

5.3 Read

What Is a Volcano?

Parícutin Volcano in Mexico

On February 20, 1943, a loud rumbling noise disturbed a small farming community in Mexico. The loud noise was Earth opening up. People first noticed the smell of rotten eggs, which was actually the smell of burning sulfur rising from below the surface. The smell was followed by smoke, ash-like particles, and heat. Overnight, a small cone-shaped structure formed in the middle of the cornfields. Lava that erupted from it flowed over the land, covering crops. People watched in amazement as over the weeks the volcano grew.

During the first year, the volcano rose to 336 m (1100 ft). Over the next eight years, layers of hot rock and lava piled up, adding another 88 m (290 ft) to the volcano. Today, many people come to visit this volcano, Parícutin, and the town near where it was born.

- Name: Parícutin
- Type: cinder cone
- Location: Mexico
- Explosiveness: very explosive (VEI = 4)
- Last eruption: 1952
- Type of eruption: regular explosions with an eruptive column several kilometers high; occasional large cannonlike explosions
- What is emitted: different-sized volcanic particles, including ash that rains down on the surrounding land; lava flows

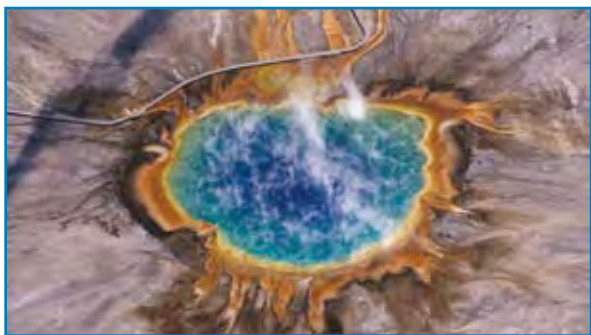


volcanic field: a place on Earth's surface where there are clusters of volcanic activity, including anywhere from 10 to 100 volcanoes.

active volcano: a volcano that is currently erupting or is expected to erupt.

dormant volcano: a volcano that is currently not erupting, but has erupted in the past and is likely to erupt in the future.

extinct volcano: a volcano that is not currently active and is not likely to erupt again.



At 87° C (188° F), the water in the center of Grand Prismatic Hot Spring, in Yellowstone National Park, is just one indication that a very large dormant volcano may lie beneath the park. Although Yellowstone has not had an eruption in 70,000 years, it is considered to be an active volcano because there is earthquake activity around it and the ground has been rising to a higher elevation.

The pictures you have seen show volcanoes of different shapes and sizes. They erupt in a variety of ways, and those eruptions emit different materials. In this section, you will learn more about volcanoes and the characteristics that make them different.

What Is a Volcano?

A volcano is any place in Earth's crust where mantle material and other substances reach the surface. The mantle material is a mixture of molten rock, rock particles, and dissolved gases called magma. As the magma travels to the surface, some rock in the lower crust is melted and mixes in with the rising magma. Once the magma reaches the surface, it is called lava. Lava is a mixture of mantle material and material from the lower crust. Substances that erupt from a volcano may be solid, liquid, or gas, depending on the makeup of the lava and the amount of pressure involved. An Earth structure formed by the accumulation of lava and other volcanic materials is also referred to as a volcano. Volcanoes of both types come in a variety of shapes and sizes.

Volcanoes are sometimes found in clusters called **volcanic fields**. Some volcanic fields are made up of multiple volcanoes, each formed by a single eruption. Parícutin is an example of such a volcano. It is part of an 1100 km (700 mi) line of similar volcanoes extending across southern Mexico.

Another type of volcanic field is formed by multiple volcanic vents, all part of the same volcano. Volcanic fields such as this can cover hundreds of kilometers. Mauna Loa in Hawaii, the world's most active and largest volcano, is part of this type of volcanic field.

Some volcanoes are currently active, while others have been silent for thousands of years. If a volcano is currently erupting or shows signs of activity, such as the release of gases, scientists consider it an **active volcano**. Some scientists also consider a volcano active if it has erupted within recorded history. If a volcano is not currently active but could become so, it is considered to be a **dormant volcano**. If a volcano is not likely to erupt again, it is considered to be an **extinct volcano**.

