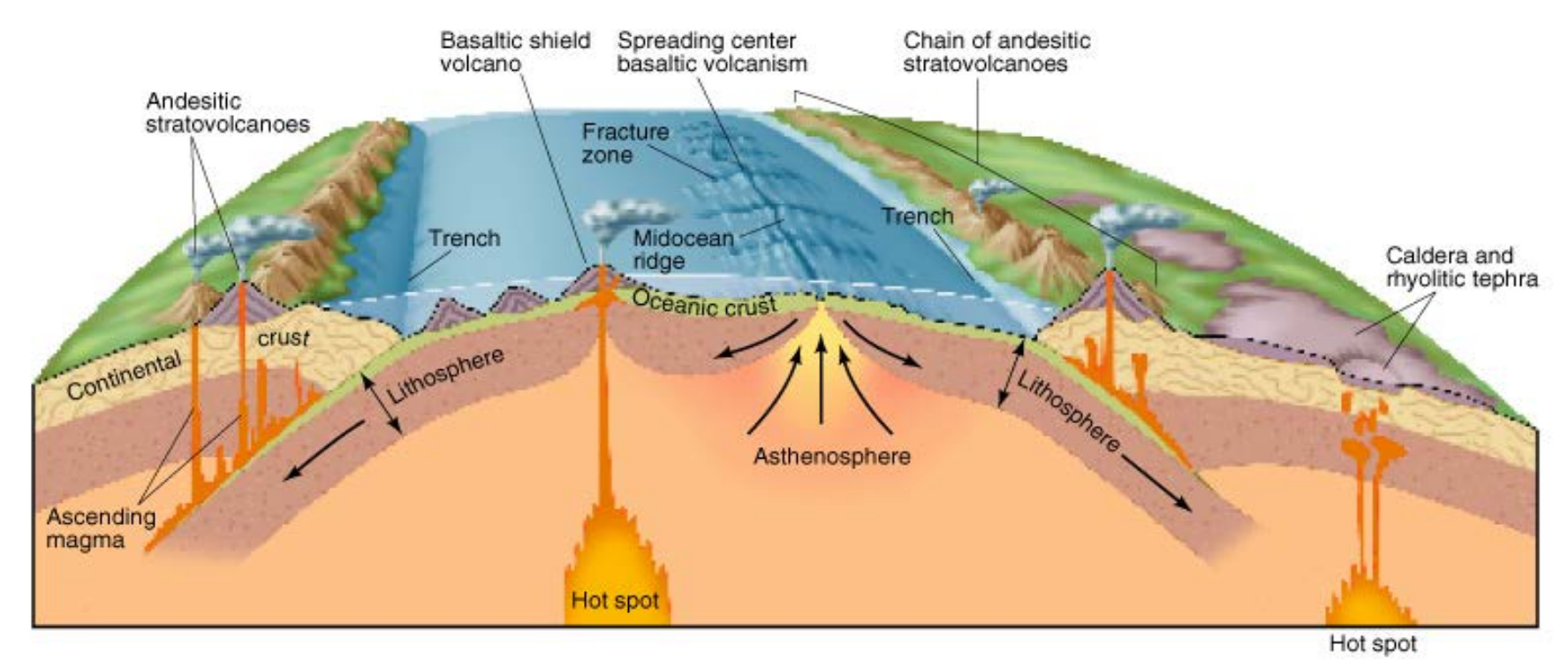
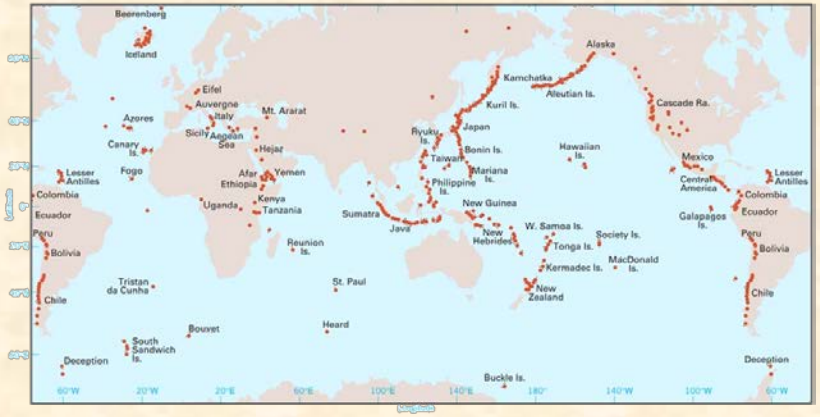
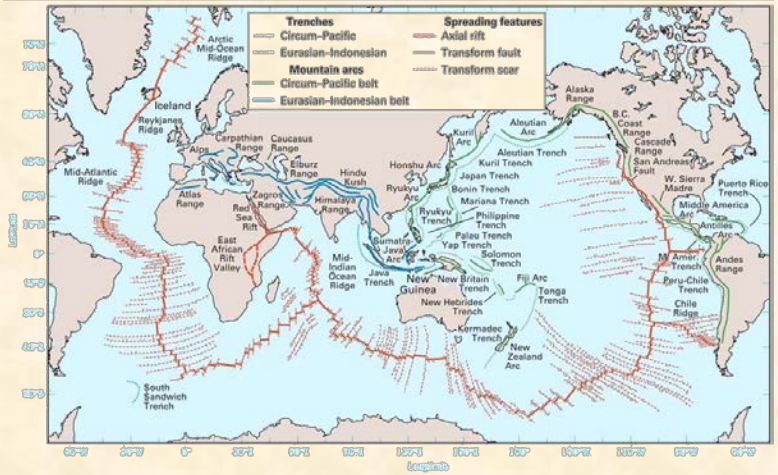
Volcanic Landforms and Processes







Background

Volcano: a rupture in the crust of a planetary-mass object (Earth) that allows lava, volcanic ash (tephra), and gasses to escape from a magma chamber below the surface.

Classification Based on Activity:

Active: have been observed in eruption during historic time

Cotopaxi, Ecuador

Dormant: have no historic record but show evidence of geologically recent activity

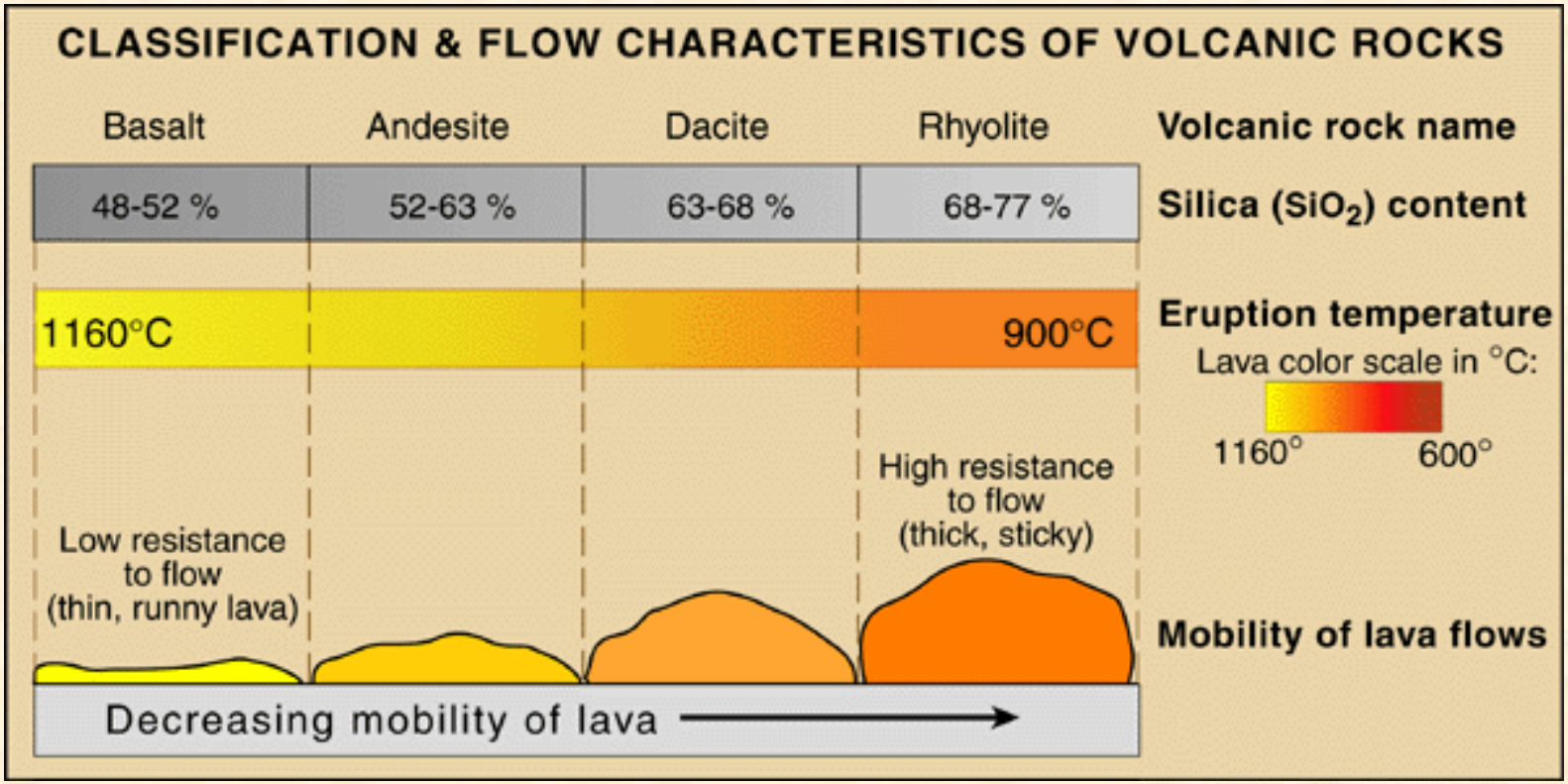
El Capitan, Arizona

Extinct: geologically dead

Background

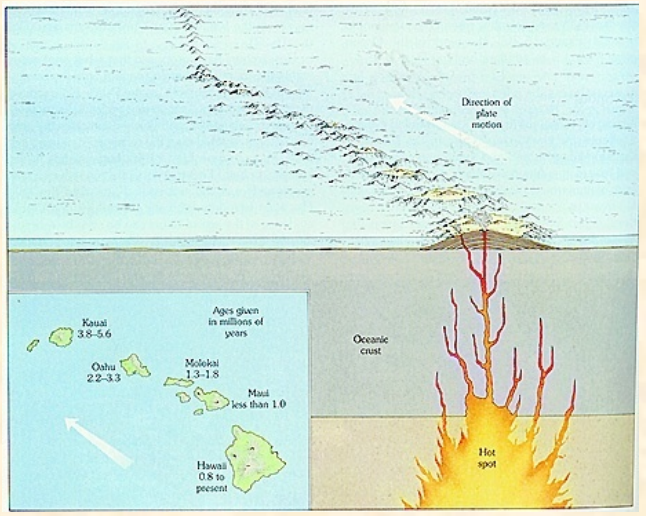
Igneous Landforms: result from both constructive and erosional processes

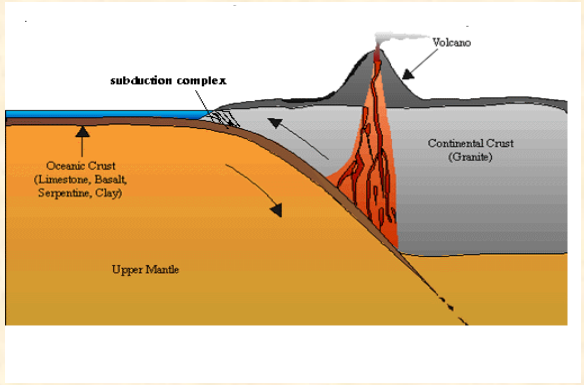
- Eruptions at the surface produce volcanic landforms primarily controlled by the type of magma (basaltic, andesitic, rhyolitic)
- Subsurface injection and differential erosion produce secondary landforms (dikes, sills, batholiths etc.)
- Viscosity influences the style of eruption, flow characteristics of lava and resulting landforms (temperature, composition, gas content)



