

Heart of Fire- Volcano Unit

Examples of Possible Science Standards to Incorporate:

Kindergarten

- 7.1.1 Recognize that many things are made of parts.
- 7.1.3 Take apart an object and describe how the parts work together.
- 7.2.2 Know that people interact with their environment through their senses.
- 7.7.1 Identify non-living materials found on/in the surface of the earth.
- 7.9.2 Identify objects and materials as solids or liquids.
- 7.9.2 Observe, discuss, and compare characteristics of various solids and liquids.
- 7.11.1 Explore different ways that objects move.
- 7.11.1 Use a variety of objects to demonstrate different types of movement. (e.g., straight line/zigzag, backwards/ forward, side to side, in circles, fast/slow).
- Inq.2 Ask questions, make logical predictions, plan investigations, and represent data.
- Inq.3 Communicate understanding of simple data using age-appropriate vocabulary.
- T/E.1 Recognize that both natural materials and human-made tools have specific characteristics that determine their use and what they do.
- T/E.1 Explain how tools are used to extend the senses, make life easier, and solve everyday problems.

1st Grade

- 7.7.1 Realize that water, rocks, soil, living organisms, and man-made objects make up the earth's surface.
- 7.11.1 Investigate how forces (push, pull) can move an object or change its direction.
- 7.7.2 Classify earth materials according to their physical properties.
- 7.9.2 Distinguish between the properties of solids and liquids.
- 7.11.1 Investigate how forces (push, pull) can move an object or change its direction.
- Inq.2 Ask questions, make logical predictions, plan investigations, and represent data.
- Inq.3 Communicate understanding of simple data using age-appropriate vocabulary.
- T/E.1 Recognize that both natural materials and human-made tools have specific characteristics that determine their use and what they do.
- T/E.1 Explain how tools are used to extend the senses, make life easier, and solve everyday problems.

2nd Grade

- 7.5.2 Draw conclusions from fossils about organisms that lived in the past.

- 7.5.3 Observe fossils or pictures of fossils and make inferences about the organisms from which they originated.
- 7.5.4 Compare pictures of fossils with animals or plants that are living today.
- 7.7.2 Describe rocks according to their origin, size, shape, texture, and color.
- 7.9.2 Investigate how temperature changes affect the state of matter.
- T/E.1 Describe how tools, technology, and inventions help to answer questions and solve problems.
- T/E.2 Recognize that new tools, technology, and inventions are always being developed.
- T/E.4 Recognize the connection between scientific advances, new knowledge, and the availability of new tools and technologies.

3rd Grade

- 7.7.1 Classify landforms and bodies of water according to their geological features and identify them on a map.
- 7.7.2 Analyze the physical characteristics of different kinds of rocks.
- 7.9.1 Describe a substance in terms of its physical properties.
- 7.7.1 Use information and illustrations to identify the earth's major landforms and water bodies.
- 7.9.1 Design a simple experiment to determine how the physical properties of matter can change over time and under different conditions.
- 7.10.1 Investigate phenomena that produce heat.
- T/E.1 Describe how tools, technology, and inventions help to answer questions and solve problems.
- T/E.2 Recognize that new tools, technology, and inventions are always being developed.
- T/E.4 Recognize the connection between scientific advances, new knowledge, and the availability of new tools and technologies.

4th Grade

- 7.3.1 Demonstrate that plants require light energy to grow and survive.
- 7.2.1 Analyze the effects of changes in the environment on the stability of an ecosystem.
- T/E.1 Describe how tools, technology, and inventions help to answer questions and solve problems.
- T/E.2 Recognize that new tools, technology, and inventions are always being developed.
- T/E.4 Recognize the connection between scientific advances, new knowledge, and the availability of new tools and technologies.
- Inq.2 Use appropriate tools and techniques to gather, organize, analyze, and interpret data.
- Inq.3 Synthesize information to determine cause and effect relationships between evidence and explanations.
- Inq.5 Communicate scientific understanding and design a method to explain the results of an investigation using descriptions, explanations, and models.
- Inq.3 Interpret and translate data into a table, graph, or diagram.

- Inq.4 Review an experimental design to determine possible sources of bias or error, state alternative explanations, and identify questions for further investigation.

5th Grade

- 7.7.1 Create a model to illustrate geologic events responsible for changes in the earth's crust.
- 7.7.1 Compare geologic events responsible for the earth's major geological features.
- 7.7.1 Describe internal forces such as volcanoes, earthquakes, faulting, and plate movements that are responsible for the earth's major geological features such as mountains, valleys, etc.
- 7.5.2 Explain how fossils provide information about the past.
- 7.2.3 Use information about the impact of human actions or natural disasters on the environment to support a simple hypothesis, make a prediction, or draw a conclusion.
- 7.2.5 Illustrate how human activities and natural disasters affect the environment.

