# VOLCANIC HAZARDS

## LESSON 1: Lava Flow

**Lava** is molten rock or magma that comes out of the Earth's surface. It happens when magma meets the surface of a volcano and spills over or erupts from various volcanic openings. **Lava flows** can be either **fluid** or **viscous** depending on its makeup, temperature, and gas levels. Lava with low silica, high temperature, and little gas is more **fluid**, while lava with high silica, low temperature, and lots of gas is **viscous**.

### Types of Lava Flows

**Pahoehoe,** which is smooth and ropey due to high fluidity, and **Aa,** characterized by a blocky and jagged appearance. Pahoehoe may transition into Aa as it cools, but Aa doesn't necessarily originate from Pahoehoe.

### Negative Impacts of Lava Flows

Lava flows typically pose minimal threat to human life since they move at a pace similar to a normal walking speed. They are also relatively easy to monitor compared to other volcanic dangers. However, they remain hazardous as they can destroy structures and livelihoods by crushing and burying them as they solidify over time. This solidification also obstructs roads and pathways, rendering affected areas inaccessible. Additionally, the intense heat of lava can ignite flammable materials like wood, plants, and buildings along its path.

### Mitigating the Negative Effects of Lava Flows

Lava flows, like other volcanic hazards, are generally unstoppable. However, measures can be taken to control and mitigate their impact on human lives. Artificial barriers can be built to divert or prevent lava from reaching certain areas. Water jets can be employed to cool and slow down the lava, potentially halting its progress. Additionally, the use of explosives can alter the flow's pathway and source, providing another means of control.

### Examples of Volcanic Eruption with Lava Flows and Response of Communities

**Mount Mayon** in the Bicol Region is one of the Philippines' most active volcanoes, having erupted numerous times throughout history, including instances of lava flows since the early 17th century. Despite this activity, no casualties from lava flows have been recorded, thanks to effective monitoring and timely dissemination of information to local communities. However, property and livelihood damages were inevitable as lava flowed through surrounding towns. The Philippine Institute of Volcanology and Seismology (PHIVOLCS) has implemented early warning systems to minimize casualties and mitigate the impacts of lava flows on the community.

In contrast, **Mount Kilauea** in Hawaii is renowned for its constant lava flows, which are a regular part of life due to the island's volcanic nature.

## LESSON 2: Volcanic Gases

Magma, containing **volcanic gases**, seeks to emerge onto the Earth's surface through openings in volcanoes. The release of these gases is a prevalent volcanic activity that occurs prior to, during, and after eruptions, emanating from various openings on the volcano.

The composition of volcanic gases varies depending on their location. Typically, **water vapor** and **carbon dioxide** form the majority of volcanic gases, with **sulfur dioxide** also being prevalent. Additionally, **hydrogen chloride** and **hydrogen fluoride** are commonly found in volcanic emissions.

### Negative Impacts of Volcanic Gas

Most volcanic gases, except for water vapor, are harmful to people. Sulfur dioxide can form sulfuric acid in the atmosphere, causing acid rain that damages the environment and harms plants, animals, and man-made structures. Direct contact with sulfur dioxide can irritate the eyes, skin, and respiratory system. Carbon dioxide is also dangerous, especially in high concentrations, as it can cause asphyxiation without warning due to its odorless and colorless nature. Additionally, it tends to accumulate in low-lying areas, posing a risk to populated areas.

### Mitigating the Negative Effects of Volcanic Gas

Unlike slow-moving lava flows, volcanic gases can be released into volcanic openings with minimal notice and are influenced by wind direction, unlike lava flows that follow the land's contour. Volcano observatories monitor volcanic gases using various techniques to detect hazardous levels. Those in the immediate area may be affected, and wearing masks is advised. It's crucial to leave the area promptly once volcanic gases are released into the atmosphere. Increasing public awareness of volcanic gas hazards is key to reducing risk.

### Volcanic Gases and their Impacts

**The Disaster in Lake Nyos:** In 1986, a significant disaster occurred due to volcanic gases at Lake Nyos in Central Africa. The lake, situated atop an old volcano, contained a large pocket of carbon dioxide gas beneath its surface. Unexpectedly a gas eruption released a massive amount of carbon dioxide into the air. Due to its odorless and colorless nature, residents were unaware of the danger. The dense gas flowed down into nearby valleys, suffocating nearly two thousand people. To prevent future casualties, a degassing pipe was installed to safely release gas pressure from beneath the lake.

### The Sulfur Gas of Mount Ijen:

Mount Ijen in Java, Indonesia, is an active volcano that emits significant amounts of sulfur-rich volcanic gases. Local miners extract sulfur from the crater area due to its high concentration. The volcano is also a tourist attraction known for its blue flames resulting from sulfur combustion. Despite exposure to high levels of volcanic gases, both locals and tourists hike in the area daily, with short-term exposure typically having no lasting effects. However, sulfur miners in the vicinity have experienced various health issues, including lung poisoning, eye irritation, and tooth decay.