Viscosity: resistance to flow

- Tectonic setting
- Source of lava
- Composition



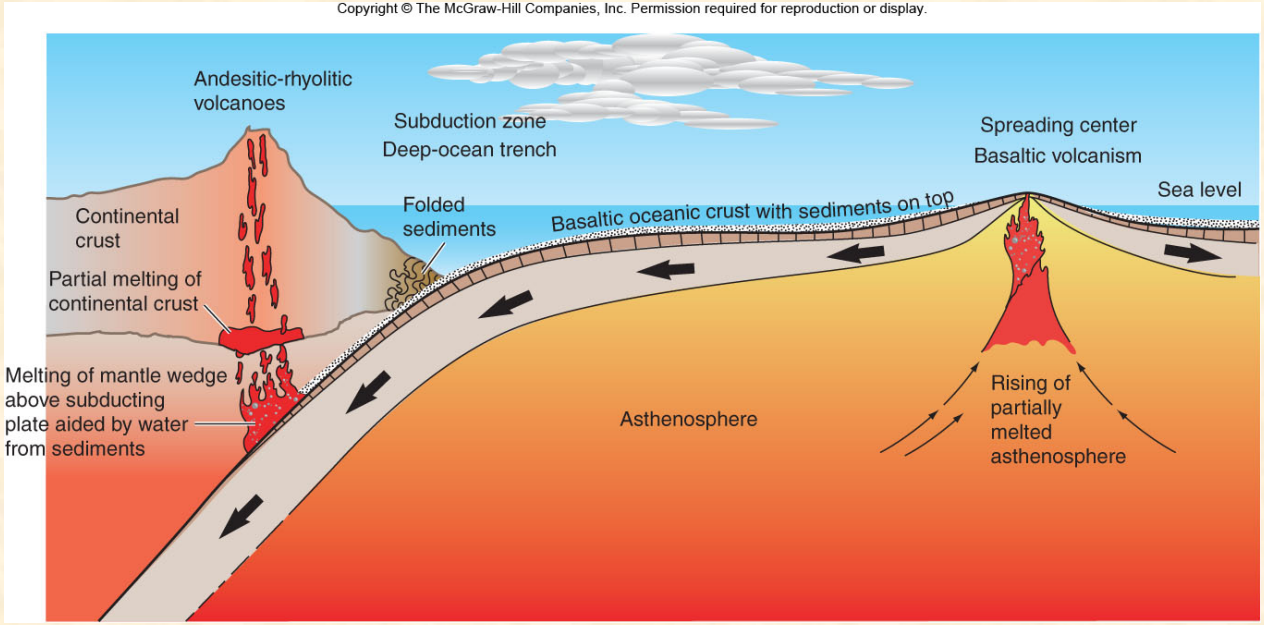


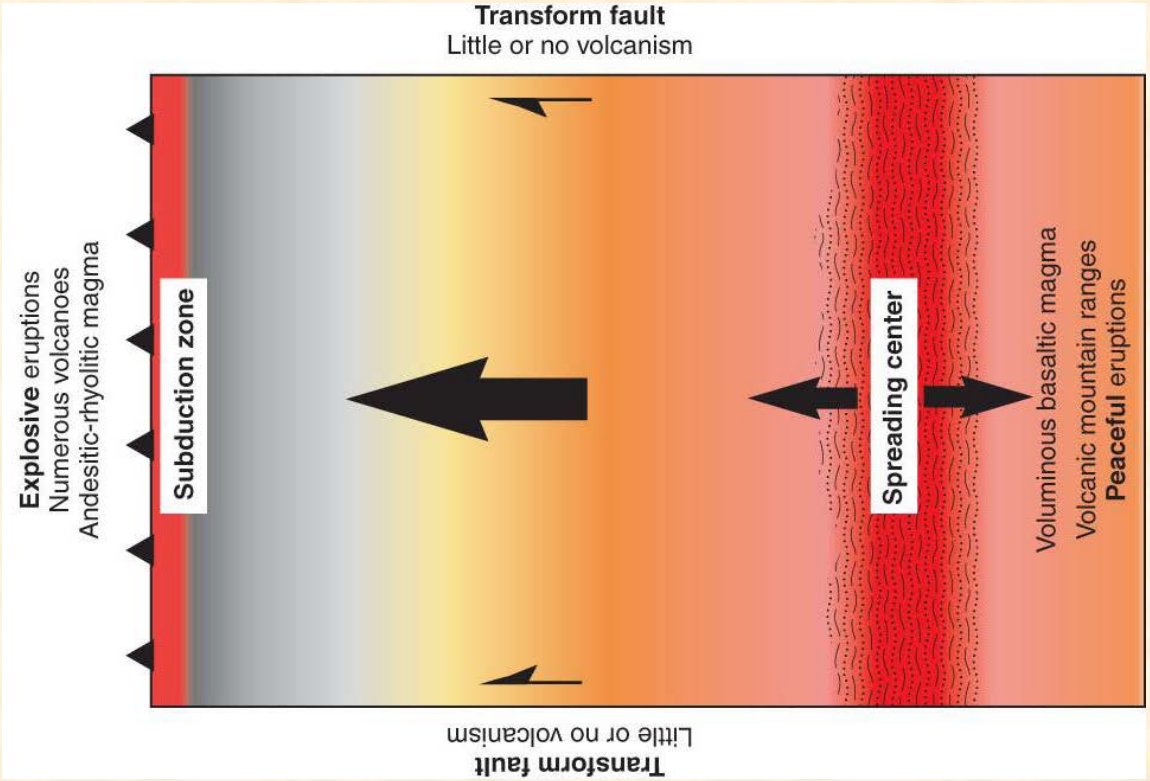
Andesite: sediments, water, oceanic crust and continental crust

Intermediate composition

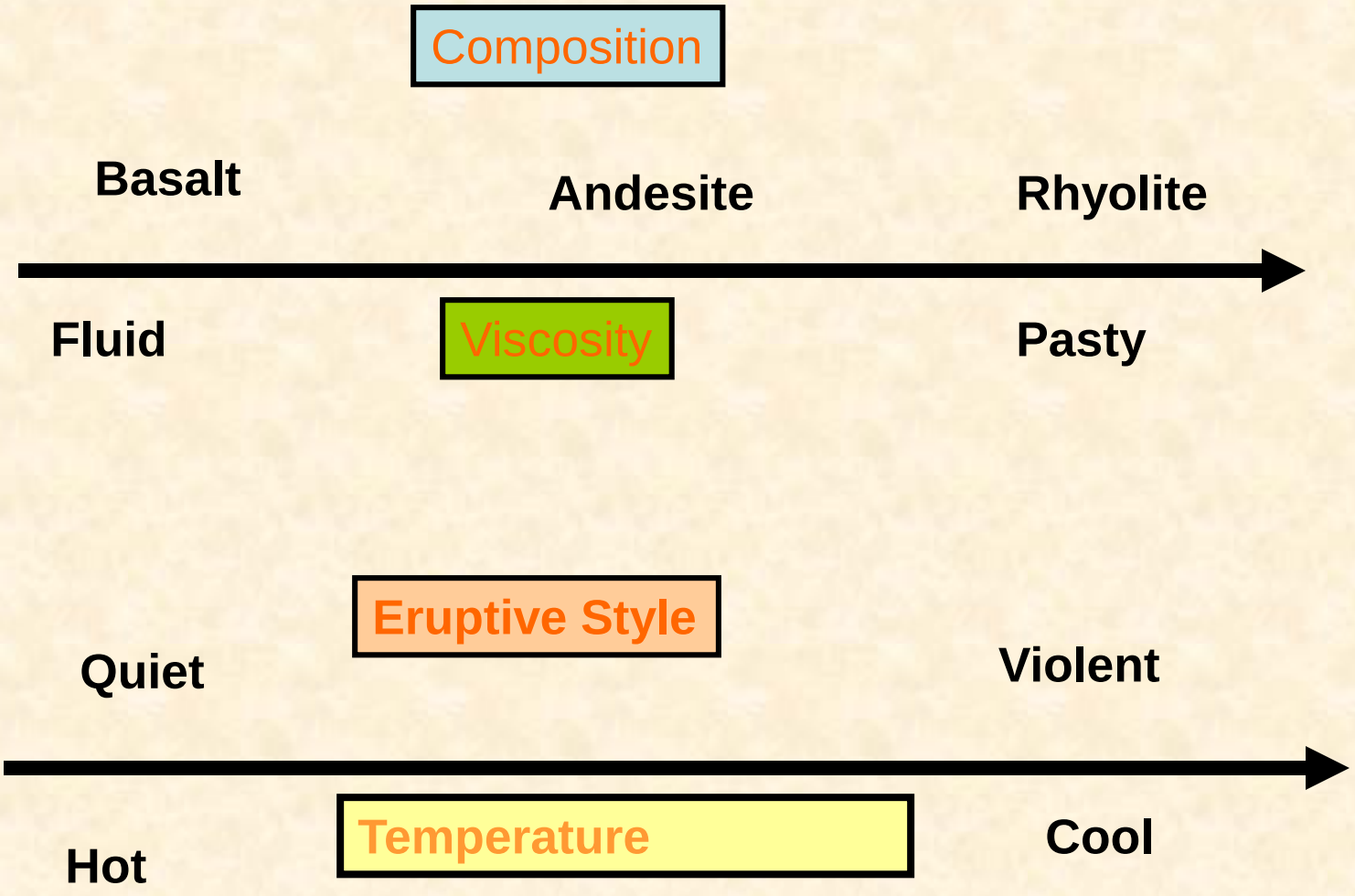
Basalt: asthenosphere and oceanic crust

Lower percentages of silicon and oxygen



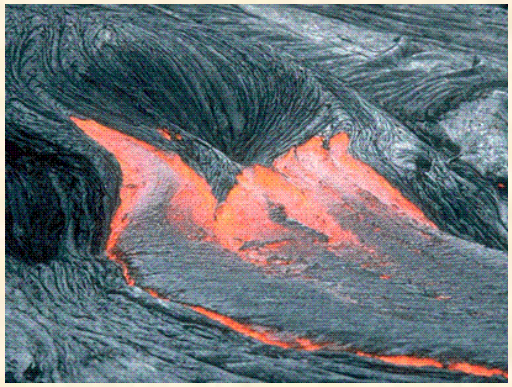


Composition, Viscosity and Eruptive Style



Eruption Products

Lava: molten rock extruded from the magma chamber through fissures or central vents of the volcanic cone.



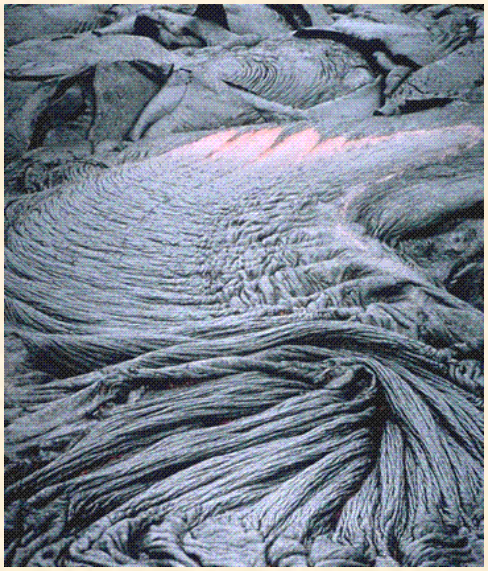
Tephra: all fragmental material produced by a volcanic eruption regardless of composition, size or emplacement mechanism. Often characterized based on size. Ash, cinders, bombs, blocks

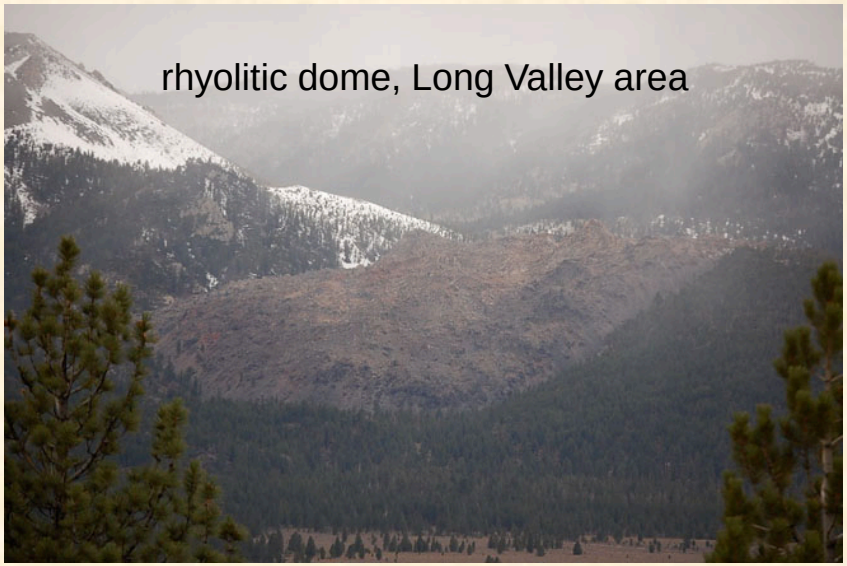
Gases: release of pressure and the rate of degassing of magma influences severity of eruption (tied to **viscosity**)

Eruption Products

Lava Flows

- Topographic features vary considerably with the composition of magma.
- Basalt: fluid, forms thin laterally extensive flows
- Siliceous, viscous magmas (rhyolite/dacite) form thick pasty flows with steep margins.
- Lobate forms, lava levees, crescent-shaped pressure ridges, irregular surfaces and lack of surface streams



