Environmental Geology
Chapter 8 – Volcanic Activity

There are approx. 1,500 active volcanoes on Earth. 400 of these volcanoes have erupted in the last century. Impact risks depend on the types of volcanoes.

About 500 million people live near volcanoes, and there have been nearly 100,000 deaths since 1883. Each year there are about 50 eruptions….~23,000 since 1985

Densely populated countries are located in the volcanic zones
Some major cities (>1,000,000 people) are located near volcanoes (e.g., Puebla, Mexico City).

Mt. Unzen, in Japan, is one of the 19 active volcanoes in Japan. It erupted and killed approximately 15,000 people 200 years ago, and erupted violently again on June 3, 1991. There were thousands of ash flows by the end of 1993, getting the dubious honor of the king of the ash flow centers. 44 people were killed, including Harry Glicken, a U.S. volcanologist who escaped death in the May 18, 1980 eruption of Mount St. Helens.

Volcanism = Volcanic activity, directly related to plate tectonics and most active volcanoes are located near plate boundaries – Divergent and Convergent. Volcanism is NOT associated with Transform boundaries. Most volcanic activity -- Approximately two-thirds of the active volcanoes is concentrated along the Pacific *"ring of fire".* In the United States: Alaska, Cascades, and Hawaii, experience two or three eruptions a year

How Magma Forms - Most magmas come from the asthenosphere

Temperature: Increases with depth close to the temperature at which rocks melt, two additional factors:
Decompression melting: Occurs when the overlying pressure exerted on hot rock within the asthenosphere is decreased
Addition of volatiles: Lowers the melting temperature of rocks
Decompression Melting
Addition of volatiles "fluids" (e.g. water)

Volcanic Origin - The tectonic origins of different types of volcanoes helps explain the chemical differences in their rock types.

Volcanism occurring at mid-oceanic ridges produces basaltic rocks. Shield volcanoes are formed above hot spots located below the lithospheric plates.

Composite volcanoes are associated with andesitic volcanic rocks and subduction zones. Caldera-forming eruptions may be extremely explosive and violent, usually found inland of subduction zones

Vulcanism and plate boundaries - There is volcanism at divergent & convergent Boundaries and at hot spots Spots. **At transform Boundaries there is <u>NO vulcanism !!!!</u>**

Volcanic eruption style – Depends on lava's viscosity and amount of dissolved gas content. *Viscosity:* Liquid's resistance to flow, which is determined by silica content (lava composition) and lava temperature . Quiet flow (low viscous basalt flow)-low gas content – more fluid/gas escapes more easily. Violent explosion (high viscous lava eruption)-high gas content in granitic (rhyolitic) to intermediate magmas

Volcano Types

Shield volcano: Built up almost entirely from numerous **Basaltic** lava flows, the slope of a shield volcano is very gentle near the top, but it increases on the flanks
Composite volcanoes: Known for their beautiful cone shape, characterized by magma with an intermediate silica content, distinguished by a mixture of explosive activity and lava flows
Volcanic domes: Characterized by viscous magma with a relatively high silica content, common rock type produced by this magma is *rhyolite*
Cinder cones: Relatively small volcanoes formed from tephra, mostly volcanic ash and larger particles, volcanic bombs

Viscosity and Volcano types

Low viscosity & silica content – Basaltic. Lava erupts "calmly" over long distances. Lava flows can cause significant property damage, but rarely cause fatalities, since they can usually be avoided at walking to jogging speeds. Lava Flows & Tephra (ash/cinders). *Basaltic Flows Common at Oceanic Hot Spots & Divergent Boundaries.* **Cinder cones** can form from tephra (Ash/Cinders/Bombs) & Lava Flows-Basaltic. These may be near larger volcanoes and cracks-fissures. **Fissures eruptions** can form large basaltic lava plateaus (e.g. the Columbia Plateau in the Pacific NW).

Higher Viscosity & More Silica - Intermed.-Andesitic Composition. Lava and Ash forms high, steep cone shape-called composite cones or stratovolcanoes **(More Explosive)**. Usually found inland-above Subduction Zones

High Viscosity & Silica – Rhyolitic/Granitic. These form volcanic domes and are highly explosive. Volcanic domes form "inland" of convergent boundary subduction zones on continental crust, and are composed of extremely thick and stubby high-silica rhyolite lava flows, often associated with incredibly explosive ash-flow sheets and *volcanic collapse craters known as **Calderas.***

Caldera Eruptions. C*alderas are Large – collapse features – formed as magma chamber empties / Supervolcanic Pyroclastic Ash Eruptions – Usually inland from subduction zones.* Giant caldera-forming eruptions are rare, but they represent enormous, global climate-changing eruptions of 100s of cubic km (or more!) of ash into the atmosphere. They can continue to produce eruptions and hazardous conditions for a million years after the initial explosion.

