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Higher Education Department

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E-CONTENT

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2.4.5. VOLCANIC ERUPTIONS

Volcanoes are Earth's geologic architects. They have created more than 80% of our planet's surface, laying the foundation that has allowed life to thrive. Their explosive force crafts mountains as well as craters. Lava rivers spread into bleak landscapes. But as time ticks by, the elements break down these volcanic rocks, liberating nutrients from their stony prisons and creating remarkably fertile soils that have allowed civilizations to flourish.

There are volcanoes on every continent, even Antarctica. Some 1,500 volcanoes are still considered potentially active around the world today. But each volcano is different. Some burst to life in explosive eruptions, like the 1991 eruption of Mount Pinatubo, and others burp rivers of lava in what's known as an effusive eruption, like the 2018 activity of Hawaii's Kilauea volcano. These differences arise due to the chemistry that drive the molten activity. Effusive eruptions are more common when the magma is less viscous, or runny, which allows gas to escape and the magma to flow down the volcano's slopes. Explosive eruptions, however, happen when viscous molten rock traps the gasses, building pressure until it violently breaks free.

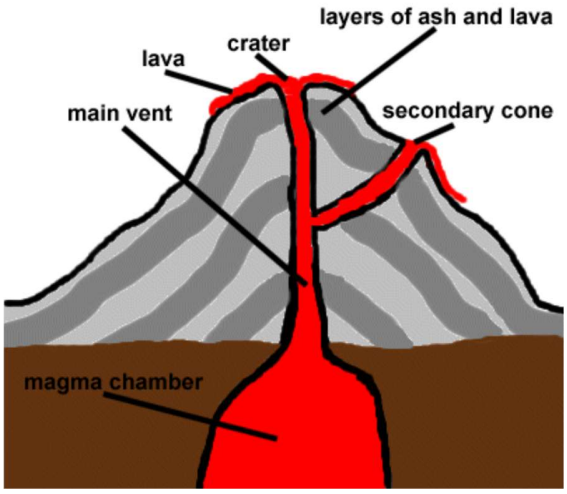

Figure 1: A simple cross section of a volcano

*A **volcano** is a vent (opening) in the earth's crust through which molten rock known as magma erupts suddenly from depth to the Earth's surface. Magma erupting from a volcano is called lava and is the material which builds up the cone surrounding the vent.*

I. DISTRIBUTION OF VOLCANOES

Some 75% of the world's active volcanoes are positioned around the ring of fire, a 25,000-mile long, horseshoe-shaped zone that stretches from the southern tip of South America across the West Coast of North America, through the Bering Sea to Japan, and on to New Zealand.

This region is where the edges of the Pacific and Nazca plates butt up against an array of other tectonic plates. Importantly, however, the volcanoes of the ring aren't geologically connected. In other words, a volcanic eruption in Indonesia is not related to one in Alaska, and it could not stir the infamous Yellowstone supervolcano.

II. HOW DO VOLCANOES FORM?

The majority of volcanoes in the world form along the boundaries of Earth's tectonic plates—massive expanses of our planet's lithosphere that continually shift, bumping into one another. When tectonic plates collide, one often plunges deep below the other in what's known as a subduction zone. As the descending landmass sinks deep into the Earth, temperatures and pressures climb, releasing water from the rocks. The water slightly reduces the melting point of the overlying rock, forming magma that can work its way to the surface—the spark of life to reawaken a slumbering volcano.

Not all volcanoes are related to subduction, however. Another way volcanoes can form is what's known as hotspot volcanism. In this situation, a zone of magmatic activity—or a hotspot—in the middle of a tectonic plate can push up through the crust to form a volcano. Although the hotspot itself is thought to be largely stationary, the tectonic plates continue their slow march, building a line of volcanoes or islands on the surface. This mechanism is thought to be behind the Hawaii volcanic chain.