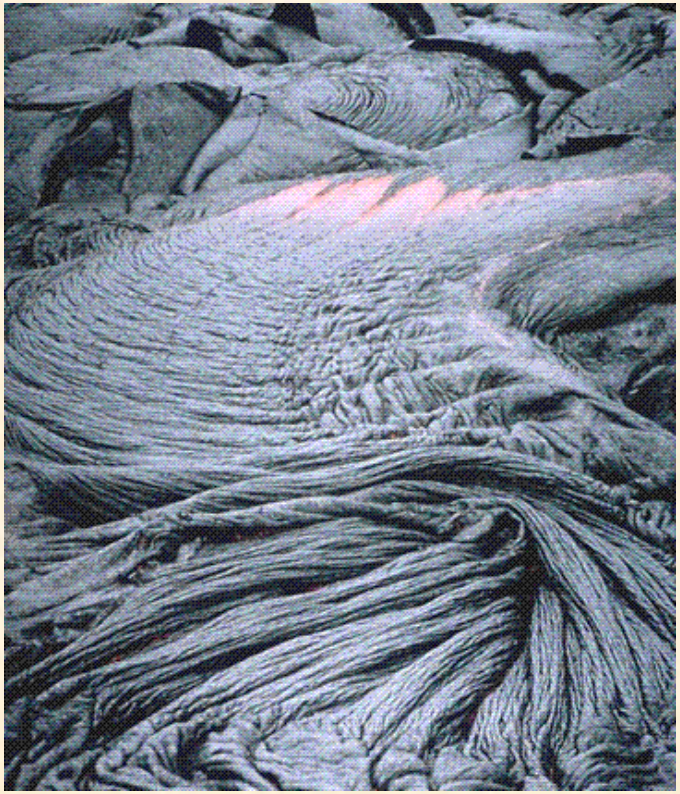


rhyolitic dome, Long Valley area

Eruption Products

Pahoehoe lava → **Aa lava** (pronounced aa-aa)

- Basaltic lava
- Low viscosity
- Cools moderately slowly
- Ropelike appearance

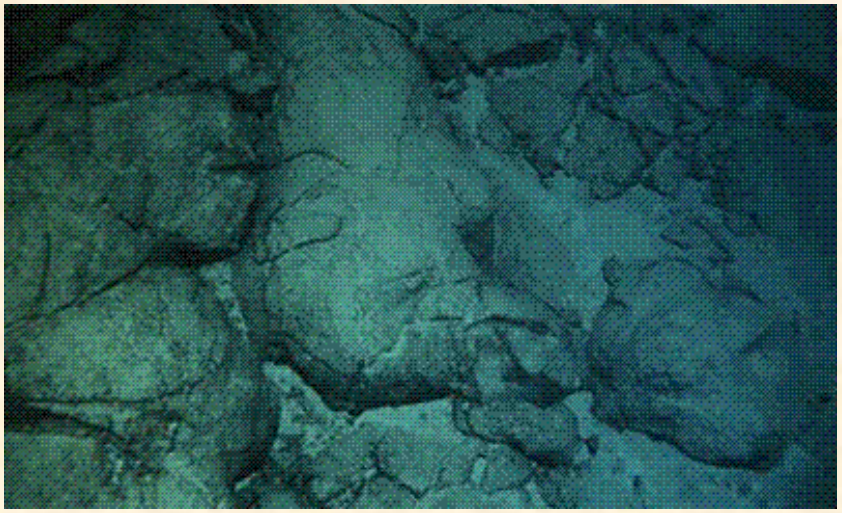


- Basaltic lava
- Higher viscosity
- Solidifies while flowing
- Angular pieces

Eruption Products

Pillow Basalts

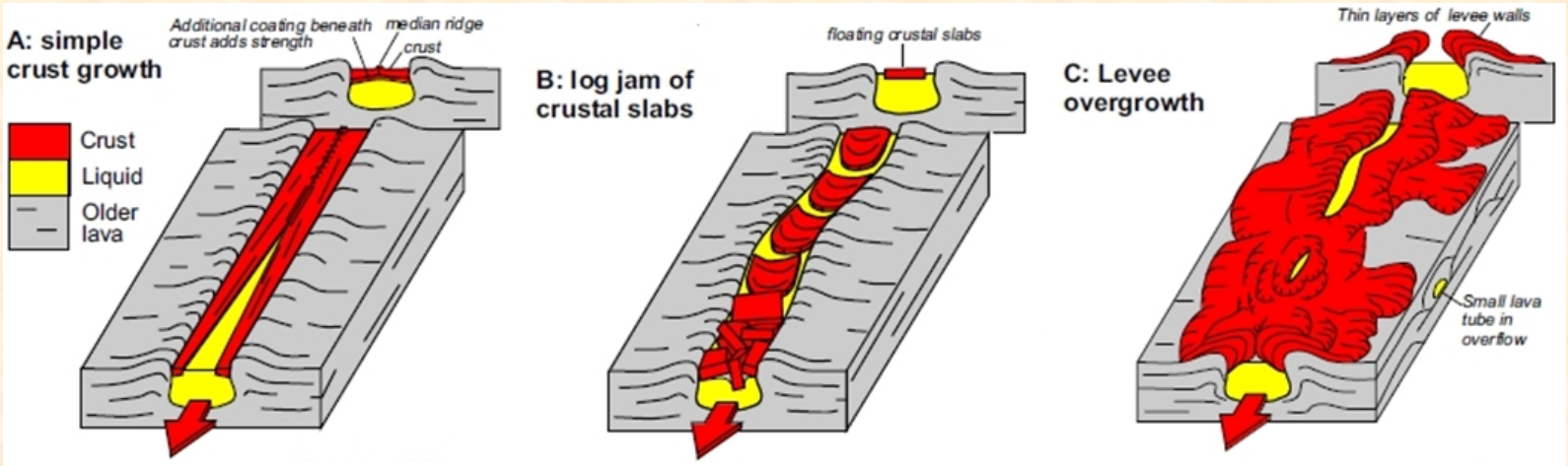
- Lava extruded underwater
- Cools and contracts
- Spherical masses
- Ocean floor

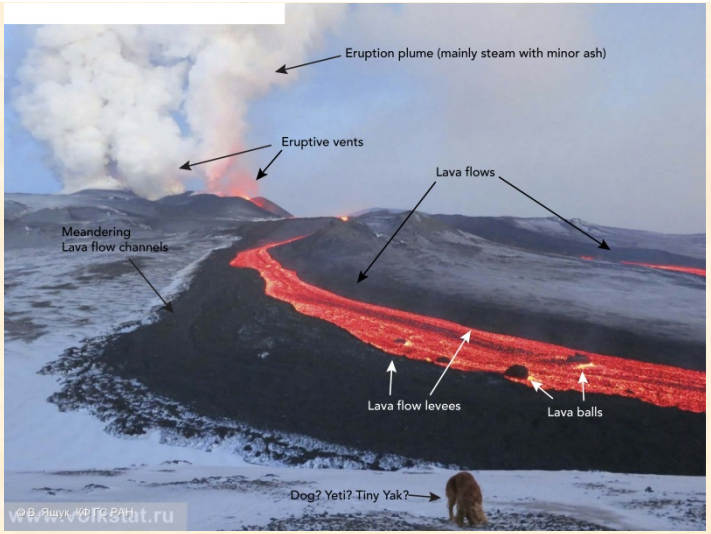


Eruption Products

Lava Levee

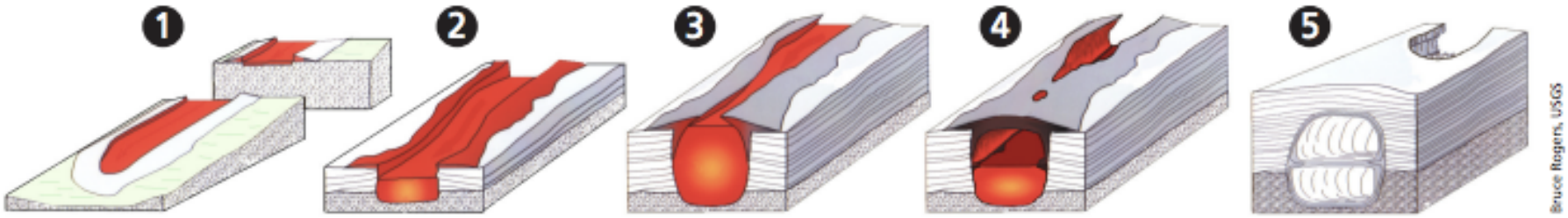
– Surface cooling, movement of crustal slabs to the flanks due to flow structure, eventual overtopping





Eruption Products

Lava Tubes



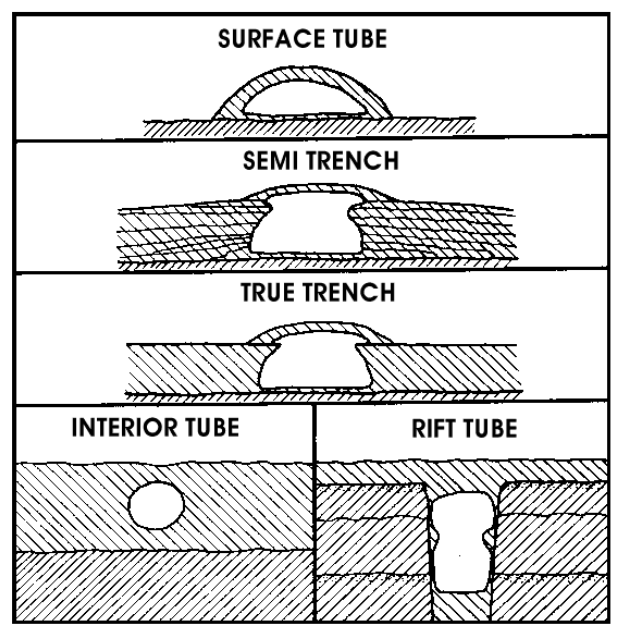
Lava flows from volcanic eruptions tend to become "channeled" into a few main streams .

The overflows of lava from these streams often cool and solidify, creating stacked layers of lava around the flow.

After many hours or days the lava melts downward into the ground giving the tube a taller, more narrow cross-section.

A solid crust can form overhead and enclose the tube. The tube then insulates the flowing lava within, allowing it to flow great distances.

After the eruption subsides and the flows harden, these lava tubes become a cave, sometimes with remnants of the ebbing lava flow preserved.



Eruption Products

Pressure Ridges (tumulus/tumuli)

- outer edge of the lava flow hardens and restricts the advancing lava underneath

Eruption Products

Tephra: generic classification for all eruption generated fragmented material

- **pyroclasts**: airborne fragments
- Size Classification

  Ash: particles < 2mm in diameter, rock, glass, minerals

  Lipilli: or **cinders**, 2mm – 64 mm in diameter, vesicular texture

  Bombs: > 64 mm in diameter, molten projectile

  Blocks: > 64 mm in diameter, solid projectile

Eruption Products

Volcanic Gases

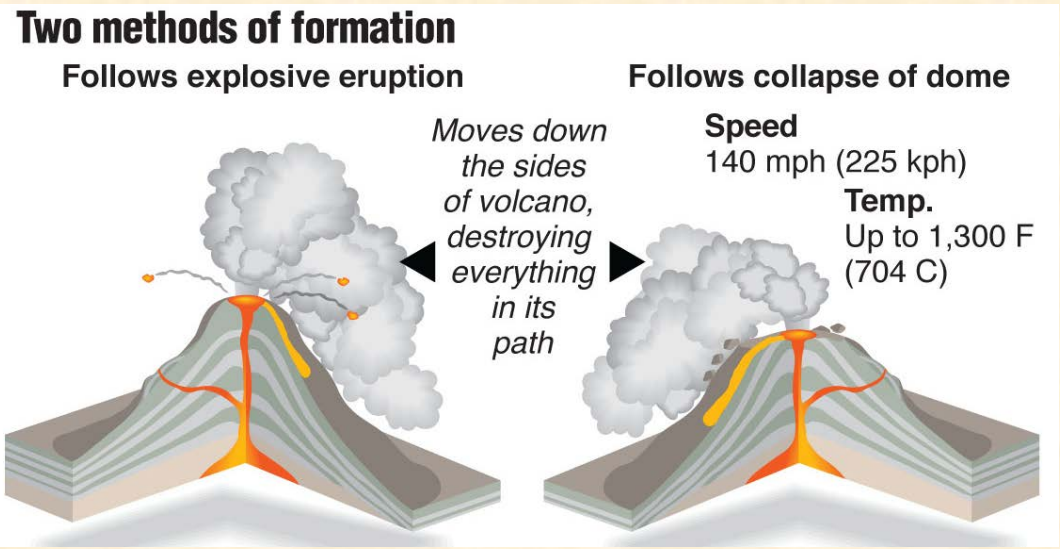
- Volatiles
  - H_2S – Hydrogen sulfide
  - H_2O – Water vapor
  - SO_2 – Sulfides
  - CO_2 – Carbon dioxide
  - N_2 – Nitrogen
  - HCl – Hydrochloric Acid

