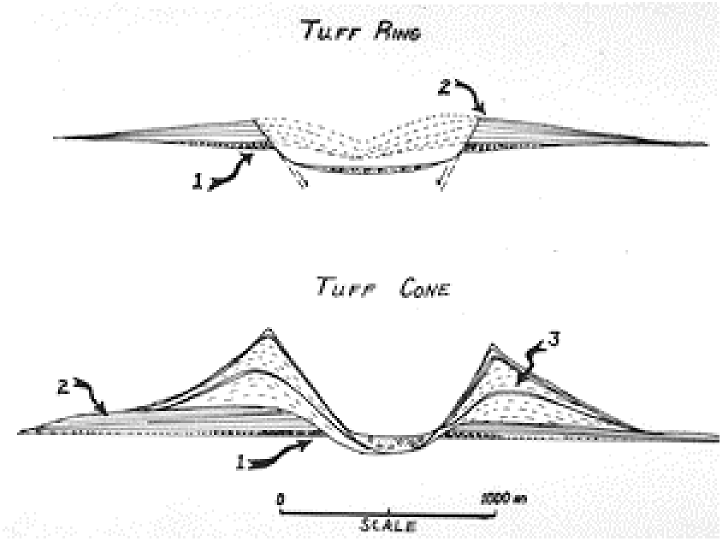


Tuff Cones

- Massive deposits
- Thickly bedded
- Palagonitized
- Bedding up to 30°
- Wet surges

Tuff Rings

- Thinly-bedded
- Poorly-indurated
- Beds less than 12°
- Sandwave beds
- Dry surges

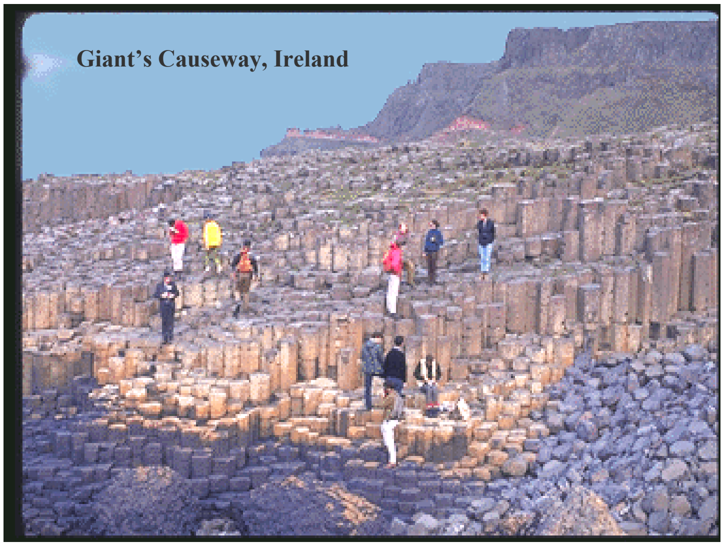


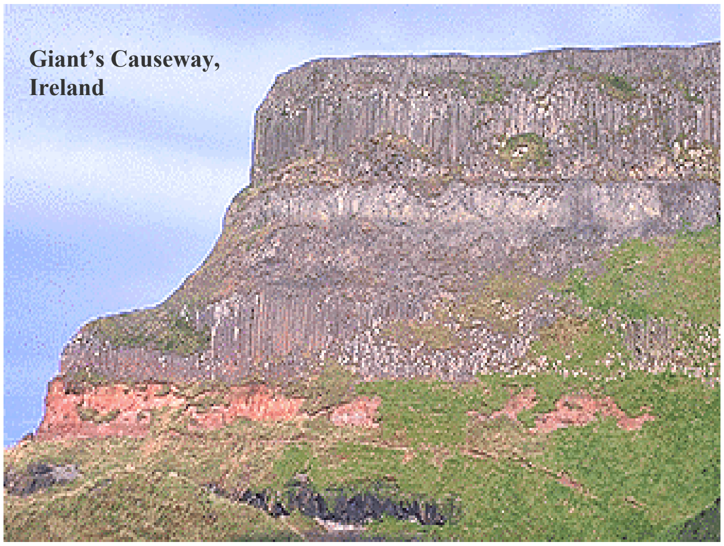
Continental Basaltic Association

- Plateau basalts
  - Characteristics
  - Origin
- Local basalt fields
  - Basin and Range of USA

