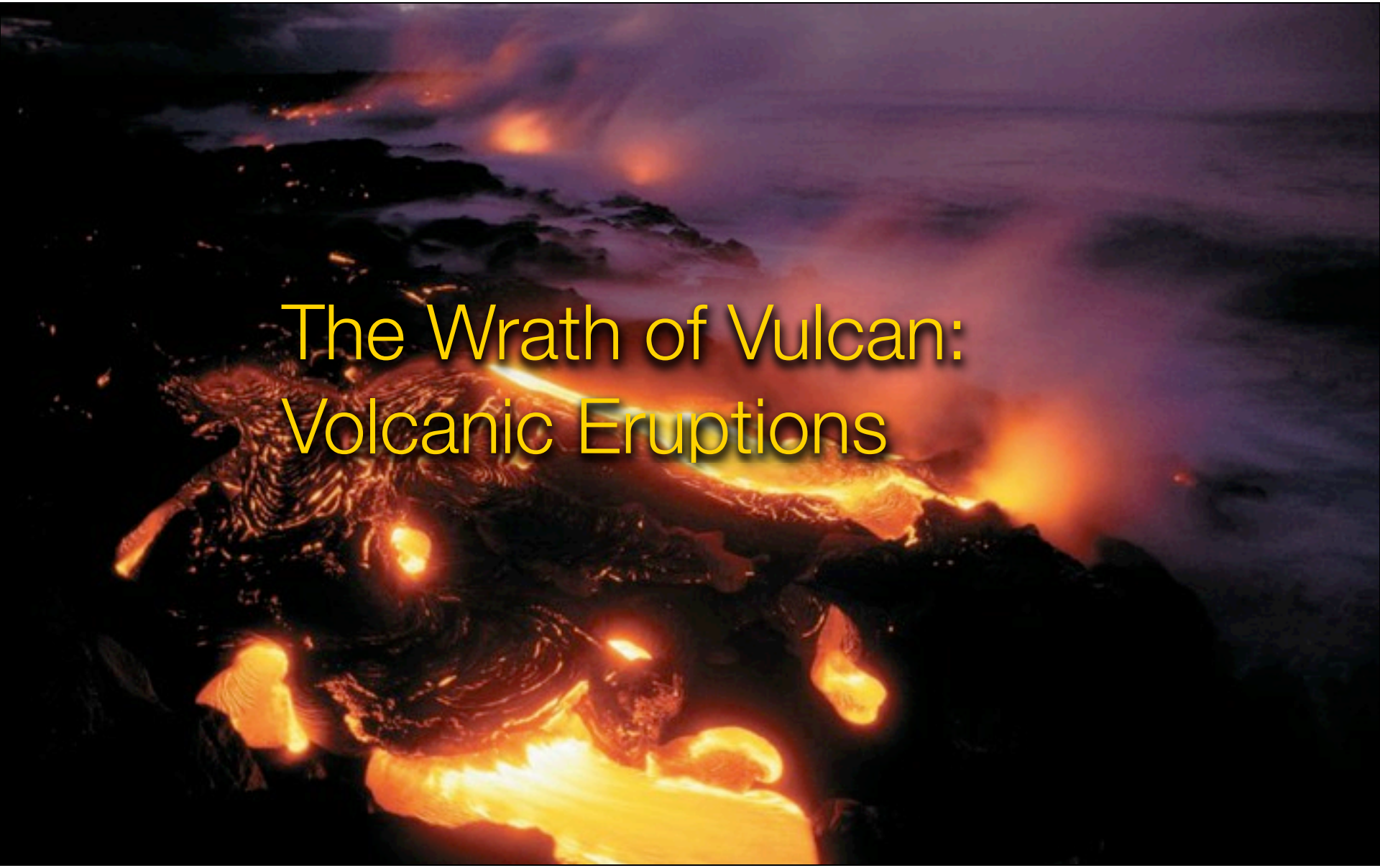

The Wrath of Vulcan:
Volcanic Eruptions

Volcanic Eruptions

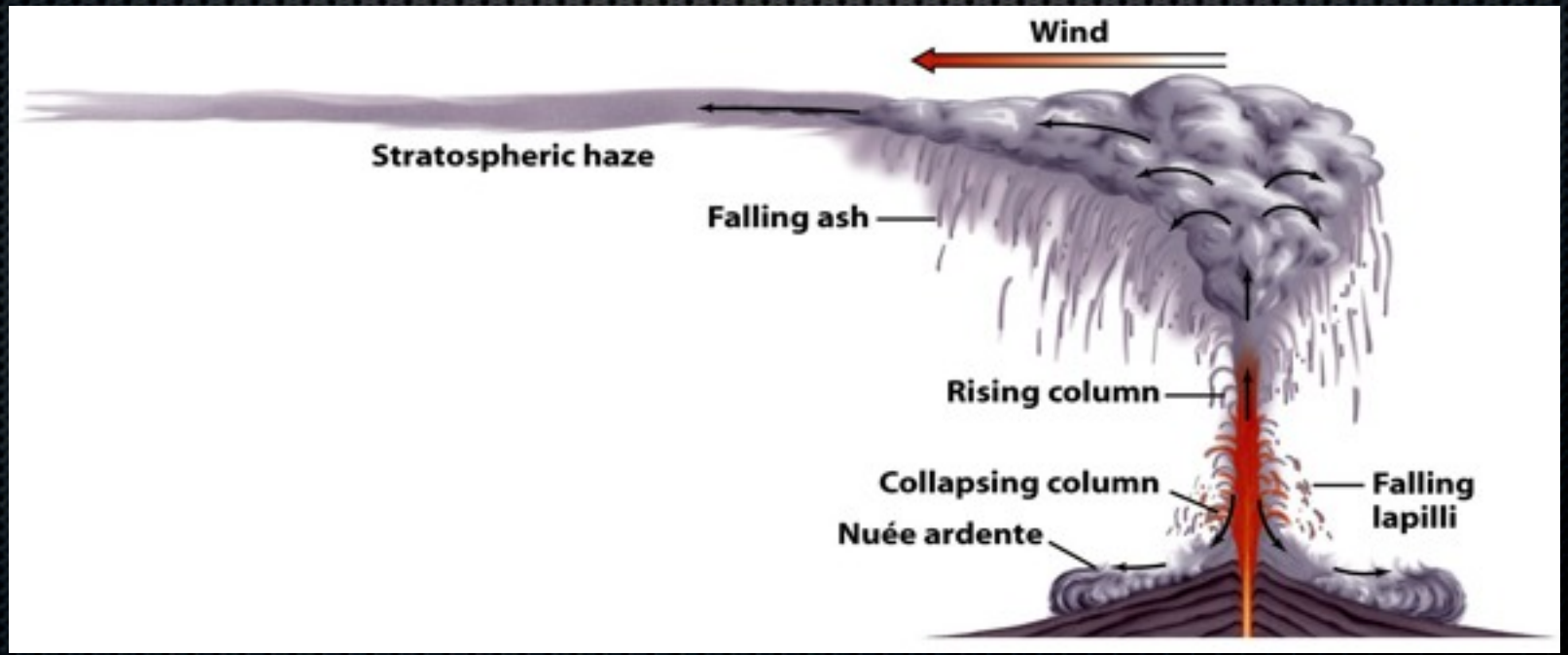
- What is a volcano?
  - An erupting vent through which molten rock surfaces.
  - A mountain built from magmatic eruptions.
- Volcanoes are caused by tectonic activity.
- Volcanoes pose a number of hazards to humans.

Volcanic Eruptions

- Unpredictable, dangerous.
- Eruptions can…
  - Provide highly productive soils to feed a civilization.
  - Can extinguish a civilization in a matter of minutes.
  - Eruptions effect climate.