6th Grade

- Inq.2 Use appropriate tools and techniques to gather, organize, analyze, and interpret data.
- Inq.3 Synthesize information to determine cause and effect relationships between evidence and explanations.
- Inq.5 Communicate scientific understanding and design a method to explain the results of an investigation using descriptions, explanations, and models.
- Inq.3 Interpret and translate data into a table, graph, or diagram.
- Inq.4 Review an experimental design to determine possible sources of bias or error, state alternative explanations, and identify questions for further investigation.

7th Grade:

- 7.7.4 Explain how earthquakes, mountain building, volcanoes, and sea floor spreading are associated with movements of the earth's major plates.
- 7.7.3 Analyze the characteristics of the earth's layers and the location of the major plates.
- 7.7.3 Distinguish among sedimentary, igneous, and metamorphic rocks and relate these to a simple diagram of the rock cycle.
- 7.7.4 Recognize that the earth's layers have different thickness, states of matter, densities, and chemical makeup.
- 7.7.4 Differentiate among the characteristics of the earth's three layers.
- 7.7.7 Analyze the relationship between plate movements, volcanoes, and sea floor spreading.
- 7.7.6 Describe the relationship between plate movements and earthquakes, mountain building, volcanoes, and sea floor spreading.
- Inq.4 Draw a conclusion that establishes a cause and effect relationship supported by evidence.

8th Grade:

- 7.9.6 Differentiate between physical and chemical changes.
- 7.9.8 Determine the types of interactions between substances that result in a chemical change.

- 7.9.8 Interpret the results of an investigation to determine whether a physical or chemical change has occurred.
- Inq.2 Use appropriate tools and techniques to gather, organize, analyze, and interpret data.
- Inq.3 Synthesize information to determine cause and effect relationships between evidence and explanations.
- Inq.5 Communicate scientific understanding and design a method to explain the results of an investigation using descriptions, explanations, and models.
- Inq.3 Interpret and translate data into a table, graph, or diagram.

High School: Geology

- 5.5.1 Describe the major evidence to explain the theory of plate tectonics.
- 5.5.2 Recognize different types of plate boundaries.
- 5.5.3 Identify the earth's layers.
- 5.5.4 Describe processes associated with volcanoes, earthquakes, and mountain building.
- 5.5.7 Investigate the relationships among volcanoes, earthquake activity, and plate boundaries.
- 5.6.1 Recognize that the earth's landforms change over time.
- 5.5.5 Identify the evidence for plate tectonics such as paleomagnetism, fossil record, continental boundaries, and hot spots.

High School: Earth Science

- 4.2.9 Describe the human impact of large scale energy transfer events: hurricanes, photosynthesis, earthquakes, volcanoes, and tsunamis.
- 4.3.2 Investigate the rock cycle.
- 4.3.1 Use models to explain the theory of plate tectonics.
- 4.3.6 Distinguish among sedimentary, igneous, and metamorphic rocks.
- 4.3.3 Explain and map the relationship between plate tectonics and mountain building, volcanoes, and earthquakes.

High School: Environmental Science

- 0.1.2 Use the theory of plate tectonics to explain the occurrence of earthquakes, volcanoes, and tsunamis.

Examples of Possible Academic Vocabulary to Incorporate:

Kindergarten:

- air
- animal
- change
- cloud
- collect
- color
- growth
- natural
- observe
- ocean
- parts
- senses
- shape
- size
- soil
- solid/liquid
- temperature
- thermometer
- tools
- water
- Map
- Globe
- weather

1st Grade:

- adult
- balance
- classify
- environment
- extinct
- freezing
- heat
- invent
- investigate
- living/non-living
- location
- matter
- mixed
- planet
- plant
- prediction
- property
- push/pull
- shelter

2nd Grade:

- Celsius/Fahrenheit
- compare/contrast
- depend
- dissolve
- distance
- energy
- evaporation
- fossil
- infer
- investigate
- observation
- parent
- reasoning
- scientific inquiry
- scientist
- similarities
- differences
- sound
- temperature pattern
- transform
- type
- Continent
- Ocean
- Equator
- History
- Past

- Present
- Future

- Technology

3rd Grade:

- atmosphere
- cross section
- conductor
- conservation
- force
- mixture
- physical change
- revolution
- Landmark
- Rural
- Urban

- Agriculture
- Geography
- Global
- Landforms
- Tools
- rotation
- threatened
- Events
- History
- thriving

4th Grade:

- condensation
- erosion
- friction
- mass
- opaque
- physical change

- producer/consumer
- radiant energy
- transparent
- weathering
- Ancient Civilizations
- Exploration

5th Grade:

- chemical properties
- conduction
- convection
- core
- crust
- dissipate
- earthquake
- faulting

- gravity
- plane
- plate movement
- states of matter
- tornado
- tsunami
- volcano

6th Grade:

- adaptive engineered technologies
- assistive engineered technologies
- cause and effect
- conductivity
- control
- criteria
- energy
- protocol
- prototype

