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Earth Science Lesson 3
Dynamic Earth Processes (Grades 8-12)

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Volcanoes

The word *volcano* comes from an island called Vulcano off the coast of Sicily.

During the Roman Empire, people believed that Vulcano was the home of *Vulcan*, blacksmith to the Gods. (Vulcan is known in Greek mythology as *Hephaestus*, the God of Fire.)

The Romans thought that the lava and dust erupting from Vulcano was coming from Vulcan's forge as he beat out thunderbolts for Jupiter, king of the Gods, to throw.

In Polynesia, people believed that volcanic eruptions were caused by Pele, the Goddess of Volcanoes. They happened when she got angry, which was pretty often.

Today we know that volcanic eruptions have a scientific -- if somewhat less romantic -- explanation.

What Makes a Volcano a Volcano?

Volcanoes are mountains -- but they are not like other mountains.

Most mountains are created by the folding and crumpling of the Earth.

Volcanoes are created by the debris from their own eruptions.

Over time, this material builds up around the *vent* that connects the volcano to the molten rock in Earth's Outer Mantle.

When pressure builds up inside the Earth, the volcano erupts -- and this molten rock is expelled.

The rock is called *magma* while it's inside the earth and *lava* once it comes out of the volcano. (The fragments of volcanic rock and lava in an eruption are also referred to as *tephra*.)

Lava is composed primarily of oxygen, silicon, aluminum, iron, calcium, magnesium, sodium, potassium, titanium and manganese.

Often a volcanic eruption is explosive -- with clouds of lava fragments shooting into the air and a pyroclastic flow rushing down the sides of the volcano. (A *pyroclastic flow* is a ground-hugging avalanche of hot ash, pumice, rock fragments and volcanic gas.)



Lava is red hot when it pours or blasts out of a vent. But it usually changes to dark red, black or gray as it cools and solidifies.

Although volcanoes can be destructive, they can be constructive too.

Over 80 percent of the Earth's surface (both above and below sea level) originally came from volcanoes.

And the gasses emitted from volcanic vents -- which are mostly water vapor -- formed the Earth's earliest oceans and atmospheres.

Different Kinds of Volcanoes

There are four kinds of volcanoes:

- Cinder Cones
- Composite Volcanoes
- Shield Volcanoes, and
- Lava Domes

Cinder Cones

A Cinder Cone is the simplest type of volcano. It builds up from blobs of lava ejected from a single vent.

As the lava is blown into the air it breaks into small fragments. These fragments fall back as *cinders* around the vent, forming a circular or oval cone.

Cinder Cones usually have bowl-shaped craters. They rarely rise more than a thousand feet above their surroundings.

Composite Volcanoes

Composite Volcanoes are sometimes also called *Stratovolcanoes* -- because they get so tall.

Some of the world's most spectacular volcanoes -- Mt. Fuji in Japan and Mount St. Helen's and Mount Rainier in Washington -- are Composite Volcanoes.



Composite Volcanoes usually have large, steep-sided symmetrical cones.

They are built up of alternating layers of lava flow, volcanic ash and cinders -- and may get to be 8000 feet high.

Once a Composite Volcano becomes dormant (inactive), erosion begins to destroy the cone. The cone then collapses, leaving a depression behind called a *caldera*.

These calderas are caused by the partial emptying of the magma chamber underneath the volcano. They are usually large and basin shaped -- and can be up to 15 miles across and 60 miles long.

Shield Volcanoes

Shield Volcanoes are built almost entirely of fluid lava flows.

During their formation, flow after flow pours out of the volcano's vent in all directions. This results in a broad, gently sloping cone with flat conical shape, which looks a little like the shield of an ancient warrior.

Some of the largest volcanoes in the world are Shield Volcanoes. In California and Oregon, many are as big 3 or 4 miles across and 2000 feet high.

The Hawaiian Islands are composed of linear chains of Shield Volcanoes. This includes *Kilauea* and *Mauna Loa* on the Island of Hawaii, two of the world's most active volcanoes.

