# Volcanic Eruptions

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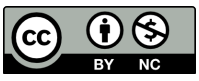

# CHAPTER 1 Volcanic Eruptions

## Lesson Objectives

- Explain how volcanoes erupt.
- Describe and compare the types of volcanic eruptions.
- Distinguish between different types of lava and understand the difference between magma and lava.
- Describe a method for predicting volcanic eruptions.

## Vocabulary

- active volcano
- dormant volcano
- eruption
- explosive eruption
- extinct volcano
- magma chamber
- pyroclast

## Introduction

In 1980, Mount St. Helens, located between Portland, Oregon and Seattle, Washington, erupted explosively. The eruption killed 57 people, destroyed 250 homes, and swept away 47 bridges. The volcano blew off its top so that it lost over 400 meters (1,300 feet) of height. Mt. St. Helens is still active ( **Figure** 1.1). Within the crater, a new lava dome formed. How did this eruption occur? Why aren't all volcanoes explosive, like Mt. St. Helens? Why did so many people die if we knew that it was going to erupt?

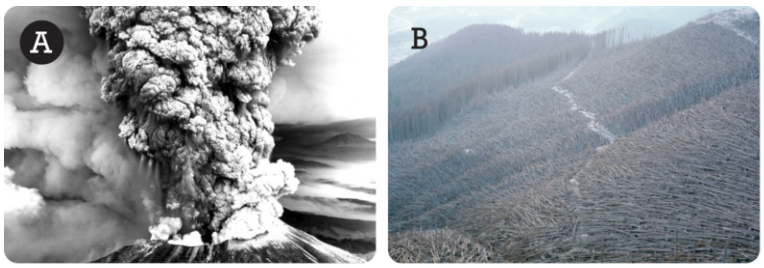


FIGURE 1.1

(A) Mount St. Helens eruption on May 18, 1980. Mt. Adams is in the background on the right. (B) The eruption of Mt. St. Helens blew down acres of trees like they were toothpicks.

## How Volcanoes Erupt

All volcanoes share the same basic features. First, mantle rock melts. The molten rock collects in magma chambers that can be 160 kilometers (100 miles) beneath the surface. As the rock heats, it expands. The hot rock is less dense than the surrounding rock. The magma rises toward the surface through cracks in the crust. A volcanic **eruption** occurs when the magma reaches the surface. Lava can reach the surface gently or explosively.

## Types of Eruptions

Eruptions can be explosive or non-explosive. Only rarely do gentle and explosive eruptions happen in the same volcano.

### Explosive Eruptions

An **explosive eruption** produces huge clouds of volcanic ash. Chunks of the volcano fly high into the atmosphere. Explosive eruptions can be 10,000 times as powerful as an atomic bomb ( **Figure** 1.2). Hot magma beneath the surface mixes with water. This forms gases. The gas pressure grows until it must be released. The volcano erupts in an enormous explosion.

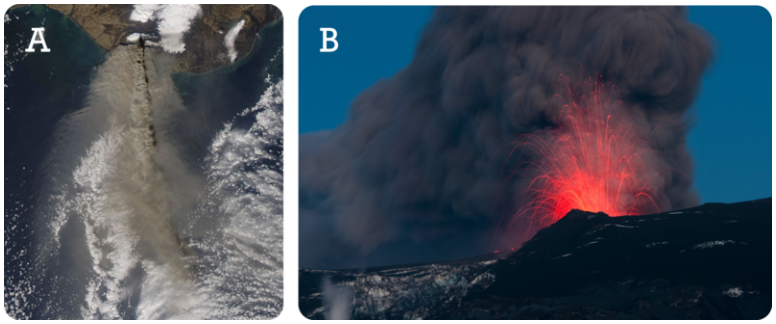


FIGURE 1.2

(A) Eyjafjallajökull volcano in Iceland spewed ash into the atmosphere in 2010. This was a fairly small eruption, but it disrupted air travel across Europe for six days. (B) The eruption seen from nearby.

Ash and particles shoot many kilometers into the sky. The material may form a mushroom cloud, just like a nuclear explosion. Hot fragments of rock, called **pyroclasts**, fly up into the air at very high speeds. The pyroclasts cool in the atmosphere. Some ash may stay in the atmosphere for years. The ash may block out sunlight. This changes weather patterns and affects the temperature of the Earth. For a year or two after a large eruption, sunsets may be especially beautiful worldwide.

Volcanic gases can form poisonous, invisible clouds. The poisonous gases may be toxic close to the eruption. The gases may cause environmental problems like acid rain and ozone destruction.

Mt St. Helens was not a very large eruption for the Cascades. Mt. Mazama blew itself apart in an eruption about 42 times more powerful than Mount St. Helens in 1980. Today all that remains of that huge stratovolcano is Crater Lake ( **Figure** below).