Stop and Think

1. What are two definitions of volcano?
2. How would you classify a volcano as active, dormant, or extinct?
3. What is the difference between magma and lava?



How Does a Volcano Form?

As you know, mantle material is moving beneath Earth's surface in a convection current. Mantle material can collect in the crust in pockets called **magma chambers**. If the pressure in a magma chamber is great enough, the magma may find its way to Earth's surface by way of a **vent**. A vent is a pipe-like channel from a magma chamber to the surface. It is the opening through which volcanic material erupts.

A volcano can have more than one vent. Parícutin erupted from a single vent. Other volcanoes may have a vent at the top, as well as several vents down the sides. Central vents typically end at a bowl-shaped depression, called a **summit crater**, at the top of a volcano.

Parts of volcanoes may also collapse, resulting in new Earth structures. When large amounts of magma escape from beneath a volcano during an eruption, part of the structure can collapse, causing an enormous depression called a **caldera**.

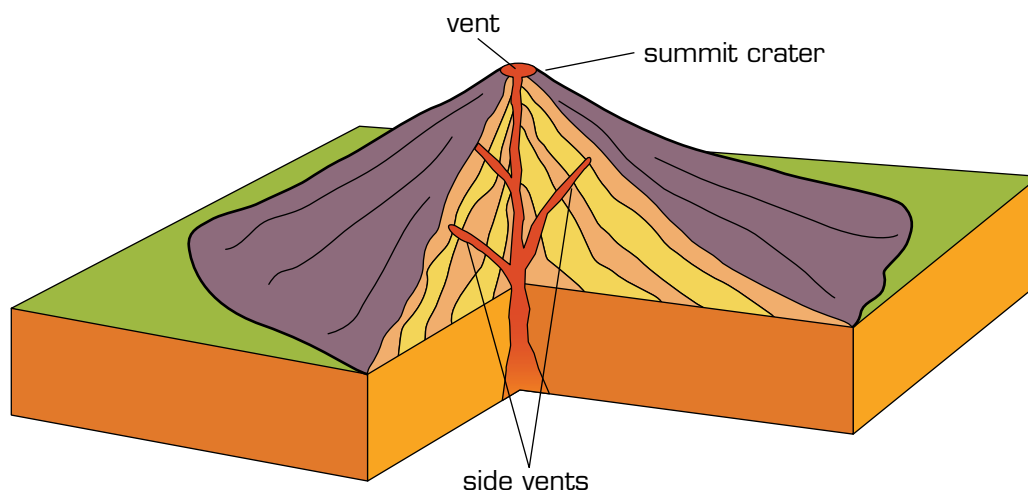
magma chamber: a pocket, or reservoir, where magma collects beneath Earth's surface.

vent: a pipe-like channel through which magma travels from a magma chamber to Earth's surface.

summit crater: a bowl-like depression at the top of a volcanic structure where the central vent ends.

caldera: a large, bowl-shaped depression formed by the collapse of part of a volcano.

The Structure of a Volcano



Different types of volcanoes have different structures, but this one shows the parts shared by most volcanoes.

Crater Lake in Oregon was formed when a volcano was drained of large amounts of lava during an eruption. The top collapsed, forming a huge caldera that later filled with water. One last eruption produced a small volcano in the middle of the lake. This Earth structure is now called Wizard Island.



You have learned how volcanoes form along the mid-ocean ridge. Recall that magma makes its way up through a gap in the ridge, created by two plates moving away from each other. As the magma cools and hardens, it becomes new ocean floor and pushes existing rock away on both sides of the ridge. Examples of volcanoes formed this way can be observed in Iceland, where the mid-ocean ridge rises above the surface of the ocean. Laki, seen in the photographs earlier in this *Learning Set*, is one such volcano.

Other types of volcanoes form as material, ejected during an eruption, accumulates around the vent. Each volcano is shaped by the eruption and the kind of material ejected. Some volcanoes form from thin, fast-moving lava that spreads over a broad area before cooling and hardening. Others form from lava that is thick and slow-moving and does not spread far from the central vent. Still others form from lava that is blasted into different-sized particles.



Stop and Think

1. Draw a diagram of a volcano, showing the basic structure and main parts. Label all parts of your diagram.
2. How does the movement of material in the mantle relate to the formation of volcanoes?

What Is a Volcanic Eruption?

