Lesson Five: Volcanoes

Background Reading: Volcanoes

Volcanic Terms:

Silca: SiO_2 – silicon dioxide. This is quartz when it crystallizes. The amount of this in the magma determines the viscosity (thickness) of the magma.
Viscosity: resistance to flowing. A more viscous magma is "thicker" in the same way that honey is thicker than water. The more viscous a magma, the greater its ability to trap gas and produce an explosive eruption. If it is too viscous (like obsidian or even rhyolite magma), it may be too thick to erupt and it will form domes and plugs.
Pyroclastic material: hot fragments blown out of a volcano. It can range from very small ash to much larger fragments (lapilli, bombs). Pyroclastic material can be ejected upward, or flow down a volcano (pyroclastic flow) as a extremely hot avalanche of pyroclastic debris.
Stratovolcano: A large, cone-shaped volcanoes consisting of alternative layers of lava and pyroclastic material. Mt Shasta and Mt Rainier are stratovolcanoes. These volcanoes are often associated with convergent plate boundaries and explosive eruptions.
Shield Volcanoes: A volcano with a broad, gentle-sloping dome formed from low viscosity basaltic lava. These volcanoes exhibit *Effusive eruptions.* These are not violent eruptions. Lava pours out onto the ground from a vent and spreads out over the land.

Three main types of volcanic rock types and associated volcanism:

Rhylolite: highest silica content (other than obsidian); it is the most viscous of all lavas; it's viscosity causes it to form domes or freeze while still in the volcanic vent.
Andesite: intermediate silica content; its relative "thickness" (viscosity) causes gas to build up pressure within the magma and result in explosive eruptions. The flows are relatively short, but extensive pyroclastic material can be produced. Andesitie volcanism can form stratovolcanoes.
Basalt: low silica content; it is the least viscous of the lavas and consequently it tends to create large flows and less explosive eruptions. This ability to flow also results in shield volcanoes with low-sloping sides due to the runoff of lava. The flows can cool to produce columnar jointing and the more fluid lava will cool to form a ropey appearance (pahoehoe lava).

Plate Settings and Volcanism

Divergent Boundary: typically divergent boundaries are sites of basaltic volcanism. This is true of the oceanic ridges. Pillow basalts form as the submarine lavas at mid-ocean ridges cool. The initial stages of continental plate divergence can result in more silica-rich volcanism, due to the silica-rich nature of the continental crust.
Convergent Boundary: Convergent plate boundary volcanism can be complex. It typically produces andesitic lavas and this results in formation of stratovolcanoes. However, basaltic volcanism is also common at convergent boundaries. The Cascade Volcanic Chain is an example of the variety of volcanism present at a convergent boundary. The Cascade chain includes stratovolcanoes, shield volcanoes, pyroclastic deposits, and obsidian domes.
Hot Spots: (Oceanic-basalt or Continental-rhyolite): This can be anywhere in the lithosphere. If they occur within oceanic crust (like Hawaii), they produce basalt

volcanism and shield volcanoes. If they occur within continental crust they can be silica rich and produce very explosive volcanoes such as the Yellowstone Caldera.

Geologic Hazards / Risk

- Lava Flows – most only travel a few meters per hour and are slow enough for people to get out of the way.
- Pyroclastic Hazards;
    - Ash falls
    - Lateral blast
    - Pyroclastic flows -ash flow (very fast and burns up everything in its path)
- Poisonous Gas - H_20, $C0_2$, $S0_2$ - suffocation
- Lahars / Mudslides
    - Related to rapidly melted snow/ice
    - Flow rates: volcano base= up to 40 meters/second
    - 1Km out on plain = up to 10 meters/second
    - May be triggered by earthquakes, storms, gravity, volcanic eruptions
    - Travel Rapidly, may be little advance warning.

Prediction of Volcanic Eruptions

- seismic activity - earthquakes
- thermal, gravity, magnetic, electrical changes
- tilting or swelling (ground level change)
- gas emissions
- historical information
- rock type - silica rich or not?
- Usually days to hours of notice. Size and direction of blast are harder to predict.

Preparation

- Identify Potentially Hazardous Volcanoes
    - Plate Boundaries
    - Past History - Dating of Deposits
    - Current Status - Predictors
- Identify Nature of Hazard
    - Rock Type - How Explosive
    - Other Hazards - Lahars, Poisonous Gas
- Education, Zoning, Evacuation Plans
- Continued Monitoring

Magma Types and Volcanic Landforms

Composition	Silica Content	Viscosity	Tendency for Pyroclastic (explosiveness)	Volcano Type; Volcanic Landform
Mafic Basaltic Magma	50% = low	Low	Least	**Shield Volcano** **Basalt Plateau** (Flood Basalt) **Cinder Cone** **Underwater Fissure**
Intermediate Andesitic Magma	60% = intermediate	Intermediate	Intermediate	**Composite Volcano** (Stratovolcano) **Volcanic Domes**
Felsic (Silicic) Rhyolite Magma	70% or greater = high	High	Greatest	**Volcanic Domes** (Obsidian) **Calderas** (Supervolcanoes)