- tides
- Ancient Civilizations
- Anthropology
- Archeologists
- variable

7th Grade:

- metamorphic
- minerals
- mitosis
- momentum
- phenomenon
- Impact
- Topography
- rock cycle
- sedimentary
- speed
- velocity

8th Grade:

- chemical change
- density
- element
- Innovation
- Interest
- exothermic
- variation

High School: Earth Science

- cleavage
- convection currents
- Earth's inclination
- fossil record
- fracture
- geologic cycle
- glaciers
- global warming
- plate tectonics
- plate boundaries
- (convergent, divergent)
- topographic map
- tectonic cycle

Heart of Fire

"Nature raves savagely, threatening the lands"



-- Pliny the Elder, who died of asphyxiation after observing the destruction of Pompeii by the 79 A.D. eruption of Mount Vesuvius.

Welcome to the greatest show on Earth. Propelled by intense heat simmering beneath the crust, Earth's surface is dramatically reshaping itself in an endless, slow-motion ballet called plate tectonics. Its huge, rocky plates separate, collide, and slide past each other causing earthquakes, feeding volcanic eruptions, and raising mountains.

Deep inside Earth, there are many layers. *Ask the students if they can think of any of the layers.* There are four main layers. Hold up a hardboiled egg and ask if anyone knows what it is. *Have the extra egg already split into the correct layers in case there may be a problem.* Most likely students will say an egg, but discuss how the egg will serve as a model of the earth.

Split the egg, have the layers of the Earth image in front of the students and inform the class that today we're going to be discussing the layers of the earth, and what happens when those layers change and interact, then explain:

*The shell represents the crust of the earth. Earth's crust is made up of interlocking pieces of land called *tectonic plates* that float on the hot taffy-like mantle underneath, they look like cracked pieces of shell (crack an eggshell without breaking it all the way, this is like tectonic plates)

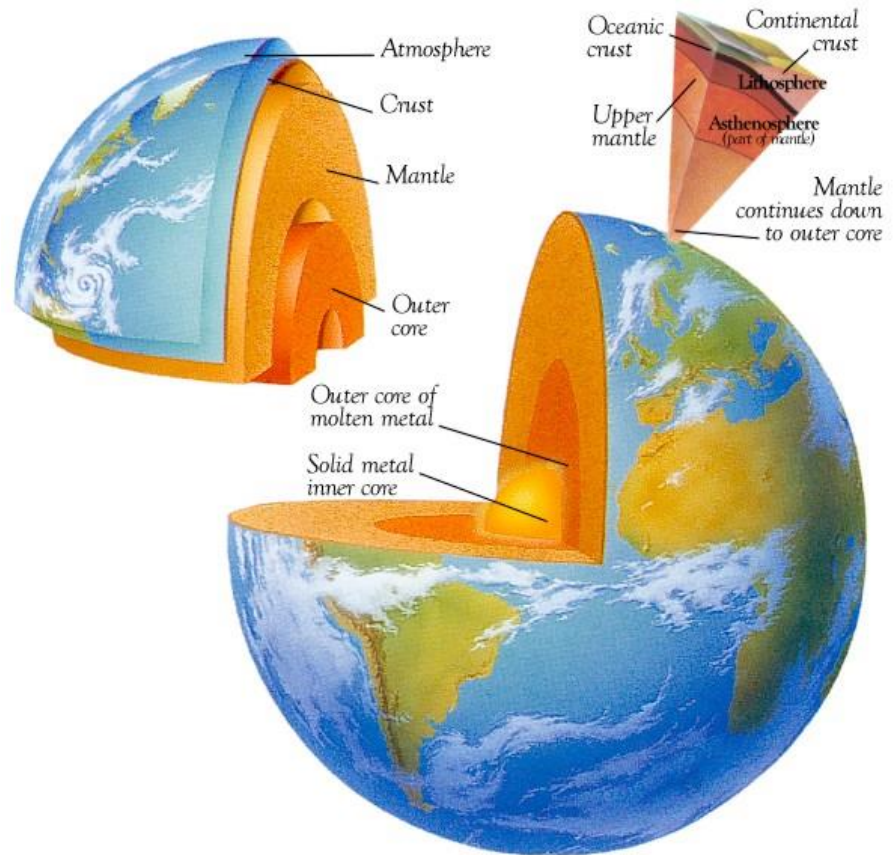
*The egg white represents the mantle of the earth, a large layer of rock that is mostly solid, but also flows slowly, like plastic

*The outside of the yolk represents the outer core and the inside of the yolk represents the inner core, a hot ball of molten metal. *What does molten mean?*

You can use a butter knife to cut a wedge out of the yolk to show the inner core.

Draw a big circle on the board and use colored chalk (or whiteboard markers) to separate the layers inside of the big circle. Tell the students a little bit more about each layer and label them with four different colors of chalk on the board as:

- *Crust – approximately 6 to 40 miles in thickness.
- *Mantle – approximately 1,800 miles in thickness
- *Outer Core – approximately 1,375 miles in thickness.
- *Inner Core – Approximately 1,750 miles in thickness.