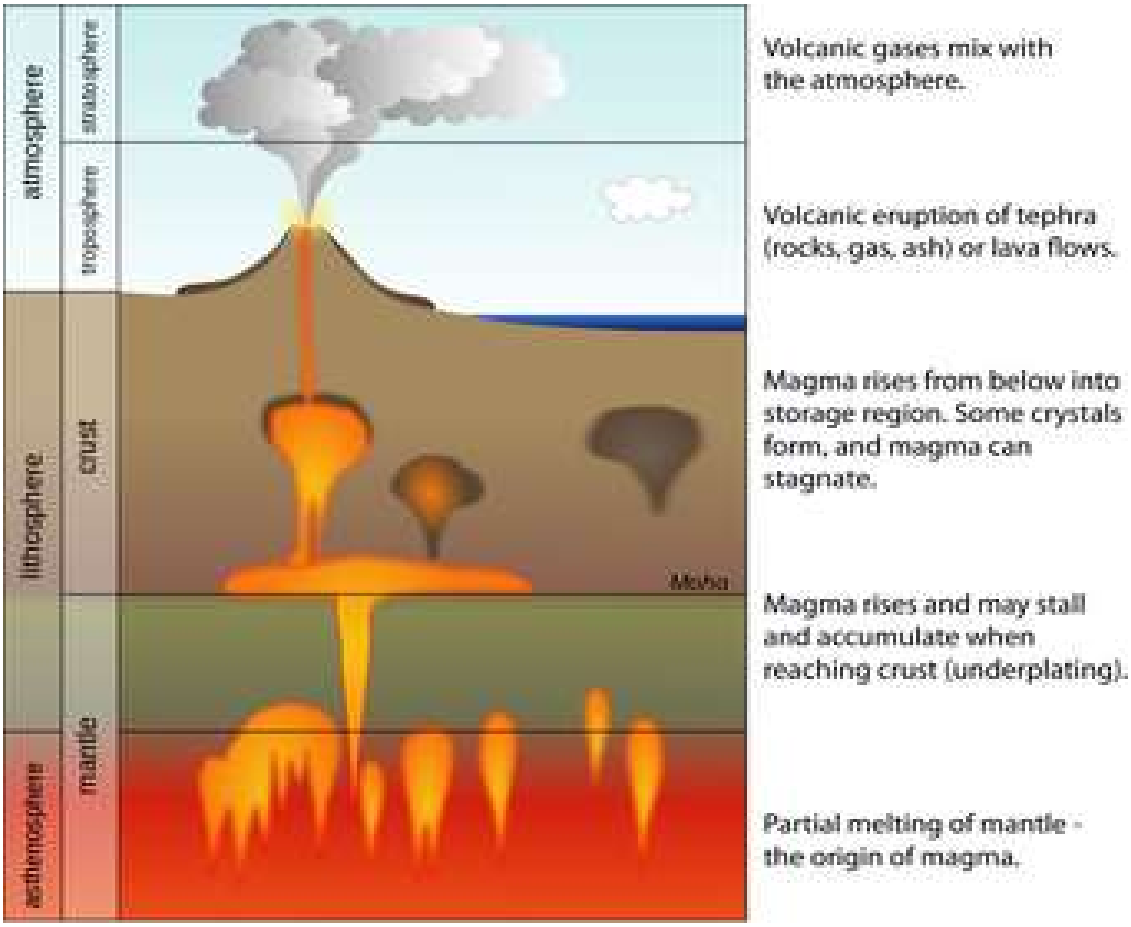

Figure 2: Illustration of the basic process of magma formation, movement to the surface, and eruption through a volcanic vent.

III. CAUSES OF VOLCANOES

Volcanoes occur when material significantly warmer than its surroundings is erupted onto the surface of a planet or moon from its interior. On Earth, the erupted material can be liquid rock ("lava" when it's on the surface, "magma" when it's underground), ash, cinders, and/or gas. There are three reasons why magma might rise and cause eruptions onto Earth's surface. Volcanoes on Earth form from rising magma. Magma rises in three different ways.

- Magma can rise when pieces of Earth's crust called tectonic plates slowly move away from each other. The magma rises up to fill in the space. When this happens underwater volcanoes can form.

- Magma also rises when these tectonic plates move toward each other. When this happens, part of Earth's crust can be forced deep into its interior. The high heat and pressure cause the crust to melt and rise as magma.

- A final way that magma rises is over hot spots. Hot spots are exactly what they sound like-hot areas inside of Earth. These areas heat up magma. The magma becomes less dense. When it is less dense it rises. Each of the reasons for rising magma are a bit different, but each can form volcanoes.