Types of Volcanoes

	Volcano Type	Characteristics	Examples
Low Viscosity ↑	**Flood Basalt; Basalt Plateau**	Very fluid basaltic lava; Widespread flows emitted from fissures	Columbia River Plateau Deccan Plateau (India)
	Shield Volcano	Basalt lava forming a shallow-sided cone	Hawaiian Volcanoes; Medicine Mountain Volcano
	Underwater Fissure	Basalt erupts in the deep ocean. The presence of water creates small explosions as the water is vaporized. New oceanic crust is formed.	Mid Atlantic Ridge East Pacific Rise West Mata Volcano
	Cinder Cone	Explosive pyroclastic eruptions; small, steep-sided cone; sometimes associated with Shield Volcanoes.	Paricutin (Mexico); Numerous cones in Lava Beds National Monument; Red Mountain (Arizona)
	Composite Volcano (or Stratovolcano)	More viscous lava (usually andesitic); steep-sided large cone; eruptions include lava flows as well as more explosive pyroclastic eruptions, including small pyroclastic flows.	Mount Shasta Mount Rainier Mount Saint Helens
	Volcanic Domes or Plugs	Very viscous lava (may be volcanic glass); generally, small and associated with calderas or composite volcanoes.	Mount St. Helens Lava Domes; Mono Craters
↓ High Viscosity	**Caldera from a Caldera Eruption**	Very large volcano explosion and collapse; very large pyroclastic flows.	Yellowstone Long Valley Mt. Mazama (Crater Lake)

Tables: Bazard and Wright, 2017

Worksheet 5.1: Volcanoes

1. Mt. Hood in Oregon is a composite volcano. If you were to hike up Mt.Hood, what type of rock would you expect to find most often when you stop to observe outcrops along your way?

2. Last summer, I visited an obsidian flow in the Newberry Caldera in Central Oregon. What is the composition of the magma that produced this flow?

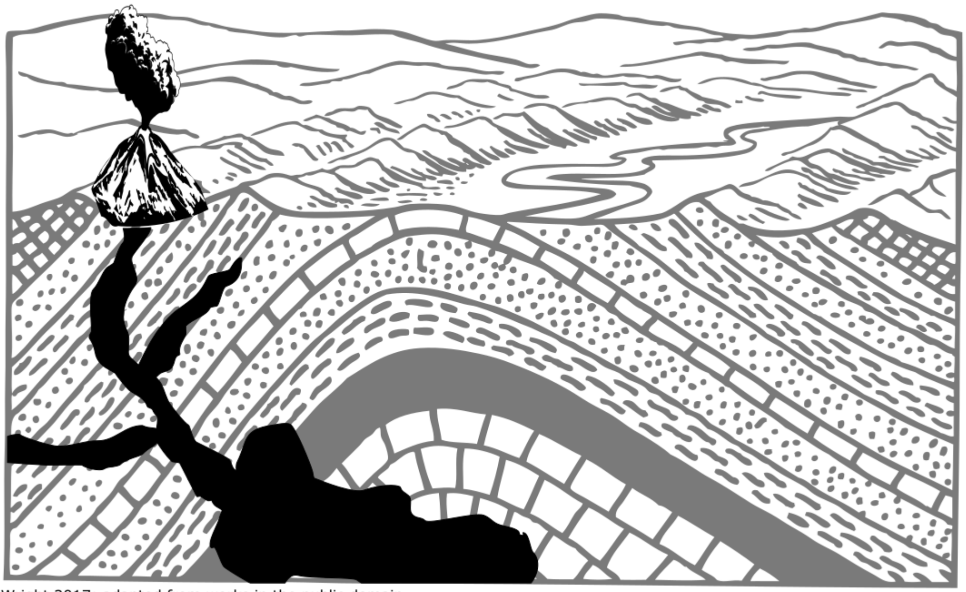
3. The Big Island of Hawaii is composed of multiple Shield Volcanoes, describe the appearance (color, texture, phenocrysts) of rocks that you would find in Hawaii.

4. Describe the type of volcano that would be expected at each of the following settings.
   a. A hot spot located in the middle of an oceanic plate.

   b. A convergent plate boundary with an oceanic plate subducting beneath a continental plate.