Lava Domes

Lava Domes are formed by small bulbous masses of lava too viscous to flow any great distance. Lava Domes grow by expansion from within.

As a Lava Dome grows, its outer surface cools, hardens and shatters. This spills loose fragments down its sides.

Lava Domes are frequently found within the craters or on the flanks of large Composite Volcanoes.

For diagrams of these different types of volcanoes, click:



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<http://www.cotf.edu/ete/modules/volcanoes/vtypesvolcan1.html>

For some very dramatic volcano pictures, click:

<http://www.terrageria.com/parks/np.hawaii-volcanoes.html>

Other Volcanic Structures

There are also some other structures that are caused by volcanic activity. These include:

Plugs

Plugs (or Necks) are composed of fragments of volcanic material overlying a body of magma. They tend to be funnel shaped and taper downward.

They are more resistant to erosion than the rock formations around them -- which can give them highly unusual shapes.

Plugs that bear a particularly strong imprint of the explosive eruption of gas-charged magma are called *diatremes*.

One spectacular diatreme is Shiprock, New Mexico, in the heart of the Navajo Nation.

To see what it looks like and read the Navajo myths surrounding it, click:

http://www.sacredsites.com/americas/united_states/shiprock.html

Maars

Maars are also called *tuff cones*. They are shallow craters with flat floors.

Geologists think that these craters formed above diatremes because of a violent expansion of magmatic gas or steam. They can range in size from 200 to 6,500 feet across and from 30 to 650 feet deep.

Most maars fill up with water and form lakes.

An excellent example is Zuni Salt Lake, also in New Mexico (in Zuni Pueblo).

It is 6500 feet across and 400 feet deep, and has a low rim composed of loose pieces of basaltic lava and wallrock.



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To see what it looks like, read the Zuni origin myth about it and discover its recent history, click:

http://www.sacredland.org/zuni_salt_lake.html

There are also many craters on Earth that are not of volcanic origin.

Some of these are impact craters -- craters that were formed when Earth collided with large meteorites, asteroids or comets.

One of the most famous of these is Meteor Crater, Arizona, which is 4000 feet across and 600 feet deep. Geologists think it was formed from 20,000 to 50,000 years ago. It is fascinating to visit.

To see what Meteor Crater looks like -- and learn how it was formed -- click:

<http://www.meteorcrater.com>

Different Types of Eruptions

As there are different types of volcanoes, there are also different types of volcanic eruptions.

These range from mild eruptions that merely discharge steam to violent explosions that blast great clouds of gas-laden debris high into the atmosphere.

The different types of eruptions are usually named for the volcanoes where they take place.

In a Strombolian Eruption, huge clots of molten lava burst from the crater to form luminous arcs in the sky. While in a Vulcanian Eruption, a dense cloud of ash-laden gas explodes and forms a whitish cloud above the volcano's dome.

In a Vesuvian Eruption, great quantities of ash-laden gas form a cauliflower-shaped cloud high above the volcano.

In a Pelean Eruption, large quantity of gas, dust, ash and incandescent lava fragments are blown out of a central crater. These fragments fall back and form glowing avalanches that move downslope as fast as 100 miles an hour. Pelean Eruptions are also called "glowing cloud" eruptions.

Hawaiian Eruptions can be either fissure-type or central-vent eruptions.



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In a fissure-type eruption, molten incandescent lava spurts from a fissure in the volcano. This feeds lava streams that flow downslope.

In a central-vent eruption, a fountain of fiery lava can spurt to a height of several hundred feet or more.

Phreatic Eruptions are driven by exploding, expanding steam. This happens when cold ground or surface water comes into contact with hot magma. These eruptions only blast out fragments of preexisting solid rock. No new magma is erupted.