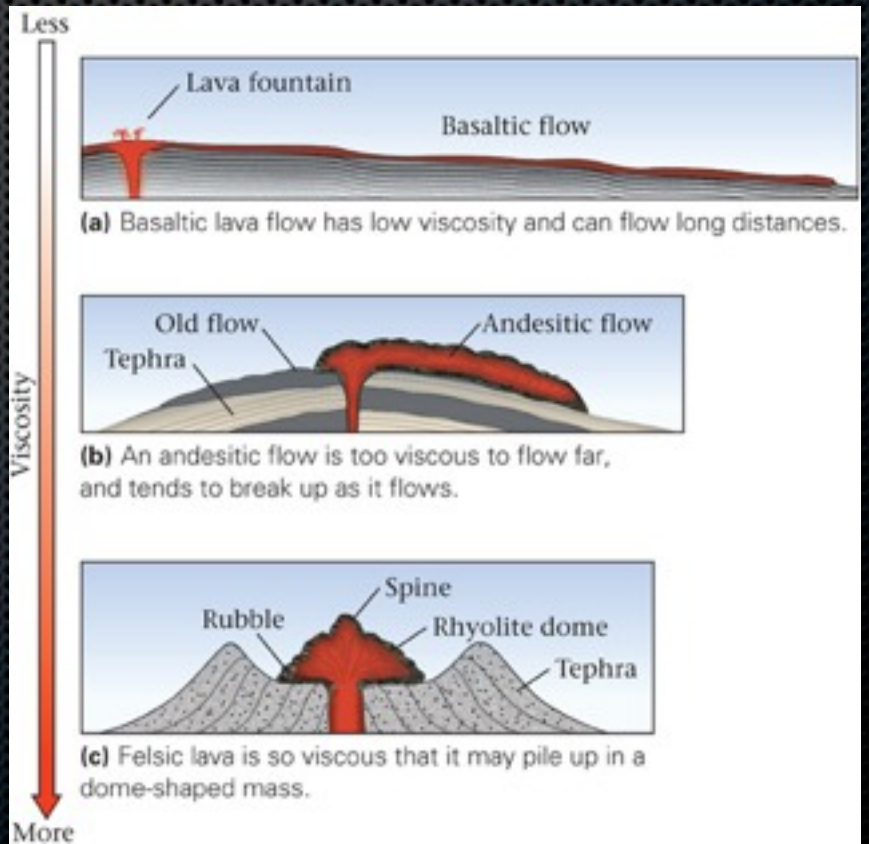
Volcanic Materials

- The products of volcanic eruption take three forms:
  - **Lava flows** – Molten rock that moves over the ground.
  - **Pyroclastic** debris – Fragments blown out of a volcano.
  - **Volcanic gases** – Vapor and aerosols that exit a volcano.



Lava Flows

- Lava can be thin and runny or thick and sticky.
- Flow style depends on viscosity, which depends upon...
  - Composition, especially silica (SiO_2), Fe, and Mg content.
  - Temperature.
  - Gas content.
  - Crystal content.



Lava Compositions

- Lavas with high silica / low Fe and Mg are called…
  - Silicic, felsic, or rhyolitic.
- Lavas with low silica / high Fe and Mg are called…
  - Mafic or basaltic.
- Lavas with moderate silica, Fe, and Mg are called…
  - Intermediate or andesitic.

Basaltic Lava Flows

- Mafic lava – Very hot, low silica and low viscosity.
- Basalt flows are often thin and fluid.
  - They can flow rapidly (up to 100 km/hr).
  - They can flow for long distances (up to several 100 km).

Basaltic Lava Flows

- Pahoehoe (pa-hoy-hoy) - a Hawaiian word describing basalt with a glassy, ropy texture.
  - Pahoehoe forms when extremely hot basalt forms a skin.
  - With flow, the skin is rolled into ropy ridges and furrows.

Basaltic Lava Flows

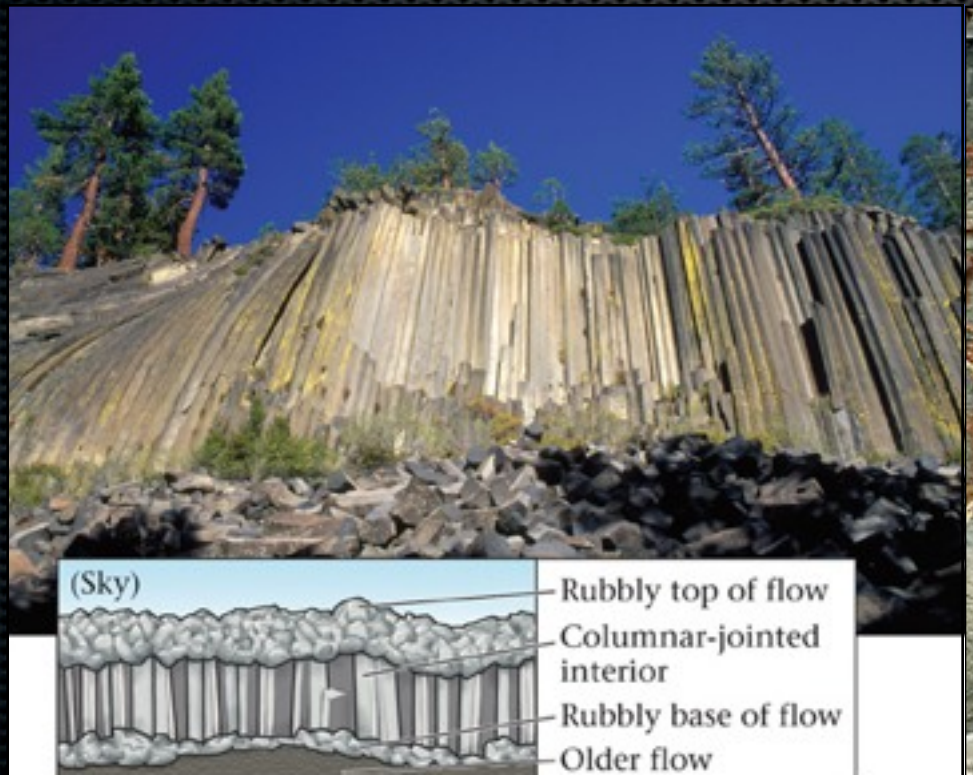
- A'a' (ah-ah) is a Hawaiian word describing basalt that solidifies with a jagged, sharp, angular texture.
  - A'a' forms when hot flowing basalt cools and thickens.
  - With flow, lava crumbles into shards and fragments.

Basaltic Lava Flows

- A cooled crust forms on top of a basalt flow.
- A conduit – a lava tube – develops in the flow.
- Tubes prevent cooling, facilitating flow for miles.
- Lava tubes become caves that can later transmit water.

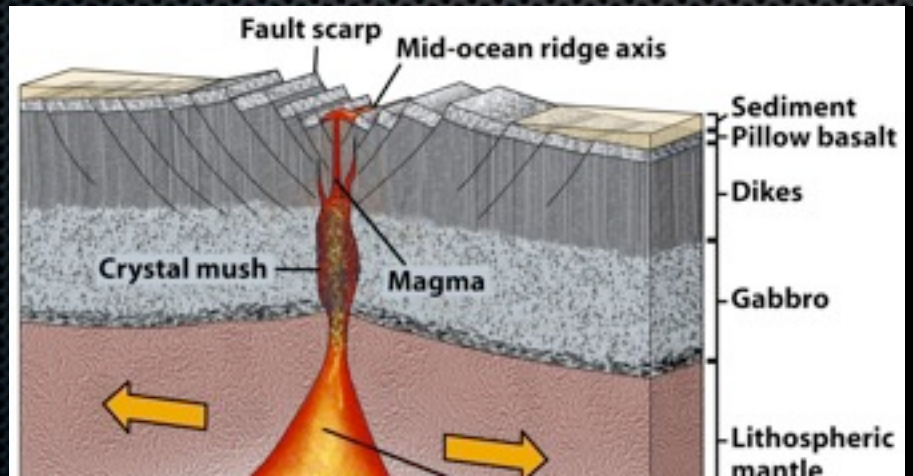
Basaltic Lava Flows

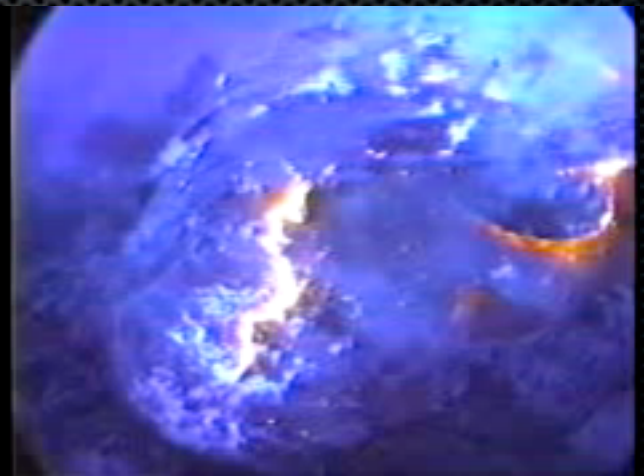
- Solidified flows may contract with vertical fractures that are hexagonal in cross section.
- This feature is called columnar jointing.