## LESSON 3: Pyroclastic Flows

**Pyroclastic flows** are fast-moving mixtures of volcanic fragments and gases that rush down a volcano's slope at speeds reaching several hundred meters per second. These volcanic fragments, known as pyroclastic materials or **tephra**, vary in size from ash to boulders. Pyroclastic flows consist of two main parts: a **basal flow** of coarse materials and a turbulent ash cloud riding above it. When this ash cloud separates from the main flow, it forms what's called a **pyroclastic surge**, which is less dense and more mobile due to its higher gas-to-tephra ratio.

### Types of Pyroclastic Flow

- **Soufrière type** - Pyroclastic flows, occurring in various forms, notably include the Soufrière type. This type results from the collapse of a tall vertical column generated by a highly explosive eruption. As gravity overcomes the eruption's upward momentum, pyroclastic materials descend, forming flows along the volcano's sides.
- **Pelée type** - The Pelée type of eruption occurs when a thick lava dome obstructs a volcano's opening, causing pressure to build until it explosively releases to one side of the volcano without forming a tall eruption column.
- **Merapi type** - The Merapi type of eruption happens when a lava dome becomes too steep over a volcanic crater and collapses under gravity's force.

### Negative Impacts and Mitigation of Pyroclastic Flows

Pyroclastic flows are among the most dangerous volcanic hazards due to their high temperature, speed, and mobility. They can cause casualties, damages, and destruction without warning, destroying virtually any structure in their path. The intense heat and speed can crush and carry away large objects, while the heat can burn forests, buildings, and other flammable materials. Resettlement in affected areas is not possible due to lingering heat. Humans can suffer from asphyxiation, burial, or incineration upon contact. Pyroclastic flows also trigger other hazards like lahars, muddy mixtures that affect areas downslope when pyroclastic materials mix with water or ice. There are no means to prevent pyroclastic flows, and they're difficult to detect before an eruption. Early warning and evacuation are the only effective measures to mitigate their risks.

### Example of Impacts of Pyroclastic Flows

The Mt. Pinatubo eruption in June 1991, one of the greatest of the 20th century, saw explosive activity after 500 years of dormancy. The most intense eruptions occurred on June 12 and 15, ejecting massive amounts of volcanic material up to 30 kilometers into the atmosphere and causing 36 hours of darkness in the surrounding area. A devastating pyroclastic flow traveled up to 16 kilometers, affecting around 20,000 indigenous people and over a million lowlanders. Despite the violence, casualties were relatively low thanks to early warnings and government evacuations, along with effective public information campaigns.

## LESSON 4: Ballistic Projectiles and Tephra Falls

**Tephras** are fragments of volcanic material ejected into the atmosphere during an eruption. They are classified based on size: **ash** (less than 2mm), **lapilli** (2-64mm), or **blocks and bombs** (greater than 64mm). Large tephra, forcefully expelled from the vent, are known as **ballistic projectiles** and can travel at speeds of hundreds of meters per second, impacting areas within a five-kilometer radius. **Tephra falls** occur when volcanic material hovers in the atmosphere before descending due to prevailing winds. These can linger for extended periods, with ash particles traveling thousands of kilometers. Deposits thin and fine as tephra disperses, and tephra falls are often referred to as ash falls, as larger tephra typically fall around thirty minutes after eruption.

### Negative Impacts of Tephra Falls and Ballistic Projectiles

Tephra falls, with their wide-ranging effects, can cover large areas depending on eruption size and wind patterns. In contrast, ballistic projectiles affect areas closer to the volcano due to their weight. Both tephra falls and ballistic projectiles pose risks to lives and property upon impact, with the impact decreasing as distance from the source increases. Accumulated tephra can lead to burial and collapse of structures, while ash mixed with water can damage infrastructure. Additionally, tephra can carry harmful particles and gases and block critical facilities like drainage and sewage systems. Suspended ash can also disrupt air travel.

### Mitigating the Negative Impacts of Tephra Falls and Ballistic Projectiles

Some tephra fall risks can be managed without evacuation. Regularly clearing ash buildup from structures and designing roofs to prevent accumulation can reduce structural failure risks. Strengthening structures helps withstand impacts and ash loads. Wearing masks or respiratory gear minimizes inhalation of ash and toxic gases.

### Examples of Impacts of Tephra Falls and Ballistic Projectiles

**Volcanic ashes of Eyjafjallajökull:** In 2010, Iceland's Eyjafjallajökull volcano erupted, emitting vast amounts of ash into the atmosphere. Despite being a minor eruption compared to previous ones, the ash caused widespread disruptions to air traffic across Europe. The effects endured for weeks, with thousands of flights canceled, leaving hundreds of thousands of travelers stranded and resulting in significant economic losses for affected countries.

**Volcanic eruption hampering war efforts:** In 1944, during World War II, a violent eruption of Mt. Vesuvius hindered Allied forces' progress against the Germans near Naples, Italy. The eruption prompted evacuation efforts to minimize casualties from ballistic projectiles bombarding the surrounding areas. Additionally, thick layers of ash covered the region, and advancing lava destroyed structures and buildings in its path.