VOLCANO WORLD

COMPUTER NOTES

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Volcano World

Chapter 1 Plate Tectonics

Chapter 1 focuses on Plate Tectonics, looking at the Earth's layers, Earth's evolution, and plate movement.

Lessons included in this chapter:

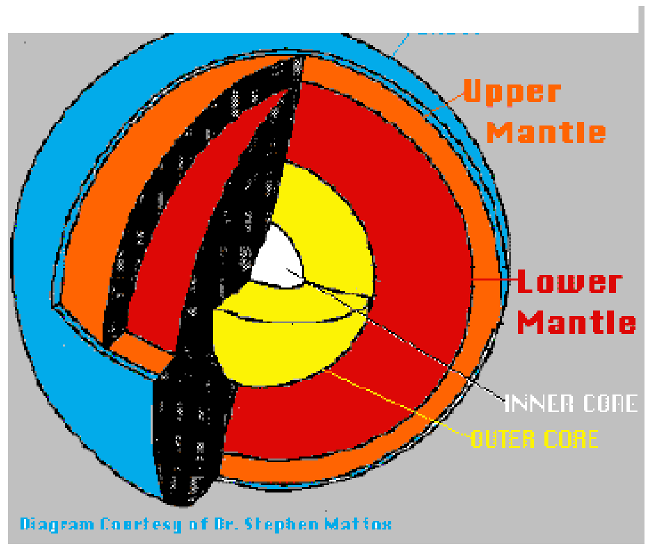
#1 The Earth's Layers

#2 Pangea to Present

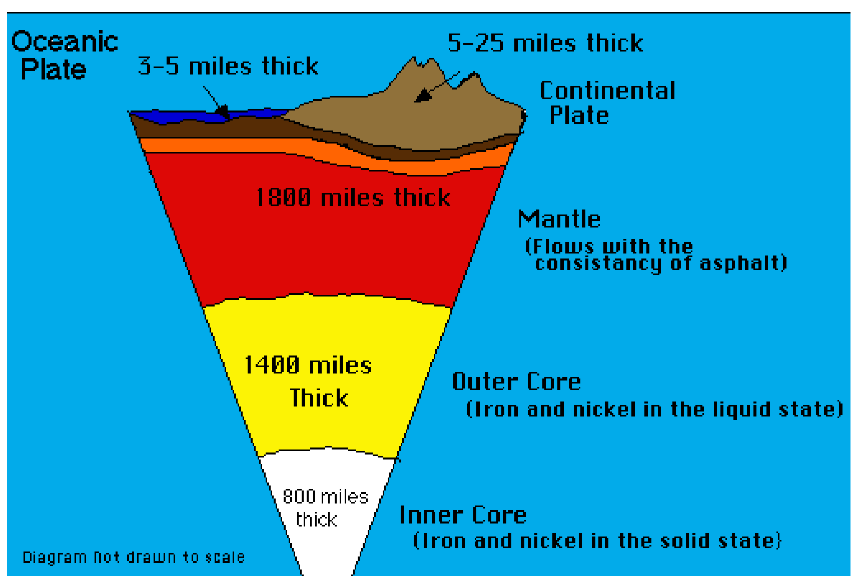
#3 How Earth's Plates Move

The Earth's Layers Lesson #1

The Four Layers



The Earth is composed of four different layers. Many geologists believe that as the Earth cooled the heavier, denser materials sank to the center and the lighter materials rose to the top. Because of this, the crust is made of the lightest materials (rock- basalts and granites) and the core consists of heavy metals (nickel and iron).

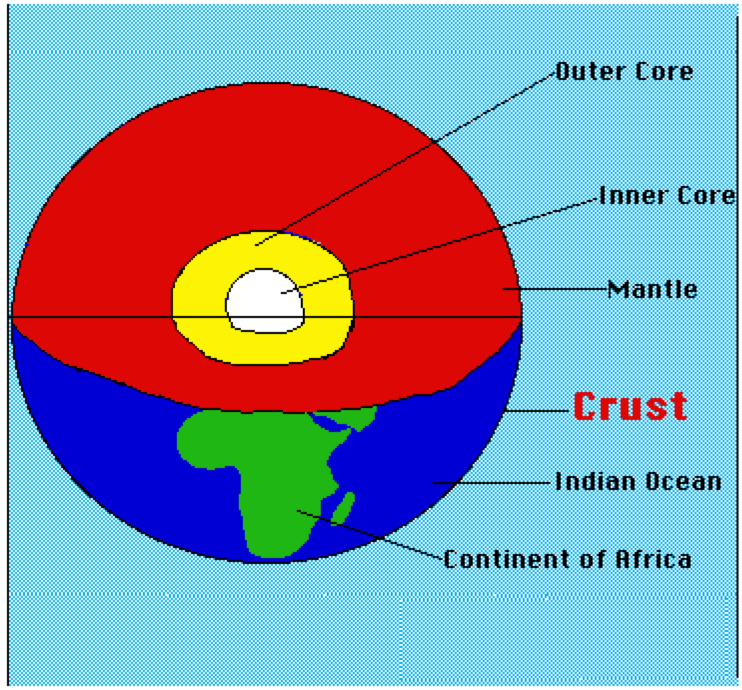


The crust is the layer that you live on, and it is the most widely studied and understood. The *mantle* is much hotter and has the ability to flow. The Outer and Inner Cores are hotter still with pressures so great that you would be squeezed into a ball smaller than a marble if you were able to go to the center of the

Earth!!!!!!

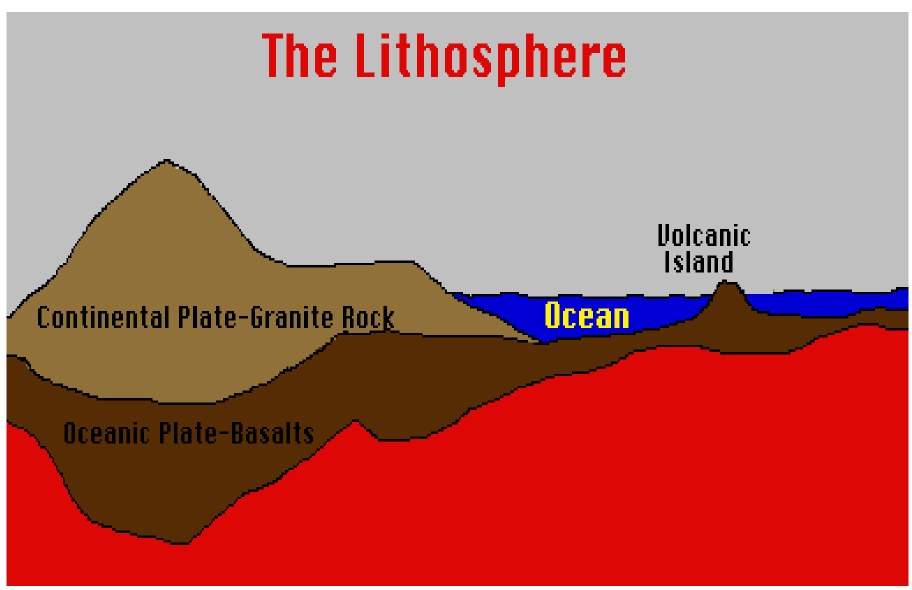
The Crust

The Earth's Crust is like the skin of an apple. It is very thin in comparison to the other three layers. The crust is only about 3-5 miles (8 kilometers) thick under the oceans(*oceanic crust*) and about 25 miles (32 kilometers) thick under the continents (*continental crust*). The temperatures of the crust vary from air temperature on top to about 1600 degrees Fahrenheit (870 degrees Celcius) in the deepest parts of the crust. You can bake a loaf of bread in your oven at 350 degrees Fahrenheit , at 1600 degrees F. rocks begin to melt.



The crust of the Earth is broken into many pieces called plates. The plates "float" on the soft, *plastic* mantle which is located below the crust. These plates usually move along smoothly but sometimes they stick and build up pressure. The pressure builds and the rock bends until it snaps. When this occurs an Earthquake is the result!

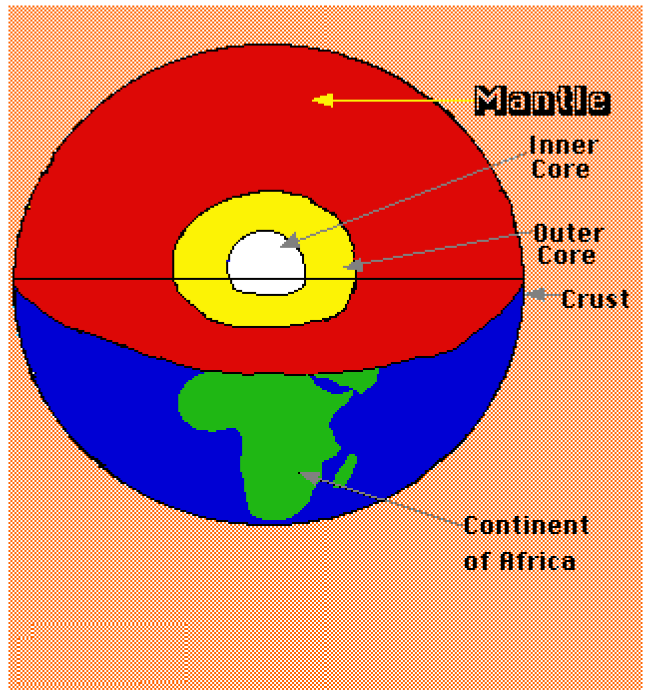
Notice how thin the crust of the Earth is in comparison to the other layers. The seven continents and ocean plates basically float across the mantle which is composed of much hotter and denser material.



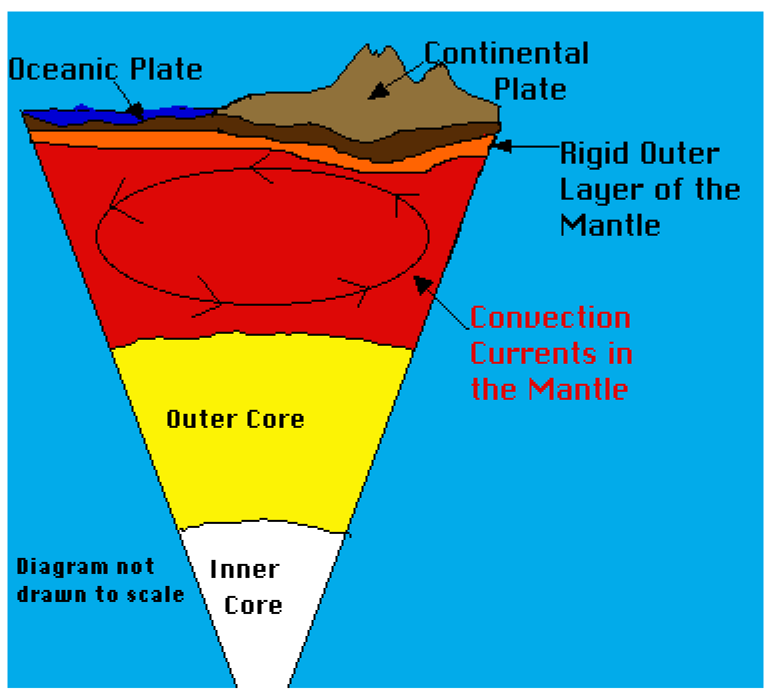
The crust is composed of two basic rock types' *granite and basalt*. The continental crust is composed mostly of granite. The oceanic crust consists of a volcanic *lava* rock called basalt.

Basaltic rocks of the ocean plates are much denser and heavier than the granitic rock of the continental plates. Because of this the continents ride on the denser oceanic plates. The crust and the upper layer of the mantle together make up a zone of rigid, brittle rock called the *Lithosphere*. The layer below the rigid lithosphere is a zone of asphalt-like consistancy called the *Asthenosphere*. The asthenosphere is the part of the mantle that flows and moves the plates of the Earth.

The Mantle



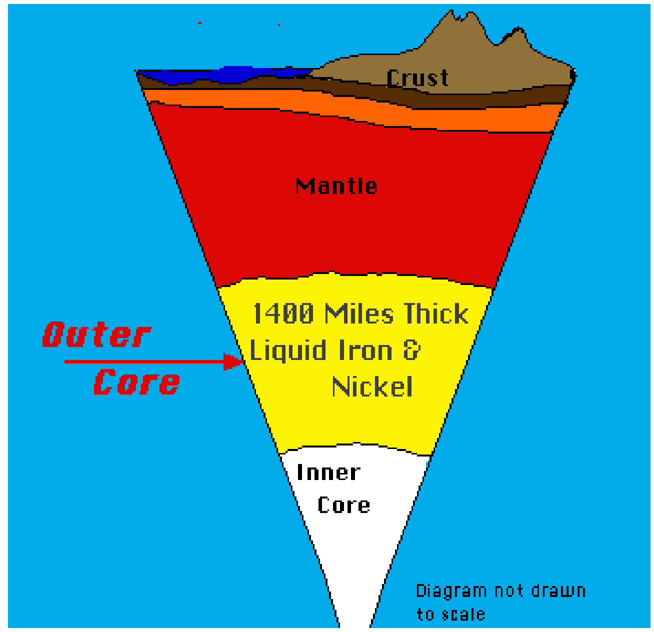
The mantle is the layer located directly under the sima. It is the largest layer of the Earth, 1800 miles thick. The mantle is composed of very hot, dense rock. This layer of rock even flows like asphalt under a heavy weight. This flow is due to great temperature differences from the bottom to the top of the mantle. The movement of the mantle is the reason that the plates of the Earth move! The temperature of the mantle varies from 1600 degrees Fahrenheit at the top to about 4000 degrees Fahrenheit near the bottom!



Convection Currents

The mantle is made of much denser, thicker material, because of this the plates "float" on it like oil floats on water.

Many geologists believe that the mantle "flows" because of convection currents. **Convection currents** are caused by the very hot material at the deepest part of the mantle rising, then cooling, sinking again and then heating, rising and repeating the cycle over and over. The next time you heat anything like soup or pudding in a pan you can watch the convection currents move in the liquid. When the convection currents flow in the mantle they also move the crust. The crust gets a free ride with these currents. A conveyor belt in a factory moves boxes like the convection currents in the mantle moves the plates of the Earth.

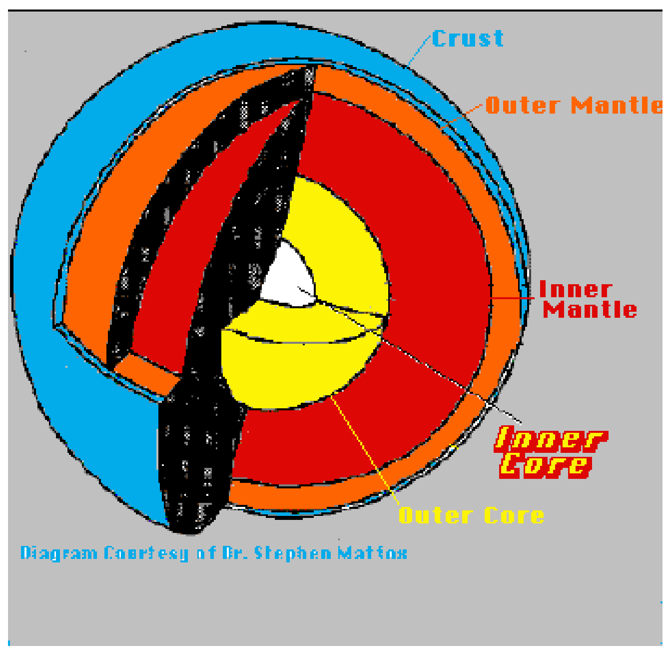


Outer Core

The core of the Earth is like a ball of very hot metals. (4000 degrees F. to 9000 degrees F.) The *outer core* is so hot that the metals in it are all in the liquid state. The outer core is located about 1800 milesbeneath the crust and is about 1400 miles thick. The outer core is composed of the melted metals nickel and iron.

Inner Core

The inner core of the Earth has temperatures and pressures so great that the metals are squeezed together and are not able to move about like a liquid, but are forced to vibrate in place as a solid. The inner core begins about 4000 miles beneath the crust and is about 800 miles thick. The temperatures may reach 9000 dgrees F. and the pressures are 45,000,000 pounds per square inch. This is 3,000,000 times the air pressure on you at sea level!!!



QUESTIONS:

1. Name the four layers of the Earth in order from the outside to the center of the Earth.

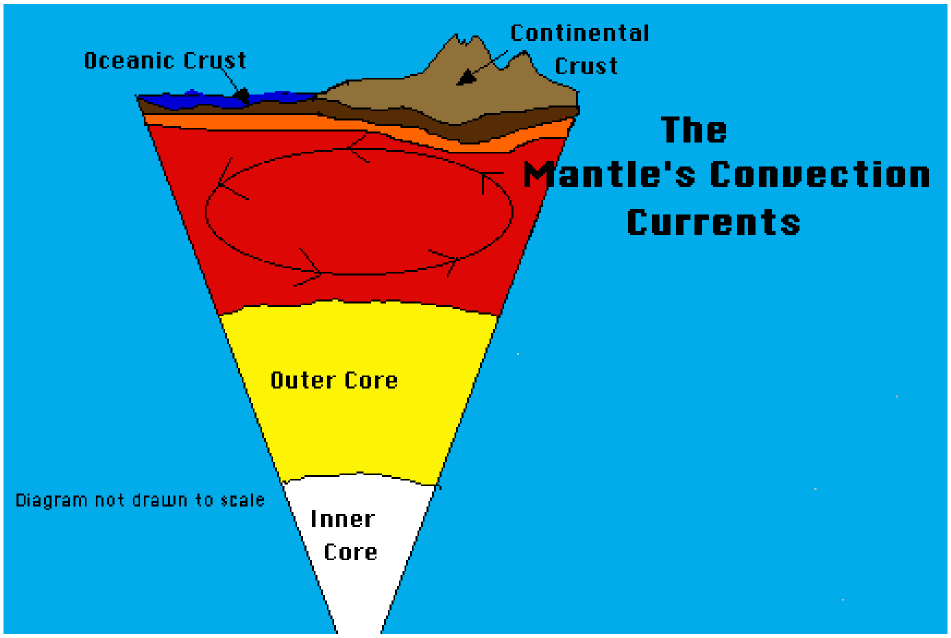
2. What causes the mantle to "flow"?

3. What are the two main metals that make up the outer and inner core?

4. Describe in your own words how the Earth's layers were formed. *"The Four Layers" will help you.*

Pangaea to the Present Lesson #2

The Earth is a *dynamic* or constantly changing planet. The thin, fragile plates slide very slowly on the *mantle*'s upper layer. This sliding of the plates is caused by the mantle's convection currents slowly turning over and over. This overturn is like a conveyor belt that moves the plates of the crust.



These plates are in constant motion causing earthquakes, mountain building, volcanism, the production of "new" crust and the destruction of "old" crust. The following cards will teach you more about the Earth's plates.

The Earth's crust is broken into many pieces. These pieces are called ***plates***. There are twelve main plates on the Earth's surface. The red lines on this map of the world represent the largest plate boundaries. A plate boundary occurs where two plates come together. There are three kinds of plate boundaries:

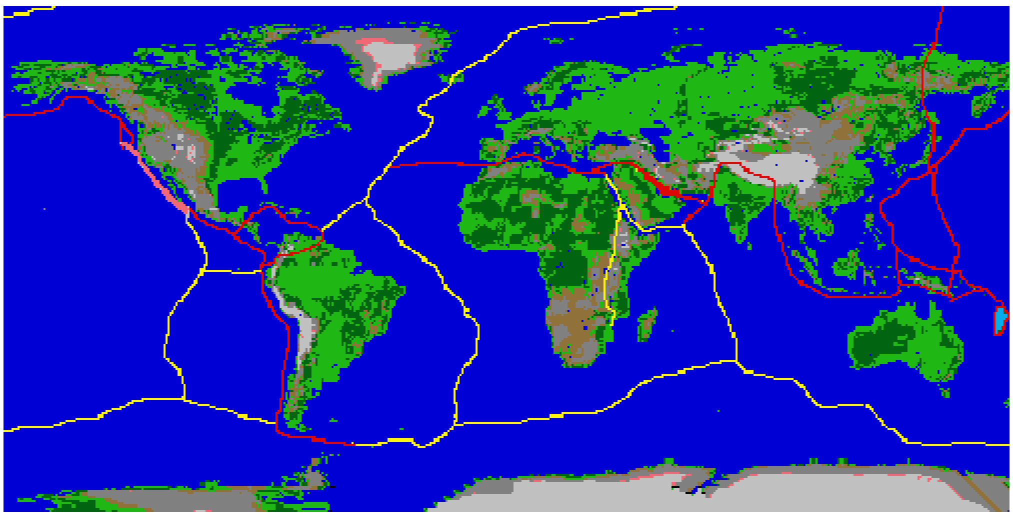
1. ***Convergent boundary*** -where two plates collide to form mountains or a *subduction zone*.

2. ***Divergent boundary*** -where two plates are moving in opposite directions as in a mid-ocean ridge.

3. ***Transform boundary*** -where two plates are sliding past each other as in the San Andreas fault of California.

The Earth's plates are in constant, but very, very slow motion. They move at only 1/2 to 4 inches (1.3 to 10 centimeters) per year!! This does not seem like much, but over millions of years it adds up to great distances of movement.

The ***Continental Drift*** ***Theory*** states that the continents have moved and are still moving today. In 1912 ***Alfred Wegener*** introduced this theory, but he did not fully understand what caused the plates to move. A ***theory*** is an explanation of a scientific process that has been successfully tested by many different methods.



The motion of the Earth's plates help scientists to understand why earthquakes, volcanoes, and mountain building occur.

You will learn more about why the plates are moving in the next lesson, *"How Plates Move"*.