Basaltic Lava Flows

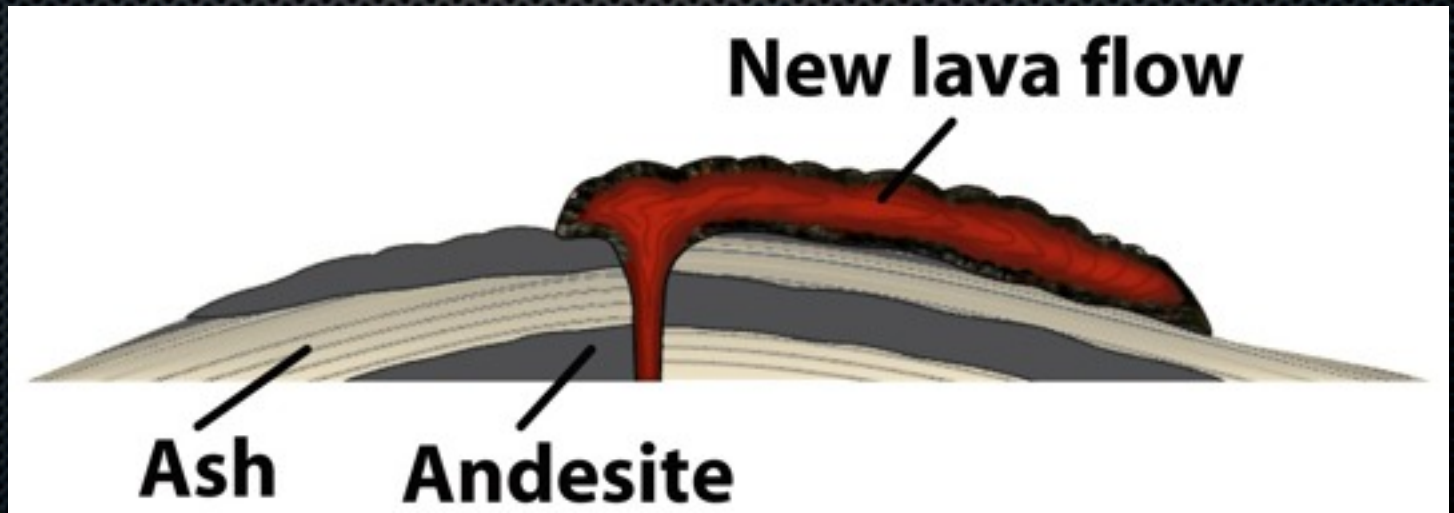
- Underwater, basalt cools instantly; it cannot flow.
- It cools to form a rounded blob called a pillow.
  - The pillow surface is cracked, quenched glass.
  - Lava pressure ruptures a pillow to form the next blob.
  - The process repeats to form a mound of pillow basalts.
- Common on the mid-ocean ridge.





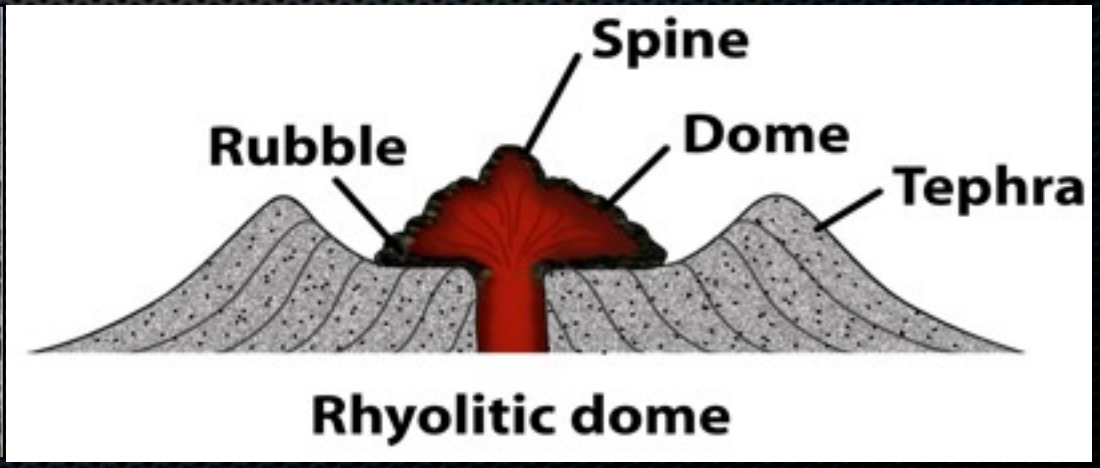
Andesitic Lava Flows

- Higher SiO_2 makes andesitic lavas viscous.
  - Unlike basalt, they do not flow rapidly.
  - Instead, they mound around the vent and flow slowly.
- The outer crust fractures, creating rubble.
- Andesitic lava flows remain close to the vent.



Rhyolitic Lava Flows

- Rhyolite, with the highest SiO_2, is the most viscous lava.
- Rhyolitic lava rarely flows.
- Rather, lava plugs the vent as a lava dome.
- Sometimes, lava domes are blown to smithereens.



Volcaniclastic Deposits

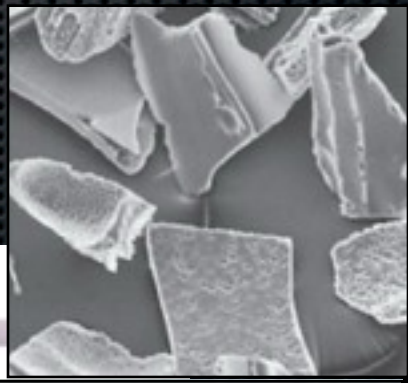
- Accumulations of fragmented igneous material.
  - Pyroclastic debris – Lava that freezes flying through air.
  - Pre-existing rock fragments.
  - Landslide debris.
  - Mudflows.

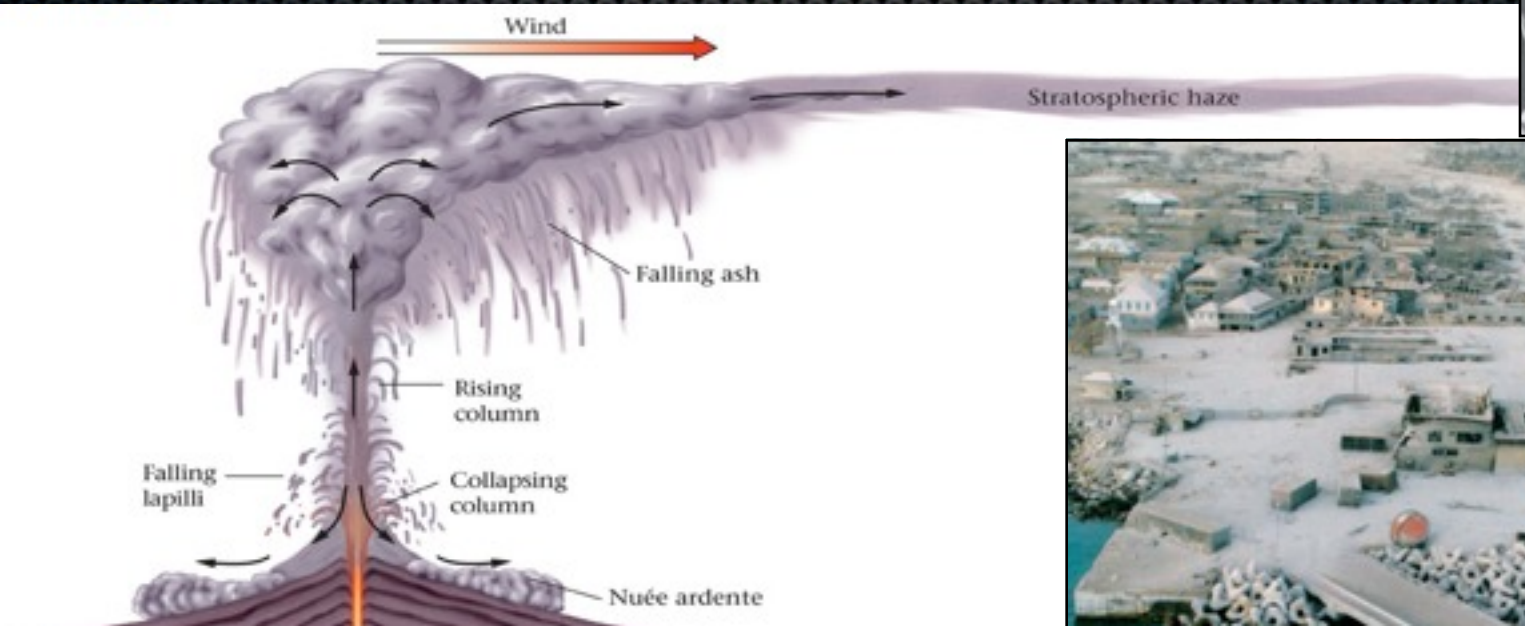
Basaltic Pyroclastic Debris

- Glass shards and fragmented lava in a range of sizes.
- Basaltic eruptions generate a lot of spatter.
  - Lapilli – Pea to plum-sized material.
  - Pele's Hair – Strands of glass created by flying lava droplets.
  - Blocks and bombs – Apple to refrigerator-sized.
    - Bombs – Streamlined fragments of ejected lava.