Contributes to eruption characteristics

- High gas content magma has the potential for violent eruptions when coupled with high viscosity
- Viscous, silica rich magmas trap gas
  - Expansion is prevented, pressure builds, eruption results in rapid degassing

Eruption Products

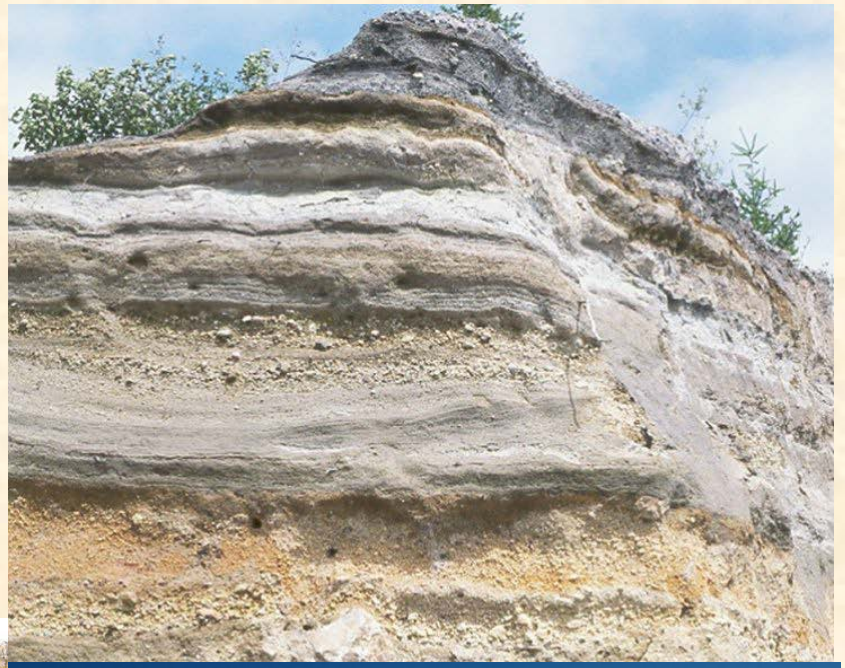
Pyroclastic Flow: high-speed avalanche of hot ash, rock fragments and gas generated during an eruption from rapid degassing of magma

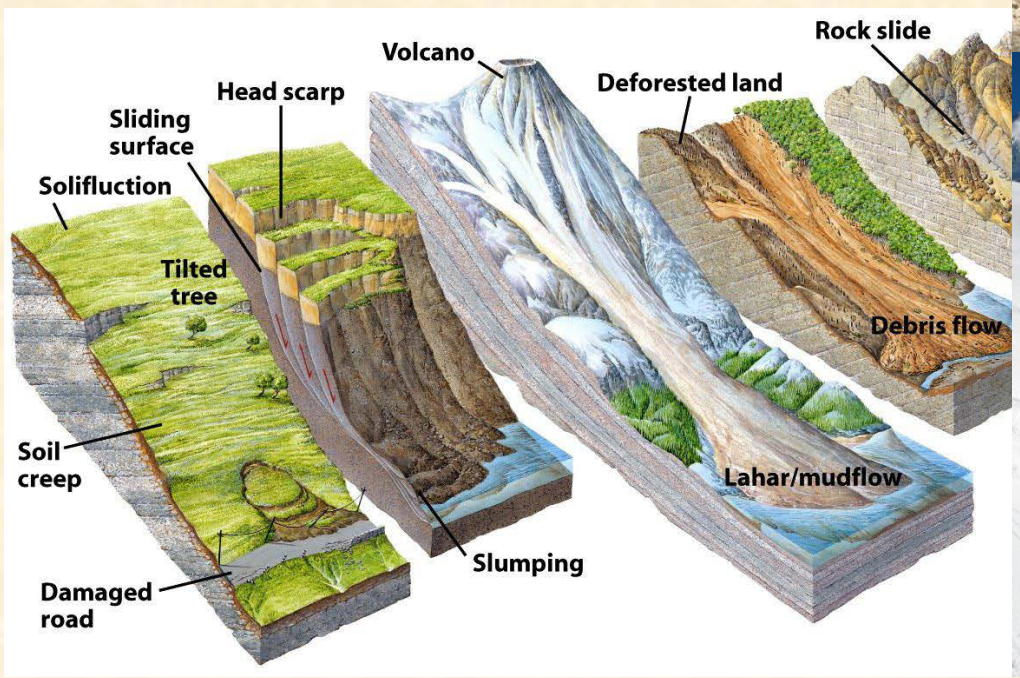


Eruption Products

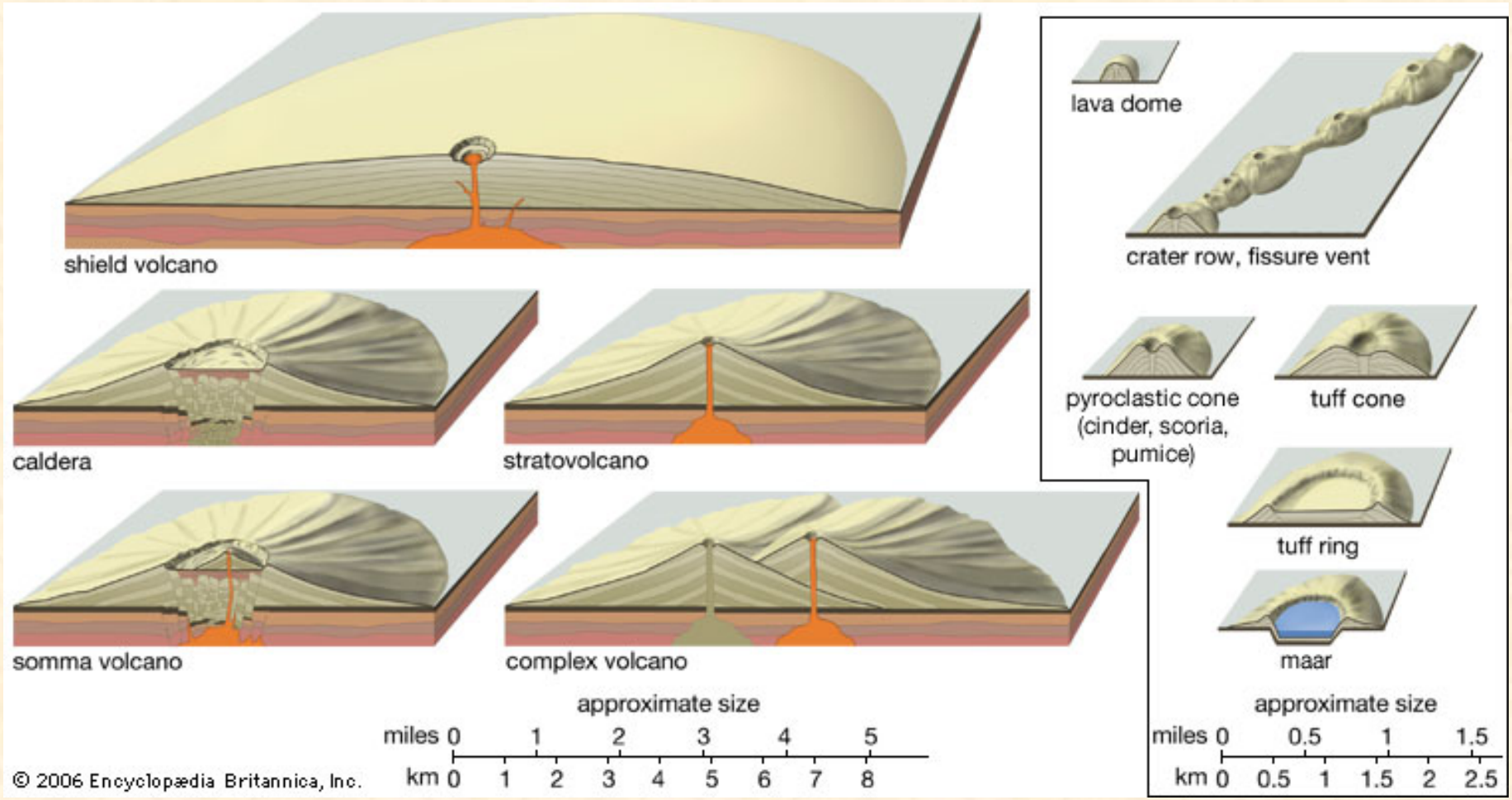
Lahar: mudflow (mass wasting event) generated when erupting magma comes in contact with snow/ice.

Fan deposits can show a classic fining upward sequence.





Volcanic Landforms



Note: forms tied to magma composition and viscosity

Volcanic Landforms

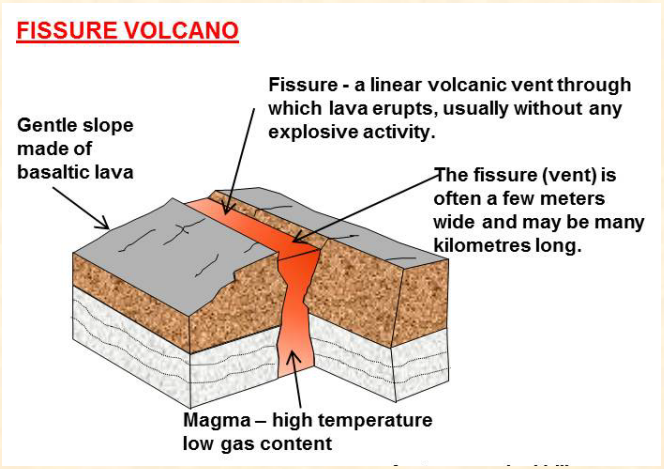
rock/magma type	silicon content and viscosity	common eruption style	common volcano form
rhyolite	very high	explosive	Caldera
andesite	high	explosive or effusive	stratovolcano
basalt	moderate	effusive	shield volcano , cinder cone

Special case: **Phreatic** eruptions occur when magma hits water. And the water flashes to steam explosively

Volcanic Landforms

Shield Volcanoes

- associated with mafic (Fe, Mg rich), low silica content lava (basalt)
- Lava thin, not viscous
- Holds little gas
- Usually quiet eruptions
- Lava travels long distances, spreads out in thin layers
- Shield volcanoes are rounded domes, with gentle slopes