How do volcanoes form?

During its early years, the earth's outer layer was much hotter than it is today. Over time, the surface of the earth cooled and hardened. Cracks



225 Million Years Ago

formed in the hardened surface, creating huge plates of rock. These plates carry the continents and make up the ocean floor, floating like islands on the hot, taffy-like rock below (Option: show students taffy and how its slow moving but pliable). Where the edges of those plates meet, the huge slabs bash into each other, grinding, rumpling, scraping, and generally shoving each other around. We experience the more dramatic of these encounters as earthquakes.



135 Million Years Ago

These collisions are more than just momentary shake-ups. They are the forces that shape mountains, create volcanoes, and generally affect what the map of the earth looks like. In fact, look at a map and you can see evidence of how the continents have moved around.



a Present Day

Ask students what might happen if the heat from the inside of the earth broke out? Does that ever happen?

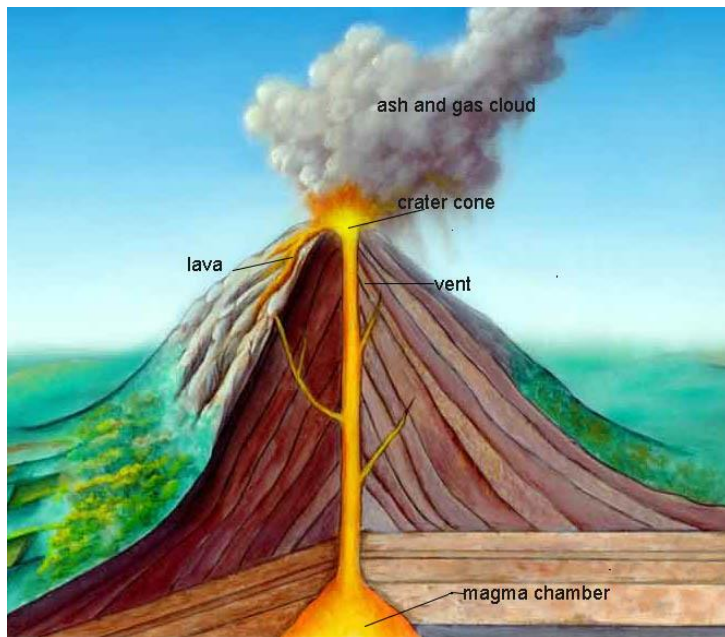
Heat from Earth's core can escape to the outside through a gap between those moving tectonic plates, or heat can "punch" through the middle of tectonic plate, releasing pressure and heat to the outside, forming a volcano.

Vivid reminders that our planet is geologically active, volcanic eruptions are generated by the same heat engine that drives Earth's plates. Volcanoes form at places where large quantities of heat escape at the surface—sometimes quite dramatically. Earth's volcanoes vary widely in size, form, and explosivity. Some erupt violently, others pour out rivers of lava.

Today, there are many active volcanoes worldwide and as the world's population grows, more and more people are living in potentially dangerous volcanic areas. Volcanic eruptions continue--as they have throughout most of geologic time--posing ever-greater threats to life and property.

Mt. Rainier looms over the Seattle/Tacoma area, endangering a population of more than three million people. South of Mexico City, Popocatépetl has begun to come to life again, putting a million nearby residents at risk. Another million people living in the Naples area are threatened by Mt. Vesuvius' continued unrest.

Between the molten iron core and the thin crust at the surface, there is the mantle, a large layer of rock that is mostly solid, but also flows slowly. When, for various reasons, rock from the mantle melts, it sometimes moves to the Earth's surface through weak spots in the crust, releasing heat, gasses, and rock--a volcanic eruption. But why does this solid rock melt and come to the surface?



From Magma to Lava

Extremely high temperature and pressure can cause the lower mantle to melt and become liquid rock, or magma. When a body of magma rises through the denser rock layers toward Earth's surface, some of it stays liquid. Magma that has reached the surface is called lava. Magma reaches the surface through the vertical main pipe of a volcano. It is forced up by pressure from deep inside the earth. When it comes out of the earth's surface it is called lava. The lava pours out of the hole or vent, at the surface of the volcano. A vent can be at the top or sides of a volcano. (*Volcano*

Image credit: Thomas, R. & Sydenham, S. Volcanoes. [Online] www.kidcyber.com.au (2000)

Demonstrate this occurrence with the following:

Materials: Clean bottle with long neck, baking soda, vinegar, dish soap, red food coloring, tablespoon, large pan

Alternate recipe:

- 1/4 cup of vinegar
- 4 tsp. of red Jello powder
- 2 tsp. of baking soda

Directions:

1) Have each student, or having them work in groups, have them place a bottle in a large pan. *Have students identify the parts: the inside of the bottle is the magma chamber; the neck is the pipe; and the opening at the top of the bottle is the crater.*

2) Have each pair put 2 tablespoons of baking soda into the bottle and then add several squirts of dish soap and several drops of food coloring.