Scientists believe these plates have been moving for millions of years. In fact, 250 millions years ago the Earth's seven continents were all grouped together into a supercontinent called Pangaea.

Just before the days of the dinosaurs the Earth's continents were all connected into one huge landmass called ***Pangaea*** .

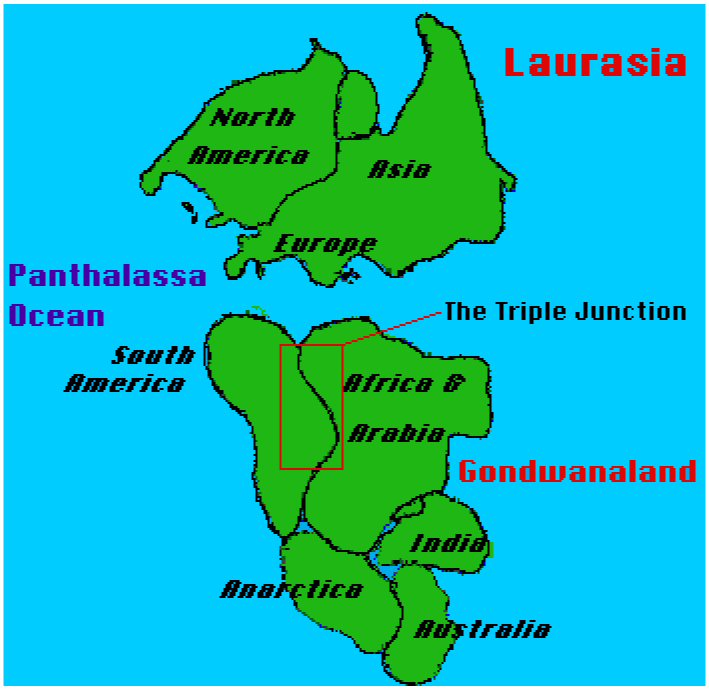
This huge supercontinent was surrounded by one gigantic ocean called ***Panthalassa.***

Notice the position of the continents of Antarctica (Far north of its current position), Australia (flipped sideways and far west of its current position) and the subcontinent of India (Hundreds of miles from Asia).

Scientists believe that the North American continent was located much farther south and east of it's position today. In fact, much of North America was in or near the tropics!! How do scientists know this?? They have found fossils from this period of time. These fossils are of tropical plants and animals. The fossils have been found in cold regions like North Dakota and Greenland!!!

180 Million Years Ago

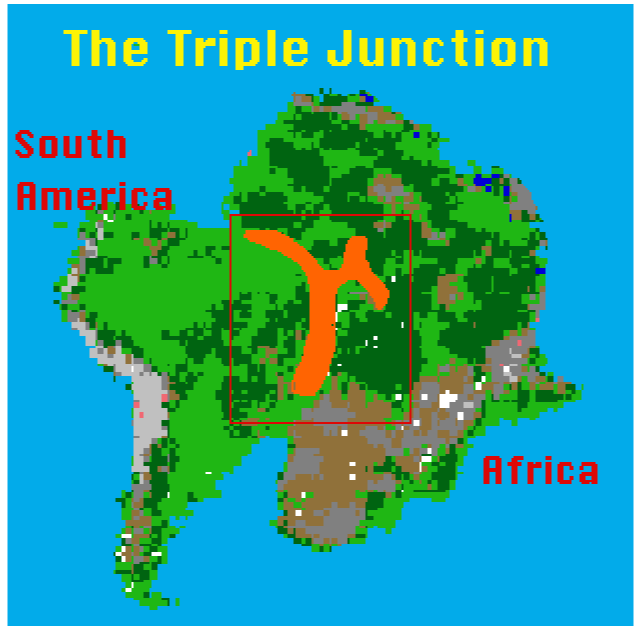
About 180 million years ago the supercontinent Pangaea began to break up. Scientists believe that Pangaea broke apart for the same reason that the plates are moving today. The movement is caused by the convection currents that roll over in the upper zone of the mantle. This movement in the mantle causes the plates to move slowly across the surface of the Earth. About 200 million years ago Pangaea broke into two new continents Laurasia and Gondwanaland. ***Laurasia*** was made of the present day continents of North America (Greenland), Europe, and Asia. ***Gondwanaland*** was made of the present day continents of Antarctica, Australia, South America. The subcontinent of India was also part of Gondwanaland. Notice that at this time India was not connected to Asia. The huge ocean of Panthalassa remained but the Atlantic Ocean was going to be born soon with the splitting of North America from the Eurasian Plate.



How do we know that South America was attached to Africa and not to North America 180 million years ago?

Scientists today can read the history of the rock record by studying the age and mineral content of the rocks in a certain area.

The ***Triple Junction*** was formed because of a three-way split in the crust allowing massive lava flows. The split was caused by an upwelling of *magma* that broke the crust in three directions and poured out *lava* over hundreds of square miles of Africa and South America.

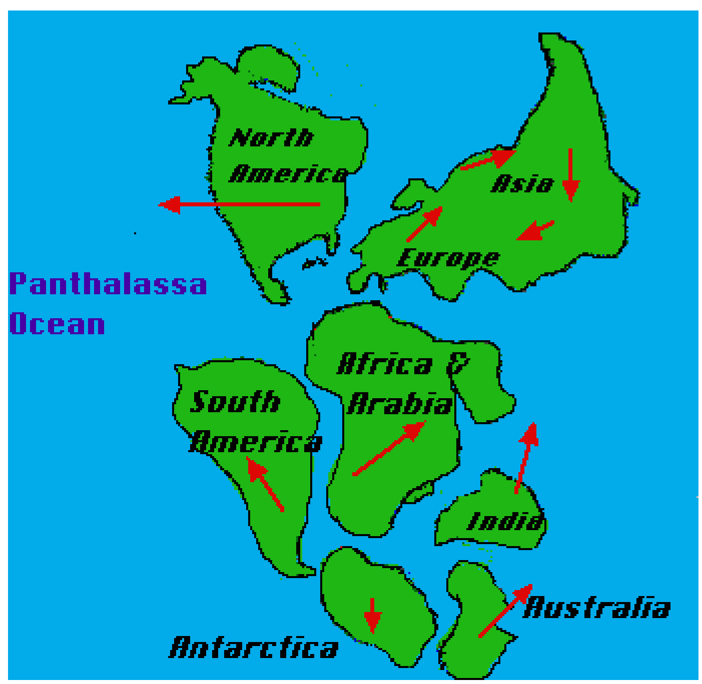


The rocks of the triple junction, which today is the west central portion of Africa and the east central portion of South America, are identical matches for age and mineral make up. In other words the rocks in these areas of the two continents were produced at the same time and in the same place. This tells us that South America and Africa were connected at one time!

Today these two continents are separated by the Atlantic Ocean which is over 2000 miles wide!

135 Million Years Ago

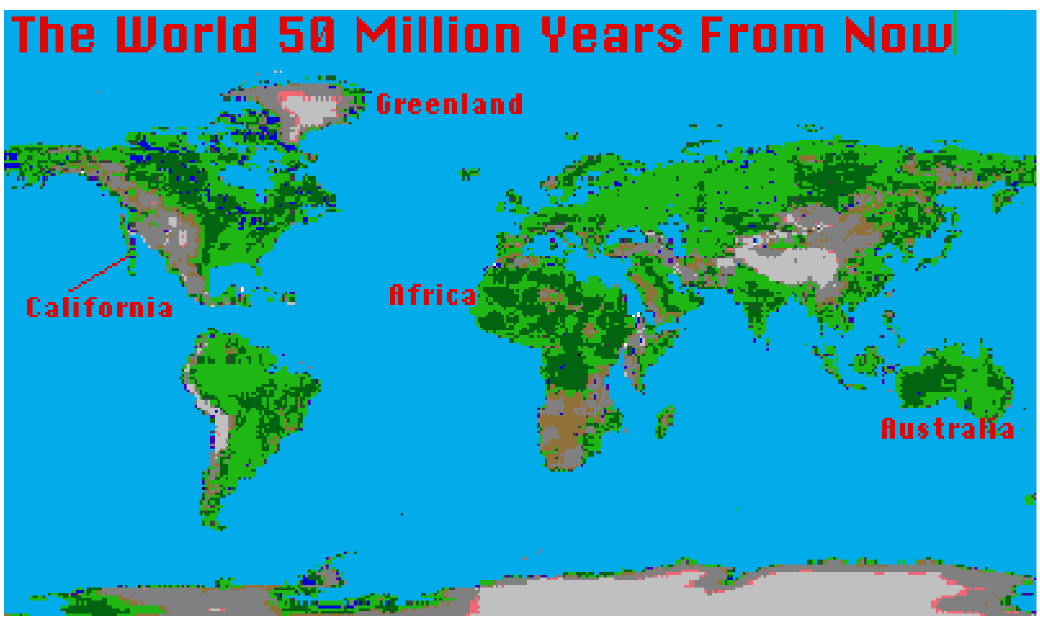
About 135 million years ago Laurasia was still moving, and as it moved it broke up into the continents of North America, Europe and Asia (Eurasian plate). Gondwanaland also continued to spread apart and it broke up into the continents of Africa, Antarctica, Australia, South America, and the subcontinent of India. Arabia started to separate from Africa as the Red Sea opened up.



The red arrows indicate the direction of the continental movements. Notice how far the Indian subcontinent has to move to get to its present position connected to Asia.

The Atlantic, Indian, Arctic, and Pacific Oceans are all beginning to take shape as the continents move toward their present positions.

The plates are still moving today making the Atlantic Ocean larger and the Pacific Ocean smaller. The yellow arrows on the world map indicate the direction of plate movements today.



Notice the position of the Indian Subcontinent today. It moved hundreds of miles in 135 million years at a great speed (4 inches per year!!!) The Indian plate crashed into the Eurasian plate with such speed and force that it created the tallest mountain range on Earth, the Himalayas! What do you predict the world will look like in 100 million or 200 million years? What new mountain ranges will form? Where will new volcanoes erupt?

The Atlantic Ocean will be much larger 50 million years from now and the Pacific Ocean will be much smaller. North and South America will have moved farther west (California moving north) while Greenland will be located farther west but also farther north. The western part of Africa will rotate clockwise and crash into Europe causing great mountain building, while the far eastern region of Africa will rotate eastward toward the Arabian peninsula. Australia will move farther north into the tropics, while New Zealand will move to the south of Australia.

All of these predictions are just that, predictions. These movements of the continents may happen if the plates continue to move in the same direction and with the same speed as they are moving today. Scientists are not certain of the movement today, let alone 50 million years into the future.

What do you think the world will look like in 50 million years???

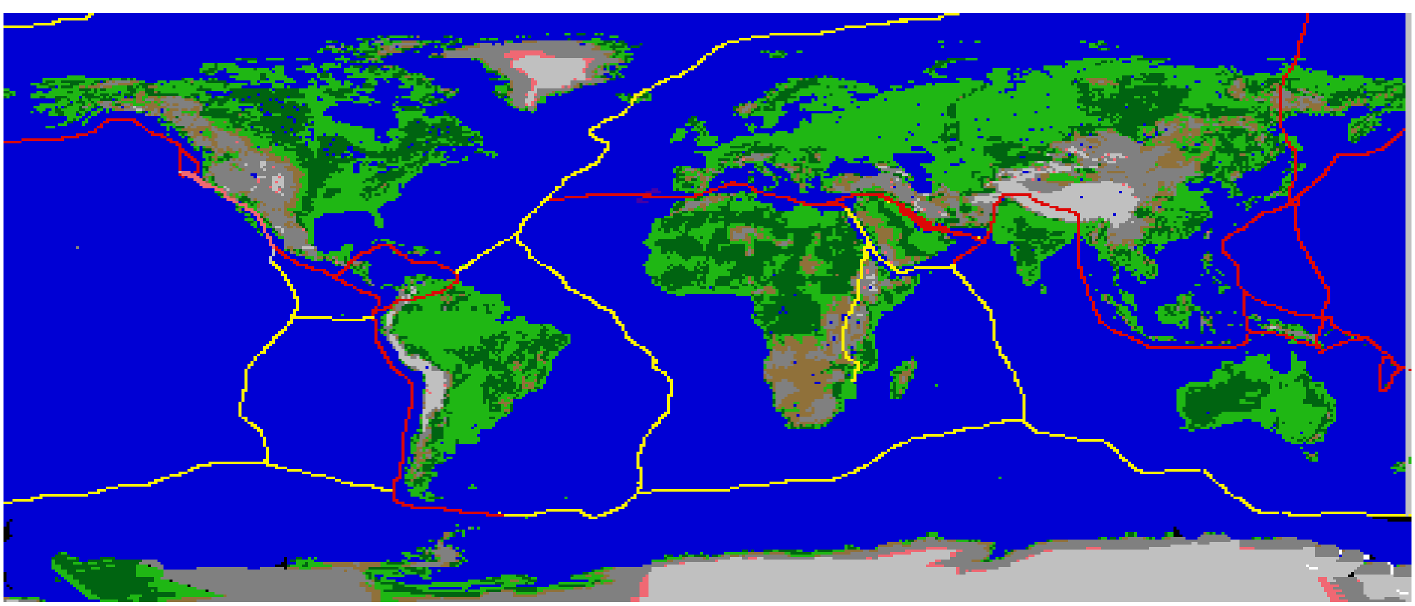
Answer for the questions on a sheet of paper. When you finish the lesson click on the "Earth" icon so that the next pair of students will be at the start of the lesson.

1. What caused Pangaea to break up?

2. What is the Continental Drift Theory?

3. What happened at the Triple Junction? Where is it located today?

How Earth's Plates Move Lesson #3



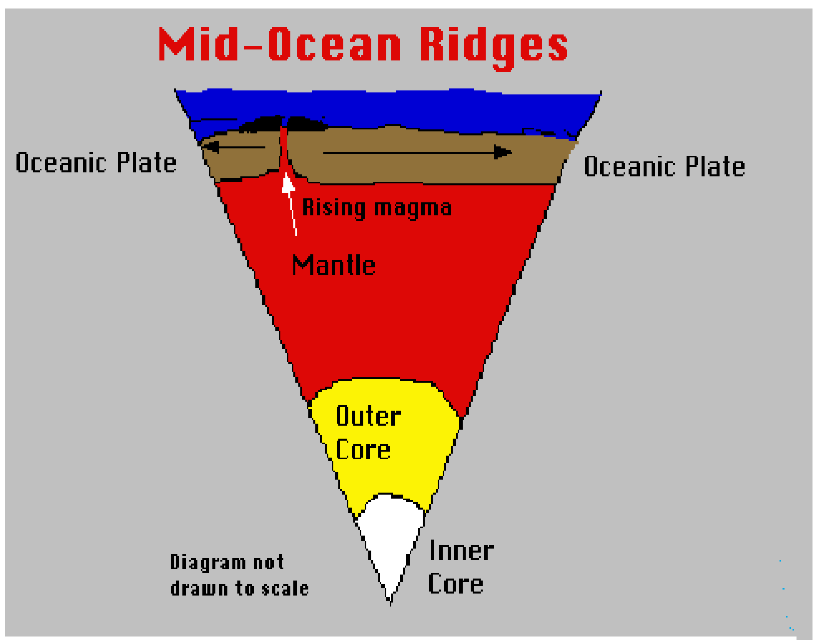
Geologists came to the conclusion in the 1960's that the Earth's rigid outer layer (crust and outer, rigid layer of the *mantle*) was not a single piece, but was broken up into about 12 large pieces called plates. The red lines on the map of the world above indicate

1. *Convergent boundaries* - two plates collide to form mountains or a *subduction zone*.

2. *Divergent boundary* - two plates are moving in opposite directions as in a mid-ocean ridge.

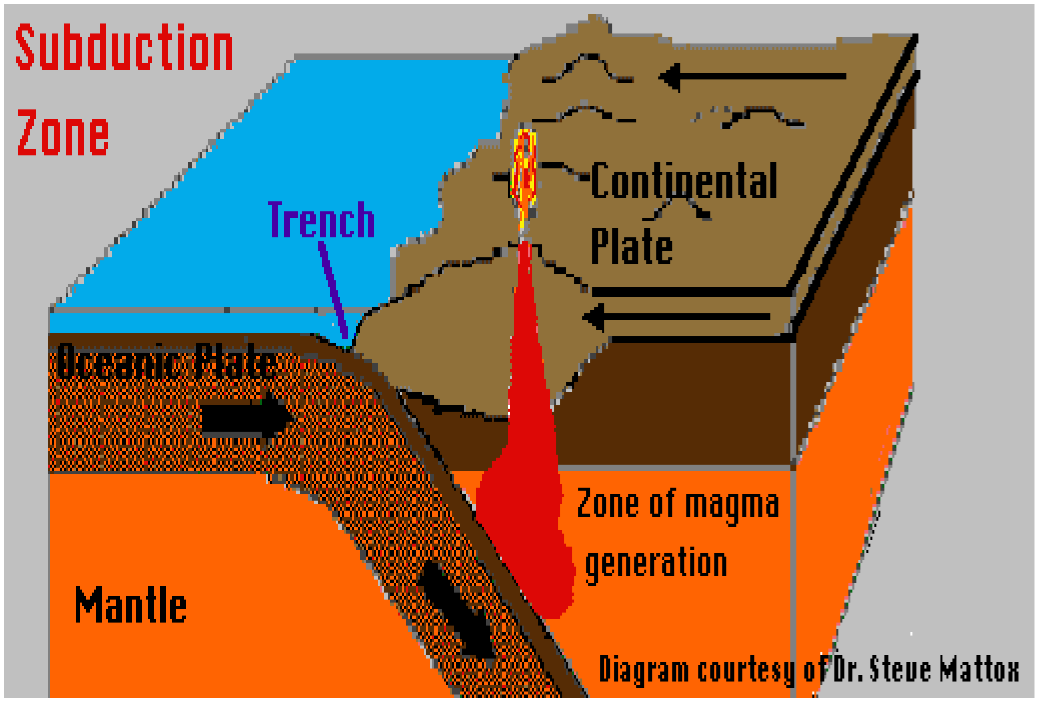
3. *Transform boundary* - two plates are sliding past each other as in the San Andreas fault of California. A transform boundary is like a tear in the Earth's crust. These plates move very slowly across the surface of the Earth as though they were on a conveyor belt. The convection currents in the much hotter mantle continually move the plates about 1/2 to 4 inches per year.

When the plates move they collide or spread apart allowing the very hot molten material called *lava* to escape from the mantle. When collisions occur they produce mountains, deep underwater valleys called trenches, and volcanoes. As mountains and valleys are being formed natural disasters such as earthquakes and volcanic activity can occur which has affected humans for thousands of years.



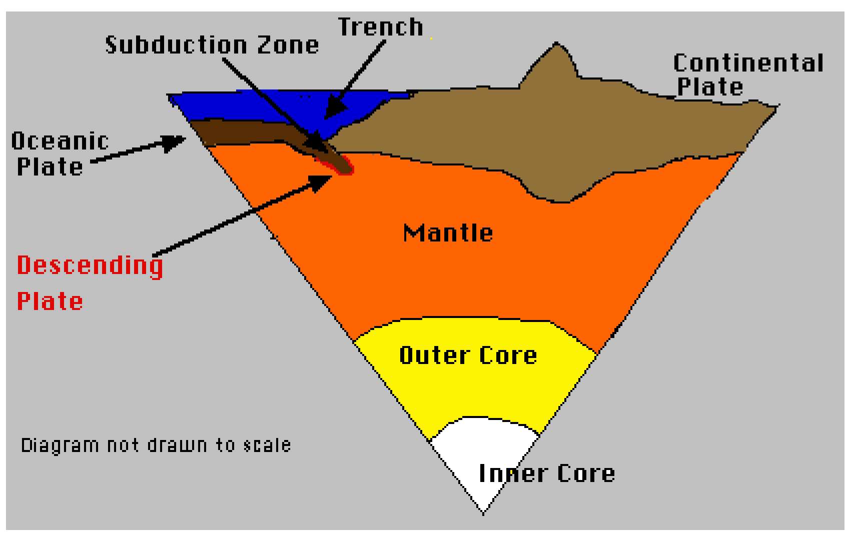
The Earth is producing "new" crust where two plates are diverging or spreading apart. This occurs in the middle of our great oceans. The ***mid-ocean*** ridges are the longest continually running mountain range in the world. These ridges are connected and are about 40,000 miles long!!

One of these mid-ocean ridges, the ***Mid-Atlantic ridge*** , is spreading apart making the Atlantic Ocean wider. As the two plates move the mantle melts, making *magma* and lava fill the void with newly formed rock. The bottom of the Atlantic Ocean is filled with some of the "youngest" crust on Earth. The island of Iceland, located in the North Atlantic, is still being formed at this Mid-Atlantic ridge.