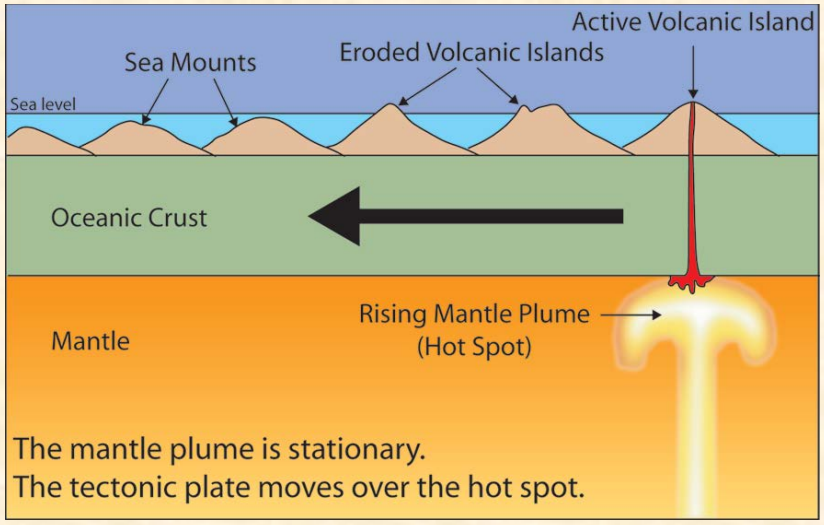


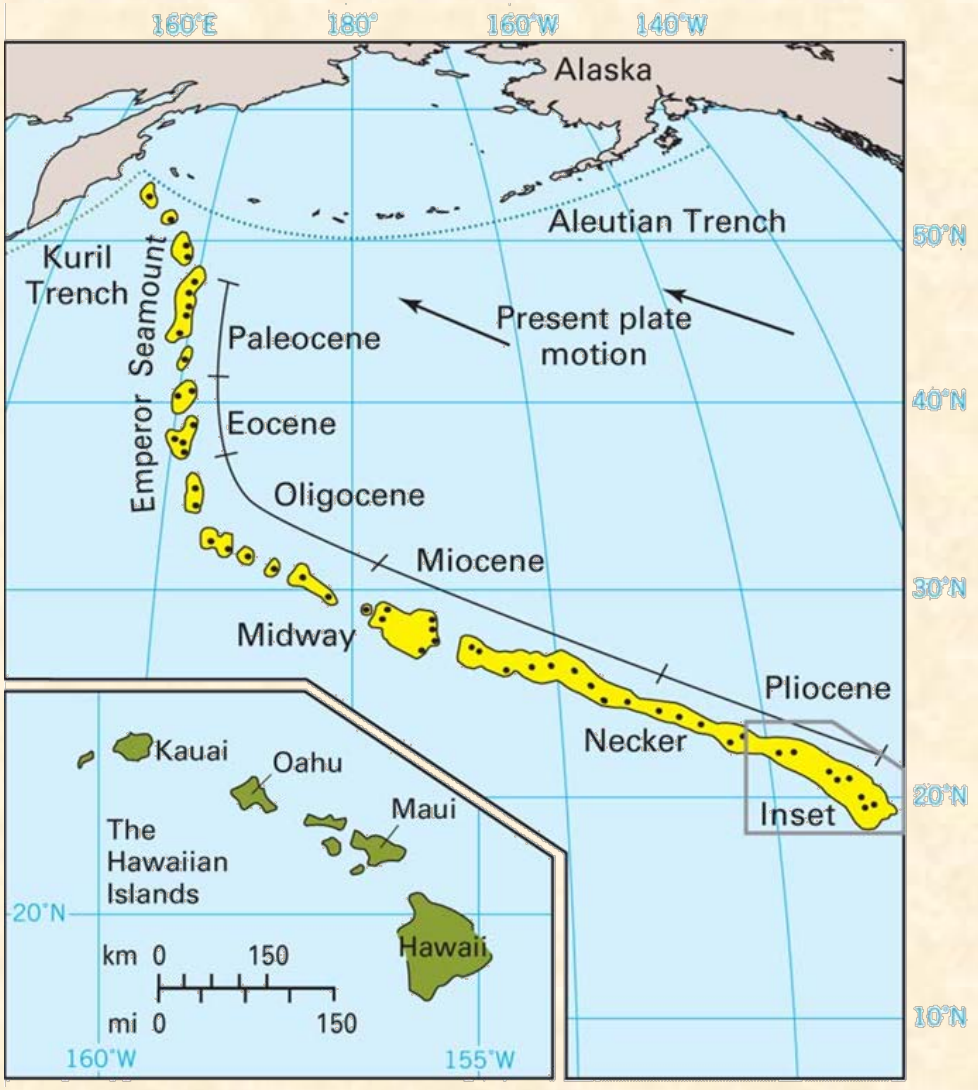
Shield Volcano: low, often large, dome-like accumulation of basalt lava flows emerging from long , radial fissures on flanks

Volcanic Landforms

Shield Volcanoes

- The Hawaiian Islands are classic examples hotspot shield volcanoes.
- Mauna Loa is over 9 miles high
- Active volcanoes at the southern end
- **Sea Mounts** submarine volcanoes
- ***Guyots*** flat topped wave eroded sea mounts at the northern end





Volcanic Landforms

Shield Volcanoes

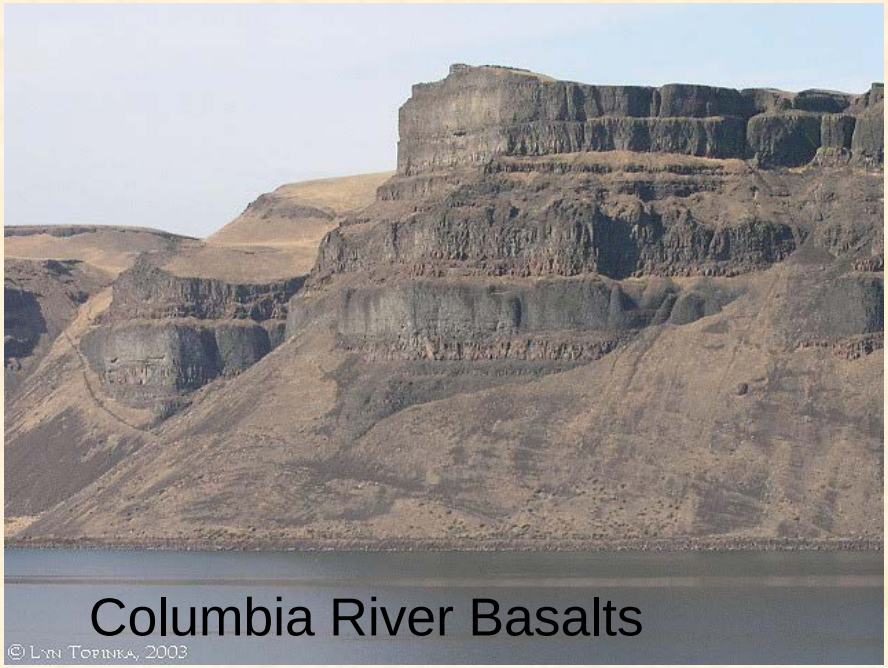
Basaltic lava also erupts:

- Along midocean ridges
  - Seafloor spreading
  - Many volcanic islands along mid-Atlantic Ridge
- Beneath continental plates
  - Hotspot generates large volume of basaltic lava
  - Forms flood basalts

Basaltic lava on Heimaey Island, Iceland, on mid-Atlantic Ridge

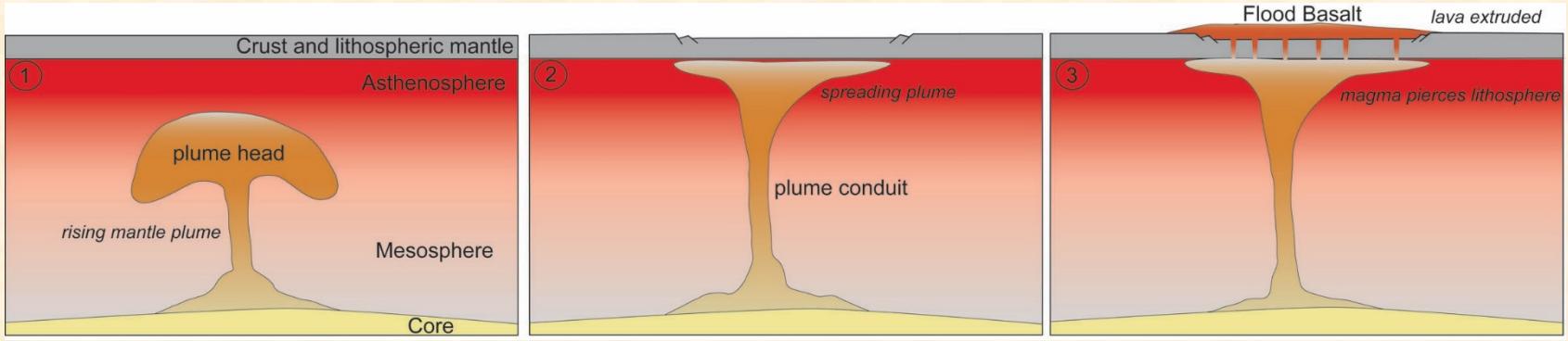
Continental flood basalts, Columbia Plateau, U.S.

Volcanic Landforms



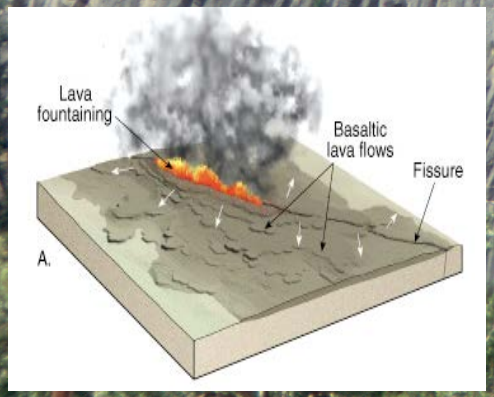
14-16 million years old

- Basaltic lava flows from fissures
- Layered structure
- Covers continental crust



Volcanic Landforms

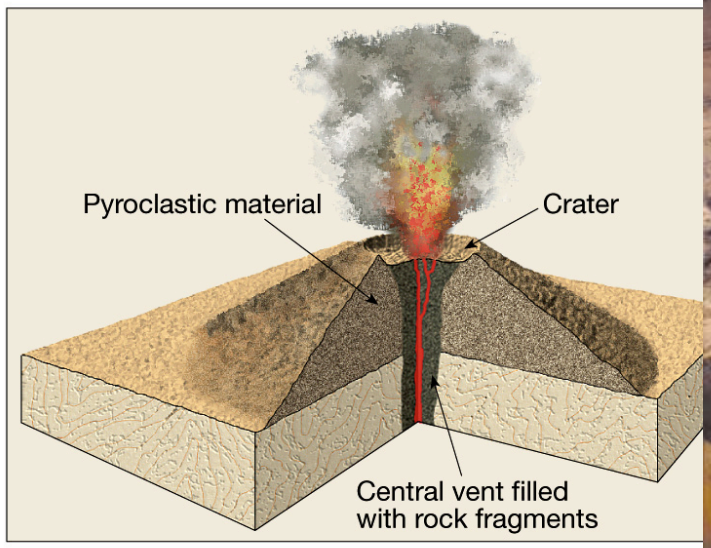
- Basaltic lava flows from fissures
- Layered structure, lava/sediments
- Columnar Jointing
- Basalt Plateaus or Flood Basalts
  - **Large scale landforms**



Volcanic Landforms

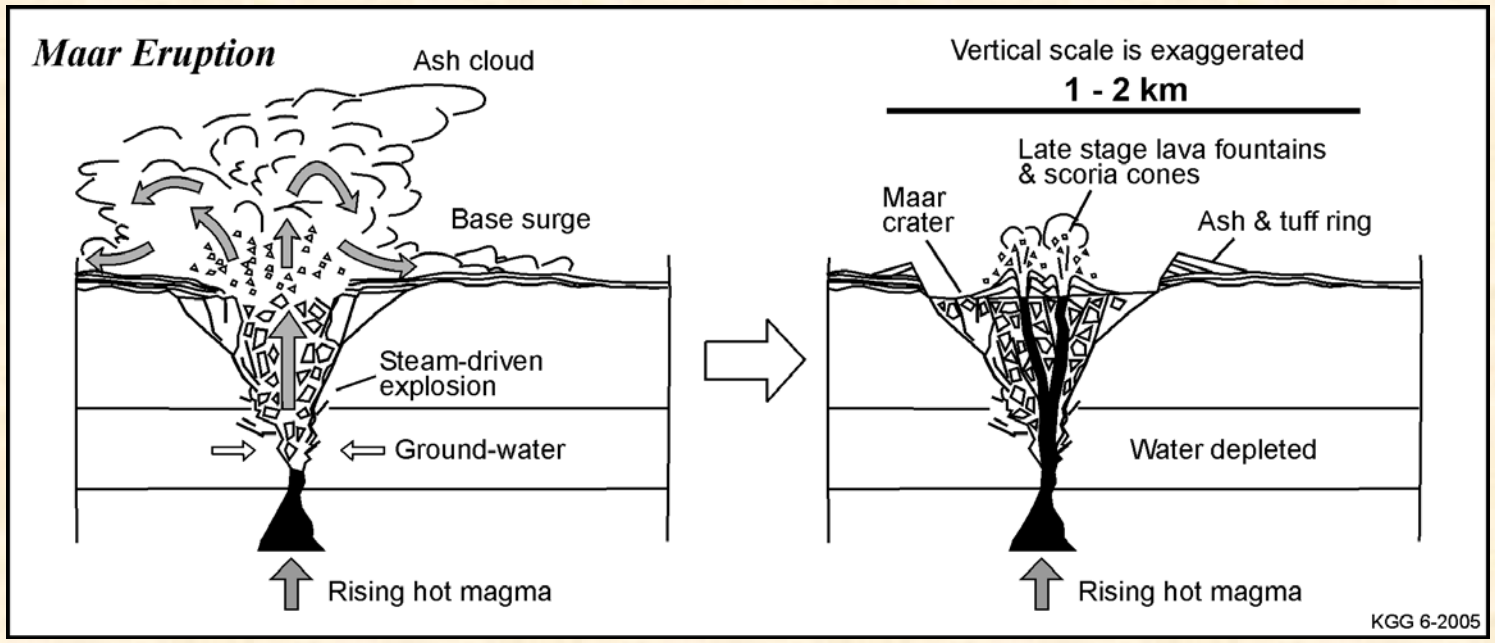
Basaltic **Cinder** (Scoria Cones) and **Spatter** Cones

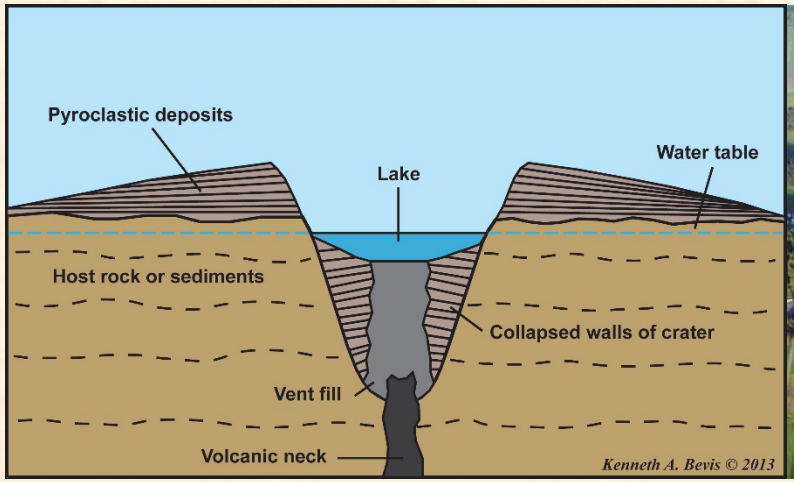
- Projectiles
  - Ballistic
  - Wind-borne
  - Tuff (ash) cones, rings, maars
  - Multiple along a fissure
- Tuff (ash) cones, rings, **maars**
  - **Phreatomagmatic** eruptions



Volcanic Landforms

Tuff Cones, Tuff Rings, Maars





Volcanic Landforms

Stratovolcanoes

The nature of an eruption depends on the type of magma involved.