A **volcanic eruption** is the release of material from under Earth's crust to its surface. Not all eruptions are alike. Extraordinary differences can occur in eruptions, depending on the location of the volcano and the material released. Lava, volcanic particles, and gases from Earth's mantle are all materials that may erupt from a volcano. Lava can be thin and runny, or it can be thick and move slowly. It can be fluid, or it can be in pieces.

Recall that hot mantle material is less dense than cool mantle material. This difference in density causes hot mantle material to rise upward toward the crust. If there are cracks, gaps, or weak spots in the crust, rising mantle material can fill them or break through.

Pressure from gases found within magma also exerts an upward push. Gases escape quite easily from thin lava, resulting in quiet eruptions that ooze out lava. If lava is very thick, gases cannot escape easily, and the pressure builds. Imagine shaking a can of soda and then opening it. The pressure that forces the liquid to spray out of a can is similar to the pressure that causes a volcano to erupt in an explosion. Large amounts of volcanic material are ejected from the crater.

Some volcanic eruptions last a long time, and some end swiftly. For example, Stromboli, in Italy, has been erupting continuously for over 2400 years, but when Mount St. Helens in the western United States erupted in 1980, the explosive phase lasted only nine hours. As you read this, there are volcanoes around the world oozing lava or blasting particles into the air. About 1300 volcanoes have been known to erupt during the last 10,000 years. It is estimated that over a million volcanoes, never observed or recorded, are adding crust deep on the ocean floor.

A **nuée ardente** is a glowing avalanche made up of red-hot volcanic particles and hot gases. These glowing clouds can travel at speeds up to 250 km (155 mi) per hour and burn or suffocate anything in their path.

volcanic eruption: the release of material from under Earth's crust to its surface.

nuée ardente: a thick, rapidly moving, deadly, gaseous cloud produced by a volcano.





Stop and Think

1. What is a volcanic eruption?
2. Why are some volcanic eruptions different from other eruptions?

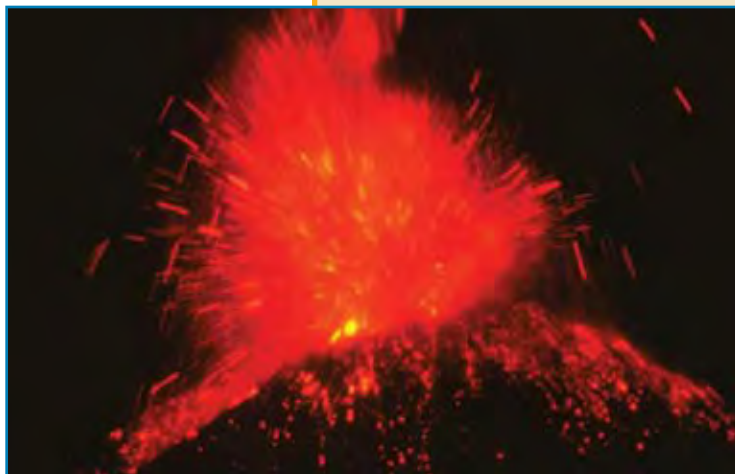
How Are Volcanoes Classified?

In this section, you will read more about the three different kinds of volcanoes you read about in the last section: shield volcanoes, stratovolcanoes, and cinder cone volcanoes. As you read about each type of volcano, look for information about the shape, type of eruptions, materials that are ejected, and volcano formation. Organize this information in the columns of a *Volcano Table* page. Leave the final column for information about the volcanoes in your region.

Cinder Cone Volcanoes

The cinder cone is the most common type of volcano, found in nearly all volcanic areas. These volcanoes are built from particles and blobs of lava ejected from a single vent. As lava is blown violently into the air, it breaks into small fragments that solidify and fall as cinders, or fragments of cooled lava. Cinder cones are small compared to other types of volcanoes. Because the particles that accumulate to form a cinder cone volcano are loosely packed, these volcanoes are not tall. These types of volcanoes sometimes form on the side of other, larger volcanoes. Cinder cone volcanoes are most likely to form where plates are moving together.

Parícutin erupting at night in 1946. Lava, in the form of glowing rocks, is blasting out of the top and tumbling down the sides of the volcano. Hot rock and ash are scattered over the surface.