Explosive Pyroclastic Debris

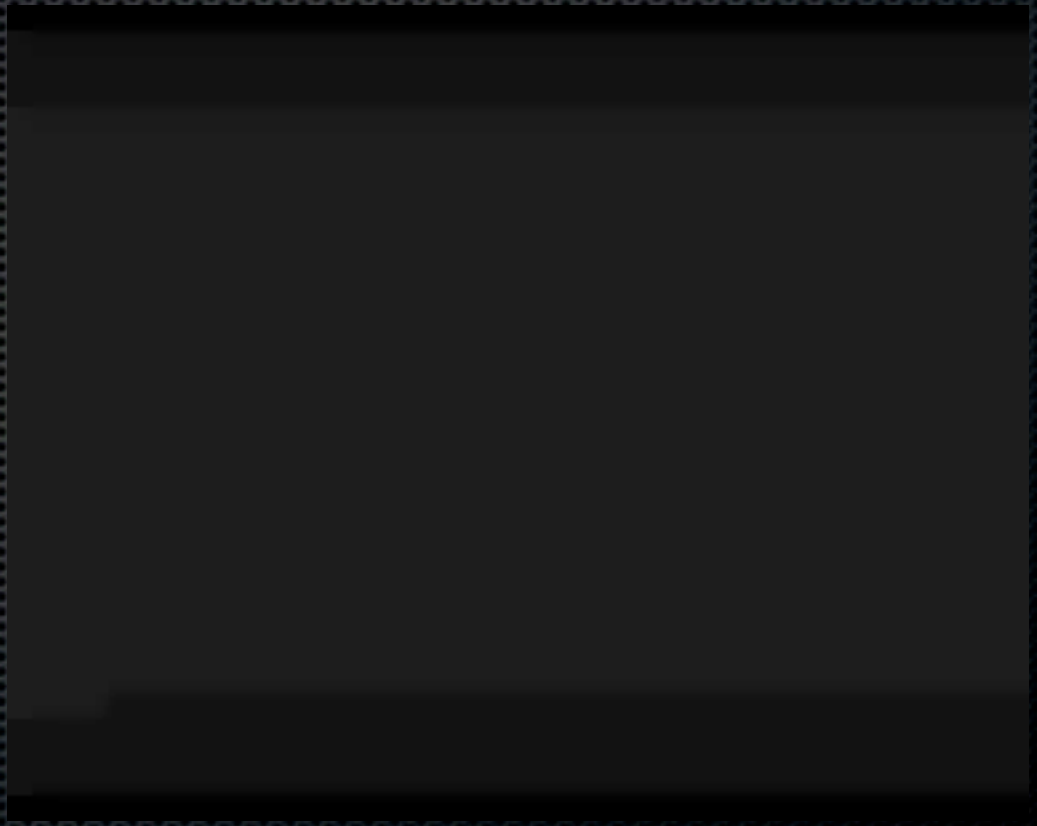
- Intermediate and felsic magmas erupt explosively.
  - More viscous than basaltic magma (from SiO_2).
  - Contain more gas.
  - Produce large quantities of volcanic ash.





Pyroclastic Flows

- Pyroclastic flows (or, ***nuee ardentes - French***):A
  - Avalanches of hot ash (200C°–450°C) that race downslope.
  - Moving up to 300 kph, they Incinerate all in their path.
  - Immediately deadly; they kill everything quickly.
  - Many famous examples: Mt. Vesuvius, Mt. Pelee, and Mt. Augustine.



Pyroclastic Deposits

- Tephra – Deposits of pyroclastic debris of any size.
- Tuff – Lithified ash with or without lapilli.
  - Air-fall tuff – Accumulations of ash that fell like snow.
  - Ignimbrite (welded tuff) – Tuff that is deposited while hot.
    - Hot pyroclastic flow material.
    - Fuses together while cooling.

Volcaniclastic Deposits

- Blocks – Preexisting rock fragmented by eruption.
  - Blown out of a volcanic vent, blocks pile up nearby.
  - Create unstable slopes that easily fail.

Lahars

- Tephra is readily moved by water as a debris flow.
- Known as lahars, these flows are often deadly.
  - Lahars move rapidly (up to 50 km per hour).
  - They have the consistency of wet cement,.
  - A distinct hazard to people living in volcanic valleys.

Volcanic Gas

- Up to 9% of magma may be gas.
  - Water (H_2O) – Most abundant gas.
  - Carbon dioxide (CO_2) – Second in abundance.
  - Sulfur dioxide (SO_2) – Rotten egg smell.
- Magma composition controls gas content.
  - Felsic magmas are gas-rich; mafic magmas are less so.

Volcanic Gas

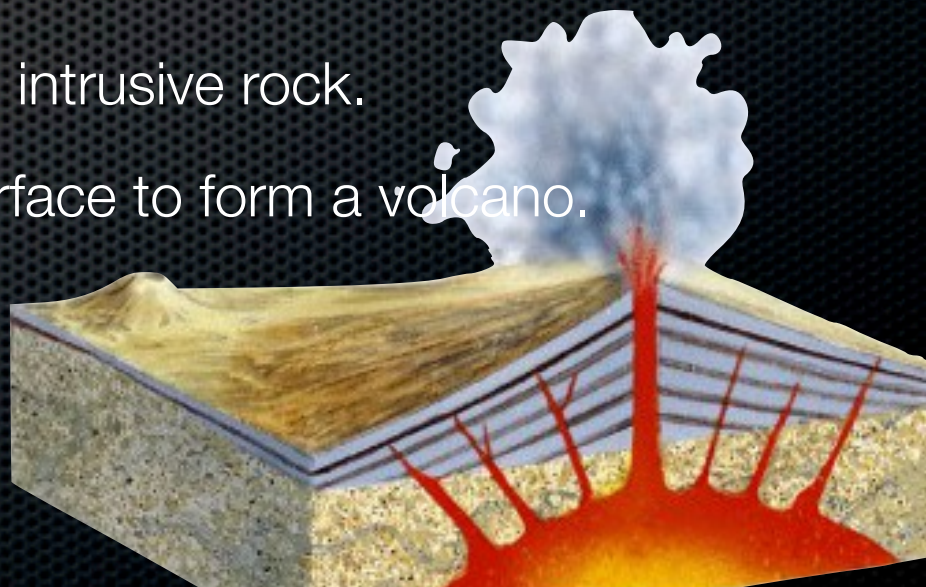
- Gases are expelled as magma rises (P drops).
- SO_2 reacts with water to form aerosol sulfuric acid.
- Style of gas escape controls eruption violence.
  - Low viscosity (basalt) – Easy escape; mellow eruption.
  - High viscosity (rhyolite) – Difficult escape; violent eruption.
- Gas bubbles in rock are called **vesicles**.

Volcanic Architecture

- Volcanoes have characteristic features.
  - Magma chamber.
  - Fissures and vents.
  - Craters.
  - Calderas.
  - Distinctive profiles.
    - Shield volcanoes.
    - Cinder cones.
    - Stratovolcanoes.

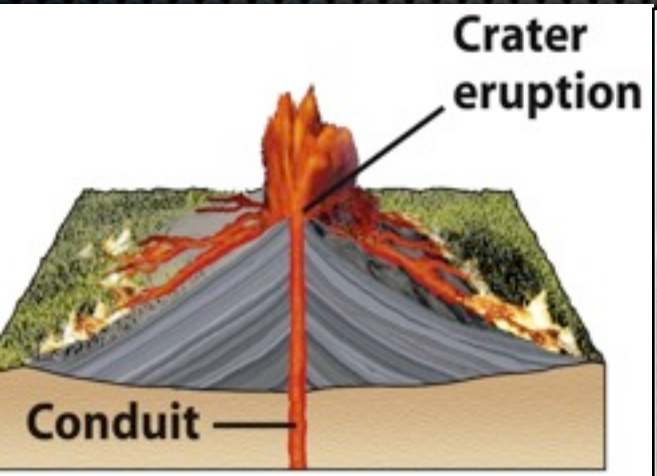
Magma Chamber

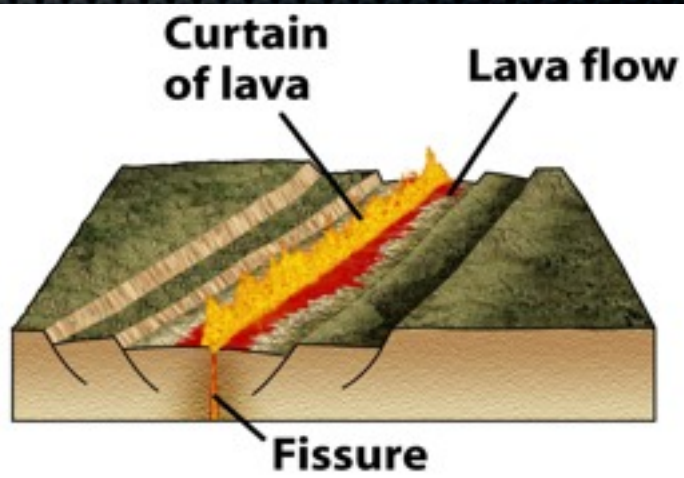
- Located in the upper crust.
  - Usually an open cavity or area of highly fractured rock.
  - May contain a large quantity of magma.
  - May inflate and deflate.
- Some magma cools here to form intrusive rock.
- Some magma may rise to the surface to form a volcano.