Examples of Plateau Basalts

- Columbia River Plateau, USA (T)
- Deccan, India (K-T)
- Parana, Brazil (J-K)
- Keeweenaw, Lake Superior (PreC)
- Karoo, South Africa (J)
- Greenland-Great Britain (K-T)





Plateau Basalt Characteristics

- Fissure eruptions, associated dike systems
- Huge volume (>10^5 km^3)
- Large discharge rate
- May herald the breakup of continents

Chemical Characteristics

- **Typically more evolved composition than MORB**
  - **Higher Si, K, Ti, P, and Ba**
  - **Lower Mg, and Ni**
- **Evolved, olivine-poor compositions**
  - **Suggest some fractionation prior to eruption**

Isotopic Evidence

- **Low initial Sr isotope ratios (<0.704)**
  - **Suggest partial melting of upper mantle peridotite**
- **High initial Sr isotope ratios (>0.704)**
  - **Suggest contamination with crustal materials**

Origin of Plateau Basalts

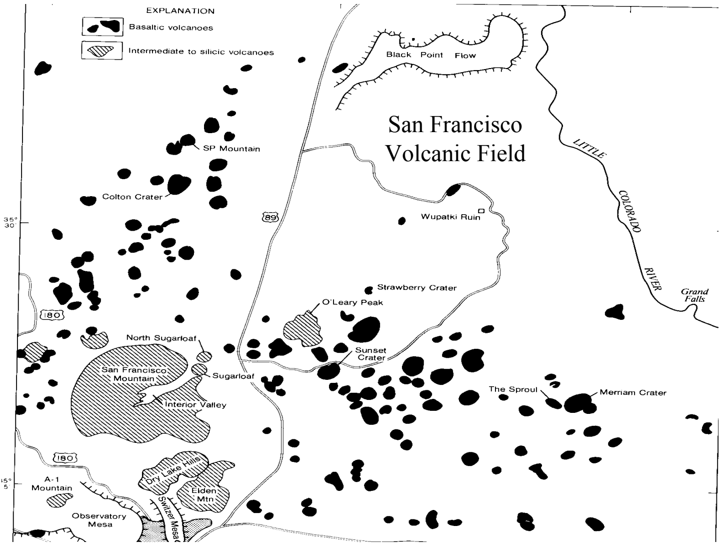
- **Low degree of fractionation**
- **Low initial Sr isotope ratio**
- **Phase relationships**
- **Suggest an origin from a peridotite zone within the asthenosphere at a depth between 60 to 100 km**

Local Basalt Fields

- **May occur in areas of continental extension**
  - **Basin and Range of western USA**
- **Characterized by scoria cones and lavas**
- **Some surround composite andesitic cones**
- **Minor bimodal basalt-rhyolite (pyroclastic) association**

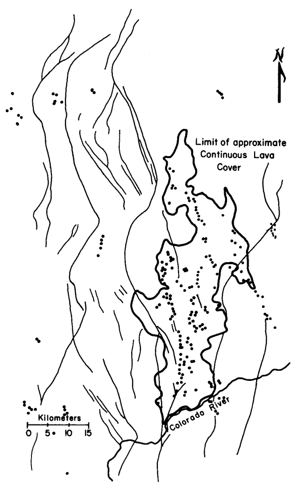
Basaltic Scoria Cone Fields

- 10s to 1000s of cones
- General elliptical shape
- Aspect ratio of 2:1 to 5:1
- 10 to 70 km in length
- Areas of extensional tectonics
- Elongate perpendicular to tension
- Widespread in western USA
- Pinacate example



Small Fields

- North rim of Grand Canyon
- Scoria cones aligned along fault planes



Origin of Local Continental Basalt Fields

- Hot magma from the mantle intrudes rifting crust
- Accumulation of basalt at depth melts silicic crust
- Silicic melt buoyantly rises to shallow chambers
- Shallow chambers erupt to produce evolved pyroclastic deposits