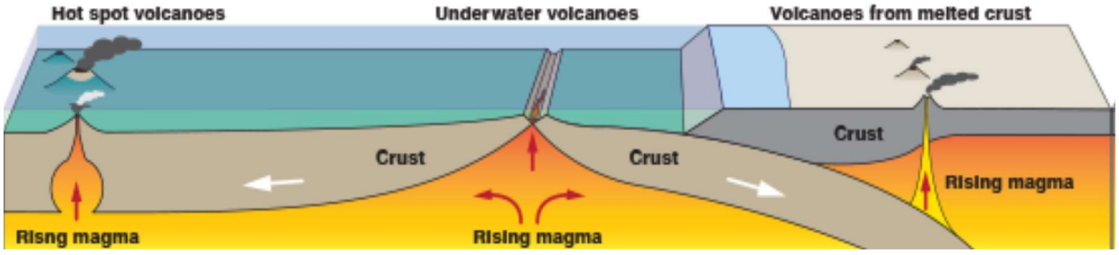

Figure 2: Volcanoes on Earth form from rising magma. Magma rises in three different ways.

IV. CATEGORIES OF VOLCANOES

Volcanoes are categorized into three main categories:

1. Active: An ***active volcano*** is one which is recently erupted and there is a possibility that it may erupt soon.
2. Dormant: A ***dormant volcano*** is one that has not erupted in a long time but there is a possibility it can erupt in the future.
3. Extinct: An ***extinct volcano*** is one which has erupted thousands of years ago and there's no possibility of an eruption.

The explosiveness of a volcanic eruption depends on how easily magma can flow and the amount of gas trapped within the magma. Large amounts of water and carbon dioxide are dissolved in magma causing it to behave in a similar way to gas expanding in fizzy drinks, which forms bubbles and escapes after opening. As magma rises quickly through the Earth's crust, gas bubbles form and expand up to 1000 times their original size.

V. TYPES OF A VOLCANO

Volcanoes can be different in appearance with some featuring perfect cone shapes while others are deep depressions filled with water. The form of a volcano provides a clue to the type and size of its eruption which is controlled by the characteristics and composition of magma. The size, style and frequency of eruptions can differ greatly, but all these elements correlated to the shape of a volcano. Three common volcanoes are:

1. **Shield volcano:** When magma is very hot and runny, gases can escape and eruptions are gentle with considerable amounts of magma reaching the surface to form lava flows. Shield volcanoes have a broad, flattened dome-like shape created by layers of runny lava flowing over its surface and cooling. Because the lava flows easily, it can move down gradual slopes over great distances from the volcanic vents. The lava flows are sufficiently slow for humans to outrun or outwalk them. This type of magma has a temperature between 800°C and 1200°C and is called basaltic magma.

2. **Composite volcano (Stratovolcano):** Also known as strato-volcanoes, these volcanoes are characterised by an explosive eruption style. When magma is slightly cooler it is thick and sticky, or viscous, which makes it harder for gas bubbles to expand and escape. The resulting pressure causes the magma to foam and explode violently, blasting it into tiny pieces known as volcanic ash. These eruptions create steep sided cones. They can also create lava flows, hot ash clouds called pyroclastic flows and dangerous mudflows called lahars. This type of magma has a temperature between 800°C and 1000°C and is called andesitic magma.

3. **Caldera volcano:** These erupt so explosively that little material builds up near the vent. Eruptions partly or entirely empty the underlying magma chamber which leaves the region around the vent unsupported, causing it to sink or collapse under its own weight. The resulting basin-shaped depression is roughly circular and is usually several kilometres or more in diameter. The lava erupted from caldera volcanoes is very viscous and generally the coolest with temperatures ranging from 650°C to 800°C and is called rhyolitic magma. Although caldera volcanoes are rare, they are the most dangerous. Volcanic hazards from this type of eruption include widespread ash fall, large pyroclastic surges and tsunami from caldera collapse into oceans.