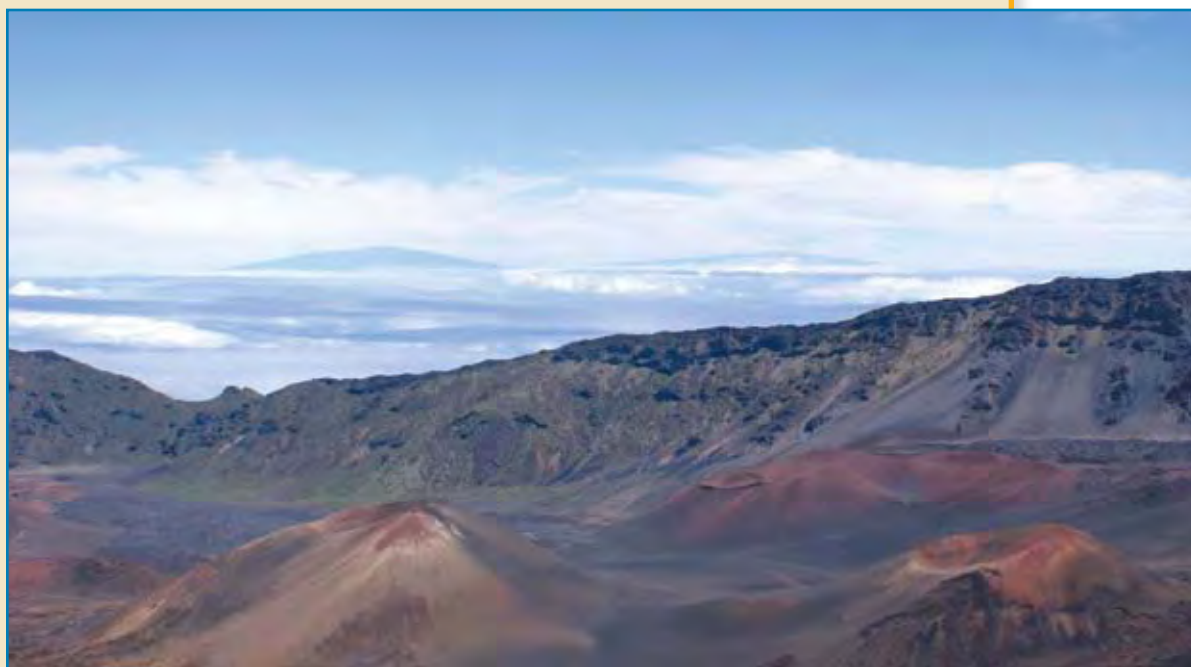


Parícutin, the volcano that grew near a small town in Mexico, is an example of a cinder cone volcano. The eruption of Parícutin lasted for nine years. For the first two years, it blasted out mainly gas and rock particles. High gas pressure created short-lived explosive outbursts, strong enough to blast the ejected lava into different-sized particles. These initial explosions were followed by seven years of lava flows. Eventually the eruptions stopped, and the volcano is now considered to be extinct.

Shield Volcanoes

Shield volcanoes form through the accumulation of fluid lava flows that pour out of a central crater. Eruptions from shield volcanoes are nonexplosive and tend to be long lasting. In most shield volcanoes, the lava spreads out, creating a volcano with gently sloping sides. Dark, runny lava flows in rivers for long distances before cooling enough to become solid. These rivers can pool into lava lakes that cool and become solid.

Most shield volcanoes form where plates are moving apart or where the crust is thin. Over time, the escaping magma can create a chain of islands or mountains. The Hawaiian Island chain is an example. Mauna Kea and Mauna Loa in Hawaii are well-known shield volcanoes. These islands are in the center of a plate in the middle of the ocean. Like similar sets of shield volcanoes, some volcanoes in the Hawaiian Island chain are young and are still erupting, while others are extinct.



Like Kilauea, the gentle slopes of Mauna Loa and Mauna Kea are typical of shield volcanoes. Shield volcanoes shown in the bottom of the photo were given that name because observers thought this type of volcano resembled a shield used in battle.

volcanic ash: any particle ejected by a volcano that is less than 2 mm across. Volcanic ash is the finest category of pyroclastic material (material ejected through the air during a volcanic eruption).