3) Have students pour vinegar into the bottle to equal the amount of baking soda. What happened? Pressure builds up inside the volcano, the gas in the magma chamber expands and moves up and out of the volcano forcing magma out as well. Lava then flows from the top of the volcano down the sides.

1) How is this like a real volcano?

2) What type of rock would the foam eventually become? *Igneous rock: (derived from the Latin word igneus meaning of fire, from ignis meaning fire) is one of the three main rock types, the others being sedimentary and metamorphic rock. Igneous rock is formed through the cooling and solidification of magma or lava.*

3) How does this demonstration show how igneous rock is formed?

Lava Types

Like ice cream, magma comes in different "flavors," or compositions. Each of these compositions will produce a different lava (once magma comes to the earth's surface it is called lava) from fluid, fast-moving basalt to slower, thicker andesite. Because rocks are made up of collections of minerals that melt at different temperatures, the makeup of the rock being melted affects which magma and then lava it makes when it melts.

Magma that reaches Earth's surface and becomes lava comes in three essential compositions that produce the three common volcanic rock types: basalt, andesite, and rhyolite.

Basaltic magma, the most common form of magma, comes from the partial melting of rock in the part of Earth's mantle called the asthenosphere. Basalt generally has the lowest silica content of the three common volcanic rocks, which makes it the least viscous.

Andesite can arise in a variety of ways, but most is produced by the partial melting of wet basalt. This often occurs where oceanic crust dives beneath another plate. Andesitic magma

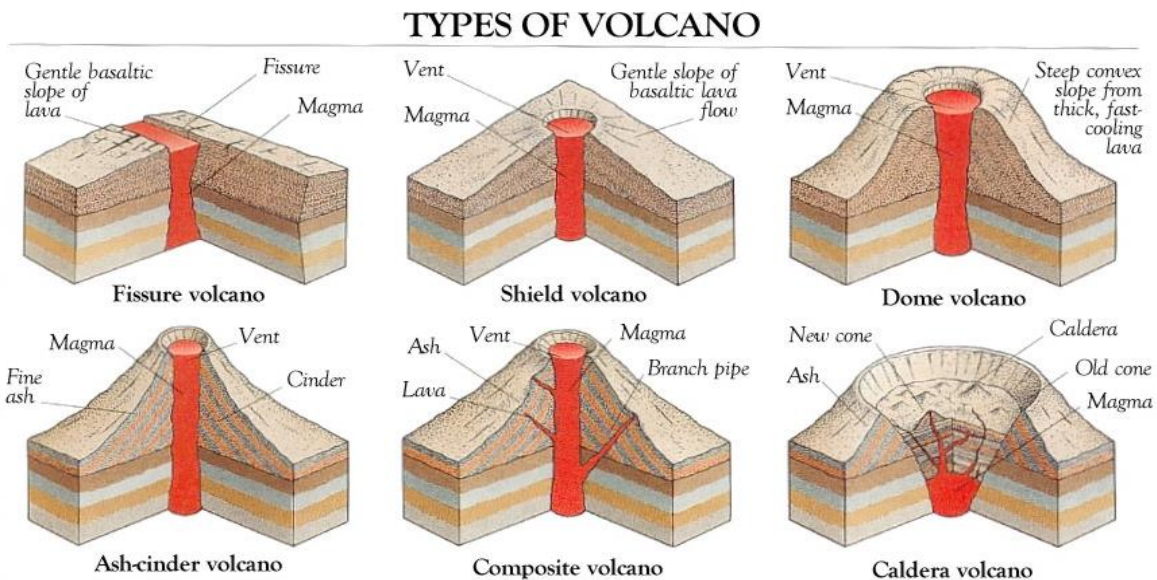
can also be made by the melting of continental crust. Compared to basaltic magmas, andesitic magmas are normally more viscous (thicker) and contain more dissolved gases.

Rhyolitic lava is rich in silica and therefore quite viscous (thick). It can arise from the partial melting of continental crust. Because of its viscosity, which results in the magma solidifying before it can reach the surface, rhyolitic lava generally is less common than other forms.

Why do volcanoes erupt in different ways?

Most volcanoes occur on plate boundaries. Plate boundaries are areas where Earth's shifting plates meet or split apart, usually with violent results.