Magma Release

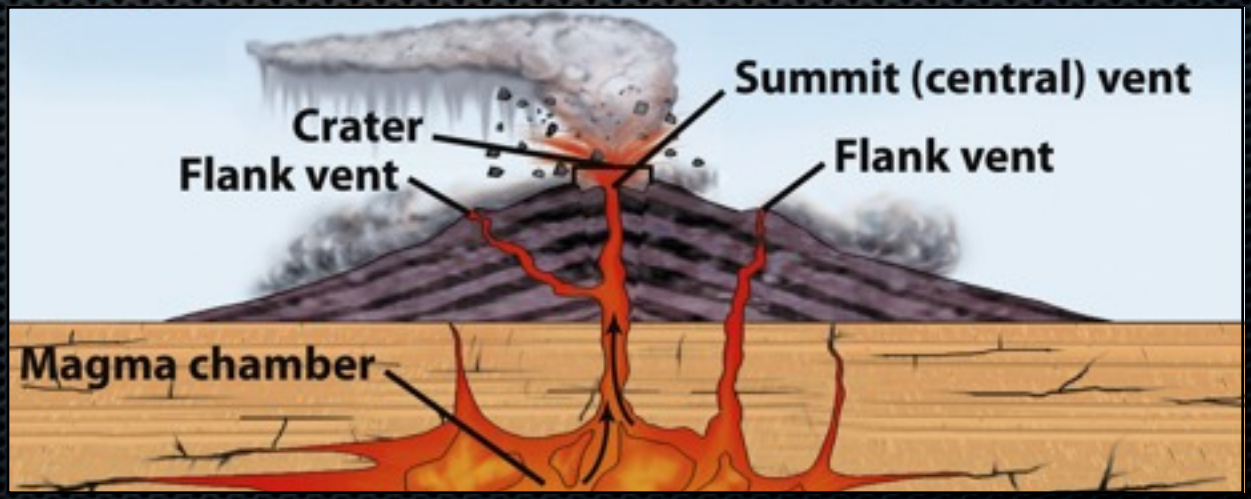
- Some magma rises via a conduit to the surface.
- Magma may also erupt along a linear tear, a fissure.
  - Fissure eruptions may display a “curtain of fire.”
  - Fissures evolve into discrete vents.





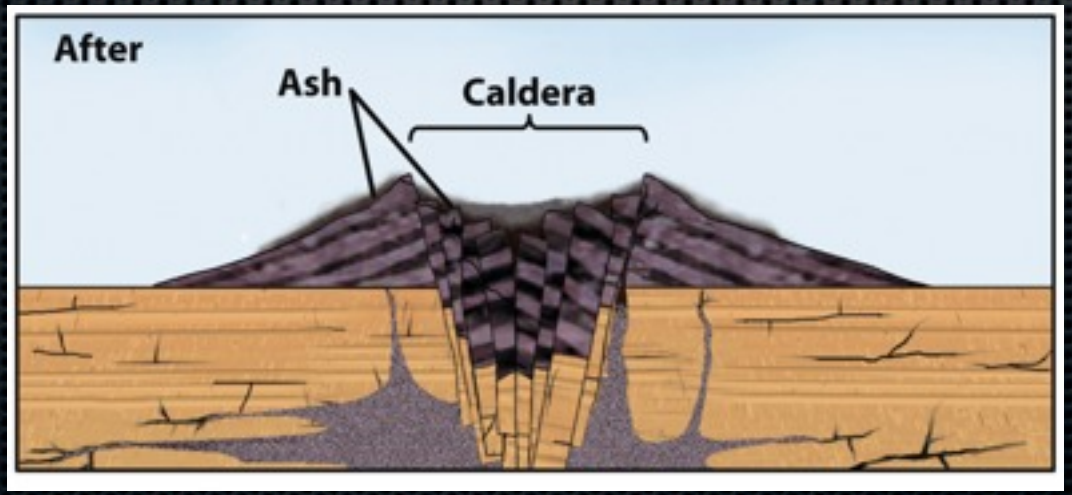
Craters

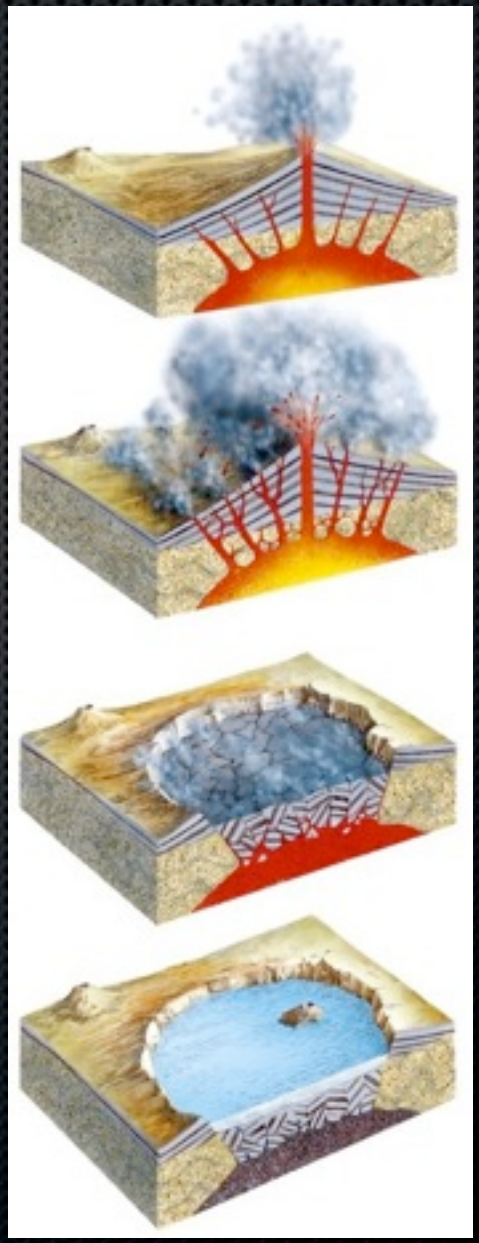
- Crater – A bowl-shaped depression atop a volcano.
- Craters are up to 500 m across; 200 m deep.
- Form as erupted lava piles up around the vent.
  - Summit eruptions – Located within the summit crater.
  - Flank eruption – Located along the side of a volcano.



Caldera

- A gigantic volcanic depression.
  - One to ten kilometers across.
  - Steep sidewalls and flat floors.
- Form from massive eruptions.
- The volcano collapses.
  - Crater Lake, Oregon.
  - Yellowstone National Park.

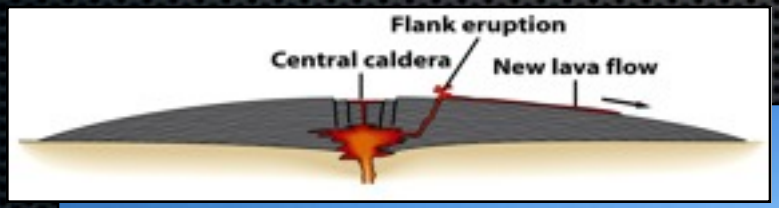





Crater Lake Caldera, Oregon

Volcano Types

- **Shield volcanoes**
  - Broad, slightly domed-shaped (like an inverted shield).
  - Made by lateral flow of low-viscosity basaltic lava.
  - Have a low slope and cover large geographic areas.
  - Mauna Loa on Hawaii is a good example.