### Non-explosive Eruptions

Some volcanic eruptions are non-explosive ( **Figure** 1.3). This happens when there is little or no gas. The lava is thin, fluid and runny. It flows over the ground like a river. People generally have a lot of warning before a lava flow

like this reaches them, so non-explosive eruptions are much less deadly. They may still be destructive to property, though. Even when we know that a lava flow is approaching, there are few ways of stopping it!

FIGURE 1.3

A lava flow in Iceland in 1984.

## Magma and Lava

Great volcanic explosions and glowing red rivers of lava are fascinating. All igneous rock comes from magma or lava. Remember that magma is molten rock that is below Earth's surface. Lava is molten rock at Earth's surface.

### Magma

Magma forms deep beneath the Earth's surface. Rock melts below the surface under tremendous pressure and high temperatures. Molten rock flows like taffy or hot wax. Most magmas are formed at temperatures between 600$^o$C and 1300$^o$C ( **Figure** 1.4).

Magma collects in **magma chambers** beneath Earth's surface. Magma chambers are located where the heat and pressure are great enough to melt rock. These locations are at divergent or convergent plate boundaries or at hotpots.

The chemistry of a magma determines the type of igneous rock it forms. The chemistry also determines how the magma moves. Thicker magmas tend to stay below the surface or erupt explosively. When magma is fluid and runny, it often reaches the surface by flowing out in rivers of lava.

### Lava

The way lava flows depends on what it is made of. Thick lava doesn't flow easily. It may block the vent of a volcano. If the lava traps a lot of gas, the pressure builds up. After the pressure becomes greater and greater, the volcano finally explodes. Ash and pyroclasts shoot up into the air. Pumice, with small holes in solid rock, shows where gas bubbles were when the rock was still molten.

Fluid lava flows down mountainsides. The rock that the flow becomes depends on which type of lava it is and where it cools. The three types of flows are a'a, pahoehoe, and pillow lava.


FIGURE 1.4

Magma beneath a volcano erupts onto the volcano's surface. Layer upon layer of lava creates a volcano.

### A'a Lava

A'a lava is the thickest of the non-explosive lavas. A'a forms a thick and brittle crust, which is torn into rough, rubbly pieces. The solidified surface is angular, jagged and sharp. A'a can spread over large areas as the lava continues to flow underneath.

### Pāhoehoe Lava

Pāhoehoe lava is thinner than a'a, and flows more readily. Its surface looks more wrinkly and smooth. Pāhoehoe lava flows in a series of lobes that form strange twisted shapes and natural rock sculptures ( **Figure** 1.5). Pāhoehoe lava can form lava tubes. The outer layer of the lava flow cools and solidifies. The inner part of the flow remains fluid. The fluid lava flows through and leaves behind a tube ( **Figure** 1.6).

FIGURE 1.5

Ropy pahoehoe flows are common on Kilauea Volcano in Hawaii.

FIGURE 1.6
A lava tube in a pahoehoe flow.

### Pillow Lava

Pillow lava is created from lava that enters the water. The volcanic vent may be underwater. The lava may flow over land and enter the water ( **Figure** 1.7). Once in the water, the lava cools very quickly. The lava forms round rocks that resemble pillows. Pillow lava is particularly common along mid-ocean ridges.

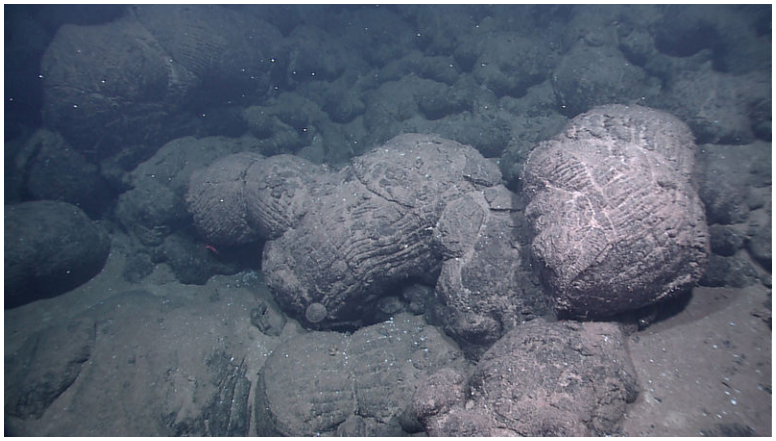

FIGURE 1.7
These underwater rocks in the Galapagos formed from pillow lava.

## Predicting Volcanic Eruptions

Volcanic eruptions can be devastating, particularly to the people who live close to volcanoes. Volcanologists study volcanoes to be able to predict when a volcano will erupt. Many changes happen when a volcano is about to erupt.

## History of Volcanic Activities

Scientists study a volcano's history to try to predict when it will next erupt. They want to know how long it has been since it last erupted. They also want to know the time span between its previous eruptions.