Stratovolcanoes

Stratovolcanoes are typically steep-sided, symmetrical cones with alternating layers of volcanic rock particles and ash, and lava. **Volcanic ash** is very small particles, less than 2 mm (less than one inch) in diameter. This is not the same kind of ash that results from a fire. It is the result of magma that has been blown apart into small particles by an explosive eruption. This eruption is followed by a quieter eruption, producing lava that flows slowly down the sides of the mountain. Usually, the lava erupting from a stratovolcano does not flow as smoothly and quickly as the lava that forms shield volcanoes. Instead, the lava is usually lumpy and slow moving, and it may even contain bits of hot, solid rock.

This type of volcano typically occurs where plates are moving together. Eruptions of stratovolcanoes are usually relatively short lived, lasting only a few days or weeks. However, stratovolcanoes tend to stay active for a long time. Stratovolcanoes may form in a few thousand years but may

remain active for tens of thousands of years before becoming dormant. Some remain dormant for tens of thousands of years and then erupt again.



Mount Pinatubo, an active stratovolcano located on the Philippine island of Luzon, had been dormant for about 500 years.



In 1991, it produced one of the largest eruptions of the twentieth century, ejecting 10 billion metric tons of magma and 20 million metric tons of sulfur dioxide.

Stop and Think

1. Summarize the similarities and differences among cinder cone volcanoes, shield volcanoes, and stratovolcanoes.
2. How does the material that erupts from a volcano affect the structure that is formed?
3. Describe two types of volcano fields.



How Can Volcanoes Erupt in the Center of a Plate?

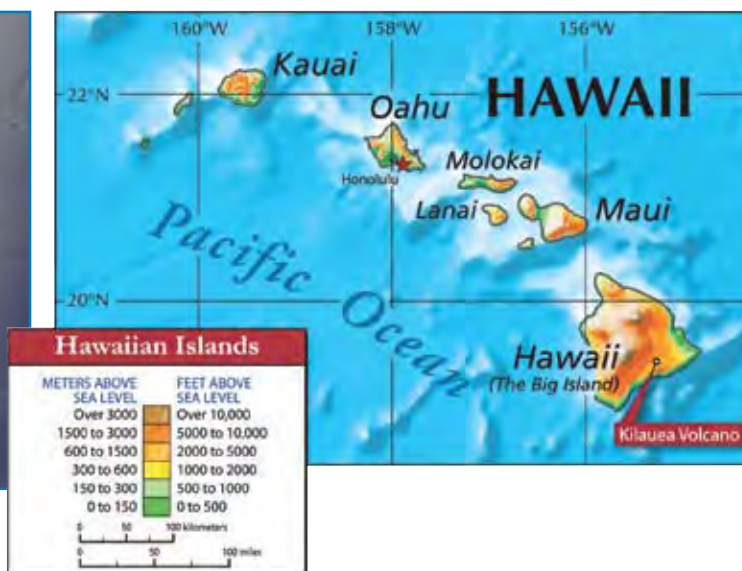
Most volcanoes around the world occur near plate boundaries. However, as you may have already observed, there are a few exceptions. For example, the Hawaiian Islands were formed in the middle of a plate where there are no gaps in the crust created by interacting plates. Geologists have determined that small, long-lasting, and very hot plumes of magma, called **hot spots**, form volcanoes in the middle of plates. As the plate moves over a hot spot, the magma melts through the crust and acts as a funnel, bringing hot magma to the surface. Some active volcanoes are found in regions where the plate is sitting over a hot spot.

hot spots: places in the middle of plates where very hot plumes of magma rise for a short time, forming volcanoes.