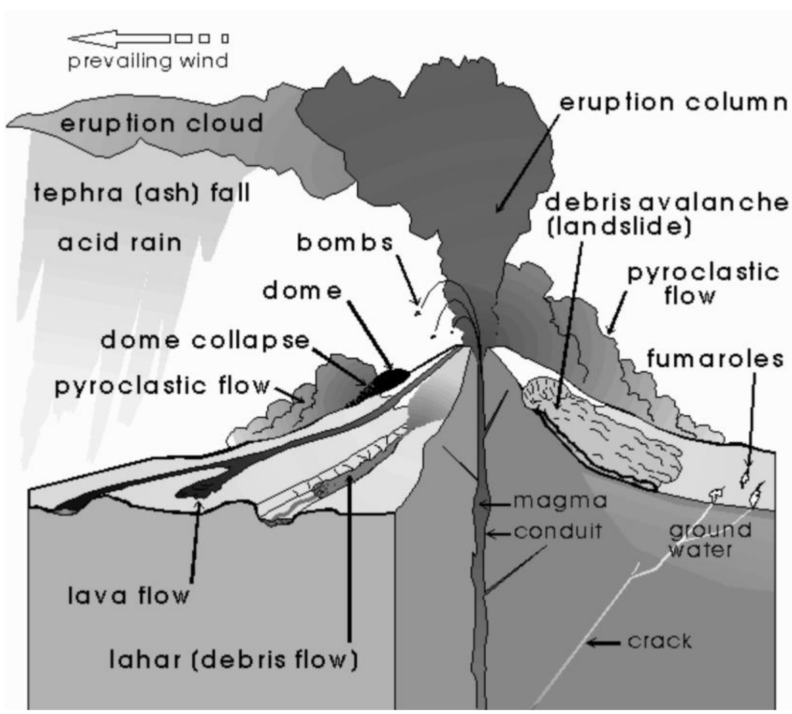
   c. A hot spot within a continental plate.

5. Label at least one dike and at least one sill in the cross section below.

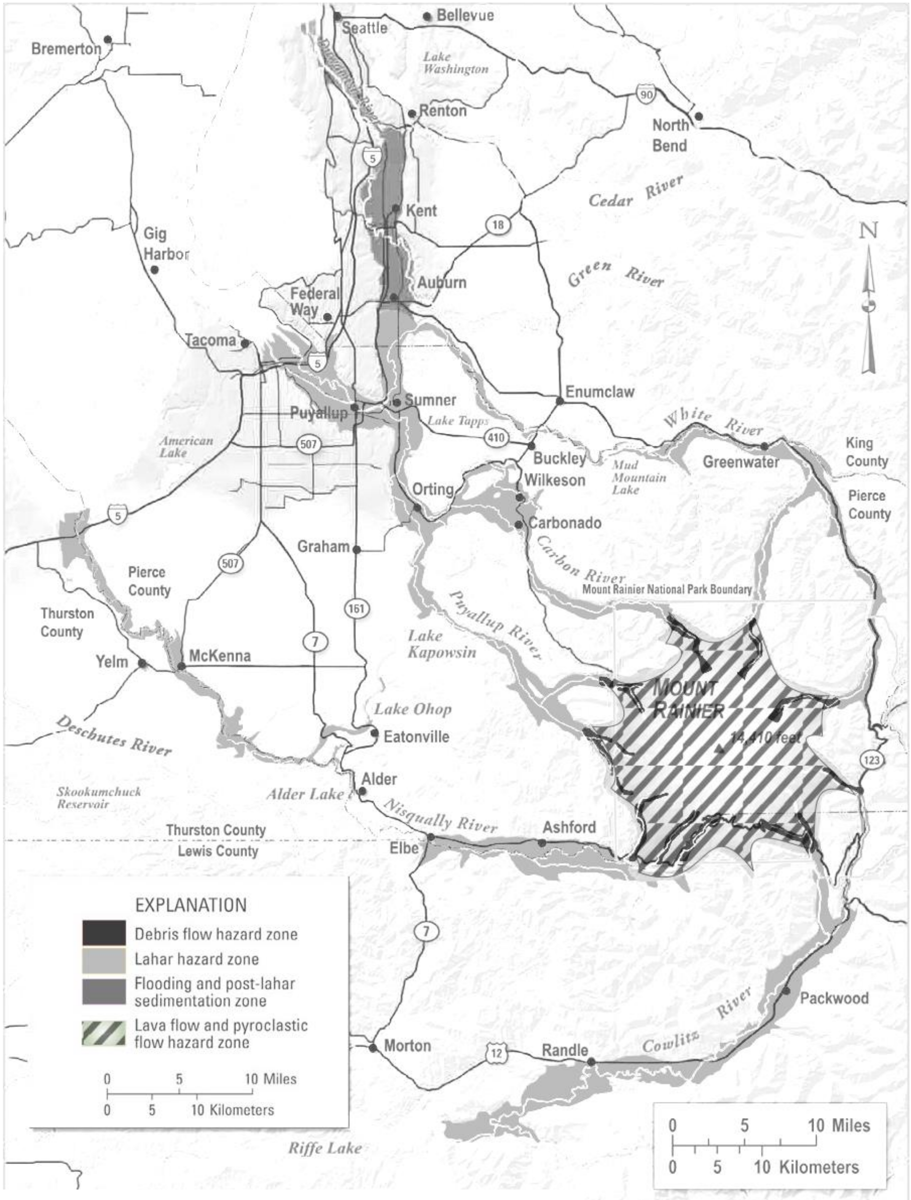


Wright 2017; adapted from works in the public domain

6. Refer to the image below showing potential volcanic hazards. What type of volcano is pictured and how can you tell?



USGS Public Domain



Modified from USGS public domain map

7. Study the volcanic hazard map above. This map shows the hazards associated with an eruption of Mt. Rainier. Note that Seattle is located just off the map to the north of Tacoma. Which of these hazards do you think is most concerning to public officials in Washington State? Why?