Felsic (Feldspar, Silica Rich) lavas associated with stratovolcanoes

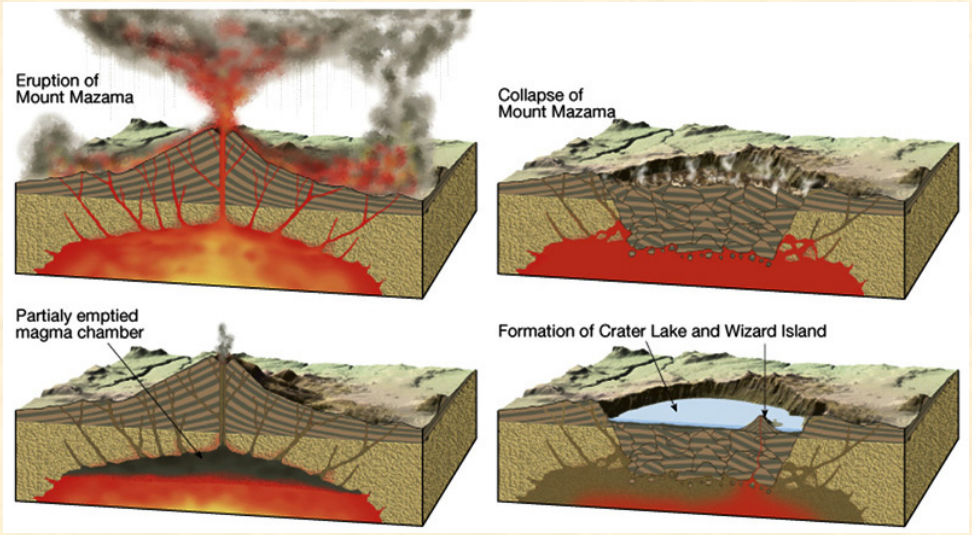
- Rhyolite, Andesite
- Thick, resistant to flow
- Builds steep slopes around volcanic vents
- Tall, steep cone, with crater

Stratovolcano: volcano constructed of multiple layers of lava and tephra

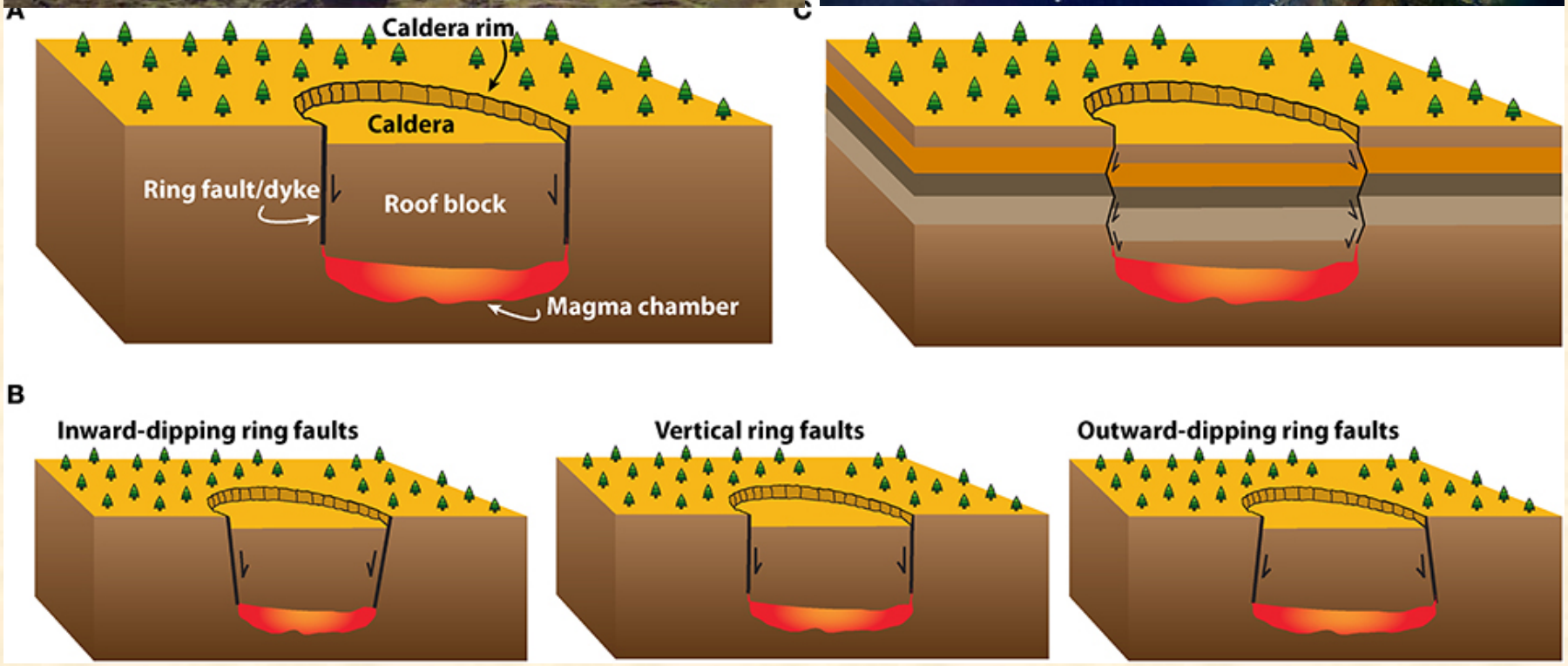
Volcanic Landforms

Stratovolcanoes

- Most active stratovolcanoes on circum-Pacific mountain belt
- Associated with subduction zones
- Felsic lavas produce explosive eruptions, degassing restricted due to high viscosity
- Central part of volcano may explode, or draining of magma chamber and collapse of roof block may create ***caldera***: central depression



Volcanic Landforms



Volcanic Landforms

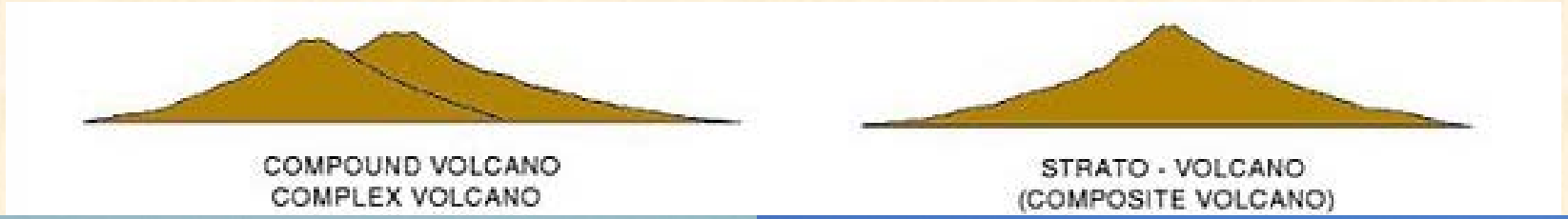
Mount Somma, Italy, summit caldera contains the upper cone of Mount Vesuvius

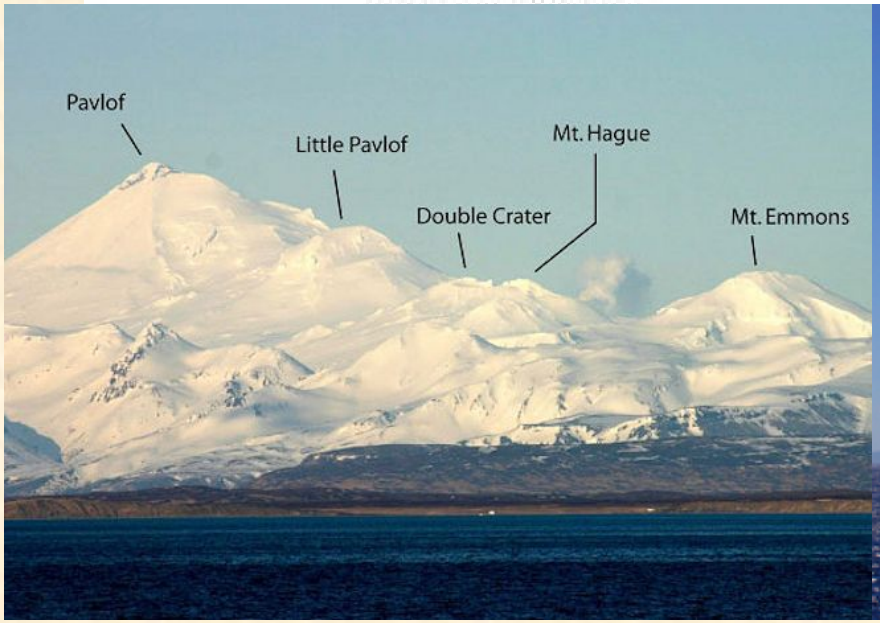
Somma: volcanic caldera partially filled by a new central cone

Volcanic Landforms

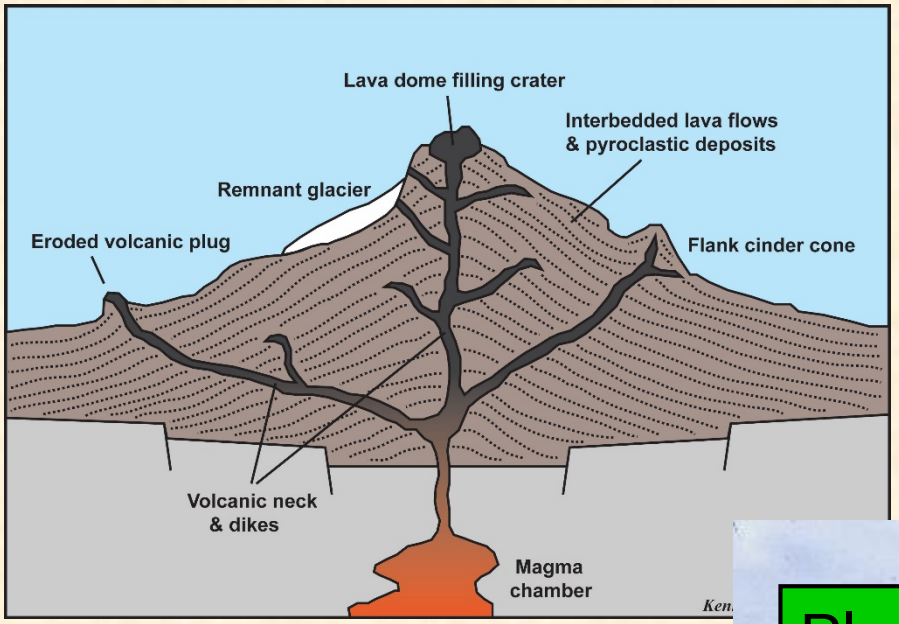
A **complex volcano**, also called a **compound volcano**, is mixed landform consisting of related volcanic centers and their associated lava flows and pyroclastic rock.

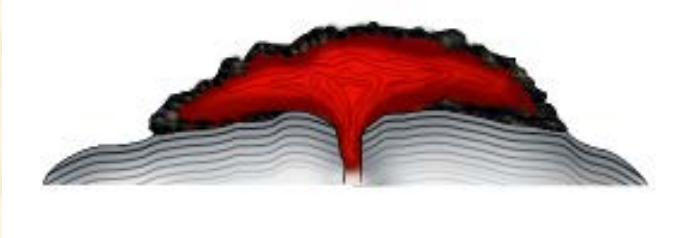
They may form due to changes in eruptive habit or in the location of the principal vent area on a particular volcano.