The most powerful eruptions of all are called Plinian Eruptions. They involve the explosive ejection of relatively viscous lava. Large Plinian Eruptions -- like the one that occurred in 1980 at Mount St. Helen's in Washington -- can spew ash and other volcanic debris miles into the sky. They also send fast-moving pyroclastic flows down the mountainside.

To see animation of the different types of volcanic eruptions, click:
<http://www.cof.edu/ete/modules/volcanoes/veruptionanimation.html>

Different Types of Lava

There are also different types of lava and lava flow. These types are:

pillow
pahoehoe, and
aa

Pillow lava is the most common. It is made by eruptions under water or ice. Pillow lava has elongated, interconnected flow lobes (units) that can be either elliptical or circular.

Pahoehoe and *aa* are Hawaiian words that came into the volcanic vocabulary in the 1880's.

Pahoehoe lava has a smooth, billowy or ropy surface. *Pahoehoe* flows tend to be relatively thin, from a few inches to a few feet thick.

Aa lava is characterized by a rough, jagged, chunky surface. Legend has it that it got its name from the sound a person would make it -- "aa" -- if he or she tried to walk across it.



Where the Volcanoes Are

There are more than 500 active volcanoes in the world -- that we know of.

Active means that a volcano is currently erupting or showing signs of unrest. Many scientists also consider a volcano "active" if it has erupted during historic (recorded history) time.

Fifty of these volcanoes are in the United States -- in Hawaii, Alaska, Washington, Oregon and California.

Most of the world's active volcanoes are along or near the margins of continents. They are usually located along or near the boundaries between shifting plates.

More than half of these volcanoes circle the Pacific Ocean in what is called *The Ring of Fire*.

This Ring of Fire is an arc stretching from New Zealand along the eastern edge of Asia, north across the Aleutian Islands of Alaska, and south along the coast of North and South America. It is located at the border of the Pacific Plate and other tectonic plates.

There are also many volcanoes in and around the Mediterranean Sea.

Some volcanoes crown island areas near continents. Others form island chains in deep ocean basins.

Submarine and Extra-Terrestrial Volcanoes

Submarine volcanoes and volcanic vents are common features of the ocean floor.

Because of the unlimited supply of water around submarine volcanoes, they behave differently from volcanoes on land. Violent eruptions may take place when seawater pours into active shallow submarine vents.

Too, lava may cool so rapidly that it shatters into sand -- which is how the famous "black sand" beaches of Hawaii were created.

Volcanoes also exist on other planets.



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Space exploration has furnished graphic evidence of past volcanic activity on the Moon, Mars, Venus and other planets.

The volcanoes on Mars are very much like Hawaiian volcanoes. They are Shield Volcanoes, although the ones on Mars are bigger.

On Mars, a volcano can grow to over 17 miles in height and 350 miles across. On Hawaii, the biggest volcanoes are only 6 miles high and 74 miles across.

People and Volcanoes

Volcanoes are among the most dramatic events in nature.

But they are very dangerous. Throughout history, many many people have been killed by them.

Volcanic eruptions can cause lateral blasts, lava flows, hot ash flows, tephra mudslides, mudflows, avalanches, falling ash and floods.

They can flatten entire forests -- and trigger tsunamis, flash floods, earthquakes and rock falls.

Nobody is safe for at least 20 miles around an active volcano.

At the present time, scientists think that the greatest chance of a new eruption is in Hawaii or Alaska.

Does that mean that scientists can predict when a volcano will erupt?

Unfortunately, not yet.

But there are warning signs. These include the movement of magma, small earthquakes and vibration, the release of gas and changes in a volcano's size or slope.

Tools and techniques have been developed to monitor these events.

But none are a sure thing.

It's very difficult to pinpoint exactly when an eruption will take place.

Often, moving magma doesn't result in an eruption, but cools below the surface.



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And with many volcanoes erupting only every few hundred or thousand years, it's just not possible to monitor every site.

But as with earthquakes, there are precautions you can take.

For a helpful checklist, click:

<http://www.icomm.ca/survival/fema-tip.don/volcanof.htm>