VI. VOLCANIC HAZARDS

Volcanic eruptions pose many dangers aside from lava flows. It's important to heed local authorities' advice during active eruptions and evacuate regions when necessary. *Volcanic hazards include explosions, lava flows, bombs or ballistics, ash or tephra, pyroclastic flows, pyroclastic surges, mudflows or lahars, landslides, earthquakes, ground deformation, tsunami, air shocks, lightning, poisonous gas and glacial outburst flooding known as jökulhlaups.*

- One particular danger is pyroclastic flows, avalanches of hot rocks, ash, and toxic gas that race down slopes at speeds as high as 450 miles an hour. Such an event was responsible for wiping out the people of Pompeii and Herculaneum after Mount Vesuvius erupted in A.D. 79.

- Similarly, volcanic mudflows called lahars can be very destructive. These fast-flowing waves of mud and debris can race down a volcano's flanks, burying entire towns.

- Ash is another volcanic danger. Unlike the soft, fluffy bits of charred wood left after a campfire, volcanic ash is made of sharp fragments of rocks and volcanic glass each less than two millimeters across. The ash forms as the gasses within rising magma expand, shattering the cooling rocks as they burst from the volcano's mouth. It's not only dangerous to inhale, it's heavy and builds up quickly. Volcanic ash can collapse weak structures, cause power outages, and is a challenge to shovel away post-eruption.

The different types of (primary) eruptive events are:	**Secondary events are**
• Pyroclastic explosions; • Hot ash releases; • Lava flows; • Gas emissions; • Glowing avalanches (gas and ash releases).	• Melting ice, snow and rain accompanying eruptions are likely to provoke floods and hot mudflows (or lahars); • Hot ash releases can start fires.

Each hazard has a different consequence, although not all occur in all eruptions or in association with all volcanoes. Volcanic eruptions are measured using a simple descriptive index known as the Volcano Explosivity Index, which ranges from zero to eight. The index combines the volume of material ejected with the height of an eruption column and the duration of the eruption.

Volcanoes which are likely to constitute a disaster threat are internationally well documented and, in many cases, monitored for possible activity. Usually, therefore, major eruptions can be predicted.

• Volcanic blast can destroy structures and environmental surrounds, and also cause fires, possibly including forest fires.

• Land surface cracking, resulting from volcanic explosion, may affect buildings and other structures.

• Lava flow can bury buildings and crops. It may also cause fires and render land unusable.

• Ash, in its airborne form, can affect aircraft by ingestion into engines.

• Ground deposit of ash may destroy crops and also affect land use and water supplies.

• Ash may also cause respiratory problems.

• Mud flows may arise from associated heavy rain.

Volcanoes are much safer than other natural events such as earthquakes, floods, and hurricanes. However, volcanic eruptions can hurl hot rocks for at least 30 km. Floods, airborne ash, or noxious fumes can spread 160 km or more. If you live or work near a known volcano, active or dormant, be ready to evacuate at a moment's notice. Stay out of the area. A lateral blast of a volcano can travel many km from the mountain.

- Be prepared for these disasters that can be spawned by volcanoes: earthquakes, flash floods, landslides and mudflows, thunderstorms, tsunamis.

- Evacuation: Although it may seem safe to stay at home or in the office and wait out and eruption, doing so could be very dangerous. The rock debris from a volcano can break windows and set buildings on fire. Leave the area before the disaster begins.

Factors of Vulnerability

- Topographic factors;
- The proximity of a population to the volcano;
- Structures with roof not resistant to ashes accumulations;
- The lack of warning system and evacuation plans.

Main causes of Mortality and Morbidity

A. Direct impact: The risk depends on the different types of event:

- Mediated trauma, crush type injuries, and lacerations can be caused by explosion and contact with volcanic mass;
- Hot ash, gases, rock and magma cause skin and lung burns, asphyxiation, conjunctivitis or corneal abrasion;

- Breathing the gases and fumes can cause acute respiratory distress;
- Acid rain provokes eyes and skin irritation.

In the case of ashfall, particularly in fine particles, bronchial asthma and other chronic respiratory conditions can be aggravated in children as well as in adults. Death is highly improbable. Nonetheless, it can occur in persons with serious symptoms if they do not protect themselves from the ashes.

B. Indirect Impact

- Ashes can have toxic consequences (i.e. gastrointestinal problem) due to ingestion of contaminated food or water.
- Ashes can have mechanical consequences. The weight of ash may cause collapse of building (i.e. trauma).
- Damage on health infrastructures and water systems can be severe. Problem of communication (ashes create serious interference) and transportation (poor visibility and slippery roads) are likely to happen.

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