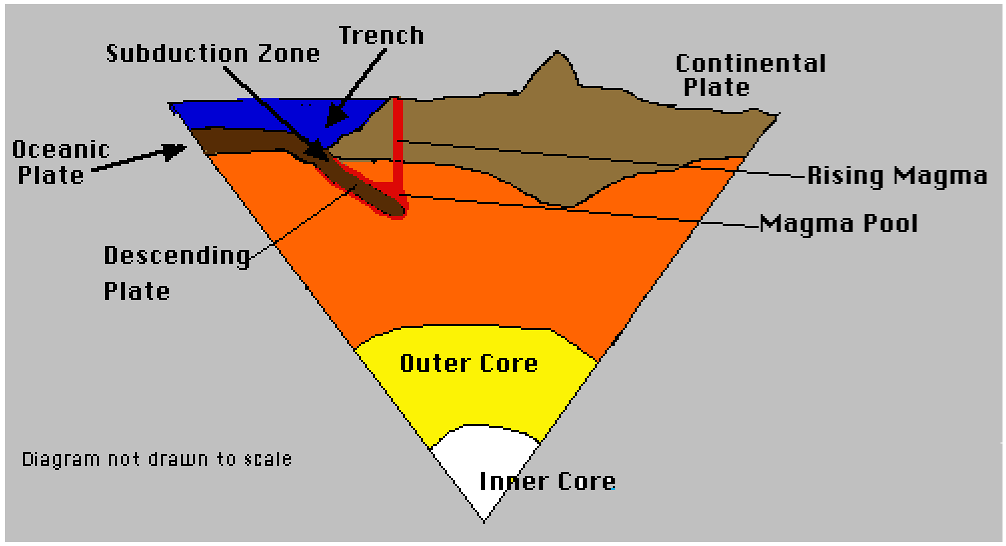
The Atlantic Ocean is getting larger as the Western Hemisphere moves away from Europe and Asia. The Pacific Ocean, on the other hand, is becoming smaller and smaller. This is occurring because the North American and South American plates are moving westward toward Asia and Australia.

The North and South American plates are crashing into the thinner and denser oceanic plates of the Pacific. This drives the oceanic plates deep into the mantle destroying the oceanic plates. This boundary in which an oceanic plate is driven down and destroyed by a continental plate is called a ***subduction zone***.



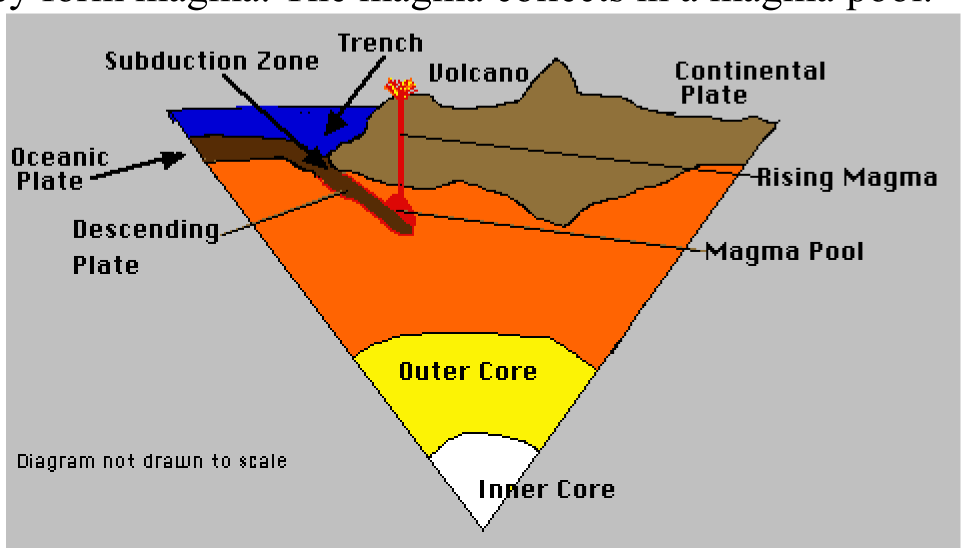
This Pacific Ocean region has more earthquakes and volcanic activity than any other area of the world. Because of all the volcanoes this region has been given the nickname of ***"The Ring of Fire"*** .

When the less dense, lighter continental plate overrides the oceanic plate a subduction zone forms. Because the oceanic plate is bent and driven down, a deep trench forms at this collision point. These trenches are the lowest points on the Earth's crust. One trench is a mile deeper than Mount Everest is tall!



As the oceanic plate descends into the mantle some of it melts. This material moves into the mantle above the plate and causes the mantle to melt. This liquid rock, called magma, rises to the surface because it is less dense then the surrounding rock. If the magma reaches the surface of the Earth, a volcano forms.

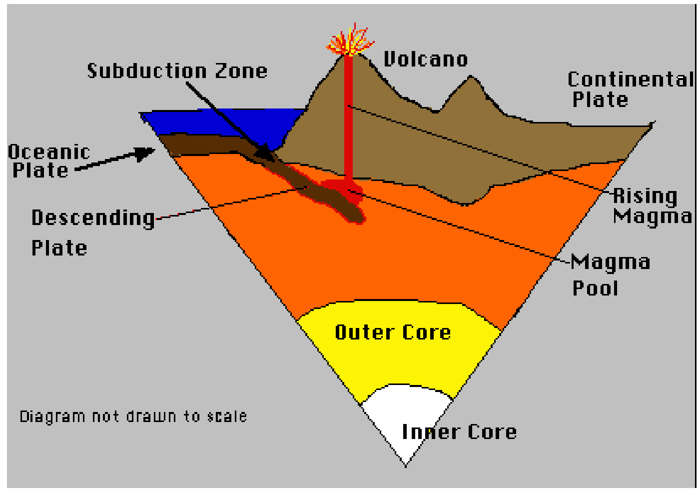
As the mantle rocks melt they form magma. The magma collects in a magma pool. Because the magma is less dense than the surrounding mantle material it will rise. Pressure in the magma cracks the overlying rocks. Then the magma injects into the crack. This process repeats thousands of times, bring the magma towards the surface.



A volcano will form if the magma reaches the surface. When magma does reach the surface it is then called lava.

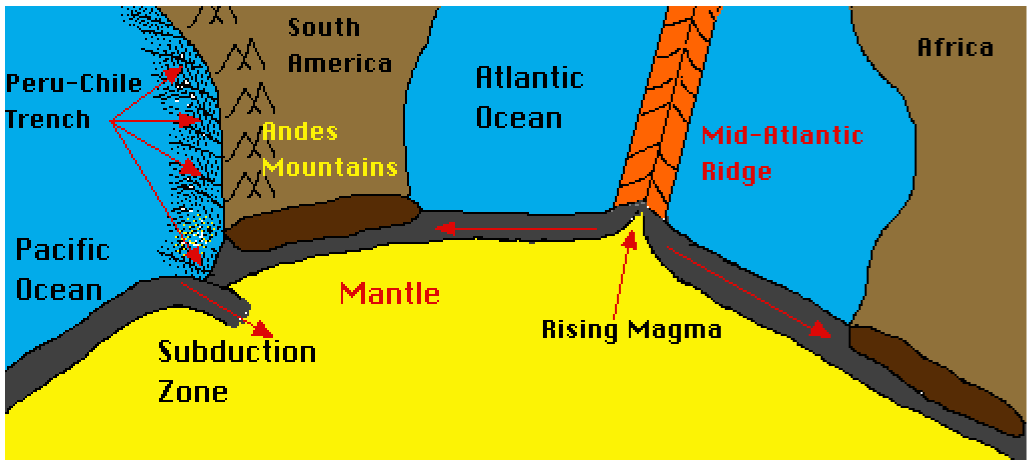
You will learn more about volcanoes in the following lessons.

As the volcano erupts it may build a mountain. The lava along with ash and other *pyroclastic* material will continue to build the mountain higher with each *eruption*.



The Cascade mountain range in the Western United States and the Andes Mountains in South America were formed in this way!!

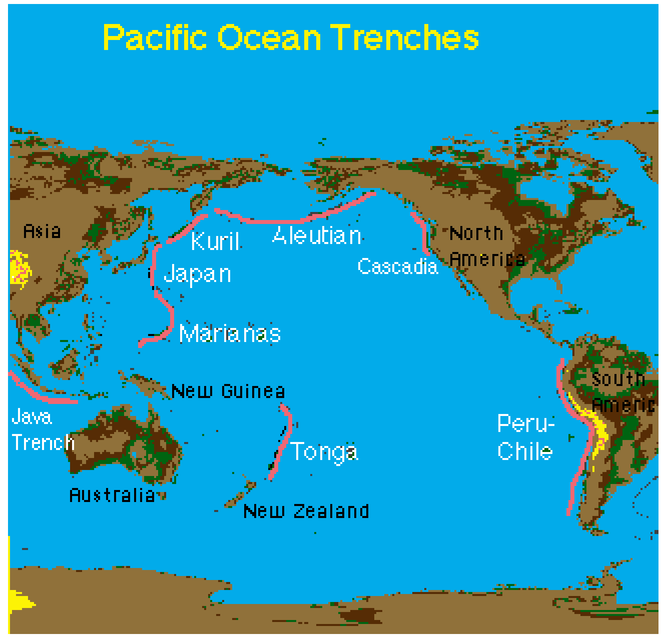
This is a cross section of the Earth in the Southern Hemisphere. The map shows a subduction zone that has created the Peru-Chile Trench at the western edge of South America. This subduction zone has produced the Andes Mountains which run along the entire west coast of South America. It also shows you the Mid-Atlantic Ridge which is spreading the Atlantic Ocean making it wider and wider. The cross section shows two processes at work;



1. "Old Crust" being destroyed at a subduction zone and

2. "New Crust" being produced at the Mid-Atlantic Ridge.

The pink lines on this map of the Pacific Ocean represent deep ocean trenches. These trenches are some of the lowest points on the crust of the Earth. Marianas Trench north of New Guinea is the deepest point on the Earth's surface at 36,201 feet below sea level. Marianas Trench is 7,173 feet deeper than Mount Everest is high!!!!



Trenches surround almost all of the Pacific Ocean. Some of the other trenches of the Pacific are the Aleutian, Peru-Chile, Kuril, and the Japan trench.

There are trenches wherever continental plates and oceanic plates collide. The Java Trench in the Indian Ocean is the deepest point of that ocean at 24,442 feet below sea level.

Answer to the following questions

1. In your own words explain what happens at a subduction zone.

2. In your own words explain what happens at a mid-ocean ridge.

3. At a subduction zone what causes magma to rise?

Chapter 2 Earthquakes and Volcanoes

Chapter 2 focuses on Earthquakes and Volcanoes.

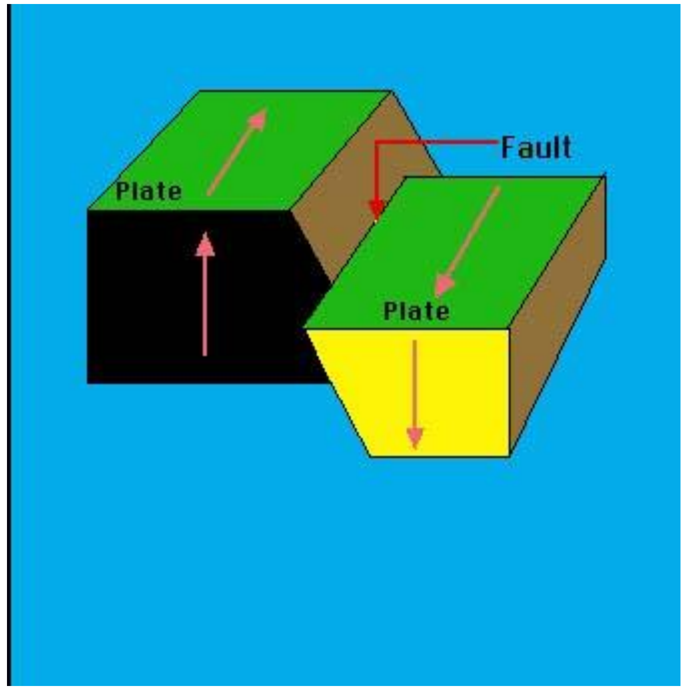
Lessons included in this chapter:

Earthquakes - The Rolling Earth Lesson #4

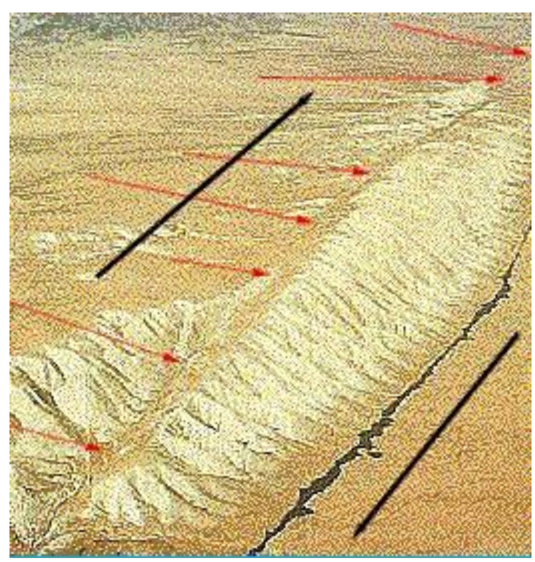
An ***earthquake*** **is a sudden, rapid shaking of the Earth caused by the release of energy stored in rocks.** This energy can be built up and stored for many years and then released in seconds or minutes. Many earthquakes are so small that they can not be felt by humans. Some, on the other hand, have caused great destruction and have killed hundreds of thousands of people. The pink lines and dots on the map of the world above indicate the regions of earthquake activity.

There are two major regions of earthquake activity. One is the ***circum-Pacific belt*** which encircles the Pacific Ocean, and the other is the ***Alpine belt*** which slices through Europe and Asia. The circum-Pacific belt includes the West coasts of North America and South America, Japan, and the Philippines.

Over one million earthquakes may occur each year on the Earth. Most earthquakes last only seconds, but some large quakes may last minutes. About 90% of all Earthquakes are produced at plate boundaries where two plates are colliding, spreading apart, or sliding past each other. When these plates move suddenly they release an incredible amount of energy that is changed into wave movement. Earthquake waves resemble sound and water waves in the manner in which they move. It is these waves that roll through the Earth's crust causing buildings to collapse, bridges to snap, mountains to rise, the ground to fall, and in some cases the ground to open up into huge cracks.

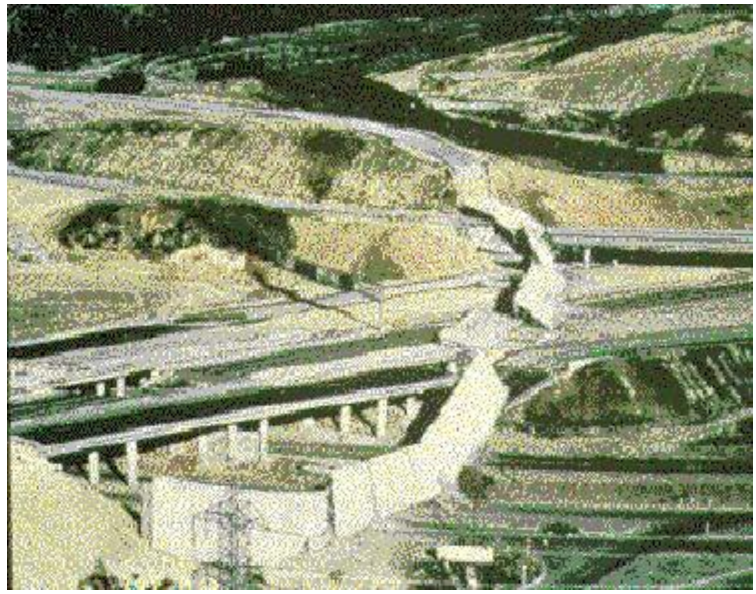


Why do earthquakes occur? Scientists believed that the movement of the Earth's plates bends and squeezes the rocks at the edges of the plates. Sometimes this bending and squeezing puts great pressure on the rocks. Rocks are somewhat elastic; they can be bent without breaking. Have you ever stretched a rubber band? You know if you increase the tension too much though, the rubber band will snap!! Rock layers act somewhat the same way, if the pressures becomes too great the rock layer will break and move. When this occurs the layers will move along a crack in the Earth's crust called a ***fault*** or the release of energy will cause a new fault line to be produced. This rupture of the rocks and the resulting movement causes an earthquake.

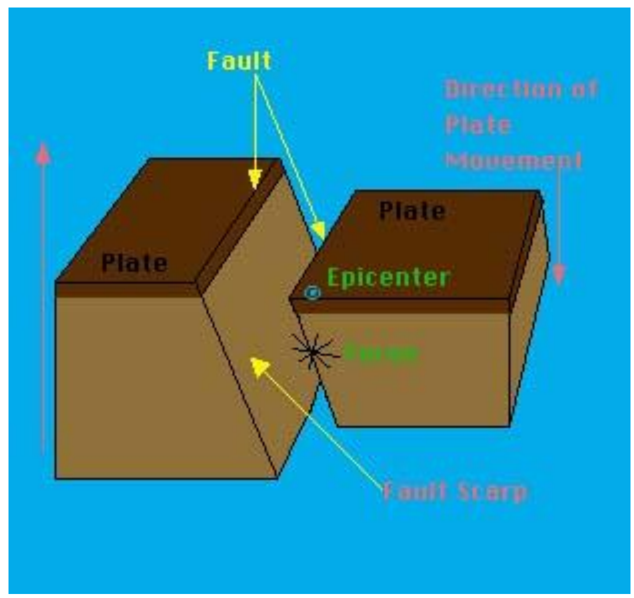


This is an aerial photo of the San Andreas fault line in California. The red arrows point to the crack in the crust that is the surface fault. This fault is the boundary between two huge plates, the North American plate and the Pacific plate. The two plates are sliding past each other in opposite directions. This type of plate boundary is called a transverse boundary. A ***transverse boundary*** is actually a tear in the Earth's crust. The black arrows represent the directions that the two plates are traveling.

This fault line is perhaps the most studied transverse boundary in the world. Many earthquakes each year occur on the San Andreas fault which runs in California from the Mexico border east of San Diego north to the San Francisco Bay area. The next photo shows the destruction that occurred during the 1971 San Fernando earthquake.



This aerial photograph shows the destruction that occurred during the February 2, 1971 San Fernando earthquake. The freeway bridge and road were extensively damaged during this shaking of the crust.

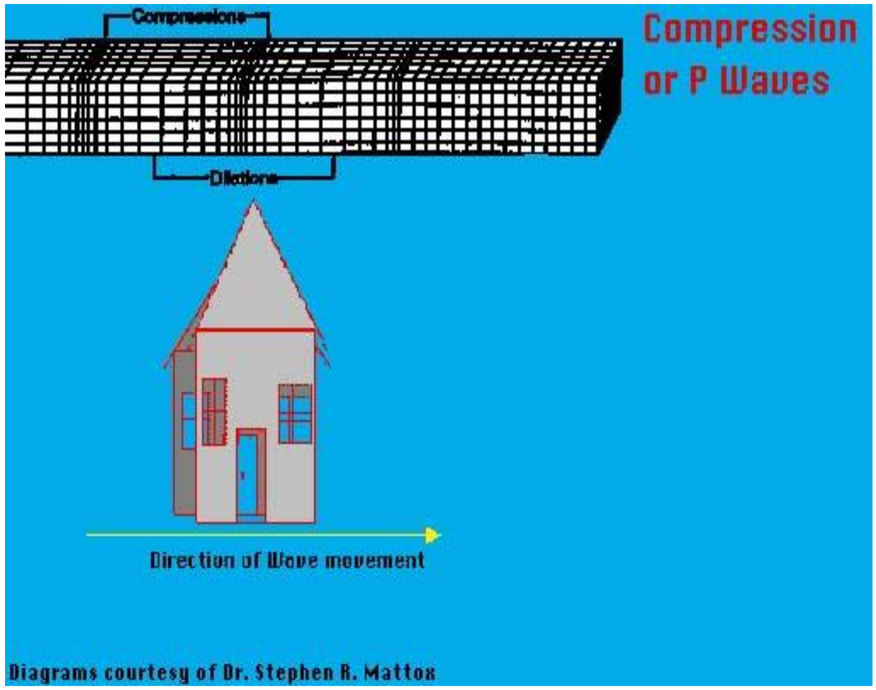


When an earthquake occurs an area of the crust will move very suddenly and with a great release of energy. The point of the actual rock rupture is called the ***focus***. The focus is usually found far beneath the surface. The point directly above the focus on the surface of the Earth is called the ***epicenter***.

When the rocks move suddenly they will produce waves in the Earth's crust. These waves move out in all directions and can produce widespread damage on the Earth's surface.

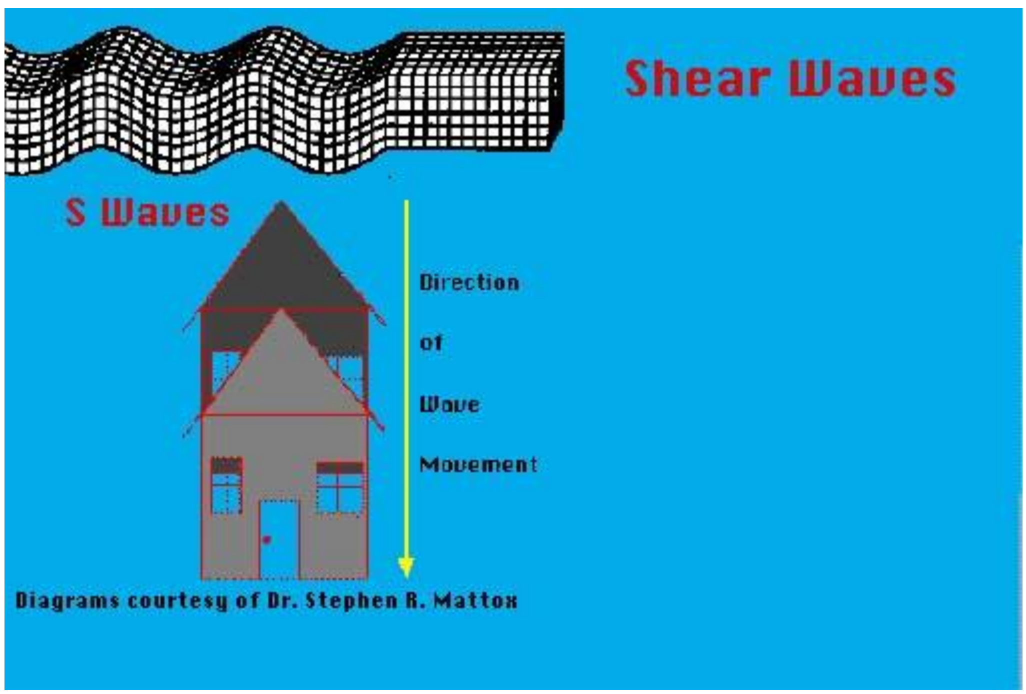
When the rupture of the rock occurs the release of energy causes ***seismic waves*** to be produced. Just as wind energy causes waves in water to move across a lake or ocean, seismic waves move through the layers of the Earth. These seismic waves are what produce the destruction that can accompany an earthquake by heaving, shaking, and cracking the ground as they pass through an area. The seismic waves spread out in all directions from the focus.