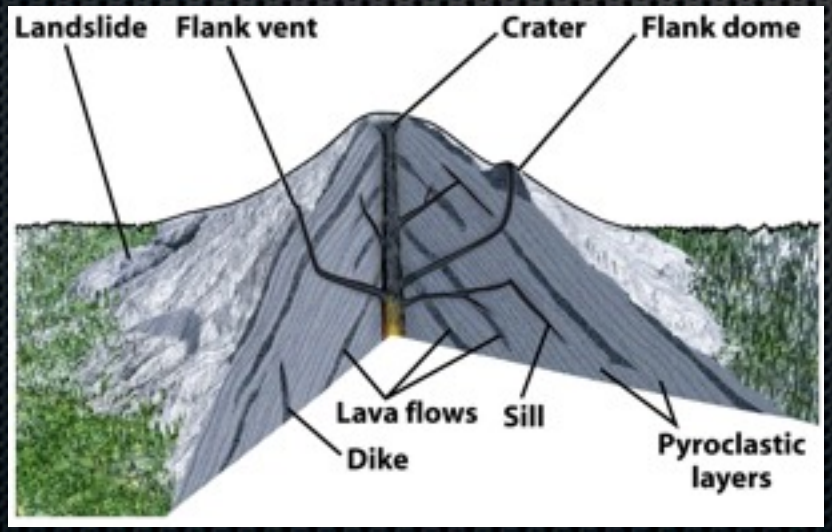


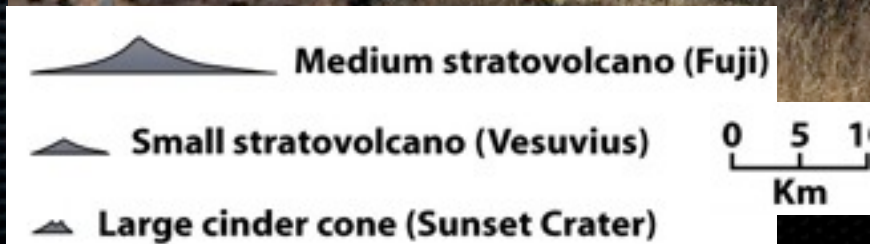
Volcano Types

- **Cinder cone** – Conical piles of tephra.
  - The smallest type of volcano.
  - Built of ejected lapilli-sized fragments piled up at a vent.
  - Slopes are at the angle of repose.
  - Often symmetrical with a deep summit crater.

Volcano Types

- **Stratovolcanoes** (Composite volcanoes).
  - Large, cone-shaped volcano.
  - Composed of alternating layers of lava and tephra.
  - Often symmetric; can be odd shapes from landslides, etc.
  - Examples include Mt. Fuji, Mt. Rainier, Mt. Vesuvius.





Eruptive Style

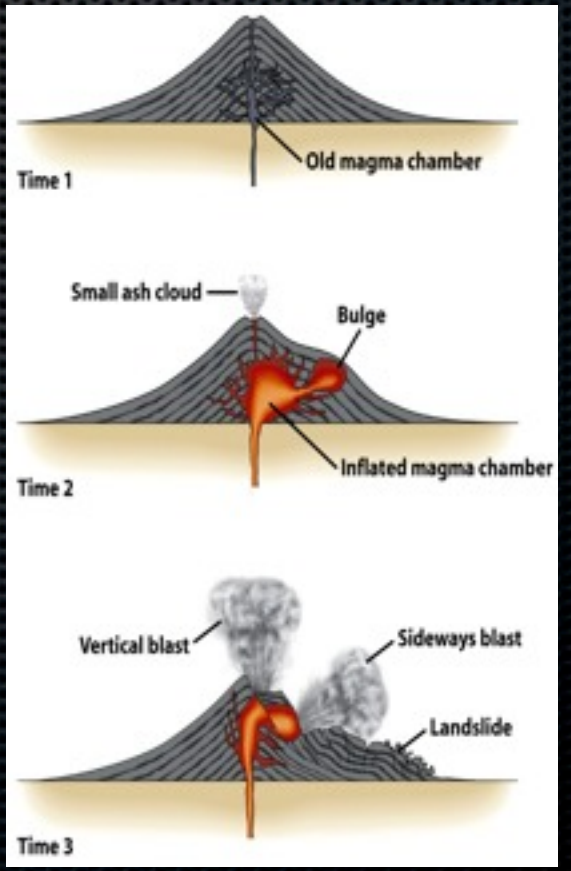
- Will it flow, or will it blow? Two dominant styles.
  - Effusive eruptions – Produce lava flows.
  - Explosive eruptions – Blow up.

Controls on Eruptive Style

- Viscosity – Controls the ease of lava flow.
  - Basalt – Low viscosity lava flows away from vent.
  - Felsic – High viscosity lava builds up at the vent.
- Gas Pressure – Greater P favors explosive style.
  - Basalt – Low viscosity allows gas release.
  - Felsic – High viscosity prevents gas release.
- Environment – Where eruption occurs is important.
  - Subaerial lava flowing on land cools slower than…
  - Submarine lava which is quickly quenched.