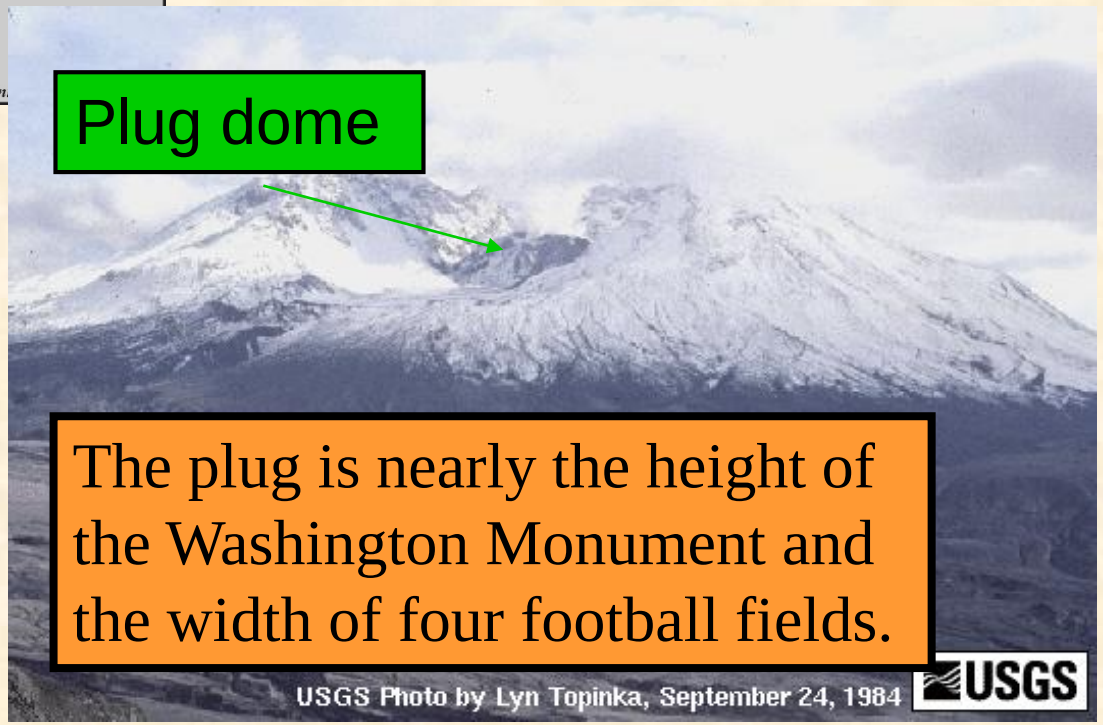


Volcanic Landforms

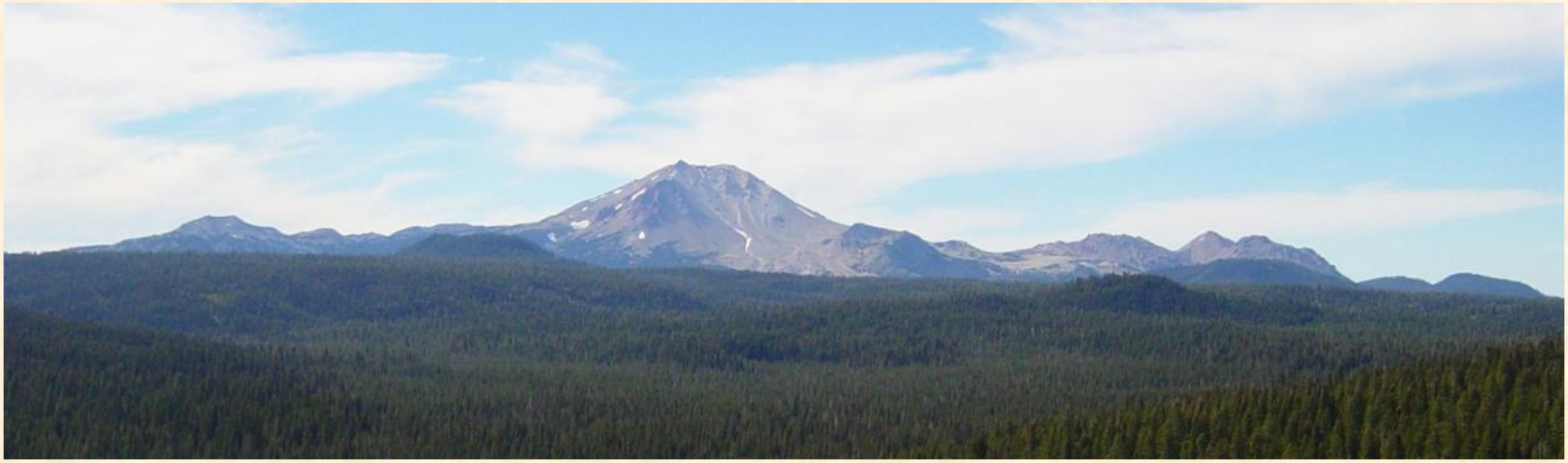




Lava Domes



Volcanic Landforms

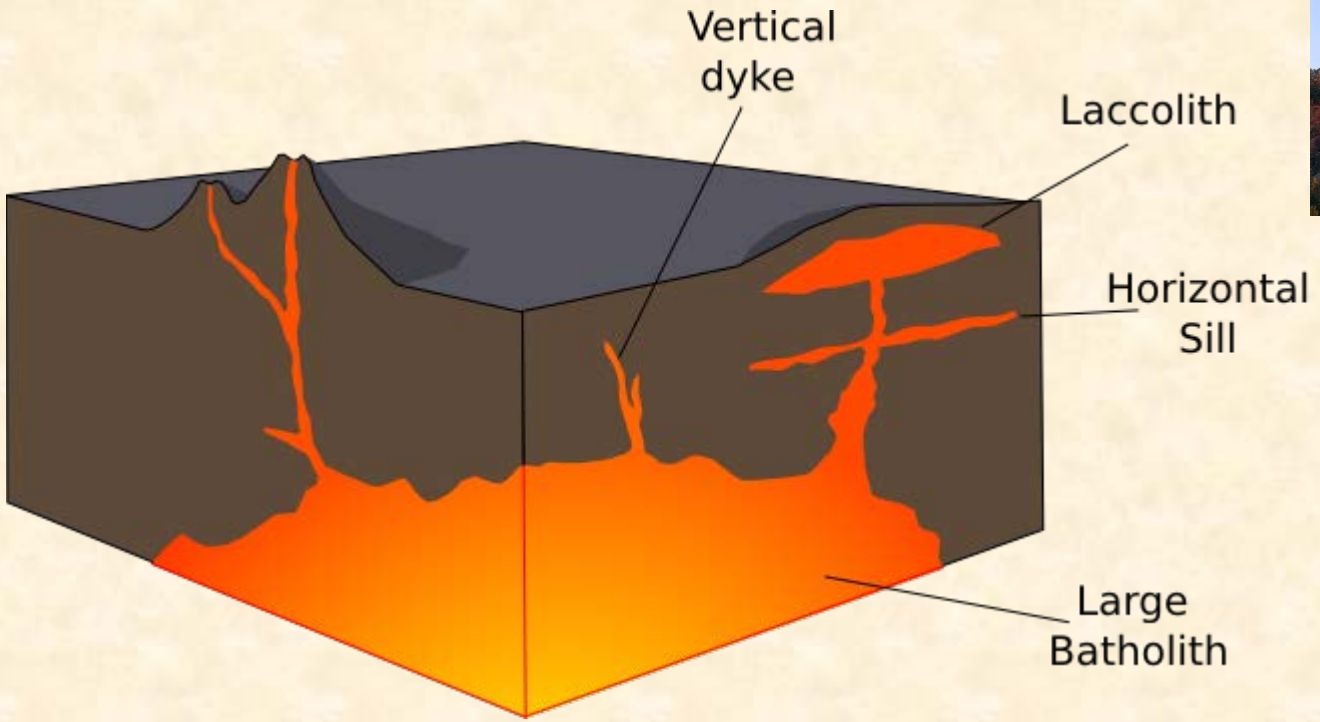


- Lassen Peak, CA is a plug dome volcanic landform
- Built from felsic lava
- One of the largest on Earth
- Carved by glaciers during the Ice Age

Igneous Intrusive Landforms

- **Denundation** exposes the features
- **Discordant Plutons**: cut across the bedding or foliation of the host rock (dykes, necks)
- **Concordant Plutons**: injections of magma parallel to the bedding or foliation of host rocks (sills, laccoliths)

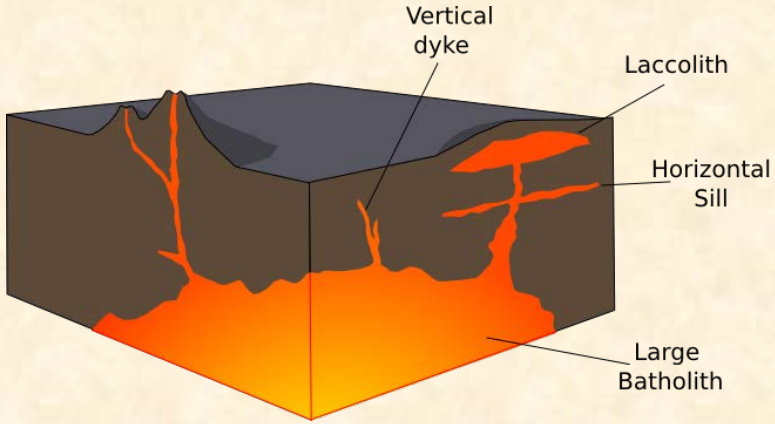
Devils Tower



Igneous Intrusive Landforms

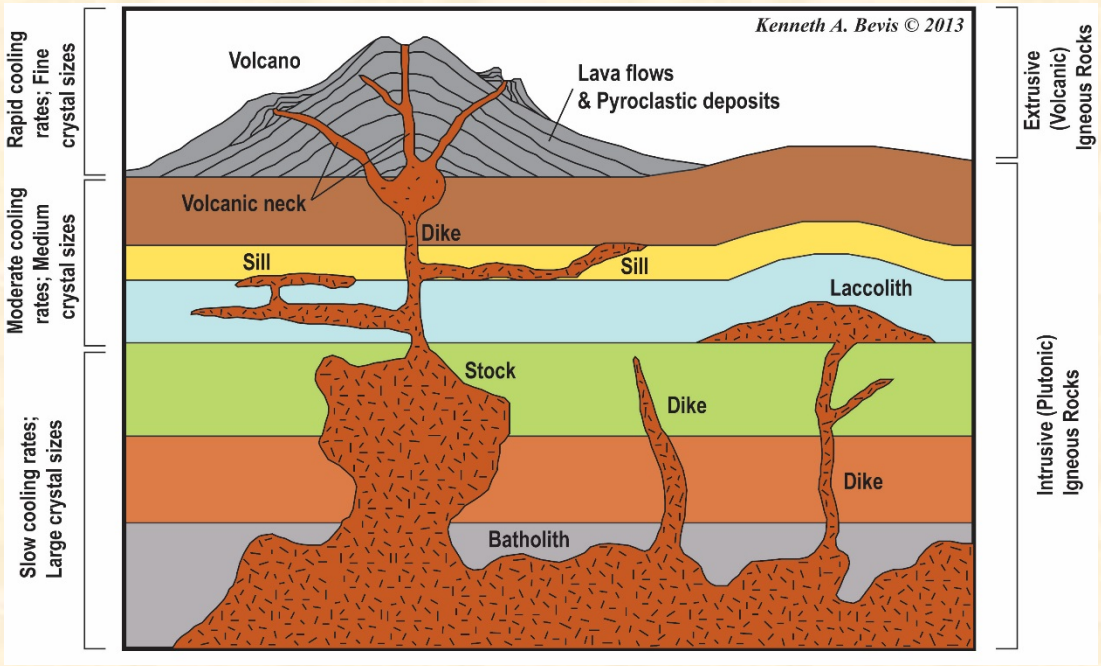
- **Discordant Plutons**: separated based on size
- **Volcanic Necks**: solidification of magma in the main conduit, exposed through differential erosion
- **Dikes**: tabular plutons, cut across bedding, usually associated with solidification in fissures