Compression waves are one type of seismic wave. They are the first to arrive at the surface of the Earth. Because of this they are given another name, ***P or Primary waves.***



P waves are the fastest of the seismic waves. They travel at incredible speeds, 14,000 m.p.h at the surface to over 25,000 m.p.h. through the core of the Earth. P waves are even able to pass all the way through the entire Earth.

When P waves strike an object they push and pull the object , like a train engine bumping into a railroad car which then bumps into another and so on all the way through the whole length of the train. This jackhammer movement is the first sign that an earthquake is occurring.

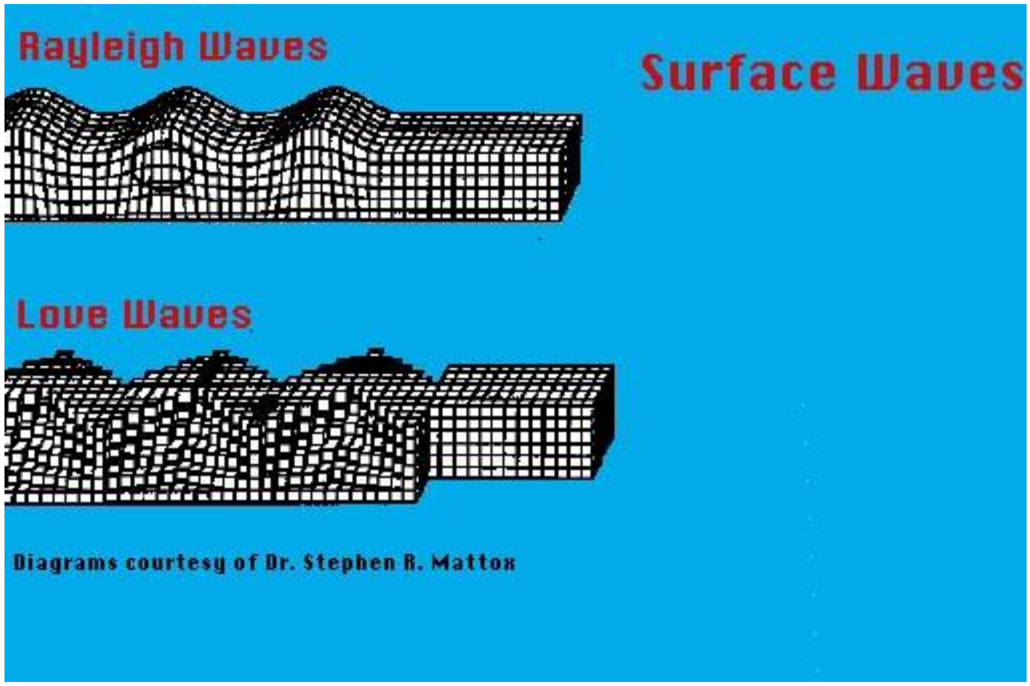


As a wave passes through a house, the house is pushed and pulled. If the house is not strong enough it might collapse.

Shear waves reach the surface shortly after the P waves and are given the name ***S or Secondary waves.*** S waves travel at about half the speed of P waves. They move objects in their paths in an up and down motion in the direction that the wave is moving.

S waves can only move through solids and because of this can travel only through the crust and *mantle* of the Earth. When S waves strike the outer core, which is made of liquid iron and nickel, the waves stop.

Surface waves are the third type of wave. These are the waves that produce the most destruction. They originate from the arrival of P and S waves at the surface. They are much slower than both P and S waves. Surface waves are limited to travel along only the surface of the Earth, just as waves in a body of water are limited to travel along only the surface of the water.



There are two types of surface waves: Love waves and Rayleigh waves. ***Love waves*** move in a manner very similar to S waves but the movement to objects in it's path is side to side instead of up and down. ***Rayleigh waves*** travel much in the same way as waves in water. Rayleigh waves have an almost circular pattern to its wave motion.

The ***Richter*** ***Magnitude*** is a number that is used to measure the size of an earthquake. The ***magnitude*** is a measure of the strength of the seismic waves that have been sent out from the focus. A scientist uses a *seismograph* to determine the strength of the earthquake. A ***seismograph*** is an instrument that measures the amount of ground motion that an earthquake produces.

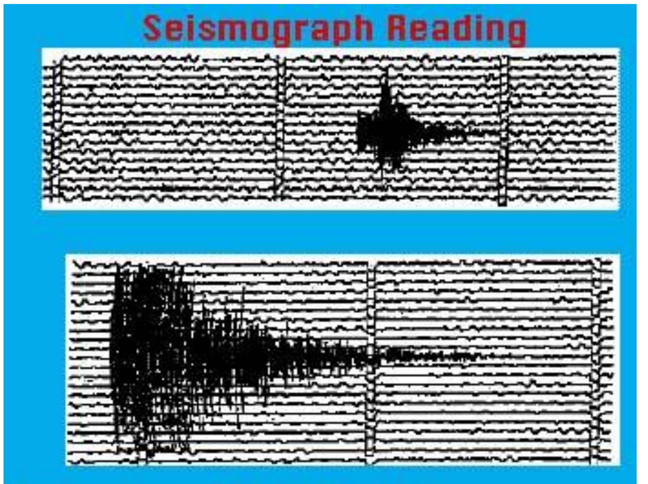
Richter Magnitude/ TNT Equivalent		
1.0	6 ounces	
1.5	2 pounds	
2.0	13 pounds	
2.5	63 pounds	
3.0	397 pounds	
3.5	1,000 pounds	
4.0	6 tons	Small atomic bomb
4.5	32 tons	Average tornado
5.0	199 tons	
5.5	500 tons	
6.0	6,270 tons	
6.5	31,550 tons	
7.0	199,000 tons	San Francisco (7.1) 1989
7.5	1,000,000 tons	Los Angeles (7.4) 1992
8.0	6,270,000 tons	San Francisco (8.3) 1906
8.5	31,550,000 tons	Anchorage, Alaska 1964
9.0	199,999,000 tons	

Each number on the Richter Scale represents an earthquake that is ten times as powerful as the number below it.

Examples: An earthquake measuring 6 is ten times stronger than a magnitude 5 quake. An earthquake of a magnitude 9 is 10,000 times more powerful than a 5.

The strongest earthquake ever measured was (the 1960 **Valdivia** earthquake (Spanish: Terremoto de **Valdivia**) or Great Chilean earthquake (Gran terremoto de **Chile**) of 22 May is the most powerful earthquake ever recorded. Various studies have placed it at 9.4–9.6 on the moment magnitude scale) was a 8.9 off of the coast of Ecuador in 1906. Earthquakes of 6 and above are considered major quakes. Earthquakes of 7 and above have the ability to do great damage and kill many people.

Each of the graphs on this page shows an earthquake reading on a seismograph. The waves from an earthquake set a writing device in motion showing the magnitude and the length of time that the earth is in motion during a quake.



Graphs courtesy of Dr. Stephen R. Mattox

The strength or magnitude is recorded in the vertical (up and down) lines. The stronger the quake the longer the lines will be drawn on the graph.

The duration (length of time) that a quake occurs is represented in the horizontal lines. The duration of the earthquake in the top graph shows a quake lasting about 40 seconds. Each box on the graph is a one minute time duration. The bottom earthquake lasted about one minute and 20 seconds.

Which earthquake was stronger??

Answer each question below:

1. How are earthquake waves produced?

2. What does a Richter Scale show?

3. What are the differences between compression, shear, and surface waves?

Volcanoes Lesson #5

Volcanic activity is the most powerful force in nature. Some volcanic eruptions are much more powerful than the largest nuclear explosion. Volcanoes have killed thousands of people and have created some of the most frightening events in human history.

Volcanoes have been the basis for myths and legends the world over.

Volcanoes are also responsible for much of the land we live on, 90% of all the continents and ocean basins are the product of volcanism. The air we breathe, and the water we drink have been produced by millions of years of eruptions of steam and other gases.

The volcanic mountain above is Mount Adams which is located in the Cascade Range of Washington.

The word volcano is derived from the name of the ancient Roman island of Vulcano which lies off the southwest coast of Italy. The Romans believed that Vulcan, the god of fire and the maker of weapons, used the volcano on that island to forge his weapons.

Volcanoes are not alive but scientists use human terms to talk about volcanoes, such as active, alive, *dormant*, resting, sleeping, *extinct*, dead, lifetime, and restless.

The island in the middle of the picture is *Vulcano*. The island was formed

by *Vulcanian* eruptions, which are eruptions of hot gas and steam followed by ejections of thick and pasty *lava*.

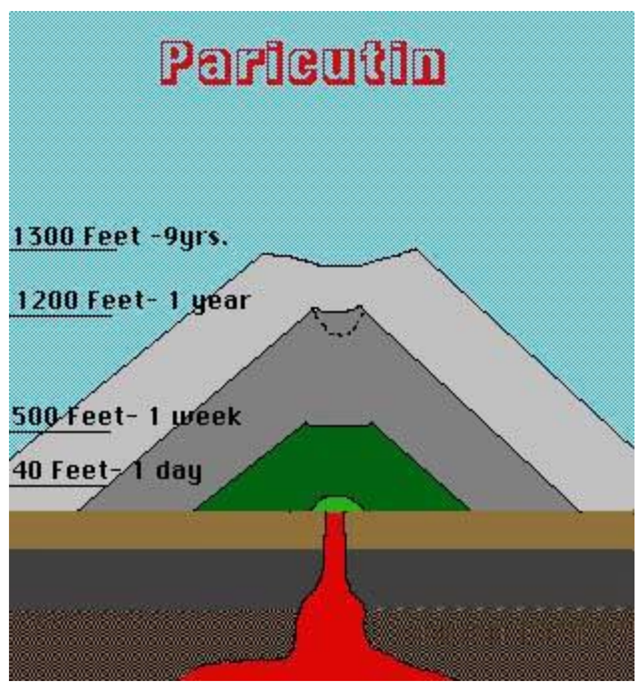
The term ***Volcano*** has two definitions;

1. An opening in the crust of the Earth in which molten rock called *magma* and gases can escape to the surface.

2. The mountain that is formed from volcanic eruptions.

This is a photo of the volcano Paricutin (Pear-A-Koo-Teen). Paricutin's cone formed from nine years of almost constant eruptions. Red hot cinders exploded from the main vent and landed near it building the cone higher and higher. This type of cone is called a *cinder cone*. You will learn more about the types of volcanic cones in the eighth lesson, "Volcanic Cones and Eruptions".

Volcanoes actually build themselves into a mountain with repeated eruptions. In 1943 a farmer in Mexico noticed that some cracks (*fissures*) in his corn field were growing wider and wider. The next day his field was engulfed by a growing volcanic cone (Light Green). During the week the cone grew 500 feet taller (Dark Green). Within a year (Dark Gray) Paricutin was over 1200 feet higher than the surrounding landscape. During the next eight years the volcano did not grow much taller but the cone's base grew wider and wider (Light gray). Paricutin stopped erupting in 1952 almost as fast as it started. The mountain has been silent since.

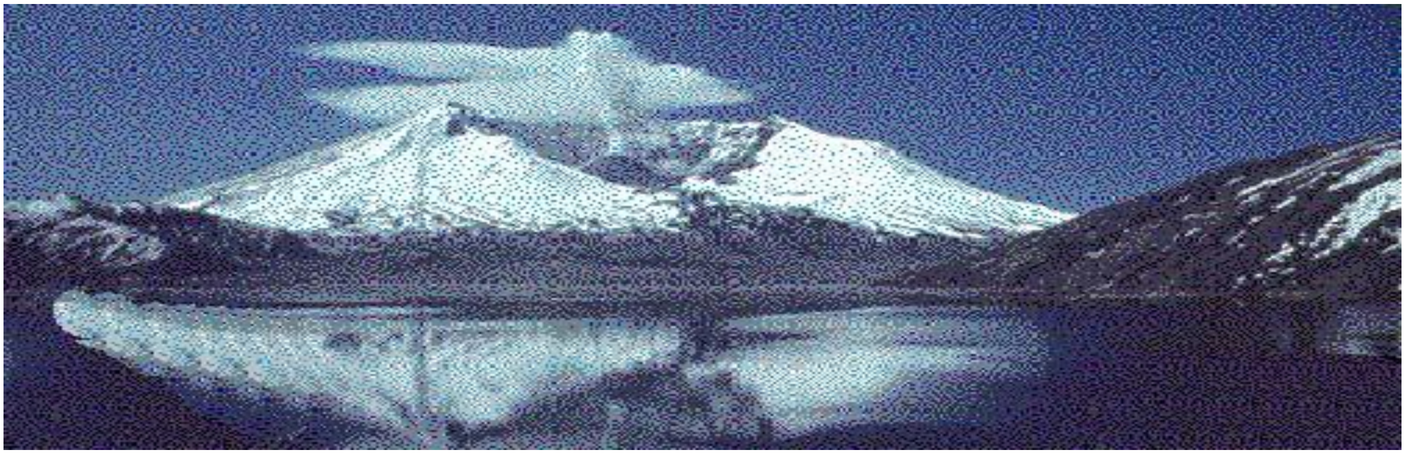


Volcanoes can build themselves into high mountains one day and in the case of Mt. St. Helens erupt violently blowing their top off the next day. Mt. St. Helens lost over 1300 feet of its summit during the eruption and simultaneous landslide of 1980.

Volcanoes are classified as active, dormant, and extinct. ***Active*** **volcanoes are either currently erupting or have erupted in recorded history.** There are over 500 volcanoes on Earth that fit this category today. ***Dormant*** **or resting volcanoes are not currently erupting but are considered likely to do so.** Mt. St. Helens had been dormant for one hundred twenty-three years before it erupted in 1980. ***Extinct*** **or dead volcanoes have not erupted in recorded history and are not expected to erupt again.**

The photo above is of beautiful Mt. St. Helens before it erupted on May 18, 1980. Mt. St. Helens was one of the most beautifully symmetrical stratovolcanoes in the world. It was called "the Fuji of the west". Mount Fuji, in Japan, is the most photographed mountain in the world. The next card will show you what this mountain looked like shortly after the eruption. The lake in the foreground changed. The lake's level is now 150 feet higher because the landslide and eruption filled the bottom of the lake with rock, soil, and pyroclasts.

This is Mt. St. Helens four months after the eruption. Notice the loss of over 1300 feet of the summit. Also notice the total devastation of the beautiful forests and how Spirit Lake rose. Spirit Lake's surface was completely filled with trees that were



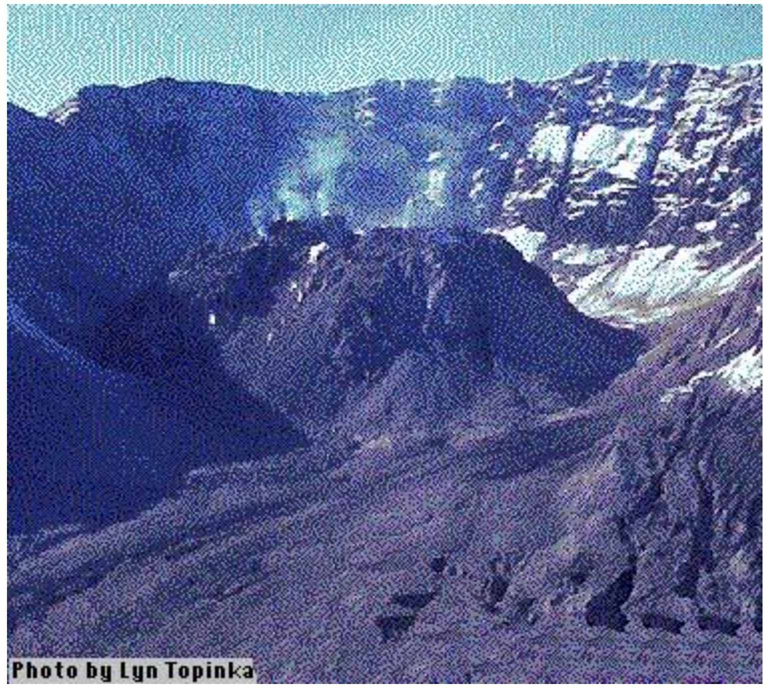
blasted into the lake by the force of the eruption. The lake is now much more shallow, wider, and longer than before the eruption. Huge trees still float across the lake today.

The eruption left a *crater* over a mile wide and over 2000 feet deep. The mountain is still active today spewing small whisps of steam. A *lava dome* is growing in the bottom of the huge crater.

A *lava dome* is a steep mass of very thick and pasty lava that is pushed up from the main vent. The lava is so **viscous** (thick and pasty) that it does not flow but slowly rises higher with each movement of magma in the *conduit*. Think of toothpaste that is slowly squeezed and then stopped and then squeezed again from the tube. This is how the lava dome in Mt. St. Helen's was formed.

The dome's exterior surface is very rough with chunks of lava that were formed from small eruptions that broke the cooled and hardened surface into blocks.

The dome slowly "grew" larger and larger over a seven year period. An earlier dome started to form one month after the famous eruption when very thick lava (dacitic lava) rose into the crater from the *magma chamber* below. This dome was destroyed by an explosive eruption just a month later.



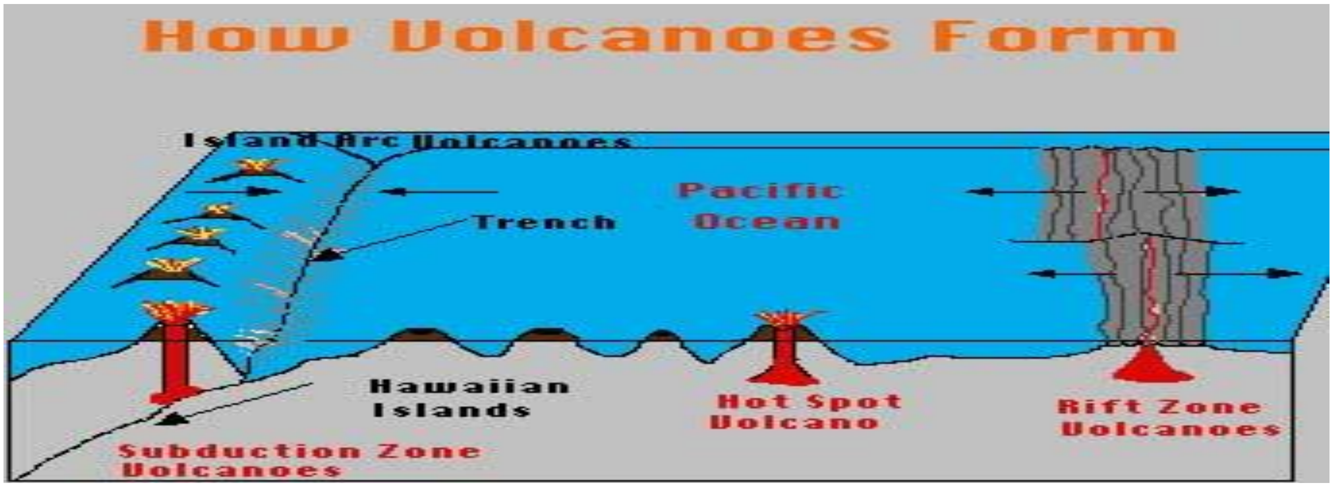
The large dome that is very visible today is over 900 feet tall (taller than an 80 story building) and over 3000 feet wide (10 football fields). As large as the lava dome is, it is still dwarfed by the huge crater that was the result of the 1980 eruption. Steamy whisps of steam are still visible from the dome telling us that the volcano's magma is filling the conduit, making the volcano still active today.

There are three ways that volcanoes form. ***Subduction Zone* volcanoes** form at the boundaries of two plates, one overriding the other. Subduction zone volcanoes are the most violent and destructive of the volcanic types. Mt. St. Helens, Mt. Pinatubo, Krakatoa, and Mt. Vesuvius are all famous explosive subduction zone volcanoes. ***Mid-ocean rift volcanoes*** form where two oceanic plates are spreading apart. There are more *rift zone* volcanoes than any other type.

These mid-ocean or rift zone volcanoes are the world's longest continuous mountain chain. This mountain chain encircles the entire Earth. It is more than 40,000 miles long.

The third way that volcanoes form occurs at a *Hot Spot*. Hot spots are usually found under *oceanic crust*, but can be located under *continental crust*. You will learn more about ***Hot Spot volcanoes*** in the lesson "Hot Spots-Yellowstone and Hawaii".

The diagram below shows the three ways that volcanoes form.



Predicting exactly when a volcano will erupt is next to impossible. Today geologists are becoming much more accurate in making the public aware that a volcano is showing signs that it may erupt in the near future.

In the months before Mt. St. Helens erupted geologists knew the mountain was getting restless. A *magnitude* 4.1 earthquake was recorded on March 20 (about 2 months before the large eruption). Many shallow earthquakes were recorded over the next seven weeks. Magma moving higher and higher inside the mountain was causing these earthquakes. As the magma rose it formed a large bulge on the north flank. This bulge was growing daily and the geologists knew that an eruption was soon to be.