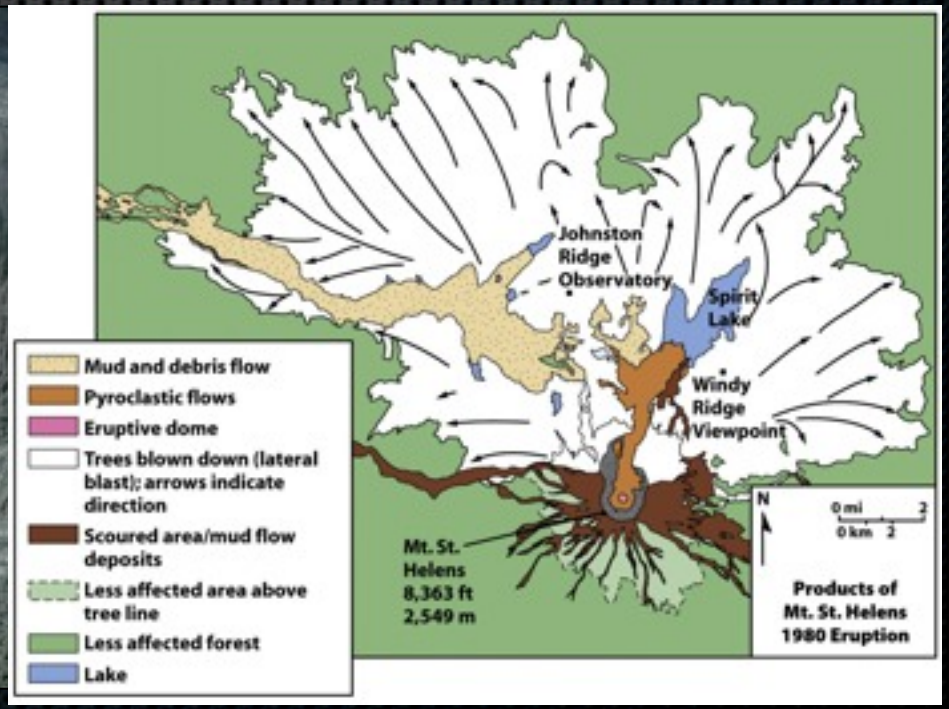
Eruptions to Remember

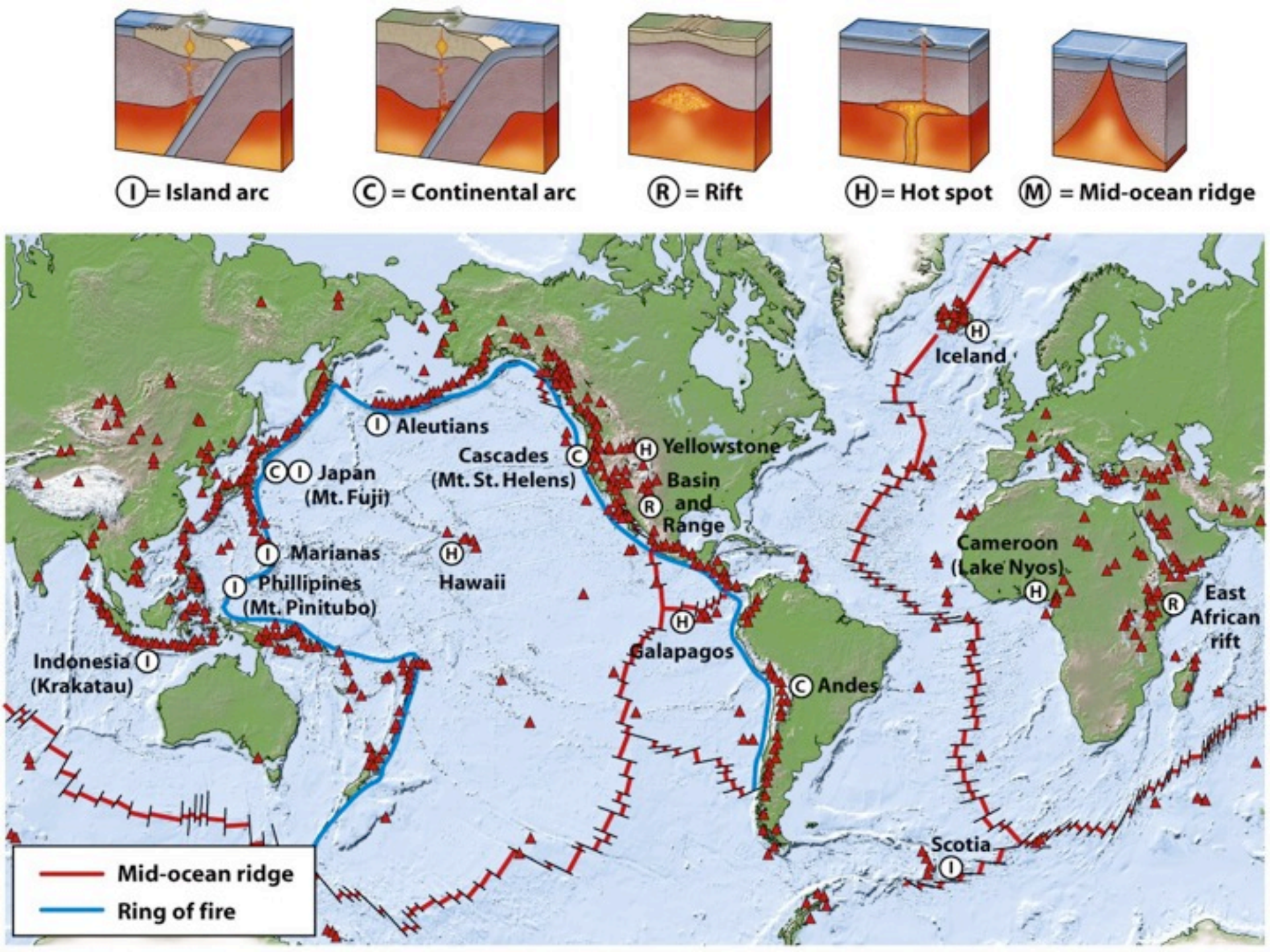
- Mt. St. Helens – Erupted May 18, 1980, 8:32 A.M.
- Earthquake triggered landslide released pressure.
  - Initial vertical blast followed by a much stronger lateral blast that tore off the entire north side.
  - 396 m was blasted away.



Eruptions to Remember

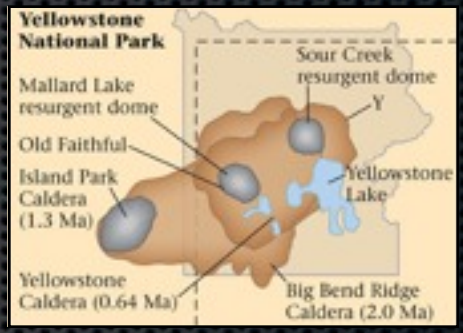
- Mt. St. Helens – Erupted May 18, 1980, 8:32 P.M.
  - The blast devastated 600 km^2 and killed 61 people.
  - Lahars plugged the Toutle River; closed the Columbia.
  - Ash fell in North Dakota; highways and rail lines stopped.
  - Destroyed timber valued at several 100 million dollars.

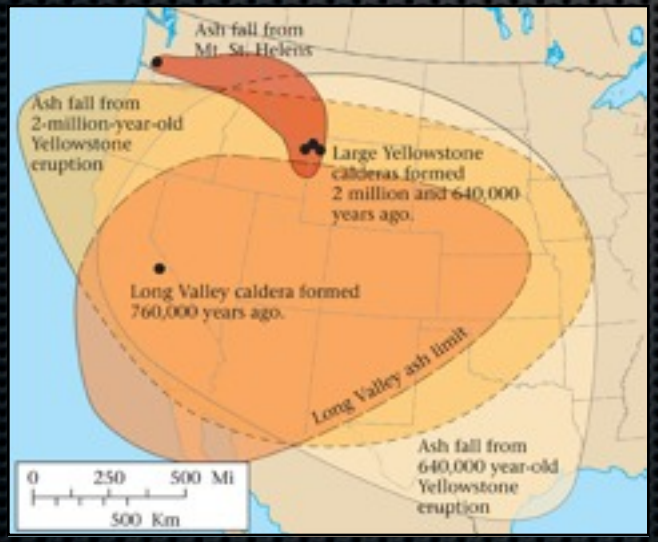


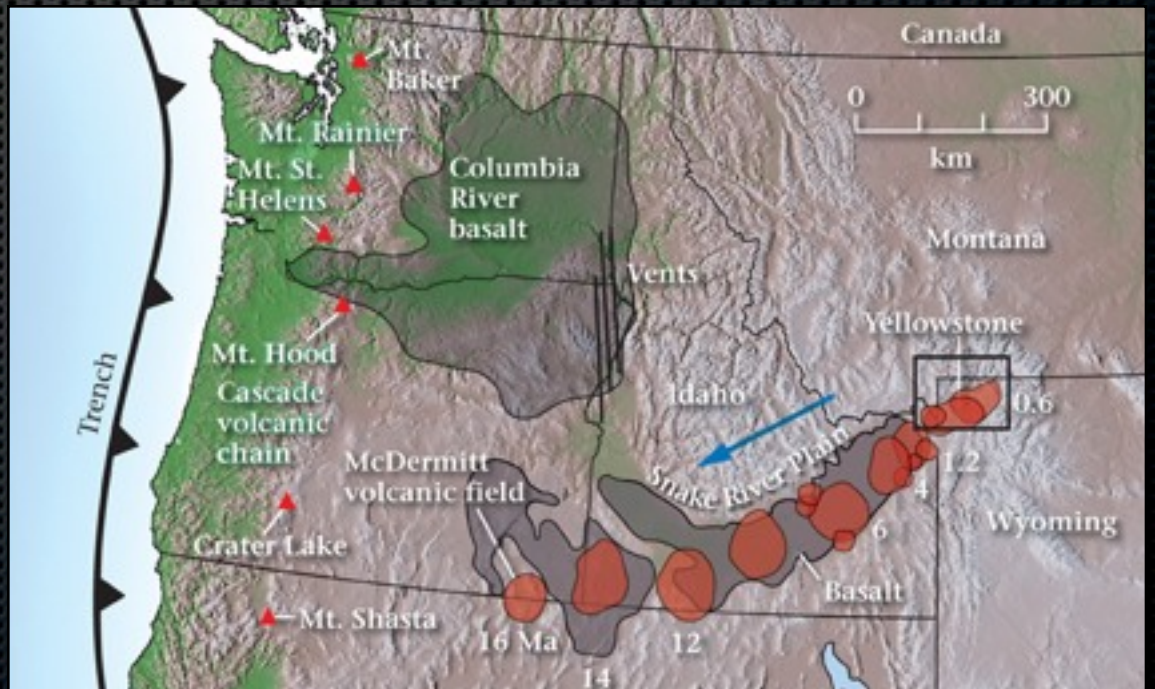

(I) = Island arc
(C) = Continental arc
(R) = Rift
(H) = Hot spot
(M) = Mid-ocean ridge
(H) Iceland
(I) Aleutians
(C) (I) Japan (Mt. Fuji)
Cascades (Mt. St. Helens) (C)
(H) Yellowstone
Basin and Range (R)
(I) Marianas
(I) Phillipines (Mt. Pinitubo)
(H) Hawaii
Cameroon (Lake Nyos) (H)
East African rift (R)
(H) Galapagos
Indonesia (I) (Krakatau)
(C) Andes
Scotia (I)
Mid-ocean ridge
Ring of fire

Continental Hot-Spot Volcanoes

- Continental Hot Spot – Cuts a continental plate.
  - Yellowstone – Eruption ~ 640 Ka created a 100 km caldera.
    - 1,000 times more powerful than Mt. St. Helens.
    - Deposited vast ignimbrite deposits.
    - Magma beneath the caldera continues to fuel geysers

