

- **Module Overview: Volcanic Hazards**

- Focus on volcanoes and later explore hazards and risks of eruptions.
- Assessment of different types of magma and erupted materials.
- Characteristics of magma influence eruption styles (peaceful vs. dangerous).

- **Definition of Volcanic Eruptions**

- A volcano is an opening in Earth's crust for molten rock, rock fragments, and gases.
- Various forms of volcanoes; classic conical shape is not universal.

- **Types of Volcanic Hazards**

- Lava flows
- Pyroclastic flows
- Volcanic bombs
- Ashfall
- Hazards from non-erupting volcanoes (e.g., debris avalanches)

- **Magma and Lava**

- **Magma:** Molten or partially molten rock beneath the Earth's surface; stored in a magma chamber.
- **Lava:** Molten rock at the Earth's surface, either flowing or airborne.
- Includes gases produced during eruptions.

- **Volatiles in Magma**

- Compounds with low boiling points kept in solution due to overlying pressure.
- Common volatiles: Water, carbon monoxide, carbon dioxide, methane, sulfur dioxide, hydrogen sulfide.

- **Eruption Dynamics**

- Magma rises as pressure decreases, causing volatiles to exsolve and form bubbles.
- Explosive eruptions fragment magma into pyroclasts.
- Eruption columns transport material into the atmosphere, potentially reaching altitudes of 50 km.

- **Igneous Rock Types and Composition**

- Igneous rocks categorized by silica content:
 - **Mafic:** Low silica (e.g., basalt, gabbro); low viscosity.
 - **Felsic:** High silica (e.g., rhyolite, granite); high viscosity.
 - **Intermediate:** Between mafic and felsic (e.g., andesite, diorite).

- **Impact of Composition on Viscosity**

- Viscosity influenced by temperature, crystal content, and silica content.
- Mafic magmas flow easily; felsic magmas are sticky and flow slowly.

- **Differences in Tectonic Settings**

- **Mid-Ocean Ridges:**
 - Diverging plates, forming mafic magma through decompression melting.
 - Pillow basalts formed underwater; minimal hazard to human life.
- **Volcanic Arcs:**
 - Melting occurs from subducting plates carrying water-rich sediments, forming more explosive intermediate to felsic magmas.
- **Hotspots:**
 - Eruptions vary based on whether oceanic or continental plates are melted.
- **Lava Forms and Properties**
 - **Pillow Basalts:** Formed underwater, characterized by glassy skin.
 - **Pumice:** Light, frothy volcanic glass, often floats on water.
 - **Cinders (Scoria):** Dark, heavier pyroclasts, used in landscaping.
 - **Bombs and Blocks:** Large pyroclasts formed from basaltic eruptions; bombs are liquid during ejection.
- **Pyroclastic Materials**
 - **Ash:** Small particles that can be transported over large distances; dangerous.
 - **Pyroclastic Flows:** High-density flows of pyroclasts and gases; extremely deadly.
- **Volcanic Gases**
 - Dominated by water vapor; other gases include carbon dioxide, methane, and sulfur compounds.
 - Fumaroles release gases; sulfur deposits are indicative.
- **Benefits of Volcanic Soils**
 - Rich in nutrients from volcanic minerals.
 - Volcanic soils are some of the most fertile on Earth, balancing risks and benefits for human habitation.

Types of Volcanic Eruptions

- **Classification Criteria:** Three Vs
 - Viscosity
 - Volatile Content
 - Volume

Peaceful Eruptions

- **Icelandic Eruptions:**
 - Associated with mid-ocean ridges (water depth of 2-3 km).
 - Iceland sits on mid-Atlantic ridge above sea level due to a mantle plume.
 - Characteristics:

- High temperatures, low silica and volatile content.
- Very low viscosity, allowing gas bubbles to escape.
- Generally non-explosive and pose little danger.
- Form flood basalts over geological time.
- Example: Fagradalsfjall eruption (2021).
 - Basaltic lava forms lava fountains and rivers.
 - Horizontal layering visible in cliffs.

- **Hawaiian Eruptions:**

- Occur on an oceanic hotspot in the middle of the Pacific Plate.
- Chain of volcanic islands due to northwestward motion of the Pacific plate over a stationary mantle plume.
- Types of lava:
 - **Pahoehoe:** Smooth, unbroken lava; can form lava rivers.
 - **RR Lava:** Stony, rough lava; more viscous than pahoehoe.
- Form giant shield volcanoes, e.g., Mauna Loa.
 - Largest volcano on Earth by volume.
 - Summit height: ~4,200 m; total height from base is ~10 km.
 - Gentle slopes (~1 in 20 gradient).

Eruption Types in Volcanic Arcs

- **Eruption Categories** (Italian Names):

- **Strombolian:**
 - Named after Stromboli.
 - Low to medium viscosity basaltic to andesitic magmas.
 - Mildly explosive, short bursts of ejecting glowing bombs.
 - Form cinder or scoria cones (e.g., Lassen Volcanic National Park).
- **Volcanian:**
 - Named after the island of Volcano.
 - Involves andesitic or rhyolitic magma (medium to high viscosity).
 - Generates explosions, pyroclastic flows, and large blocks.
 - Fewer eruptions/year (~3 to 5).
- **Plinian:**
 - Named after Pliny the Younger (Vesuvius eruption in 79 CE).
 - Highest viscosity, rhyolitic magma; very explosive.
 - Large volumes of magma ejected; can collapse into a caldera.
 - Just a few occurrences per century (four in the last 40 years; example: 1991 Mount Pinatubo).
 - Pyroclastic flows and ash fallout hazards (e.g., the impact of Typhoon Yunya).

Extreme Eruptions

- **Ultra-Plinian:**
 - Ejects more than 10 cubic kilometers of material; columns exceed 25 km in height.
 - Historical examples include Krakatau (1883) and Mount Tambora (1815).
 - Greatest eruption in geological history: Yellowstone (~630,000 years ago); ~1,000 cubic kilometers of pyroclastic material.

Volcanic Explosivity Index (VEI)

- Measures eruption size based on volume of pyroclastic material and height of eruption column.
- VEI Scale:
 - 0 to 1: Daily eruptions.
 - 2: Weekly eruptions.
 - 3: Yearly eruptions.
 - 4: Occur every few decades (1 cubic km of material).
 - 8: Largest eruptions, e.g., Yellowstone.

Summary of Eruption Categories

1. **Icelandic:** Low viscosity, mafic magma - flood basalts.
2. **Hawaiian:** Basaltic magma - shield volcanoes.
3. **Strombolian:** Basaltic to andesitic magma - scoria cones.
4. **Volcanian:** Andesitic to rhyolitic magma - stratovolcanoes.
5. **Plinian:** Rhyolitic magma - larger volume, collapsing calderas.
6. **Ultra-Plinian:** Highest viscosity/volatile content - large eruptions.

Next Lecture Focus

- Hazards and risks associated with volcanic eruptions.