What the authorities did was evacuate most of the people in and near the mountain. Some decided to stay. Almost everyone that was near the eruption was instantly killed. In all, 57 people died. Without the evacuation perhaps as many as 30,000 deaths would have been attributed to Mt. St. Helens fury.

The geologists in the photo are measuring a growing fissure near the lava dome in Mt. St. Helens crater. As magma rises the fissure will grow wider telling the geologists that the magma is raising again.

Scientists can not stop a volcano from erupting but with constant monitoring they can warn and *evacuate* people and save lives.

Many volcanoes erupt in very consistent patterns, while other volcanoes have no eruption pattern at all. This makes forecasting eruptions difficult.

What makes predicting eruptions even more difficult is the fact that many volcanoes start with one type of eruption pattern and then change eruption patterns as they grow older.

Some of the most powerful eruptions in recorded time have come from volcanoes that have been dormant for hundreds and even thousands of years.

Here we have geologists studying a *tilt* meter. A tilt meter is used to measure the growth of the lava dome in the foreground. The tilt meter will show a different angle as the dome grows. With careful study the geologists can tell if magma is on the rise and that an eruption may occur in the near future.


Photo by Holly Martinson

Answer the following questions

1. At what type of plate boundaries do volcanoes form?

2. What are the two definitions for the term volcano.

3. Write definitions in your own word for the following terms:

a) *Active Volcano*

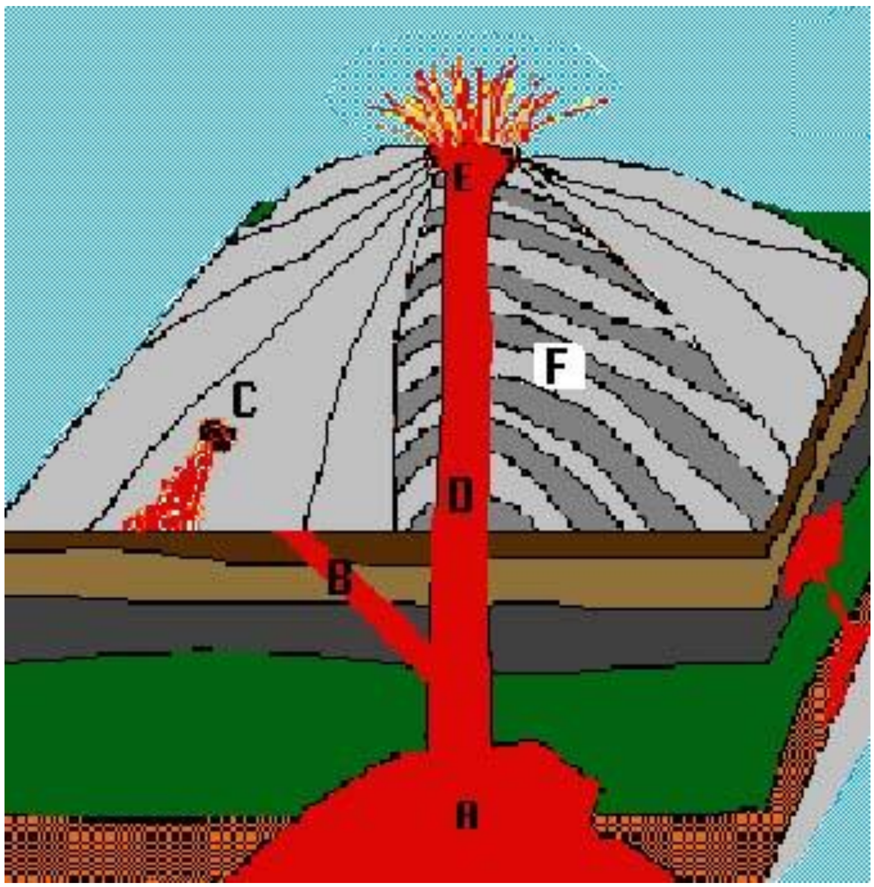
b) Dormant Volcano

c) Extinct Volcano

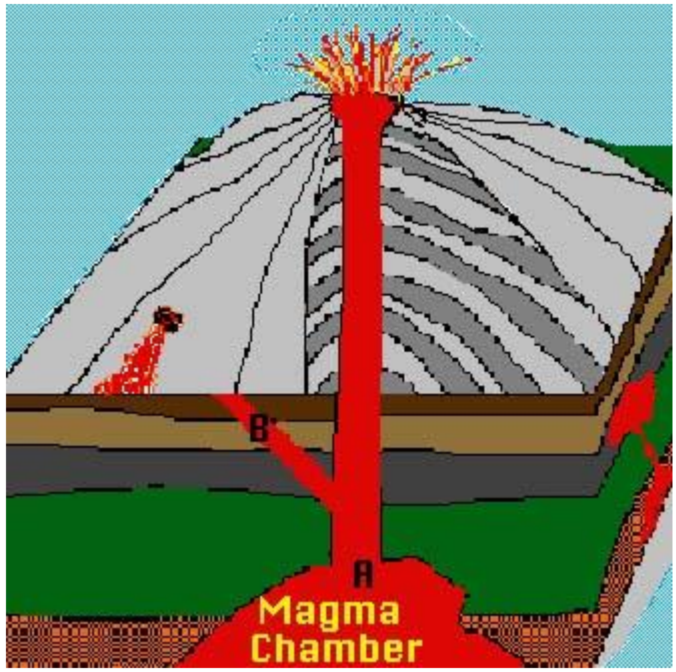
Volcanic Terms Lesson #6

The volcanic mountain in this picture is Mayo Volcano on the island of Luzon in the Philippines. Mayon is a beautiful example of a *stratovolcano*.

This is a model of the interior and exterior of a stratovolcano. The letters represent important terms that you need to know to understand how volcanoes are formed and how they work.



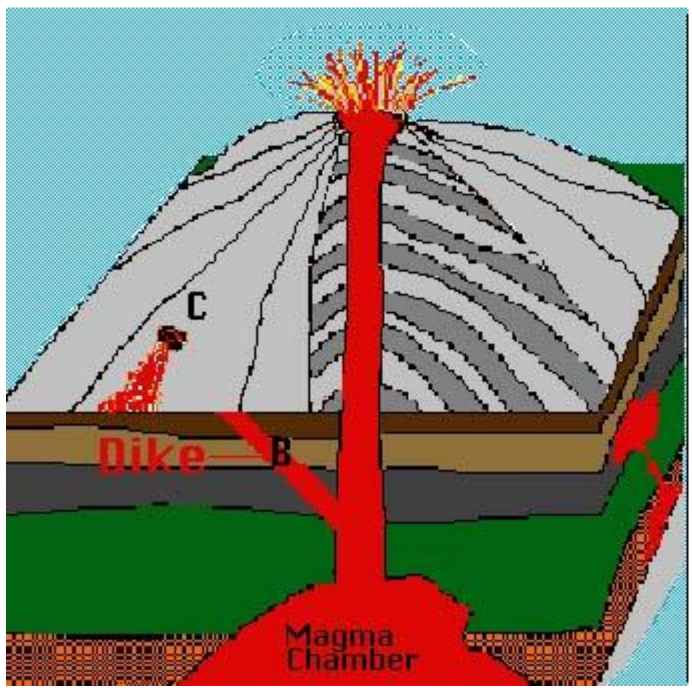
The letter A represents a ***magma chamber*.**



Magma **is molten rock that is located under the surface of the Earth.** A magma chamber is usually located far beneath the surface of the Earth where an oceanic plate is driven down into the *mantle* by a continental plate. The oceanic plate melts as it desends into the upper layer of the mantle. Some ocean water gets trapped with the oceanic plate and is turned into steam by the intense heat.

The magma is less dense and under extreme pressures that force it up toward the surface. This molten rock and gas collects in a magma chamber until it can escape to the surface.

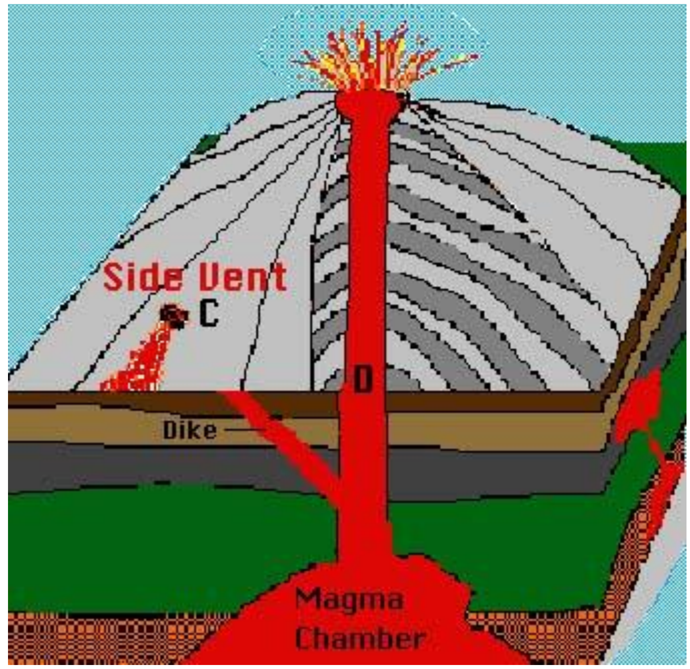
The letter B represents a ***Dike*.**



Stratovolcanoes are built by many alternating eruptions of *lava* and *ash*. The magma below and inside the mountain exerts a lot of pressure on the crust and on the volcano itself. The magma pushes its way through small cracks in the crust and finally reaches the surface. This causes a dike to be produced.

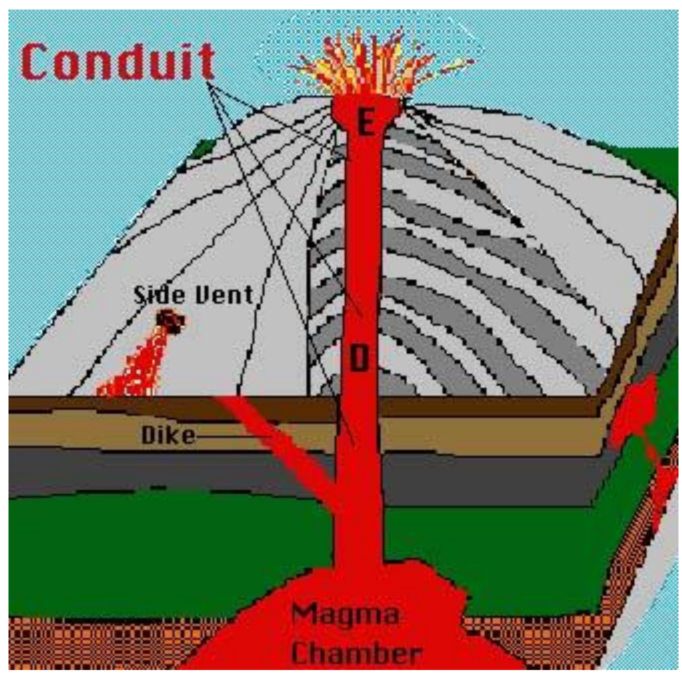
A dike is an intrusion of magma that cuts through layers of already existing rock.

The letter C represents a ***Side vent*.**



When the magma reaches the surface of the Earth it is then called ***lava.*** The lava leaving the side vent causes the volcano to add a layer of lava and usually a layer of ash with each eruption. These eruptions build the volcano higher and wider. Hawaii has volcanoes with many side vents that have built the islands with very wide bases. Some volcanoes on the other hand have few or no side vents. The materials that makes up the magma (gases, minerals, steam) determines how the magma will arrive at the surface. You will learn more about magma and lava in the next lesson "Lava Flows and Pyroclasts".

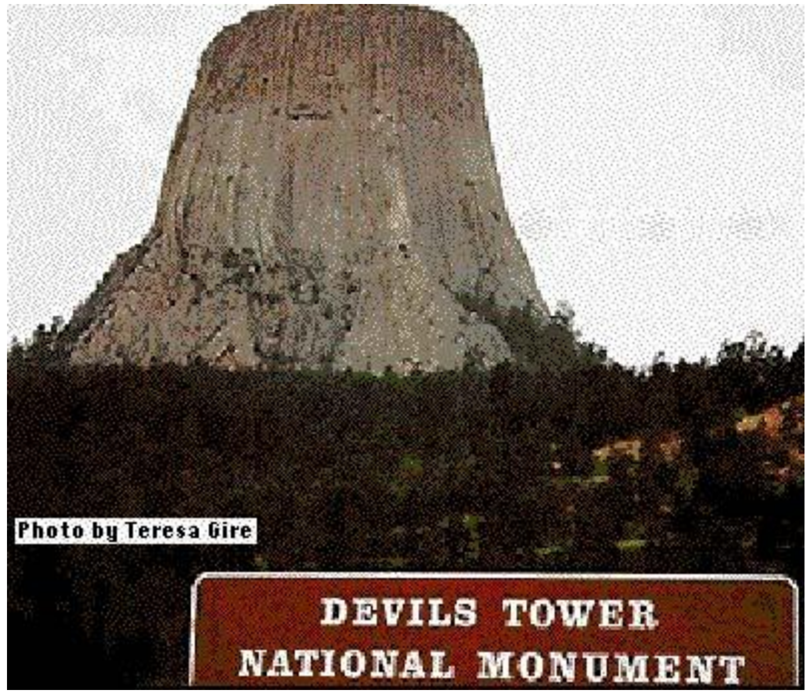
The letter D represents a *conduit*.



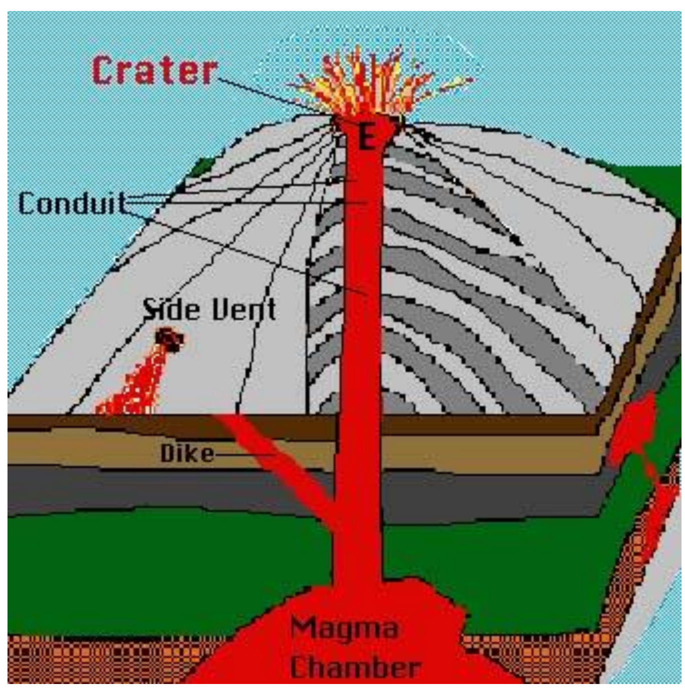
A *conduit* is the main tube or pathway for the magma to reach the surface.

Devils Tower in Wyoming is an example of a cooled and hardened conduit.

This is a photo of Devils Tower National Monument. Devils Tower in Wyoming is an ancient conduit. The source for the magma moved and the magma in the conduit cooled and hardened into a very hard lava rock called *basalt*. The volcanic cone was made of softer volcanic materials probably ash and *pumice* that slowly eroded away leaving only the conduit standing. Today we know this ancient conduit as Devils Tower National Monument.



The letter E represents the ***crater* and main vent** of a volcano.



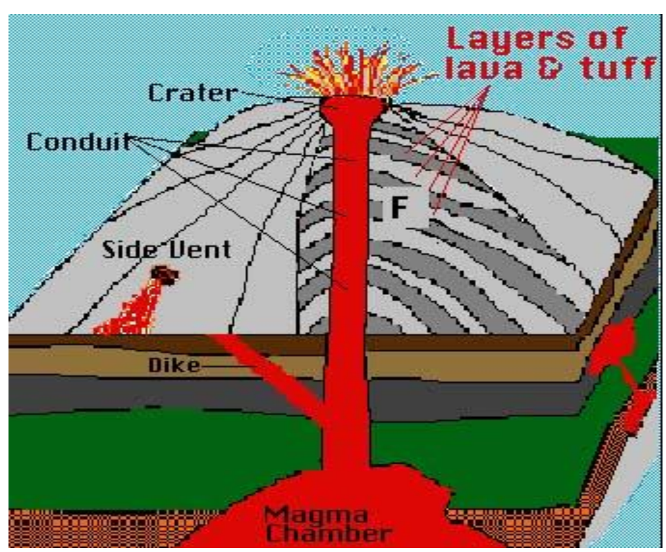
The crater is the bowl shaped opening located at the top of the volcano. The crater is also the steep sided walls made of hardened lava that surround the main vent. Lava can flow from the main vent, but not all volcanoes eject large amounts of lava. Some volcanoes explode molten rock and huge amounts of gas from the main vent.

Volcanoes are not always erupting and the crater may be a bubbling caldron of lava without enough pressure to erupt.

This photograph is of a volcanic cone. The crater is located at the top. The side vent is active and a lava flow is running down the side of the cone. A fissure is bringing the magma to the side vent. This photo is courtesy of Dr. Scott Rowland of the University of Hawaii.

You are looking at the inside of a volcanic crater. The steep walls were produced be many eruptions ejecting very liquid lava. This lava then lands on the crater walls building them higher and higher. The lava in the main event is extremely hot (probably about 1800 degrees F.) The lava on top cools and hardens because the air that it is in contact with is so much cooler than the lava. This hardened lava will then be dragged back down under the surface and remelted. You probably noticed the same process if you have ever heated soup on the stove. If you did not keep stirring the soup it formed a "scum" on top.

The letter F represents layers of *tuff* and lava.



When a volcano erupts it may eject lava, lava rock and ash. When stratovolcanoes are built some of the lava and ash lands and stays on the volcano building it higher and higher with each eruption. The ash hardens into a rock that is called tuff.

Write your answers to the following questions on a sheet of paper.

Label the following parts of a volcano by writing your answers on a sheet of paper.

A.

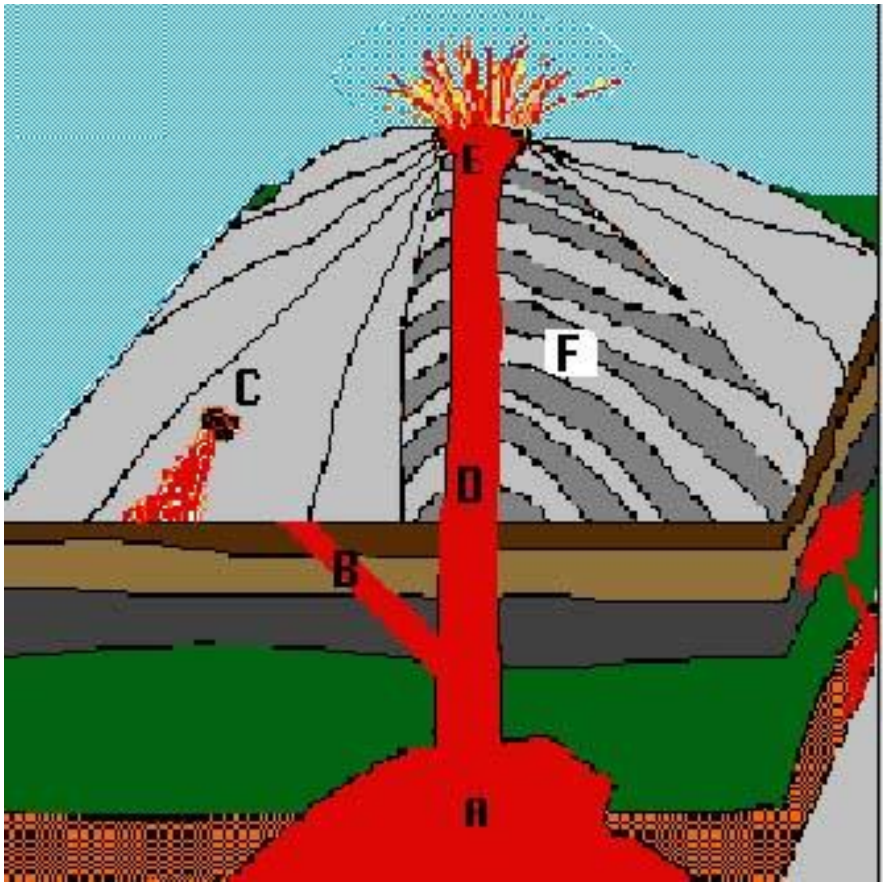
B.

C.

D.

E.

F.



Chapter 3 Cones, Eruptions, and Pyroclasts

Chapter 3 focuses on Cones, Eruptions, and Pyroclasts, looking at products of volcanic eruptions and hotspot volcanoes.

Lessons included in this chapter:

#7 Lava Flows and Pyroclasts

#8 Volcanic Cones and Eruptions

#9 Hotspot Volcanoes - Hawaii and Yellowstone.

Lava Flows and Pyroclasts Lesson #7

***Lava* is melted rock that has reached the Earth's surface through a *volcano*'s main *vent* or through side vents and *fissures*.**

Some volcanoes produce little or no lava. Some volcanoes eject ***pyroclasts*, which are fragmented or broken rock.** The word *pyroclastic* comes from a Greek word that means "Rock broken by fire".

When volcanoes do produce lava flows they are classified as either ***Pahoehoe* or *Aa*.** The lava is identical in both pahoehoe and aa lava flows, the difference comes from the amount of lava erupted and the speed of cooling. Pahoehoe lava flows are produced from a small amount of lava that moves slowly, while aa flows usually are associated with a large volume of lava that moves swiftly. Aa flows are generally 6-15 feet thick and pahoehoe flows are usually 1-3 feet thick.