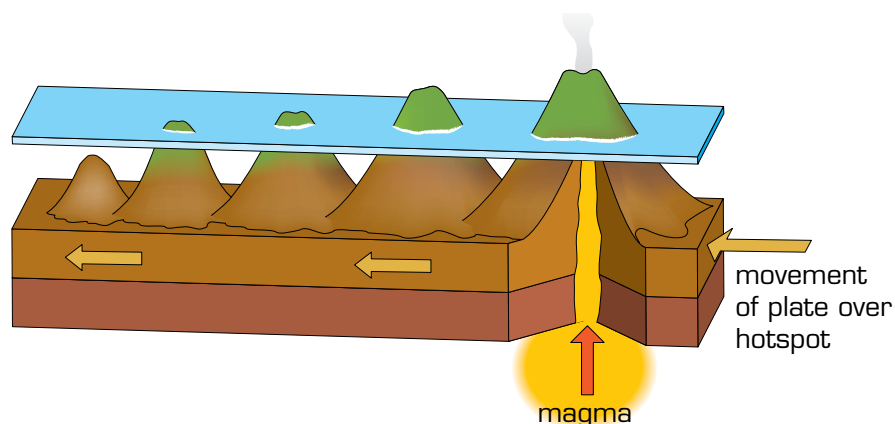
Evidence of how hot spots work can be observed in places like the Hawaiian Islands. Currently, Kilauea on the Big Island, at the southeast end of the Hawaiian island chain, is erupting and has been erupting for the past 25 years. Rocks here date back 700 thousand years.



A satellite photo of the Hawaiian Islands



Moving northwest, the islands get progressively older. The oldest rocks on Kauai date back about 5.5 million years, and the volcano is now extinct. Other similar island chains show the same pattern. As the plate moves over the hot spot, new volcanoes form and are active. Older ones, no longer sitting over the hot spot, become extinct.



Conference

Using information organized on your *Volcano Table* page, compare what is in your pen pal letter to what you now know about volcanoes. Work with your partner to fill in the column on the *Volcano Table* for volcanoes in your region. Include all the information from your pen pal letter, as well as any other information you have.

Think about how you classified the volcanoes in your region earlier, based on photographs of different types of volcanoes. Think about the new information and evidence you have. Record this new evidence, as well as any other new information, in the volcano table and on your *Region Project Board*.

Then meet with others who are also assigned your region. Compare your volcano classifications, and try to come to an agreement. Prepare to share with the class new information about the volcanoes in your region. If you have changed your mind about what type of volcanoes are in your region, make sure you can describe how and why your ideas changed. If you have not changed your mind, describe the information that makes you even more certain of the characteristics and classification of the volcanoes in your region.

Communicate

Now that you have gathered new information about the volcanoes in your region, take time to share it with your class. When it is your turn to present, discuss how each pair had initially classified the volcanoes in the region by comparing them to the photographs in *Section 5.2*. If you changed the way you classified the volcanoes, explain why and what you based your decision on. If you are even more confident of your first classification, tell the class what you learned that supports your ideas.

As others present their ideas, listen carefully, as you may hear something that makes you think about the volcanoes in your own region. Perhaps you will hear something that raises a new question that you would like to investigate further. Keep these things in mind, as they can be added later to the *Project Board*.

When everyone has finished presenting, answer the following questions together, as a class.

Reflect

1. The shape of a volcano is determined by the way it erupts. Choose one type of volcano and describe how its shape is determined by the materials that erupt from it.
2. Some volcanoes erupt quickly and are short lived while others erupt for very long periods. How does pressure and material type affect the length of the eruption?
3. You know a lot now about different volcanoes. What does this knowledge tell you about the ways plates might interact with each other?
4. Suppose you know what types of volcanoes are in your region. What can that information tell you about the interactions between the plates in your region?



Volcano Table				
				5.3.1
Name: _____		Date: _____		
Fill in the columns with information about volcano types. Use the last column to fill in information about your region.				
	Shield Volcanoes	Stratovolcanoes	Cinder Cone Volcanoes	Volcanoes in my region
Common shape				
Type of eruption				
Materials that are ejected				
How the volcanoes form				
Where the volcanoes form				
Other information				
Location in our region				
Questions				

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Be a Scientist

Predicting if a Volcano Will Erupt

Volcanoes can occur in some of the most beautiful locations in the world. People will always want to live in these places, despite the danger of living in the shadow of a fiery volcano. People need places to live as the world's population is growing. This sometimes forces them to accept the risks and live near one of Earth's volcanoes. But this can put hundreds, or even hundreds of thousands, of humans at risk. Fortunately, volcanoes usually provide some early-warning signs that, when interpreted correctly, can save lives.



If scientists had been able to detect the early warning signs of a volcanic eruption in 79 A.D. near Pompeii, Italy, more than 10,000 people who died in the two-day eruption of Mt. Vesuvius might have been saved.