Shiprock, NM



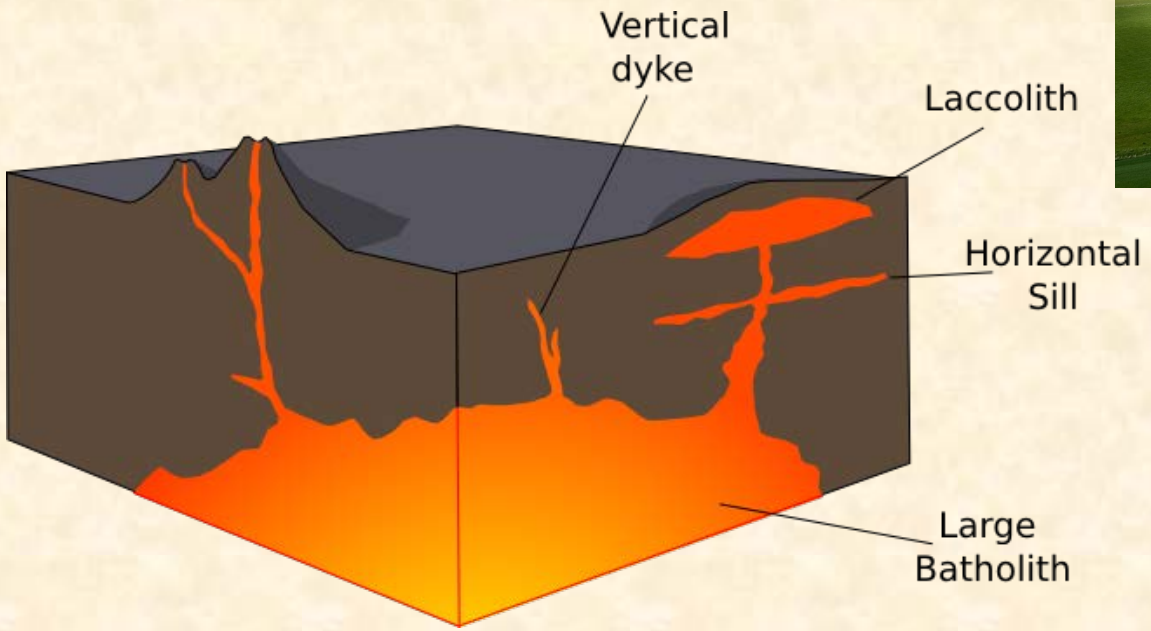
Igneous Intrusive Landforms

- **Discordant Plutons**:
- **Stocks**: irregularly shaped, larger than other intrusions < 100 km^2
- **Batholiths**: irregularly shaped, larger than other intrusions > 100 km^2



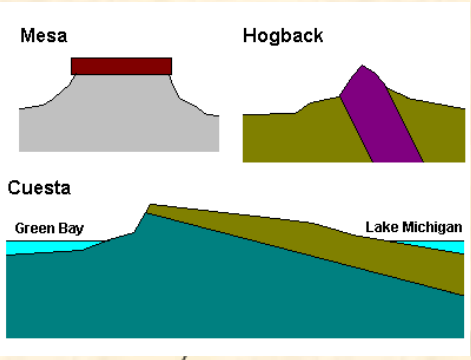
Igneous Intrusive Landforms

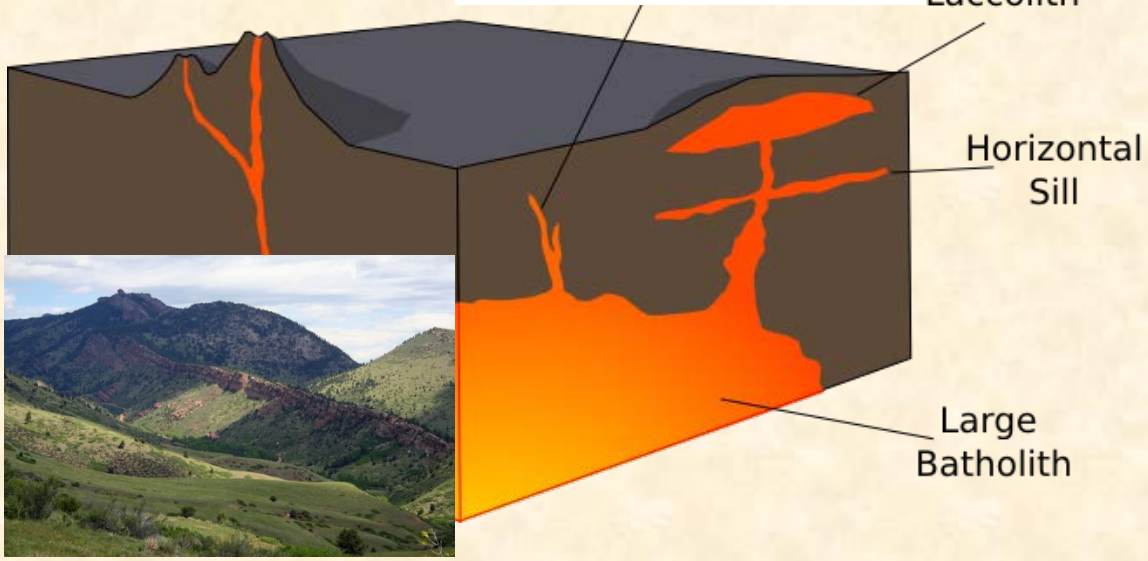
- **Concordant Plutons**:
- **Laccolith**: mushroom-shaped plutons
  - injected parallel to the structure of the host rock
  - domes up the overlying rocks
  - < 10:1 diameter vs thickness (laccolith grades to sill)



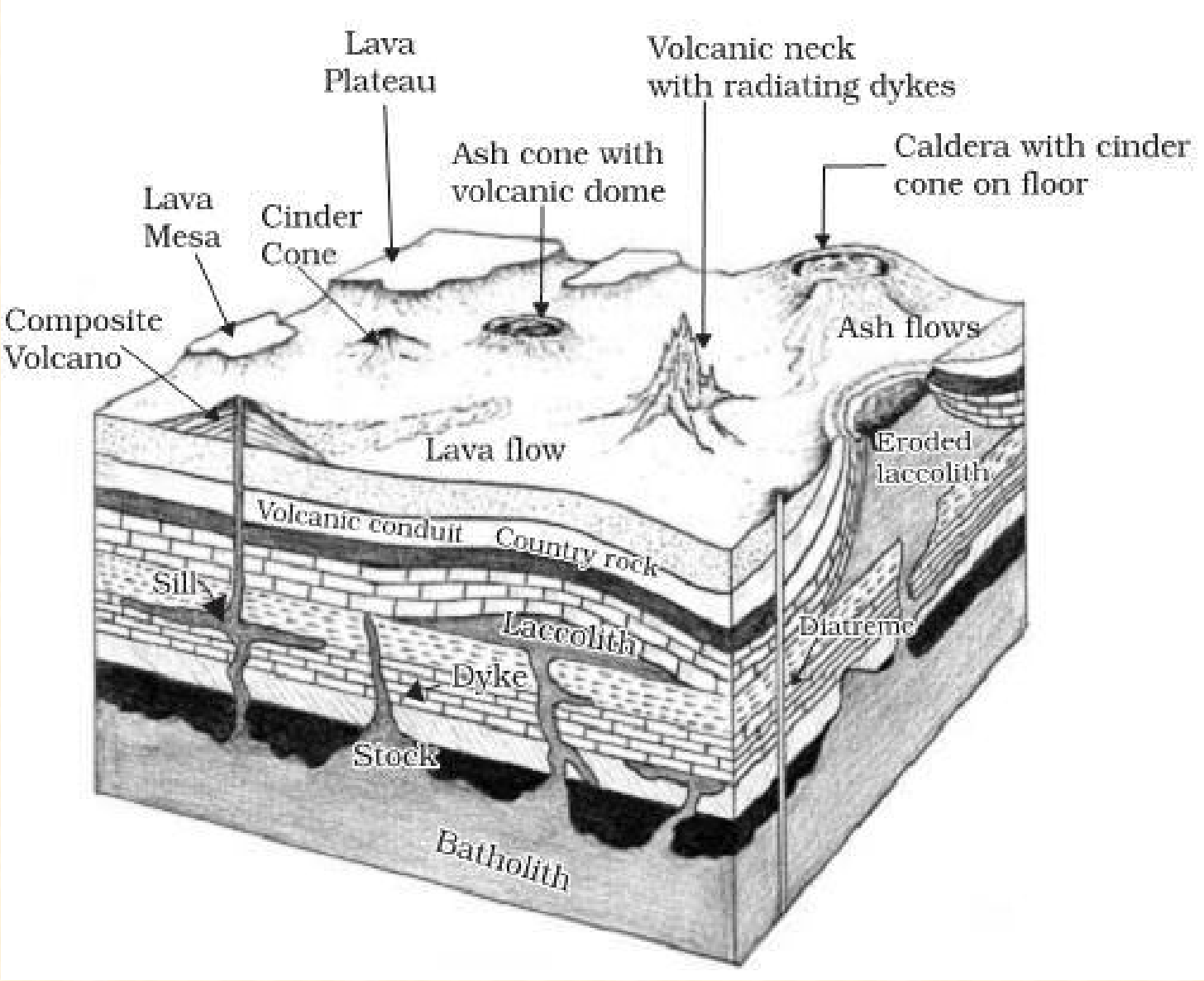
Igneous Intrusive Landforms

- **Concordant Plutons**:
- **Sills**: tabular plutons intruded parallel to the structure of enclosing rocks
  - Injected along bedding planes of sedimentary rocks
  - Mesas, buttes, cuestas, hogbacks
  - Order cm – 10s m thick, km in length

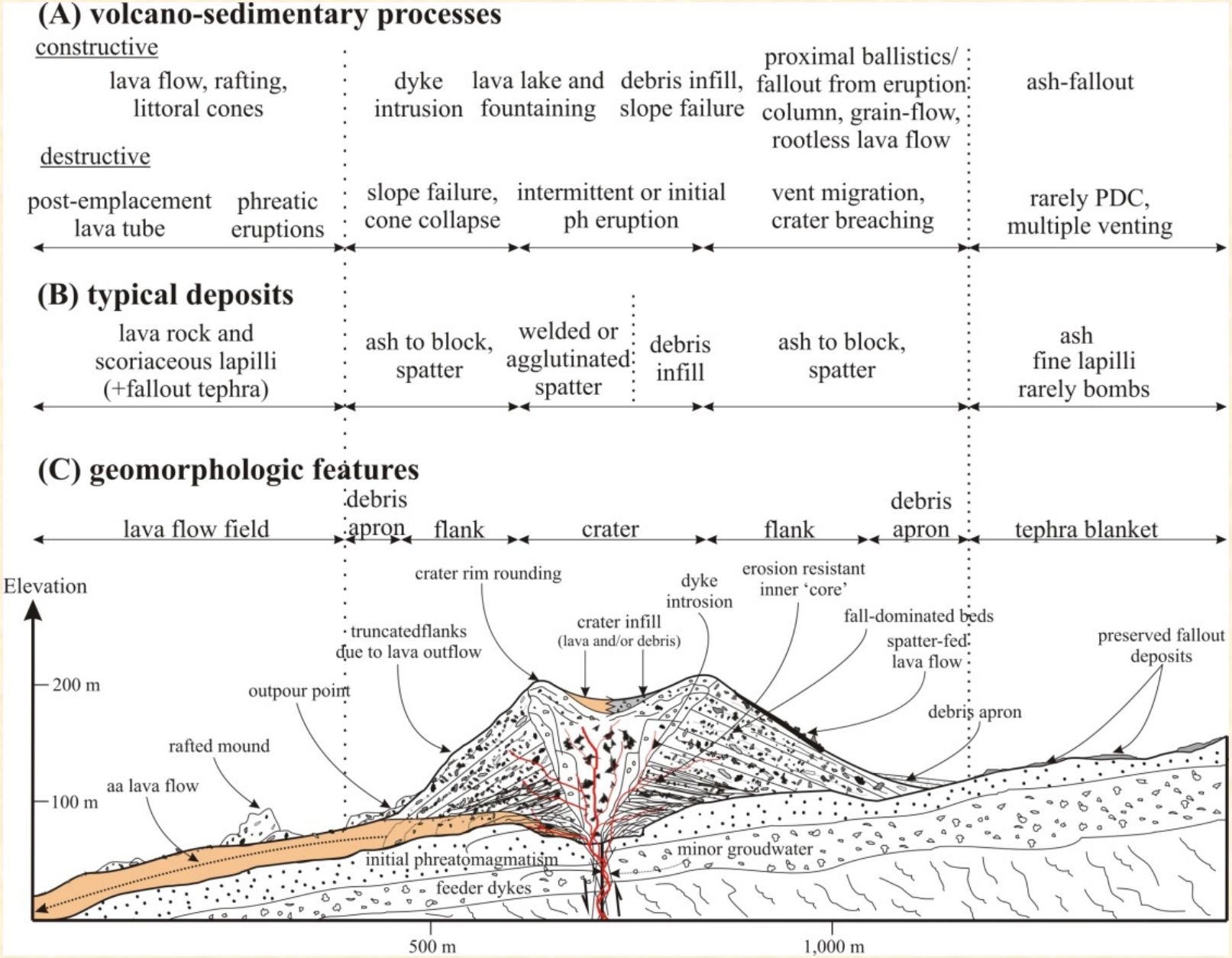




Examples of Geomorphic Features and Sequences



Examples of Geomorphic Features and Sequences



Additional Background Material