If the lava is very hot and has a ***low viscosity*** (runny with a low gas and *silica* content) the lava flow is called Pahoehoe. If, on the other hand, the lava has a ***high viscosity*** (thick and pasty with a high gas and silica content) it is called Aa.

Silica is a white or colorless crystal that is present in sand and quartz. It is one of the most abundant compounds in the Earth's crust.

The photograph shows a pahoehoe flow below and an “Aa” flow below that.

Pahoehoe (Pa-Hoy-Hoy) ***lava flows*** are very hot, thin and runny. When it cools is has a smooth to ropey texture because of the low silica content which makes it cool quickly.

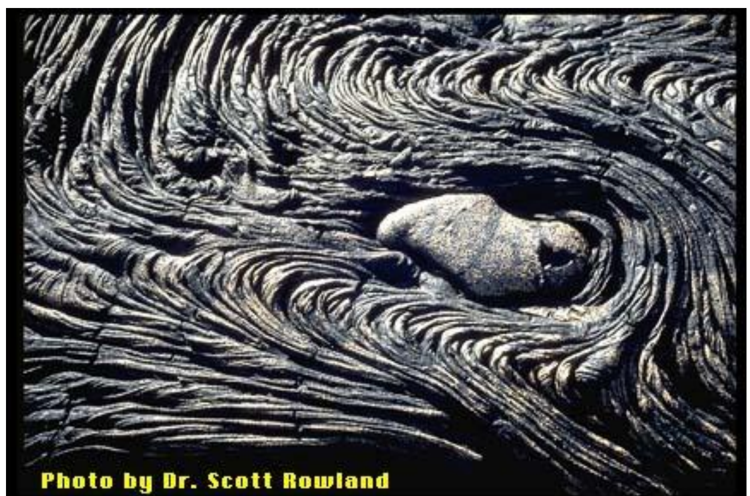


Photo by Dr. Scott Rowland

Pahoehoe flows creep along generally at less than 3 feet per minute but some flows have been measured at over 20 miles per hour. The terms Pahoehoe and Aa are from the native Hawaiian language and are now used by geologists the world over.

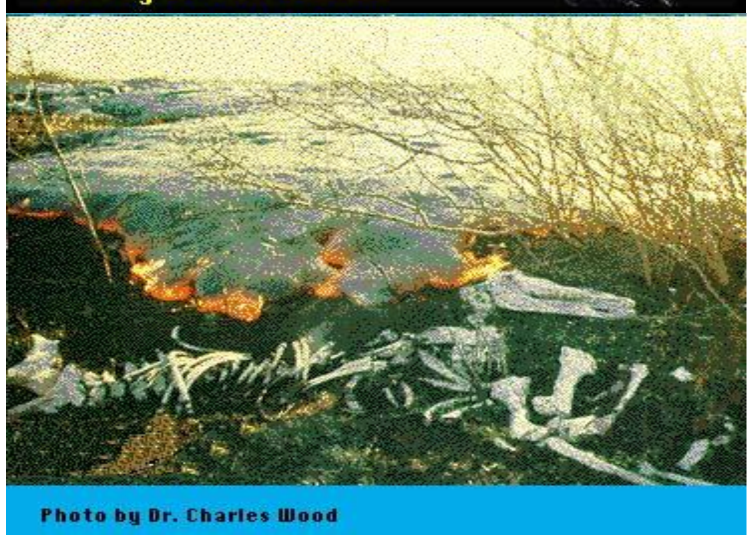


Photo by Dr. Charles Wood

This pahoehoe flow is advancing on the skeleton of a large mammal perhaps a horse or a cow. The lava will engulf the animal and may fossilize the remains!!

Notice how the flow advances in globs of lava. These globs of lava are called ***lobes.***

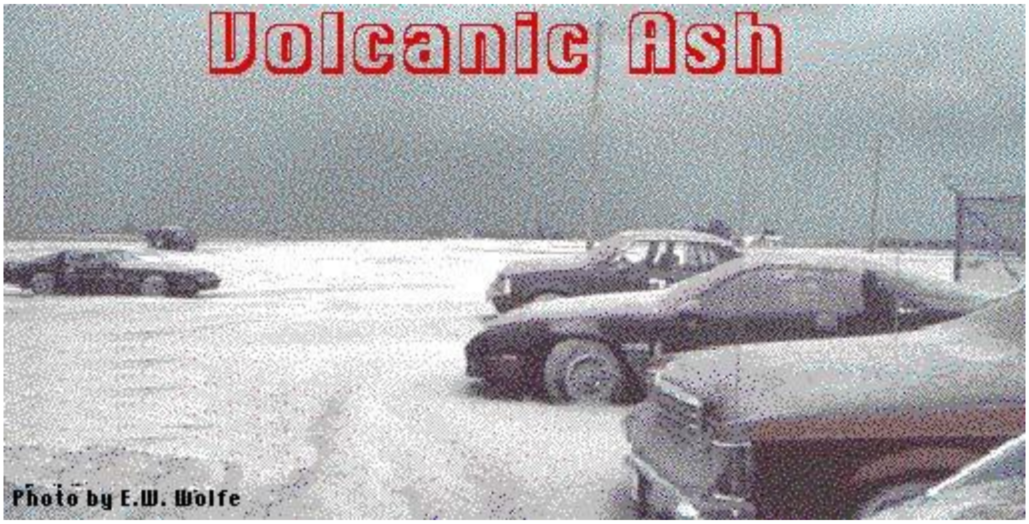
Aa lava flows are formed when the lava is produced in a manner that allows it to cool quickly. When a *fire fountain* shoots the lava high into the air it cools somewhat before it can flow after landing on the surface. Aa lava also forms when there is a huge amount of lava produced or a steep slope moves the lava at high speeds. These high speeds put the lava in greater contact with the air, which makes it cool more quickly.

Notice the rough and fragmented upper surface of the photo at the right. Would you like to walk barefoot on this after it cools?

A pahoehoe lava flow produced the *lava tube* in the picture above.

A ***lava tube*** forms when the lava on the outer surface of the flow cools much faster than the inside of the flow. The outside becomes cooled hardened lava rock while the inside stays molten and also keeps flowing. If something happens to stop the flowing lava there will be nothing to fill the void and a tube is the result.

No, this is not a North Dakota blizzard. This photo is showing the *ash* fall from Mt. Pinatubo's (Phillipines) *eruption* in 1992. Many inches of ash fell and the U.S. Naval and Air Force bases near the mountain were closed because of the eruption.



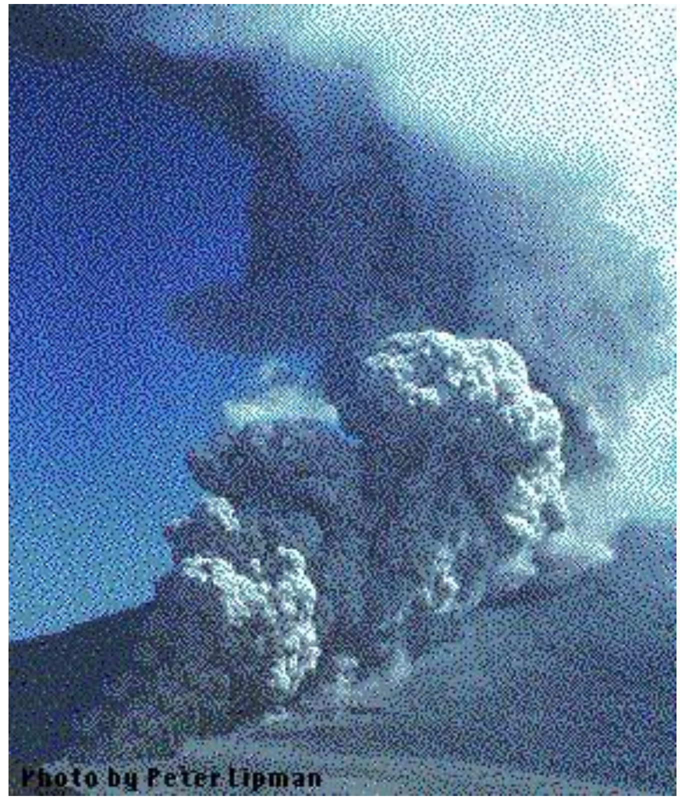
When Mt. St. Helens erupted in 1980 the ash cloud rose to an altitude of over 50,000 feet that is almost 10 miles high! The mountain kept spewing ash for another nine hours on May 18th. The ash deposits were many inches deep in many cities in Washington. This ash choked humans and animals. People were forced to wear gas masks so they could go outside of their homes.

Pyroclasts are particles that are ejected during a volcanic eruption. They range in size from very small particles called dust to ash (1/10 of an inch) to *lapilli* ("little stones" 1/10 of an inch to 2 inches) to the largest of the pyroclasts, blocks and bombs (2 inches to many feet in diameter).

Volcanic Ash is any very fine grained material erupted from a volcano that is less than 1/10 of an inch (2 millimeters) in diameter. This is very fine material and was given the name ash because it resembles ashes from the burning of wood or coal.

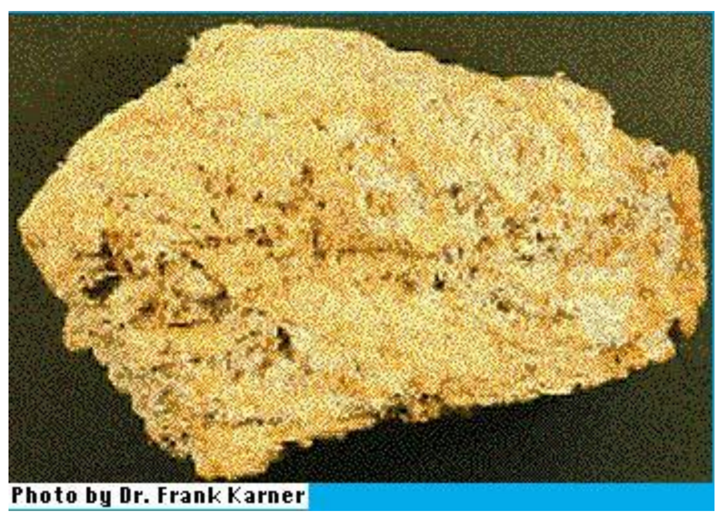
Volcanic ash is rock that has been exploded and shattered by steam inside the volcano. Ash and lava flows build stratovolcanoes into mountains with repeated eruptions.

***Pyroclastic flows* are spinning mixtures of pyroclasts (small pieces of *obsidian*, ash, *pumice*, and cinders) and very hot gases.** They flow down the side of the volcano at speeds up to 100 miles per hour and at temperatures sometimes over 700 degrees Fahrenheit!! With temperatures that high pyroclastic flows kill everything it their path.



There were two pyroclastic flows from Mt. St. Helens main eruption in 1980. The first flow was called the "stone wind" and it annihilated everything in its path. Huge trees over one hundred feet tall were snappped and splintered like twigs. Temperatures of over 700 degrees ate up all the oxygen in the area. All animal life in its path was destroyed in seconds including 57 humans. Later in the day another pyroclastic flow piled pumice and ash in thick deposits for many miles around the mountain.

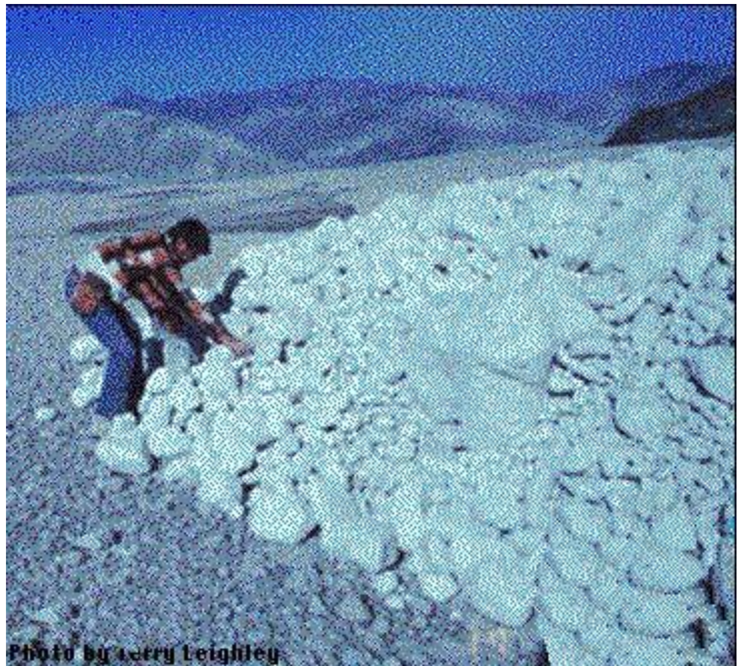
The photo above is a pyroclastic flow down the north flank of Mt. St. Helens.



***Pumice* is a very light colored, frothy volcanic rock.** Pumice is formed from lava that is full of gas. The lava is ejected and shot through the air during an eruption. As the lava hurtles through the air it cools and the gases escape leaving the rock full of holes.

Pumice is so light that it actually floats on water. Huge pumice blocks have been seen floating on the ocean after large eruptions. Some lava blocks are large enough to carry small animals.

Pumice is ground up and used today in soaps, abrasive cleansers, and also in polishes.

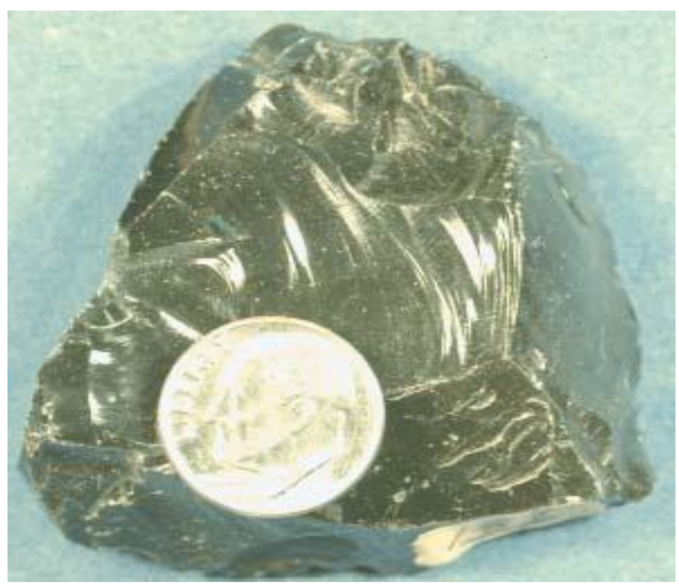


Bombs and blocks are the largest of the pyroclasts.

***Blocks* are angular chunks of rock that has been ejected from a volcano during an eruption.**

The photo to the right is of a geologist studying pumice blocks from the May 18, 1980 eruption of Mt. St. Helens.

A *bomb* is formed as lava hurtles through the air, cooling and forming a hardened lava rock. A bomb's shape is usually more rounded or streamlined. Notice the teardrop shape of the bombs.



***Obsidian* is a very shiny natural volcanic glass.** When obsidian breaks it fractures with a distinct conchoidal fracture. Notice in the photo to the left how it fractures. Obsidian is produced when lava cools very quickly. The lava cools so quickly tht no crystals can form.

When people make glass they melt silica rocks like sand and quartz then cool it rapidly by placing it in water. Obsidian is produced in nature in a similar way.

Obsidian is usually black or a very dark green, but it can also be found in an almost clear form.

Ancient people throughout the world have used obsidian for arrowheads, knives, spearheads, and cutting tools of all kinds. Today, obsidian is used as a scapel by doctors in very sensitive eye operations.

Answer the following questions

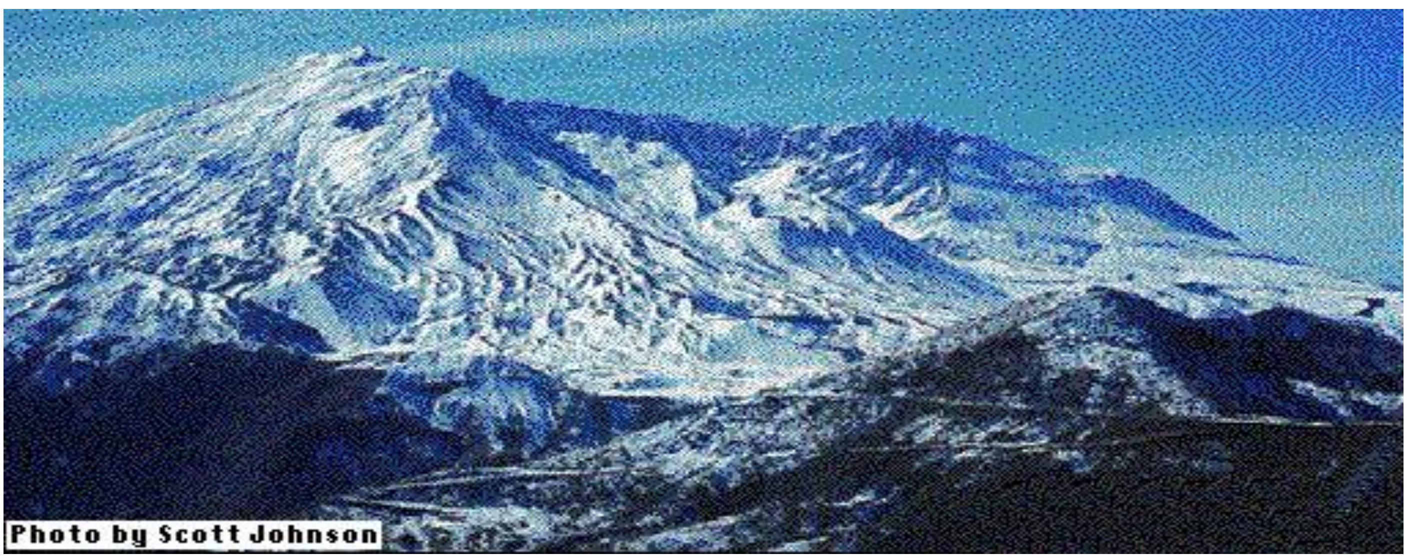
1. Describe pahoehoe and aa lava flows.

2. What is a pyroclast and how do they form?

3. Write a definiton for the following;

- High viscosity
- Low viscosity

Volcanic Cones and Eruptions Lesson #8



The photo above is of Mt. St. Helens today. This once beautiful mountain was changed dramatically on May 18, 1980. The *eruption* that occurred was a *Plinian* eruption, which is the most violent eruption classification.

As you learned in the last lesson, different magmas have varying amounts of *silica* and gas that cause the *lava* to either be thick and pasty or thin and runny. The thickness and thinness of the magma will determine how a volcano will erupt and what kind of a cone will form.

Volcanoes will erupt for two reasons

1. The magma deep under the crust is less dense than the surrounding rock causing it to rise.

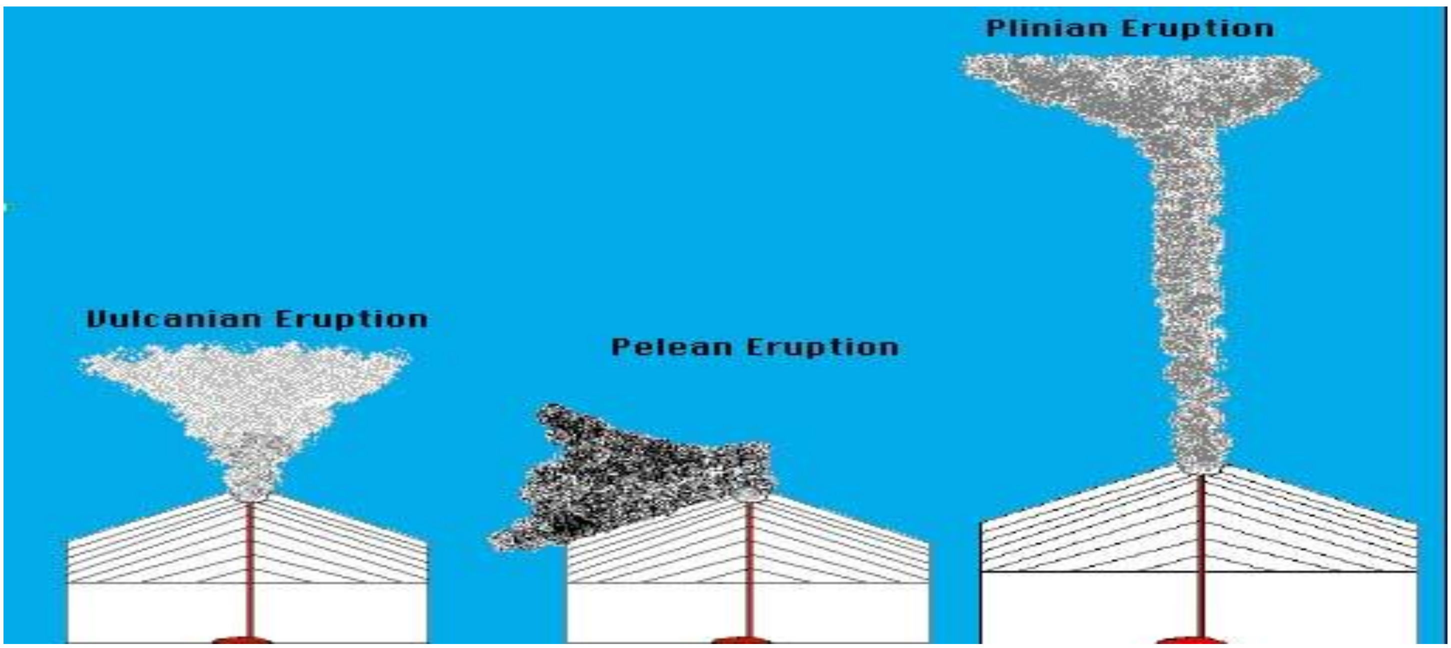
2. As the magma approaches the surface of the Earth the gas that is in the magma will come bubbling out because the pressure surrounding the magma will decrease nearer the surface.