Three warning signs used by scientists to predict volcanic eruption are small earthquakes and vibrations caused by the movement of magma, changes in the quantity and composition of gases released by a volcano, and swelling or bulges on the slope of the volcano caused by a buildup of magma.

Similar to the way weather forecasters predict weather, scientists can predict volcanic eruptions. However, just like a weather forecaster, they can only predict the chance of an eruption. They cannot predict the severity or duration of an eruption. To successfully predict a volcanic eruption, scientists need three things—a detailed eruptive history, proper instrumentation installed at the volcano, and a way to

continuously monitor and interpret data from the instruments. This limits the number of volcanoes that can be watched, as it is not possible to monitor every volcano site in the world.

Recorded histories are not available for most volcanoes, but volcanoes leave some records of their own. Scientists dig through the remains of previous eruptions looking for clues that can tell them about the type of eruption, duration, direction of lava flows, or the explosiveness. They may map old lava flows or sift through volcanic particles. Today, scientists can use data collected for worldwide distribution on the Internet, just like you did, to collect information.

One of the most important tools used by scientists to predict eruptions is a seismograph. This instrument detects and records the small earthquakes produced by the movement of magma. Other instruments measure amounts of sulfur dioxide. Remember the smell of rotten eggs that preceded the eruption of Parícutin. That was the tell-tale smell of sulfur dioxide that increases in concentration right before an eruption. Other instruments are used to detect any swellings or bulges in the slopes of a volcano, indicating that magma is building up.

Today, satellites are also used in the science of predicting volcanic eruptions. They can be used for mapping both old and new lava flows and for gathering data about the concentrations of gas in an area. As new technologies are advanced, scientists will probably be able to predict eruptions more accurately in the future.



Most of the work of a volcanologist, a scientist who studies volcanoes, involves examining the remains of past volcanic eruptions and monitoring volcanoes that have the potential to erupt in the future.

What's the Point?

A volcano is a place on Earth's surface where material from the mantle escapes through the crust. When material escapes from the mantle and reaches Earth's surface, the event is called a volcanic eruption. The ejected material, including lava and volcanic particles, often falls back down or collects around the volcano's vent. Layers build up, sometimes quickly and sometimes over many years, forming a structure that is also called a volcano. The type of material that erupts from a volcano determines the size and shape of the resulting structure. The type of eruption and volcanic formation depends on the location and type of material that is ejected from it.

Some volcanoes erupt rather quietly, oozing out thin, runny lava. This type of lava forms broad, flat shield volcanoes. Other volcanoes erupt with a blast, ejecting thick lava, as well as ash, rock fragments, gases, and other debris. This material forms steep-sided stratovolcanoes made up of alternating layers of lava and rock particles. Volcanoes that erupt explosively and blast rock particles into the air are likely to form cinder cones.



More to Learn

Underground Volcanic Activity

igneous intrusion: magma that rises toward the surface but cools and hardens below Earth's surface before it breaks through.

igneous rock: a rock that has solidified from molten or partly molten materials (magma).

Stone Mountain, located in a suburb of Atlanta, Georgia, is a large granite dome that is 251 m (825 ft) tall and covers about 2.4 km² (593 acres). That is almost 600 football fields. It sprawls even farther underground, reaching across several surrounding counties. This unique formation formed millions of years ago from magma deep within Earth. The rising magma pushed up the crust, but the magma never reached Earth's surface. It stopped rising about six miles beneath Earth's surface and began to cool, forming a kind of rock called granite. As more magma rose in the same area, the underground mass became larger and larger. Over time, the layers of crust above the granite formation wore away, finally exposing the huge chunk of granite at the surface.



Stone Mountain is an example of an **igneous intrusion**. An igneous intrusion forms from magma that cools and hardens below Earth's surface. Over time, magma forms a kind of rock called **igneous rock**. Sometimes the surface rock layers above the igneous intrusion is worn away, exposing the igneous rock. When this happens, the huge intrusive rock is exposed as a landform. Other times, an intrusion produces a landform by pushing up on layers of soil and rock above it until the intrusion reaches Earth's surface.

The same artist who carved Mt. Rushmore in North Dakota, carved Jefferson Davis, Robert E. Lee, and "Stonewall" Jackson into the side of Stone Mountain, a large granite body near Atlanta, Georgia.