Plate margins that are coming together are called convergent margins, while those that are splitting apart are called divergent. A third type, transform-fault margins, are sliding against each other, going in opposite directions, like when you rub your hands together. Volcanoes can occur on convergent or divergent plate margins or over a hotspot, Hot-spots are formed because a very hot area (focus) in the earth's mantle burns its way through the earth's crust. In the surroundings of boundaries of tectonic plates the following types of volcanoes occur:



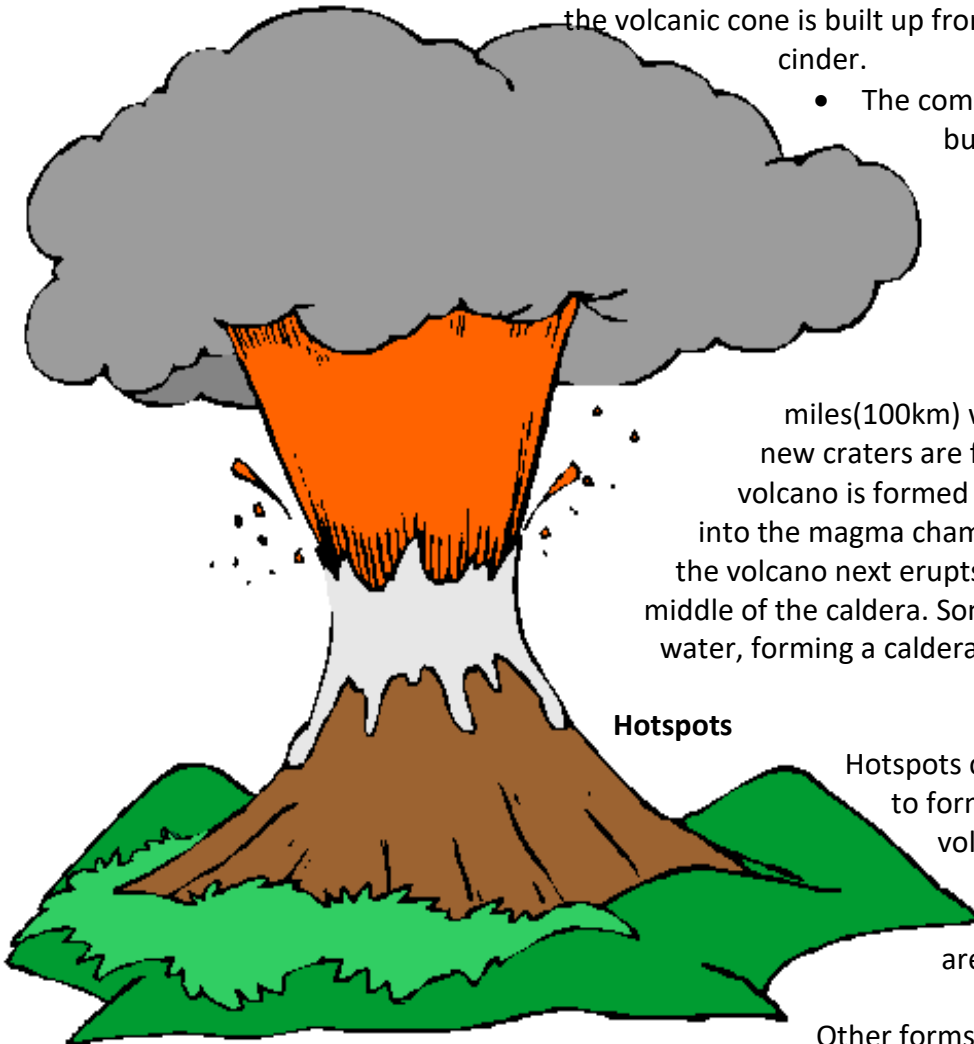
- The fissure volcano: Is a long crack in the earth's surface through which magma erupts. These cracks may form as two tectonic plates pull apart. You'll find them mainly near mid-ocean ridges.

The ordinary plate margin volcanoes can be divided in different types, relating to their forms:

- The shield volcano: This is a broad, shallow volcanic cone, which arises because the running lava, which is fluid and hot, cools slowly. A shield volcano is built almost entirely of fluid lava flows. Flow after flow pours out of the volcano's vent or vents in all

directions, to build a broad, gently sloping cone. From the side the volcano looks like a warrior's shield, which is how it got the name.

- The dome or cone volcano: This one has a steep, convex slope from thick, fast-cooling lava. A cone volcano is made up of layers of hardened lava and ash, built up each time the volcano erupts.
- The ash-cinder volcano: Throws out - besides lava - much ash into the air. Through this the volcanic cone is built up from alternate layers of ash and cinder.



- The composite volcano: These are also built up from alternate layers of lava and ash but, besides its main crater, it has many little craters on its slope.

- The caldera volcano: An older volcano with a large crater which can be 62 miles (100km) wide. In this crater many little new craters are formed. A crater or caldera volcano is formed when a cone volcano collapses into the magma chamber, forming a caldera. When the volcano next erupts a new cone is formed, in the middle of the caldera. Sometimes, the caldera fills with water, forming a caldera lake.

Hotspots can also cause shield volcanoes to form. As plates move over hotspots, volcanoes spring up and die down in turn, often creating an island chain. The Hawaiian Islands are the result of a hotspot.