Have you ever had a can of soda pop explode all over the room? This "eruption" of pop is caused by the same scientific principle that causes a volcano to erupt violently. When you open the pop can the pressure is released so quickly that the gas that is dissolved in the pop comes rushing out along with some of the pop.

Volcanoes are classified by the eruption type and by the volcanic cone shape.

There are three *basic* cone shapes and six eruption types. The three cone shapes are ***cinder cones, shield cones, and composite cones or stratovolcanoes.***

The six eruption types are in order from least explosive to the most explosive; ***Icelandic, Hawaiian, Strombolian, Vulcanian, Pelean, and Plinian.***



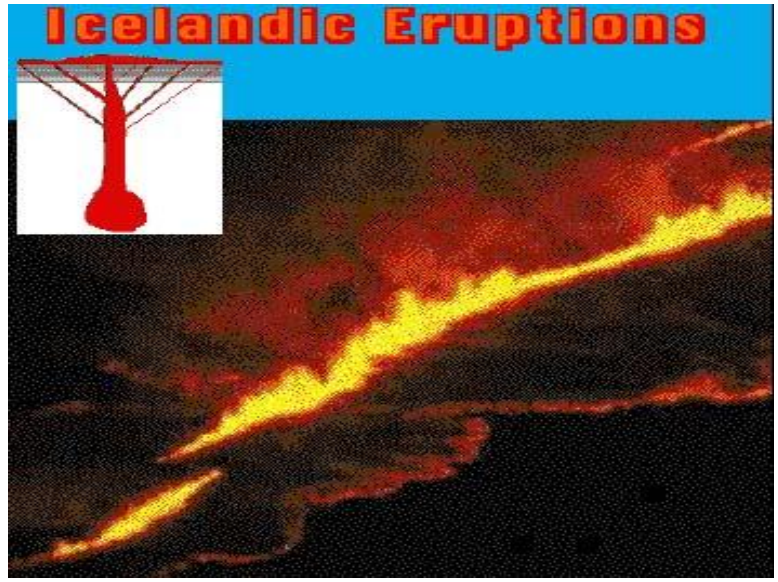
Notice how, as the eruptions become more violent, the cone shapes become more steeply constructed.

You will read about these volcanic types in more depth later in the lesson.

***Icelandic, flood, or fissure eruptions* are all terms for volcanic eruptions that flood the surface of the Earth with massive amounts of very hot, very thin, runny lava.** The lava comes out of the ground through long cracks in the surface called *fissures*. Some of these fissures can be up to 15 miles long.

The type of cone produced from icelandic eruptions is a shield cone. Shield cones are very low and very broad shaped volcanoes. These volcanoes erupt many times over the same area forming huge, and thick lava plateaus.

The Deccan Plateau of India was formed this way and covers 100,000 square miles (A little smaller than the state of Montana). The Columbia Plateau of the western United States is the largest lava plateau in the world. It covers almost 100,000 square miles and is almost a mile thick in places.



The photo above is of Krafla Volcano on the island of Iceland.

Hawaiian eruptions are similar to Icelandic eruptions because both eruption types have many fissures bringing the lava to the surface. Both types of eruptions are known for their beautiful fire fountains like the one shown above. The lava that flows from both types of eruptions is very hot, thin, and runny which allows for fast flowing lava flows.

The main difference lies in the fact that most Hawaiian eruptions have the greatest quantity of lava pouring out of the main *vent* at the volcano's summit, not along side fissures. These summit eruptions build the cone steeper and higher. The volcano above was formed from Hawaiian eruptions.

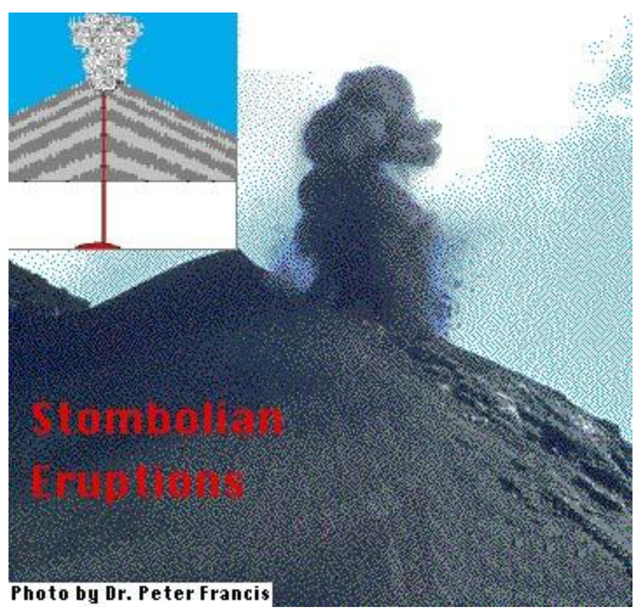
Shield cones were named by Icelandic people because the cone's shape reminded them of a warriors shield layed down. **Shield cones form from hot, runny lava**

that is erupted from the the volcano through its summit and the many side vents and fissures throughout the volcano's flanks (Sides). Shield cones are low, very broad, and gently sloping volcanoes. The volcano pictured above is Mauna Kea, which is located on the big island of Hawaii.

Mauna Loa, which is also on the big island, is the largest volcano on Earth and the tallest mountain in the world if measured from the floor of the ocean where it was formed. Mauna Loa is 13,677 feet above sea level but over 17,000 feet of mountain lies under the water. This volcanic mountain is over 30,000 feet tall from sea floor to the summit. Maua Loa started to form above the Hawaiian *hot spot* about one million years ago and broke the surface of the ocean about 500,000 years ago.

Strombolian and Vulcanian eruptions are more explosive than Icelandic and Hawaiian eruptions.

Strombolian eruptions are named for the volcanic island off of the coast of Italy. Stromboli has erupted over many centuries almost constantly. Stromboli has been named the "Lighthouse of the Mediterranean" because it erupts every 20 minutes or so.

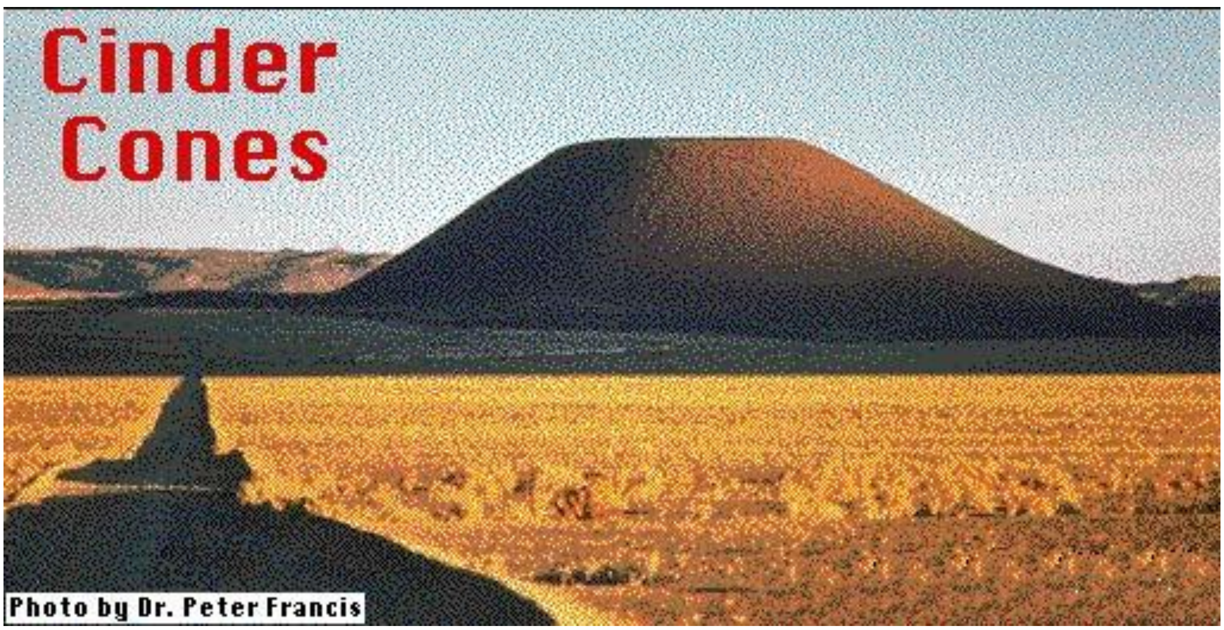


***Strombolian eruptions* are short lived explosive eruptions that shoot very thick and pasty lava into the air along with bursts of steam and gas.**

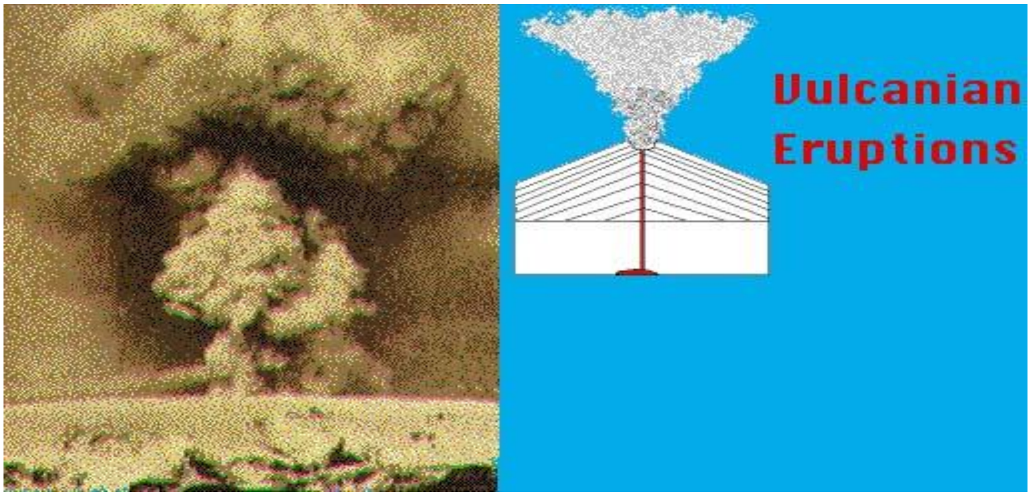
Strombolian eruptions usually produce little or no lava. Because of this the cones that are produced by this type of eruption is a very steep sided cone called a cinder cone.

The photo on the previous page shows a strombolian eruption taking place from a cinder cone.

Cinder cones get their name from the material that forms them, cinders. Cinder cones are the simplest volcanic *formation*. They form from explosions of red, hot magma cinders and *ash*. These cinders and ash settle around the main vent and build a steep sided cone. Very little lava is erupted from a cinder cone. Cinder cones very rarely rise to more than 1,000 feet above the surrounding landscape. Cinder cones are known for their very violent, explosive, exciting eruptions. Paricutin in Mexico and Mt. Vesuvius in Italy are famous cinder cones.



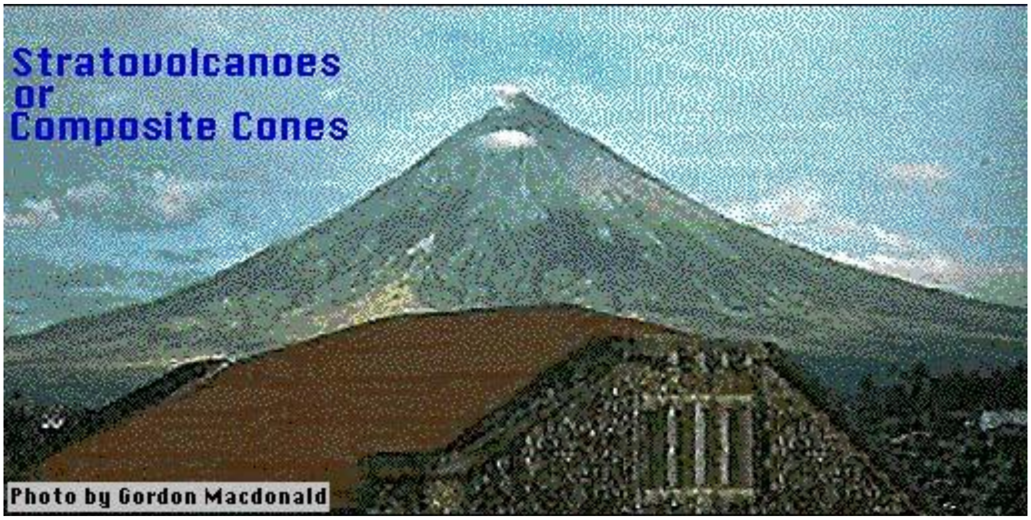
Vulcanian eruptions are more violent and explosive than strombolian eruptions. Vulcanian eruptions are named after the island of Vulcano off the coast of Italy. This is the same island that gave us the name "Volcano". Vulcanian eruptions contain high dark clouds of steam, ash, and gas. The ash plume builds a



cauliflower shaped head and a thinner more treetrunk-like base. When the volcano quits erupting ash and gases it then ejects thick pasty lava. Vulcanian eruptions usually build a steep sided cone that is more symetrical than a cinder cone. This more symetrical cone is called a strovolcano.

Vulcanian eruptions will send an ash plume to a height of 2 -9 miles. The photo to the left is of Katla volcano in Iceland which erupted in 1918.

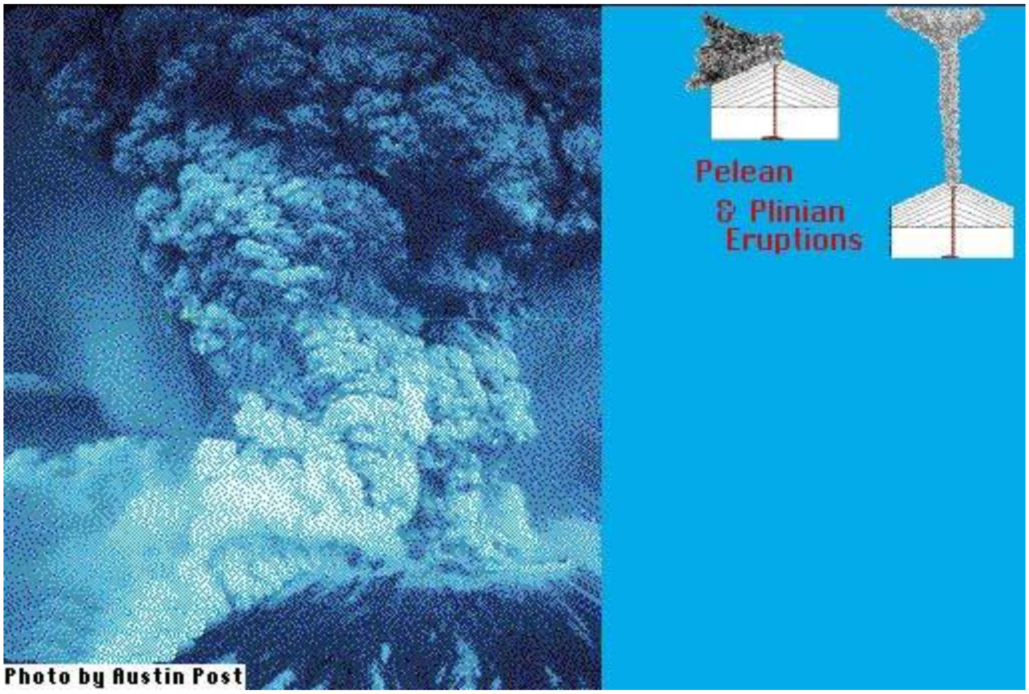
Stratovolcanoes or composite cones are formed from a combination of eruptions. First the volcano will have an explosive eruption that ejects huge amounts of steam, gas and ash. This will be followed by the ejection of lava. A large stratovolcano will be built with many layers of ash and lava.



Stratovolcanoes are the most common type of volcanic cone. There are many famous stratovolcanoes in the world. Mt. St. Helens and Rainier in Washington, Mt. Fuji in Japan, Mt. Pinatubo in the Philippines, and Mt. Etna in Sicily are all examples of stratovolcanoes.

The photo above is of the volcano Mayon, which is in the Philippines.

Pelean and Plinian eruptions are the most dangerous and explosive of the eruption types. ***Pelean eruptions*** are named for the catastrophic eruption on the island of Martinique in the Caribbean Sea in 1902. The eruption and the *pyroclastic flow* that followed killed 29,000 people almost instantly. "Glowing clouds" of gas and ash flew down the mountain at over 70 miles per hour. The cloud was so full of ash that it was heavier than air and hugged the ground as it approached the coast. The temperatures were probably around 700 degress F. which would annihilate everything in its path.



The only person to survive was a prisoner that was sentenced to death. The only reason he survived was that he was imprisoned in a very thick walled cell and the only door faced away from the explosion.

A ***Plinian eruption*** is the most explosive of the eruption types. Mt. St. Helens eruption was a plinian eruption. Plinian eruptions are characterized by a very high ash cloud that rise upwards to 50,000 feet (almost 10 miles) high. Very deadly *pyroclastic* flows are also part of plinian eruptions.

Mt. Vesuvius, which erupted in 79 A.D. in Italy, was a classic Plinian eruption. Very hot ash falls killed thousands of people in the city of Pompei. Ash falls as high as 17 feet buried the city. Plinian eruptions were named for Pliny the Elder of Rome who died in one of the many eruptions of Vesuvius.

The photo on the left side of this card shows Mt. St. Helens in its plinian eruption on May 18, 1980. The ash cloud rose to a height of over 50,000 feet.

Answer the questions

1. Name the six eruption types and the three cone shapes.

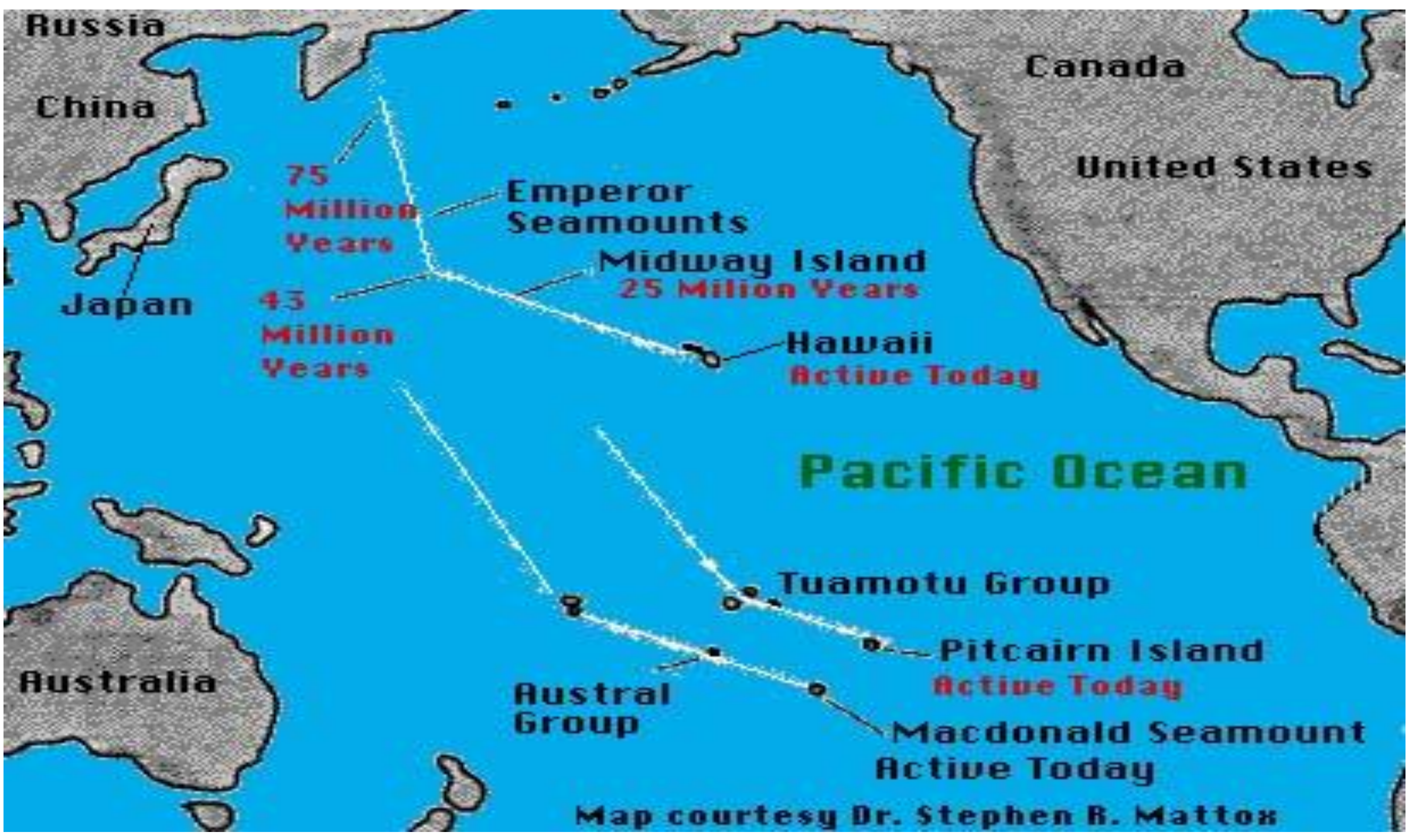
2. Describe how a: Shield cone form; Cinder cone forms; Stratovolcano forms

3. Draw diagrams to represent the six eruption types.

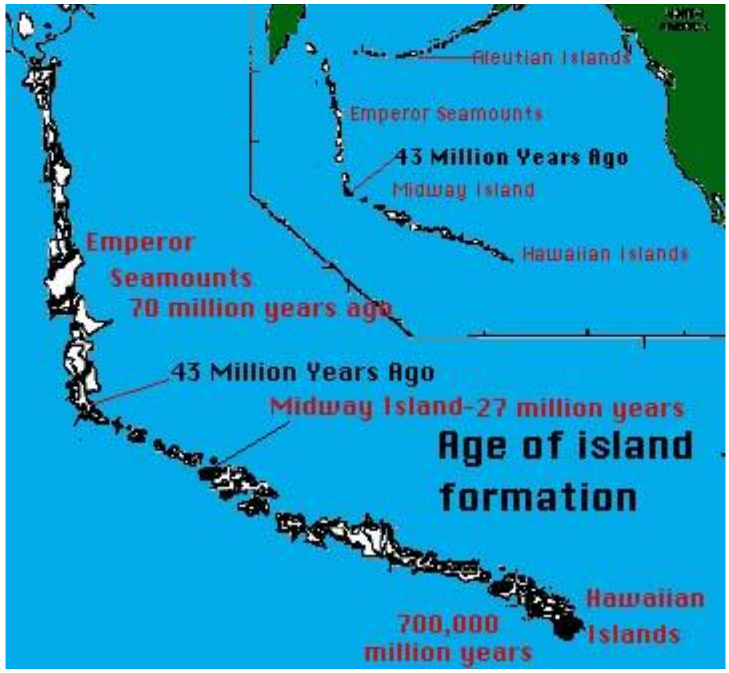
Hotspot Volcanoes - Hawaii and Yellowstone Lesson #9

This lesson was adapted and modified from Dr. Stephen Mattox's, "A Guide to The Geology of Hawaii Volcanoes National Park".