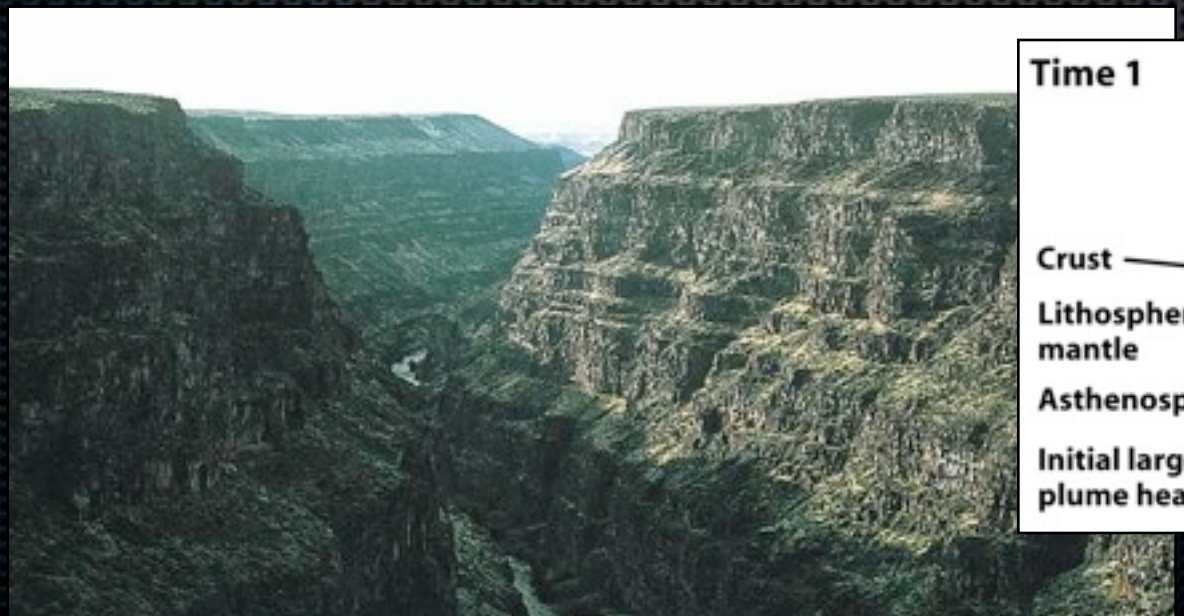


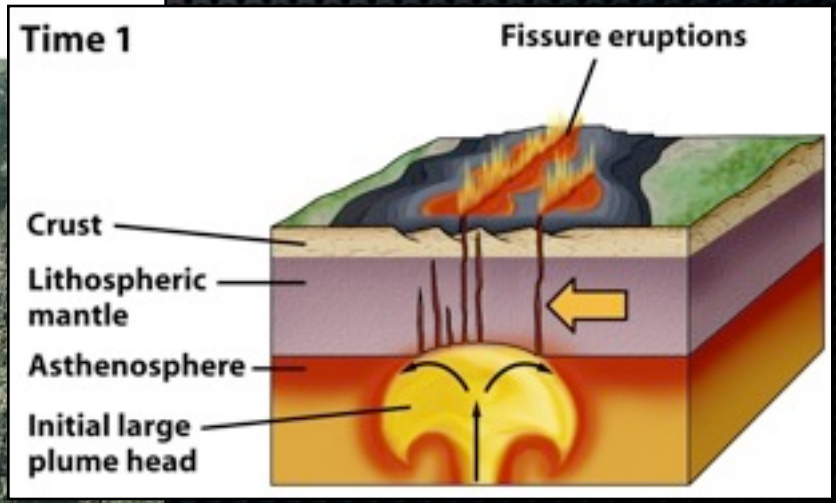




Flood-Basalt Eruptions

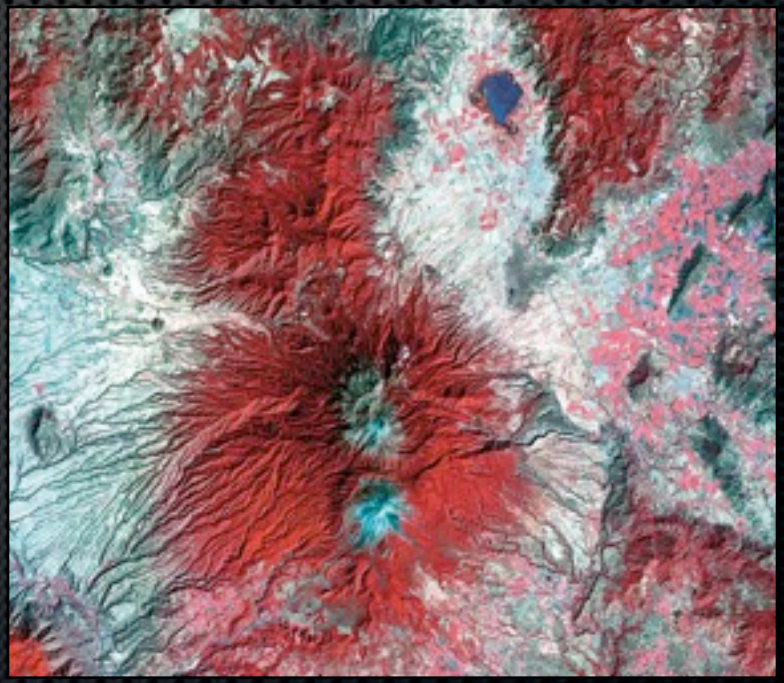
- Voluminous lava eruptions above a plume.
  - Thinned lithosphere erupts magma from long fissures.
  - Lava spreads over large areas; great thicknesses stack up.
  - Create plateaus called Large Igneous Provinces (LIPs).





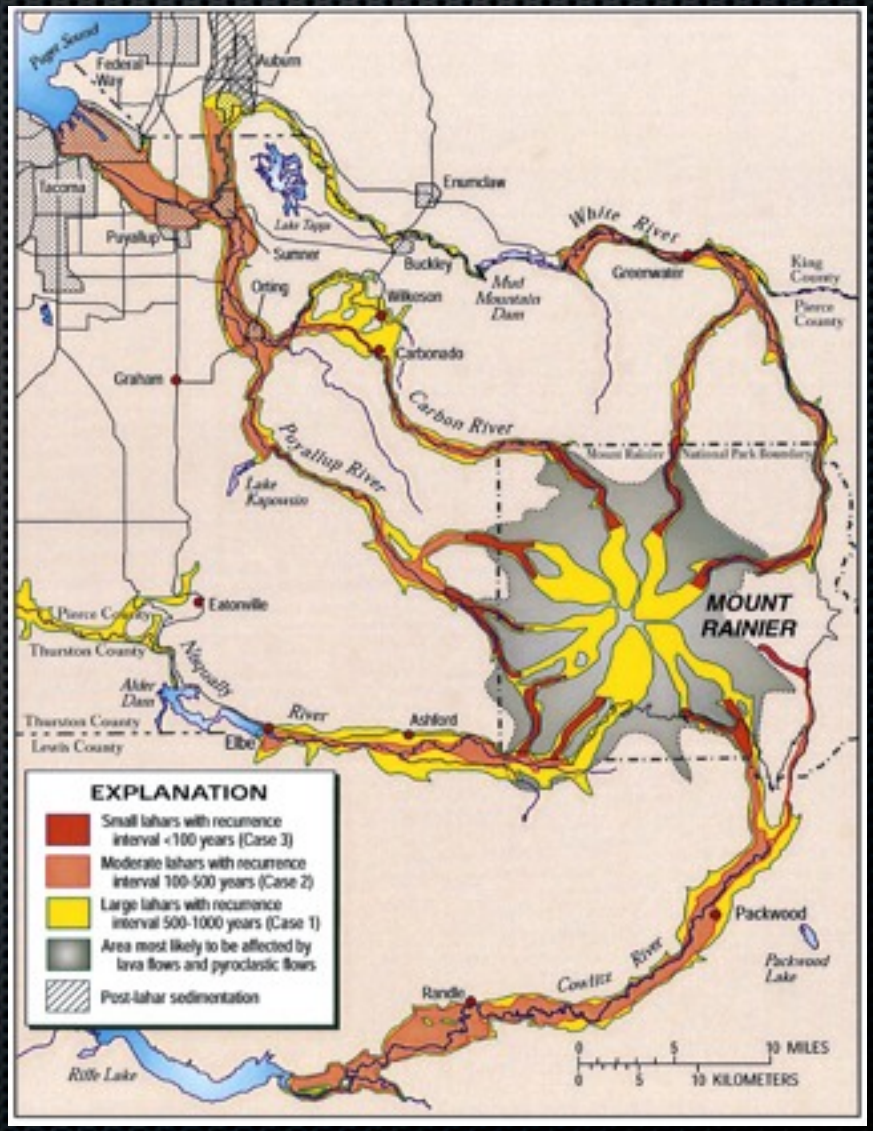
Volcanic Hazards

- Volcanic eruptions cause great harm to humans.
  - Eruptions have profoundly influenced human history.
  - In the past 2,000 years: an estimated 250,000 deaths.
- Many populated areas ring active volcanoes.
  - More humans live in volcano hazard areas than ever before.



Mitigating Hazards

- Danger assessment maps.
  - Delineate danger areas.
    - Pyroclastic flows.
    - Lahars.
    - Landslides.
  - Used for planning, zoning.



Volcanoes and Climate

- Volcanic eruptions can be large enough to alter climate.
  - Ash and aerosols high in the atmosphere block sunlight.
  - This causes atmospheric cooling.
    - 1815 was the “year without a summer” due to Tambora.