Other forms of volcanism are the Geysers and the Hot Springs. You often find them in the neighborhood of volcanoes, where the earth's crust is thinner and the heat of the magma further penetrates into the earth's crust. A Geyser is a hole in the earth's crust, spouting fountains of boiling water. Hot rock heats up water in an underground chamber and when the water boils, it sends out a fountain of boiling water, up to 1,640 ft. (500 m) into the air. A Hot Spring works in the same way, but the water is not so hot that it spouts with pressure.

What happens when a volcano erupts?

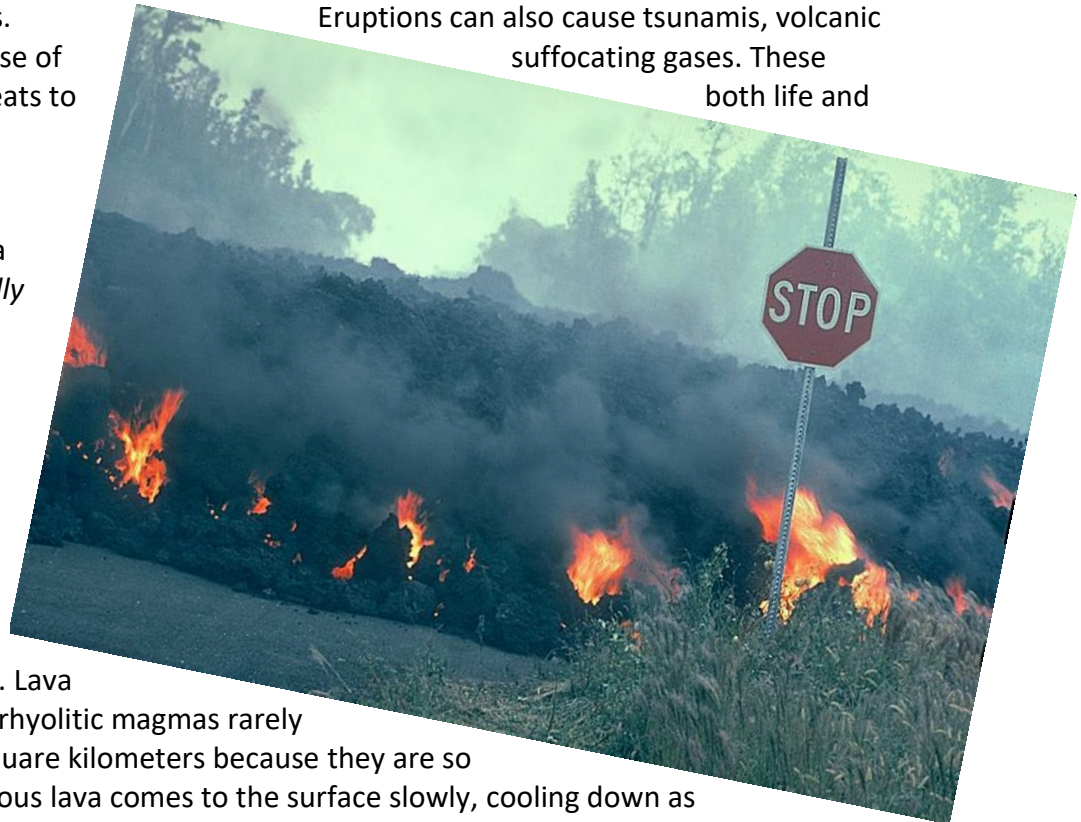
When you think of a volcanic eruption, you probably imagine red-hot lava flowing down the side of a volcano. Lava, ash, and debris flows are the most common and serious volcanic

hazards, but others do exist. Severe eruptions can disrupt the climate for long periods or cause atmospheric shock waves. earthquakes, or the release of hazards pose serious threats to property.

Eruptions can also cause tsunamis, volcanic suffocating gases. These both life and

Lava Flows

Lava flows are of course a threat, but they are *usually* slow enough that people can get out of the way. Economic loss from lava flows--including burned buildings and ruined crops--is more common. Because lava flows normally don't cover very large areas, the damage is usually limited. Lava flows from andesitic and rhyolitic magmas rarely cover more than a few square kilometers because they are so thick (viscous). More viscous lava comes to the surface slowly, cooling down as they rise, so lava flows don't travel very far before cooling even more and slowing down. If large quantities of lava are squeezed out quickly, then areas of up to a few hundred square kilometers can be covered. The most hazardous lava flows, are from more fluid basaltic eruptions.



Falling Ash

In an explosive eruption, pent-up gases escape violently. Magma breaks into pieces and bursts from the volcano in a column of ash and fiery fragments. The cooled fragments that fall back to Earth are called tephra. In a large eruption, tephra

can cover vast areas with a thick layer of very hot ash, presenting a much greater hazard than lava flows. Animals, plants, and people, can't breathe when hot ash falls on them and burns them and fills their lungs and it can also cause machinery to stop working. It can even be deadly.