Caldera Eruptions in the U.S. - Two caldera eruptions have occurred in the continental U.S. in the one past million year.Both calderas have experienced recent upwarping of their floors and earthquake activity, indicating magma chambers are still active below! **Yellowstone, Wyoming – Calderas -Last Caldera Forming Eruption – 640,000 yrs ago, and Long Valley, CA (near Mammoth Mtn) -** Last cataclysmic eruption ~700,000 years ago. Minor eruptions in the last 1000 years. The magma chambers lies several kms below the surface. These are not extinct volcanoes.

Volcanoes in Arizona – The most recent eruption in AZ was the Bonito Flow at Sunset Crater, around 1180 A.D. – Sunset Crater. The San Francisco Peaks – Flagstaff (Composite Volcano) erupted between 1 million and 400,000 years ago and is part of a Volcanic Field – 50 miles East to West that began erupting 6 million years ago. The volcanic field includes composite volcanoes, lava domes and cinder cones.

Geysers are formed by groundwater that is heated by magma/igneous rocks

Volcanic Impact Risks - *Lava flows*: From the vent of a crater or along a line of fissures. The most common and abundant type: Basaltic lava flow
Pahoehoe lava: Less viscous, higher temp, with a smooth ropy surface texture
A'a lava: More viscous, lower temp, with a blocky surface texture

Can lava flows be stopped? Efforts have met with mixed success. Methods have included hydraulic chilling (chilling with water) and wall construction. Methods may work best with smaller and slower moving flows

Volcanic Impact Risks -*Pyroclastic* flows – These include an enormous amount of rock fragments, volcanic glass fragments, and volcanic bombs, and are associated with explosive volcanic eruptions. They are more deadly if there is a lateral blast (from the side). Pyroclastic avalanches are a danger, and fire hazards exist from hot temperatures.

Volcanic Impact Risks - Ash flows - Covering large area, 100s or 1,000s of $km^{2.}$ Wider impact if ash flows reach upper atmosphere. Hot ash flows are also called nueé ardentes and can move at rapid speed (100 km/h) causing great harm to

human health and structures, block solar radiation from the ash(cold!), and be hazardous for air traffic

Volcanic Impact Risks -Poisonous Gases. Volcanic gases include H_2O CO_2, CO, SO_2, H_2S in air and dissolved in water. Poisonous gases can be dangerous for health, plants, and animals, and produce smog air, acid rain, and toxic soil.

- In 1986 - Lakes Nyos and Monoun disasters killed 1700 people & 3000 cattle in Cameroon, W. Africa

Mount Pinatubo - June 15–16, 1991. Killed 350 people and destroyed a U.S. military base. Nearly 1-ft depth of ash covered buildings over a 40-km radius. Huge cloud of ash 400 km wide into nearly 40 km elevation, affecting global climate (cooler summer the next year; global temp differences -0.5° C, $\sim 1^{\circ}$ F)

Mount St. Helens - May 18, 1980, erupted after a 120-year dormancy. Earthquake (4–5 magnitude) precursor, triggered massive landslide displacing water in Spirit Lake and traveling an 18-km distance down the Toutle River. The lateral blast impacted an area out to 19 miles at 1000 km/h, and mudflows (lahars) reached nearly 100 km (60 miles) away - Cowlitz and Columbia Rivers. Ash/tephra materials spread over WA, ID, and west MT. Its maximum altitude (peak) was reduced by 450 meters (over 1476 ft). 54 people were killed, and it damaged 100 homes, 800 million feet of timber: Total cost $3 billion

The Cascades and Volcanic Risk
All of these effects/hazards have occurred in recent history of Pacific NW Cascade volcanoes, and will occur again and again in the future. Portland, OR, Seattle and Tacoma, WA are all within the danger zones of composite cone volcanoes, capped with snow and glaciers, that have erupted within the past 2000 years.

Landslides – another risk – These may be slow moving or fast, and near bodies of water **can pose a Tsunami risk.**

Forecasting Volcanic Activity – Things to look for

- Seismic Activities: Earthquakes as precursors
- Thermal, magnetic and hydrologic conditions
- Amount of volcanic gas emission
- Topographic monitoring: Tilting and special bulging
- Remote sensing: Radar 3-D interferometry
- Geologic history of a volcano
- Sharp increase in earthquakes related to fracturing a few days before eruption (warning)

Forecasts and evacuations have been successful at Mount St. Helens (although the lateral blast was unexpected), Mt. Pinatubo (Philippines), and Hawaii

Evacuation is the main response to volcanic hazards.

Public Perception and Adjustments that can be made to prepare or respond to hazards - Based on education level, age and residence time living near a volcano effects one's perception. Many have no other choices as to where to live. Agriculture can be aided by fertile volcanic soils. Public education and communication are the main tools used to reach goal of reducing volcanic hazard and preventing future volcanic crises from becoming volcanic catastrophes.

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