Oceanic Subalkaline Basaltic Association

- Two types of basaltic provinces
  - Intraplate volcanoes (hot spots)
  - Spreading plate boundaries (ocean ridges)
- Iceland
- Oceanic rifts
  - Mid-Atlantic rise
  - East-Pacific rise

Iceland

- Subaerial outcropping of the mid-Atlantic ridge
- No continental sial is present
- Mostly contains quartz tholeiitic
- Minor alkali basalts
- A few eruptive centers
  - Fe-rich andesite, dacite, & rhyolite
  - Produced by olivine fractionation
- Origin from rising mantle plume?

Icelandic Shields

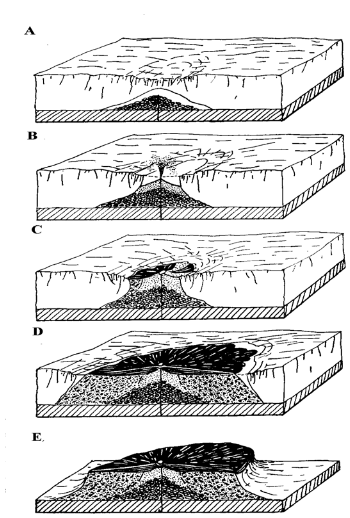
- Moderate size
- Extremely symmetrical
- Small size >800 m high
- Uniform slope ~ 8º
- Tube-fed pahoehoe lavas

Subglacial Volcanoes

- Pillow lavas
- Pillow breccias
- Hyaloclastites
- Dikes
- Flat top with lava

Sub-glacial

- Sequence of intrusion
- Final form is a table mountain



Oceanic Rifts

- Their lavas comprise 70% of the earth's surface
- Sea floor spreading is the mechanism of their origin

Oceanic Lithosphere

- Layer 1
  - 0 to 1 km thick, sediment
- Layer 2
  - 1 to 3 km thick, basalt flows, pillows breccia, dikes
- Layer 3
  - 4 to 8 km thick, fractured mafic intrusions
- Below layer 3 is is subcrustal peridotite

Ocean Floor Basalts

- MORB
  - Reference composition to other basalt types
  - See book Table 5-5 for chemical characteristics
- Low K_2O content & large-ion lithophile elements
- Originate in the mantle
- Partial melts within the asthenosphere
- Olivine tholeiitic composition (Ol and Hy in norm)

Ocean Floor Lavas

- Evidence of disequilibrium
  - Corroded phenocrysts of Mg olivine and Ca plagioclase
  - Chemically evolved groundmass
  - Anomalous melt inclusions
- Uniform composition of lavas
  - Suggest recurrent mixing in shallow chambers under rifts

Depleted Magma Source

- Several lines of evidence
  - Extremely low concentrations of incompatible elements
  - Rb/Sr ratio too low to yield Sr isotopic ratio (~0.703)

Models for Ocean Floor Lavas

- Thin lid model
  - Primitive lavas fed from center of chamber
  - More fractionated materials from margins
- Evolving system
  - Several small chambers at different stages of fractionation
- Strong role of crystal fractionation
  - Supported by presence of mafic cumulate horizons

Ophiolites

- Alpine ultramafic bodies
- Hartzburgitic type
  - Mainly hartzburgite and dunite
  - Minor dikes & veins of other types
  - Can not be the source of basaltic magmas by melting
- Lherzolitic type
  - Mainly lherzolite , minor pyroxenite
  - May yield basaltic magmas by partial melting

Alpine Ultramafic Association

- Steinmann trinity
  - Ultramafic rocks
  - Pillow basalts (spilitic = metasomatized basalt)
  - Chert (with argillite and limestone)
- Origin by obduction
  - Ocean floor thrust onto continental crust during mountain building

Ophiolite Sequence

- Refractory residue of upper mantle hartzburgite
  - Deformed and drained of low-melting point materials
- Overlying fossil magma chambers
- Capping of fractionated basaltic lavas and dikes
  - Sheeted dike complexes