Volcanoes can be active, dormant, or extinct ( **Figure** 1.8). An **active volcano** may be currently erupting. Alternatively, it may be showing signs that it will erupt in the near future. A **dormant volcano** no longer shows signs of activity. But it has erupted in recent history and will probably erupt again. An **extinct volcano** is one that has not erupted in recent history. Scientists think that it will probably not erupt again. Scientists watch both active and dormant volcanoes closely for signs that show they might erupt.


FIGURE 1.8

(A) Mount Etna in Italy is certainly an active volcano. (B) Mount Rainer in Washington State is currently dormant. The volcano could and probably will erupt again. (C) Shiprock in northern New Mexico is the remnant of a long-extinct volcano.

## Earthquakes

Earthquakes may take place every day near a volcano. But before an eruption the number and size of earthquakes increases. This is the result of magma pushing upward into the magma chamber. This motion causes stresses on neighboring rock to build up. Eventually the ground shakes. A continuous string of earthquakes may indicate that a volcano is about to erupt. Scientists use seismographs to record the length and strength of each earthquake.

## Slope Tilt

All that magma and gas pushing upwards can make the volcano's slope begin to swell. Ground swelling may change the shape of a volcano or cause rock falls and landslides. Most of the time, the ground tilting is not visible. Scientists detect it by using tiltmeters, which are instruments that measure the angle of the slope of a volcano.

## Gases

Scientists measure the gases that escape from a volcano to predict eruptions. Gases like sulfur dioxide ($SO_2$), carbon dioxide ($CO_2$), hydrochloric acid (HCl), and water vapor can be measured at the site. Gases may also be measured from satellites. The amounts of gases and the ratios of gases are calculated to help predict eruptions.

### Remote Monitoring

Satellites can be used to monitor more than just gases ( **Figure** 1.9). Satellites can look for high temperature spots or areas where the volcano surface is changing. This allows scientists to detect changes accurately and safely.

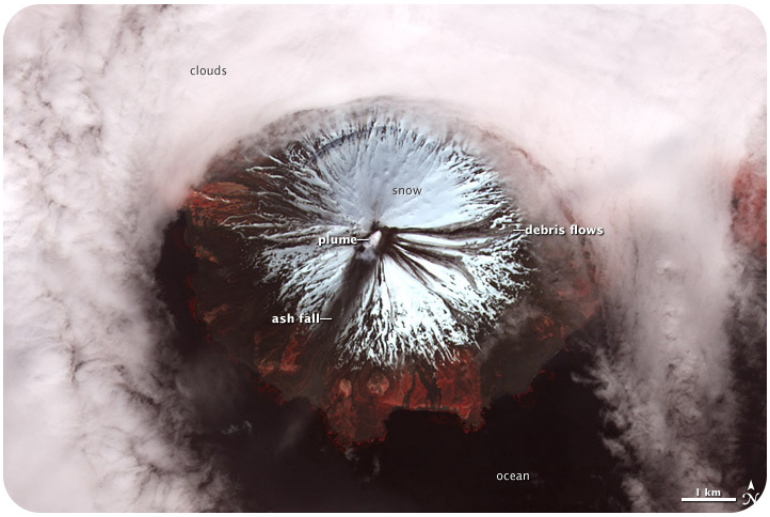


FIGURE 1.9
Mount Cleveland, in Alaska, is monitored by satellite.

### Costs and Benefits of Predictions

No scientist or government agency wants to announce an eruption and then be wrong. There is a very real cost and disruption to society during a large-scale evacuation. If the scientists are wrong, people would be less likely to evacuate the next time scientists predicted an eruption. But if scientists predict an eruption that does take place it could save many lives.

## Lesson Summary

- Volcanoes are produced when magma rises towards the Earth's surface because it is less dense than the surrounding rock.
- Volcanic eruptions can be non-explosive or explosive depending on the thickness of the magma.
- Explosive eruptions happen with thick magma and produce tremendous amounts of material ejected into the air.
- Non-explosive eruptions mostly produce various types of lava, such as a'a, pahoehoe and pillow lavas.
- Some signs that a volcano may soon erupt include an increase in earthquakes, surface bulging and released gases that can be monitored by scientists.

## Lesson Review Questions

### Recall

1. Describe what happens during an explosive volcanic eruption.

2. Describe what happens during a non-explosive volcanic eruption.
3. What are pyroclasts?

### Apply Concepts

4. What is a magma chamber and what are its characteristics?
5. The boiling point of water is 100$^o$C. Why might water make an eruption more explosive?
6. Why is predicting volcanic eruptions so important?

### Think Critically

7. What factors are considered in predicting volcanic eruptions?

## Points to Consider

- What types of evidence would scientists use to determine whether an ancient volcanic eruption was explosive or non-explosive?
- Are all volcanoes shaped like tall mountains with a crater on the peak?
- What language do you think gives us the names a'a and pāhoehoe?
- What changes in the pattern of earthquakes might indicate a volcano is about to erupt?

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