Do you remember that there are three ways that volcanoes can form? They form at subduction zones, mid-ocean ridges and at something called a *hot spot*. In this lesson you will learn about what causes hot spots to produce volcanoes.



What do you notice about the lines of island groups in the Pacific Ocean?



A geologist in the 1960's, by the name of Tuzo Wilson, noticed that there were straight lines of submarine volcanoes and volcanic islands in the Pacific.

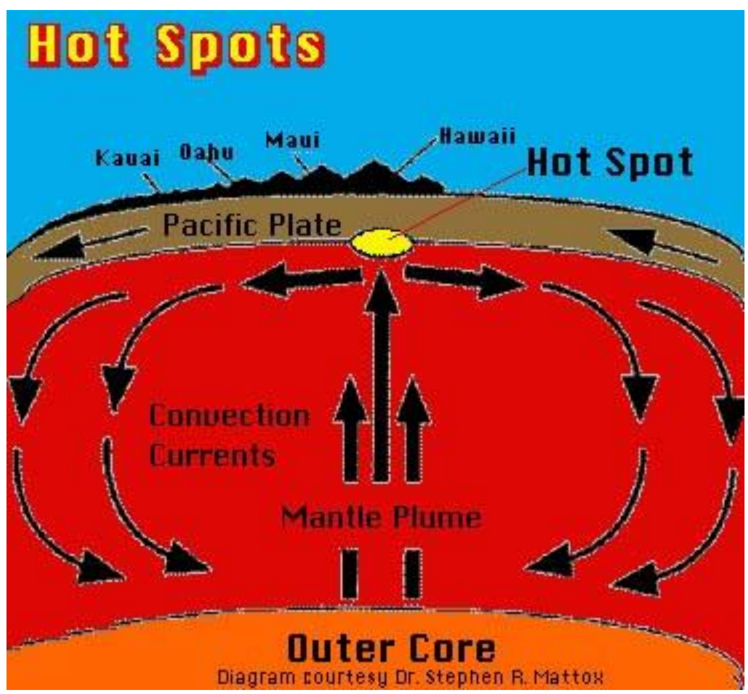
These linear chains of volcanoes ran in parallel lines to each other. (See white lines on the map)

The active volcanoes in these chains are all located in the southeast corner and are the last island in that group.

The oldest islands were the northern most islands in the group. Coincidence???

What Tuzo Wilson decided was that the Pacific plate was moving over three hot spots. The Hawaii-Emperor Seamounts, Tuamotu, and the Austral groups of islands each formed over a different hot spot.

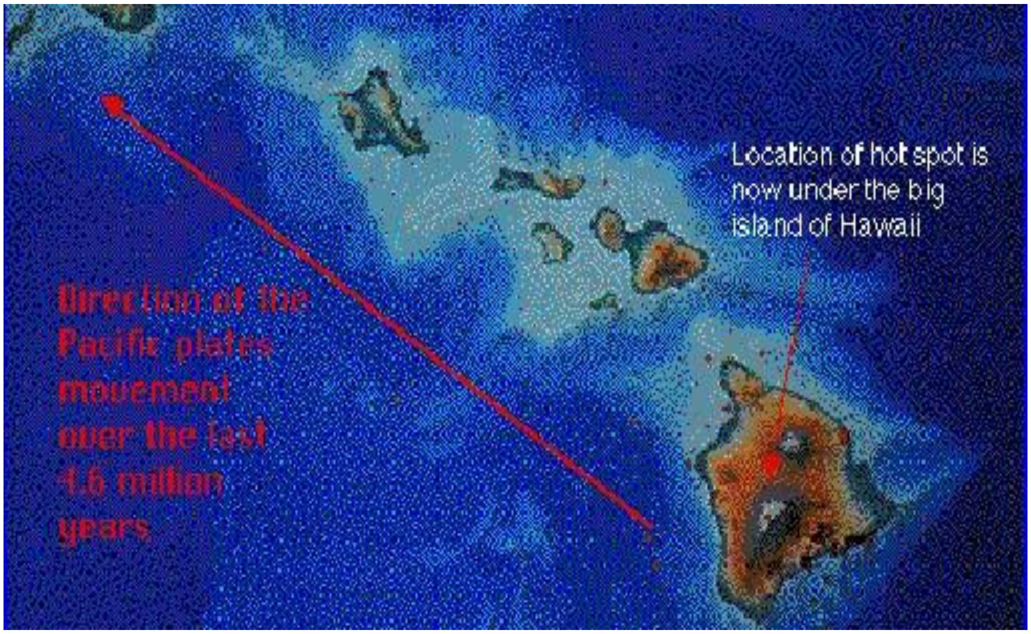
About 43 million years ago the Pacific plate shifted its path to a more northwesterly direction. All the island groups changed course at the same time!!



He also concluded that all the islands in the Emperor Seamount- Hawaiian chain all formed over the same hot spot that is currently under the big island of Hawaii today.

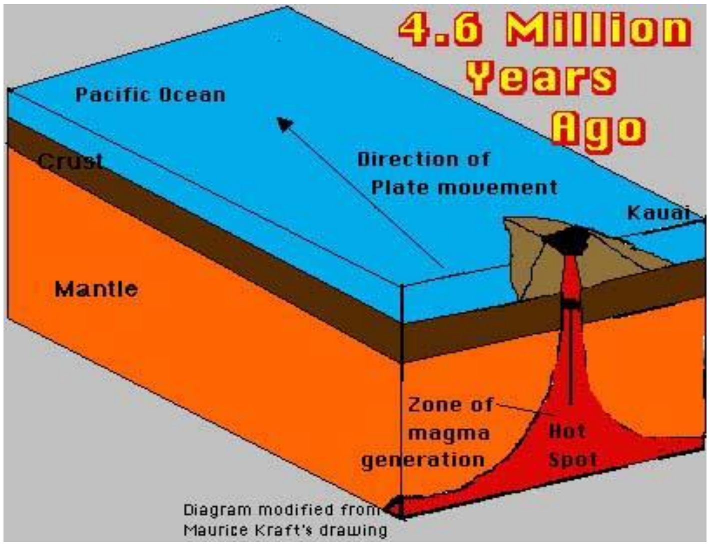
A hot spot occurs because of the intense heat of the outer core. This heat radiates through the *mantle* bringing hot solid rock upward to the hot spot. These areas of rising solid rock are called ***mantle plumes.*** Because of lower pressure in the upper region of the mantle the rock begins to melt. This forms *magma* which rises inch by inch until it reaches the surface forming a volcano.

In 1971 W. Jason Morgan added to the hot spot theory. When the rising solid rock (mantle plume) reaches the plates it splits and spreads horizontally. This split or flow causes the plates to drift.



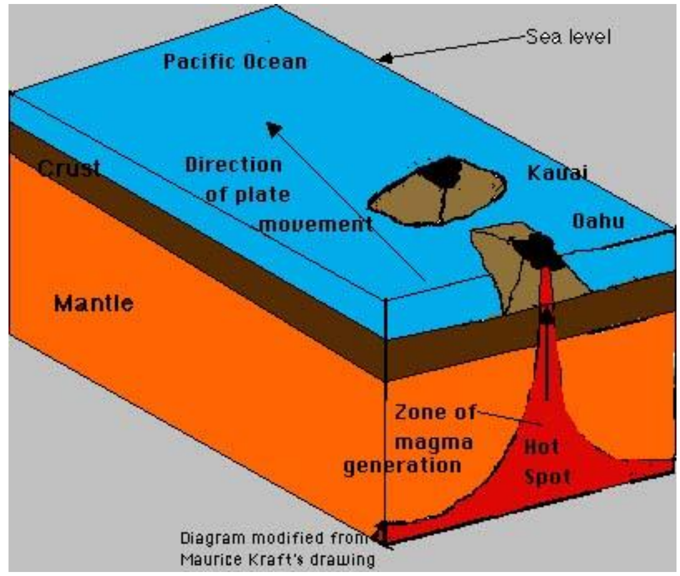
Morgan proposed that there are 20 different hot spots in the world. Most hot spots are located at mid-ocean ridges, but there are a few located in the middle of plates, like Hawaii and Yellowstone.

This is a map of the Hawaiian Islands today. They didn't always look like this. 4.6 million years ago there was only one island in this group. As the Pacific plate moved slowly northwesterly it produced the Hawaiian Islands, one at a time. Today the big island of Hawaii sits over the same hot spot that produced the other islands.

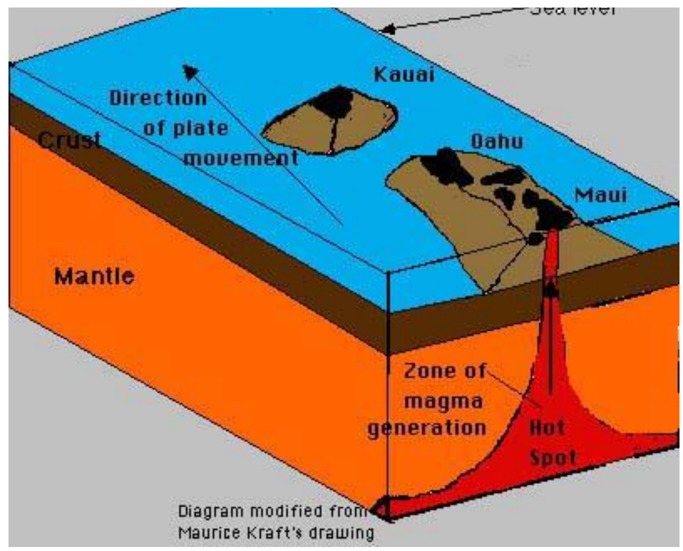


The first Hawaiian Island to form over the hot spot was Kauai. It began to break the surface of the Pacific Ocean about 4.6 million years ago.

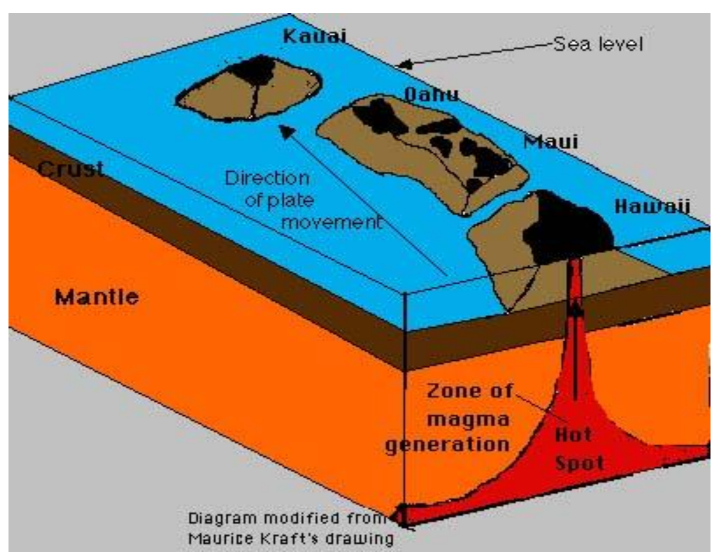
As the Pacific plate moved westward another island formed. That island was Oahu. The capital and largest city of Hawaii, Honolulu, is located on this *extinct* volcanic island.



The islands of Oahu, Molokai, Lanai, and Maui share the same volcanic base. They all formed from separate volcanoes that were connected by huge lava flows. These volcanic islands also formed from the same hot spot.

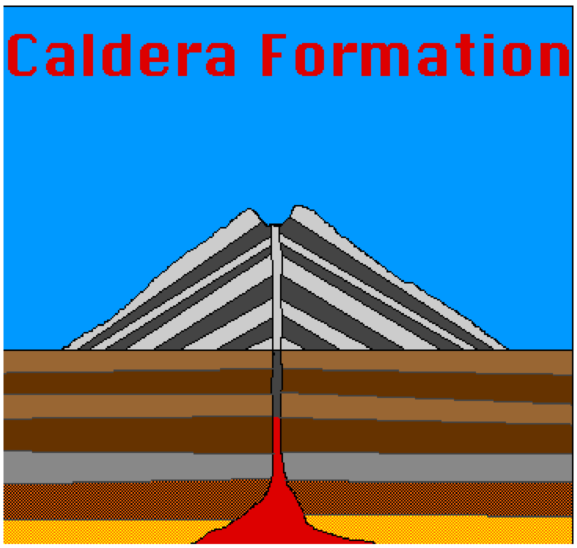


Today the Big Island of Hawaii sits over the hot spot and has the only active volcanoes in that island group. Konala, Hualaiai, Mauna Kea, Mauna Loa and Kilauea volcanoes have built the island over the last 500,000 years. Mauna Loa volcano is the largest volcano on Earth. It is over 30,000 feet tall from the seafloor where it was born to the summit, which is 13,684 feet above sea level.



This is a *caldera*.

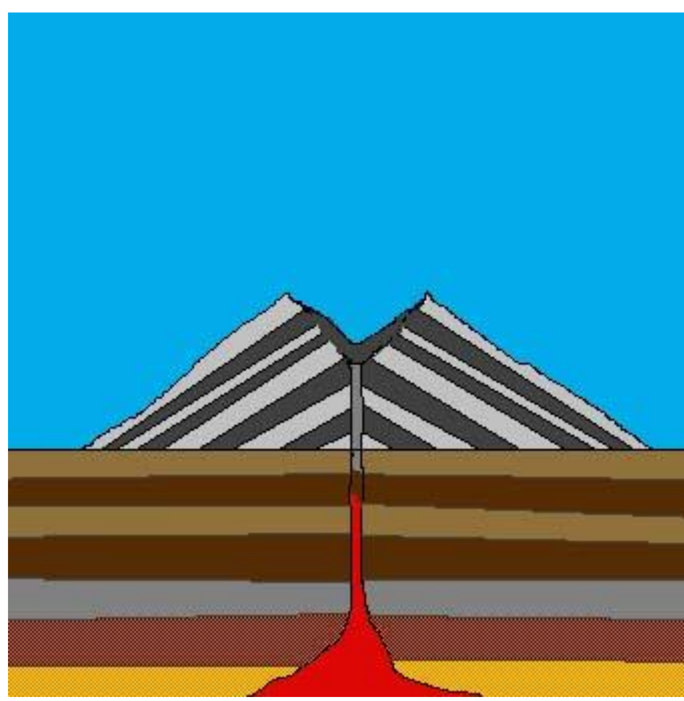
A *caldera* is a large bowl-shaped *crater* that is formed by the collapse of a volcanic cone after an *eruption*.



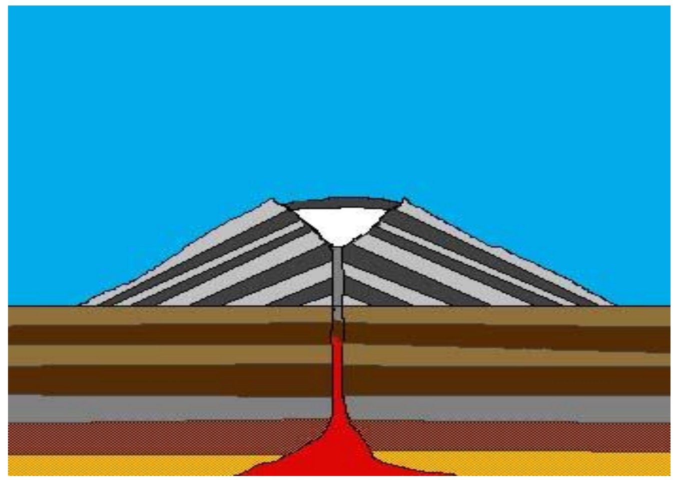
The animation shows the steps in the formation of a caldera.

The volcano usually shows signs of erupting by producing earthquakes as the magma rise in the volcano.

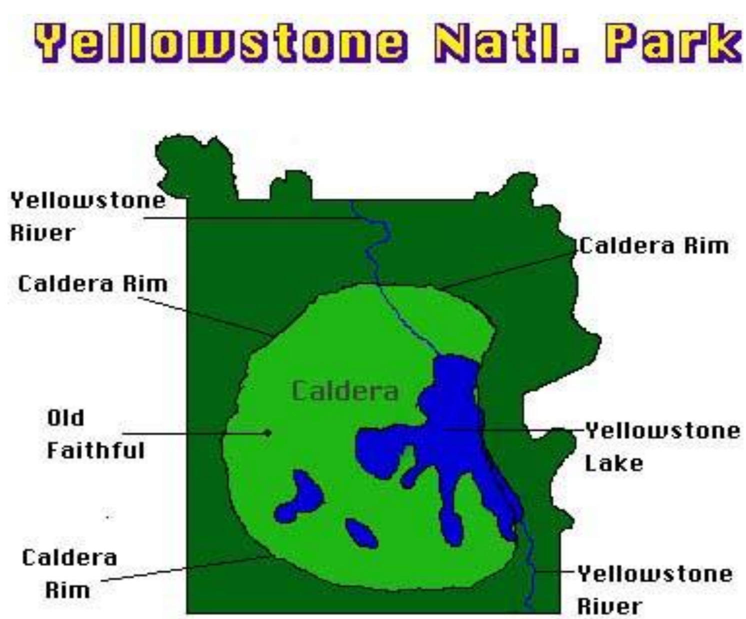
When you shake a can of soda pop and then open it, you will get a shower of gas (carbon Dioxide) and pop. Why? Because the pressure was much higher in the can than outside of the can. When you opened the top the pressure released very quickly shooting the gas and pop out.



After a huge ejection of *lava* there may be no magma left in the chamber to fill the *conduit* and crater. When this happens there is a hollow space under the summit of the mountain where the magma used to be. The top of the mountain then collapses creating a caldera.



The caldera may fill with water creating a lake. This is what happened at Crater Lake in Oregon. The ancient volcano Mount Mazama erupted violently about 6,000 years ago creating a caldera. The caldera slowly filled with snowmelt and rain forming beautiful Crater Lake.



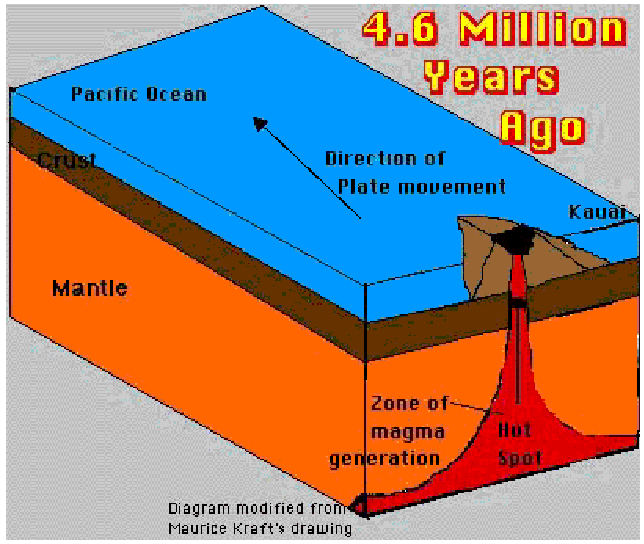
Another caldera forms most of the first national park of the United States, Yellowtone. The geysers and hot springs that make the park famous the world over are all volcanic in origin. In other word the park sits on top of an active volcano!!!!

This is a map of Yellowstone National Park. Yellowstone sits atop a continental hot spot. As the North American plate moves steadily westward the hot spot affects different areas of the continent. Volcanic activity can be traced across the

United States as the plate has moved across this hot spot.

This caldera is one of the largest calderas in the world. It is over 65 miles across!!

Millions of years ago the North American plate was hundreds of miles east of where it is today. As the plate moved west it slowly moved over the hot spot that is now under Yellowstone. The hot spot has created volcanic features through the western portion of the United States. Craters of the Moon National Monument in Idaho was created by the same hot spot.



This is exactly the same process that formed the Hawaiian Islands. The North American plate continues to move, which means that millions of years from now the hot spot will be under South Dakota or Iowa!!

Today Yellowstone National Park sits directly over the hot spot. The volcano is quiet today, only the geysers and hot springs remind us that there is a huge volcano under the beautiful scenery. Only 600,000 years ago a huge eruption filled the area with lava flows. After the huge eruption there was a void under the top of the volcano. The weight of the volcano caused the top to come crashing down forming the large caldera in the park.

Answer the following questions

1. What is a Hot Spot?

2. How does and hot spot form?

3. How does a caldera form?