On August 24, A.D. 79, the Roman city of Pompeii was buried by the catastrophic eruption of Mount Vesuvius. Some people of Pompeii grabbed their beasts of burden and attempted to flee the area; others perhaps chose to wait until the streets were clear of the panicked masses; still others sealed themselves up in rooms, supposing that the ashes and poisonous gasses would not harm them there. The unfortunate people who could not escape in time to avoid disaster were killed by falling buildings, overcome by



the mephitic gas, or simply buried by the rapidly falling ash. Their bodies were quickly covered by the volcano's mineral deposits, which covered Pompeii in a layer more than 30 feet thick and they became forgotten fossils.



The pumice and thick volcanic ash that ended the lives of so many also encased the city in a virtual time capsule for the next 17 centuries. The city remained largely lost and forgotten until rediscovered by archaeologists in the early 1700s, resulting in Pompeii today being one of the most complete and intact archaeological sites in the world. Portions of the site remain uncovered, and excavation and research teams are still attempting to reveal this mysterious city's secrets.

As archaeologists excavated the site, they

found it was strewn with air pockets where victims' bodies had decomposed within the hardened volcanic debris. By filling these hollows with plaster, they were able to create casts, such as the ones shown here, that reveal with remarkable detail the suffering of Pompeii's citizens, pets, and livestock in their last moments

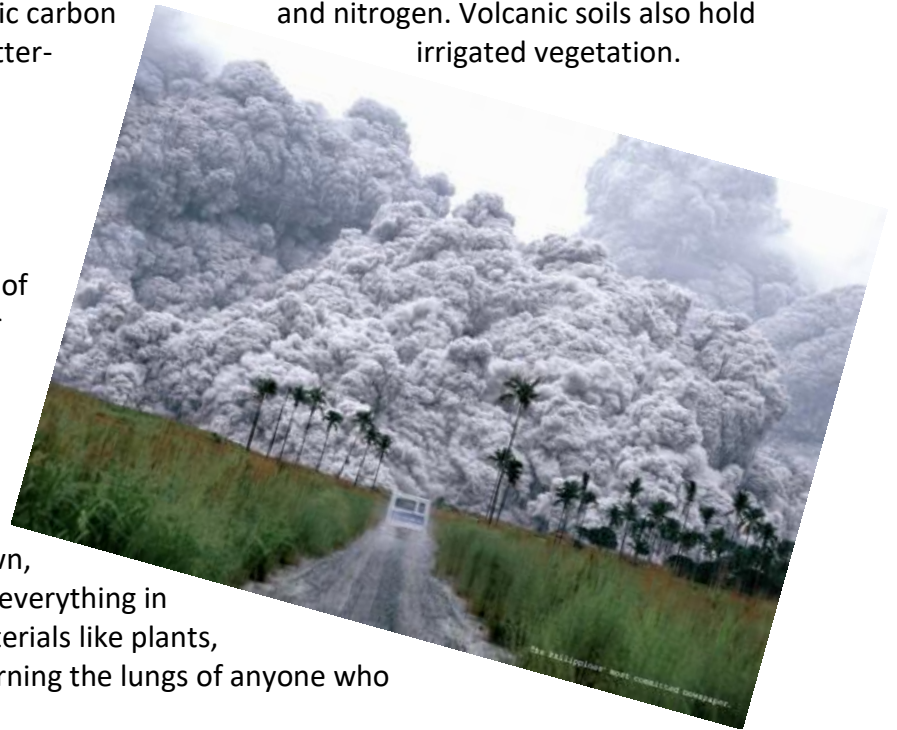
Thin layers of very fine tephra can accumulate thousands of miles away from the volcano, even all the way around the earth. Heavier layers of several centimeters or more can cover tens of thousands of square miles.

Large fragments of tephra can cause significant damage on impact, colliding with structures or setting things on fire. Accumulations of tephra do their damage by burial: roofs collapse, for example, or crops are killed. If you put a tarp on your lawn eventually all the grass would die. That's what it is like when a thick layer of ash lays on the ground. The plants can't reach oxygen or sunlight and so they die.

Massive quantities of volcanic ash inflict a lot of immediate damage, but in the long term, they make soil and oceans healthier. This process may take weeks, months or even thousands of years, but eventually, these particles of exploded magma work their way into our habitats, providing plant life with crucial organic carbon and nitrogen. Volcanic soils also hold a great deal of water, allowing for better-irrigated vegetation.

Glowing Avalanches

Pyroclastic flows are ground-hugging avalanches of hot ash, pumice, rock fragments, and volcanic gas that rush down the side of a volcano at speeds of over a hundred kilometers an hour or more, extending as far as 200 kilometers from the volcano, with temperatures reaching over 500 degrees Celsius, temperatures hot enough to burn wood. They destroy everything in their path knocking down, shattering, burying, or carrying away everything in their way and causing flammable materials like plants, houses, and gas to burn as well as burning the lungs of anyone who breathes in the hot ash.

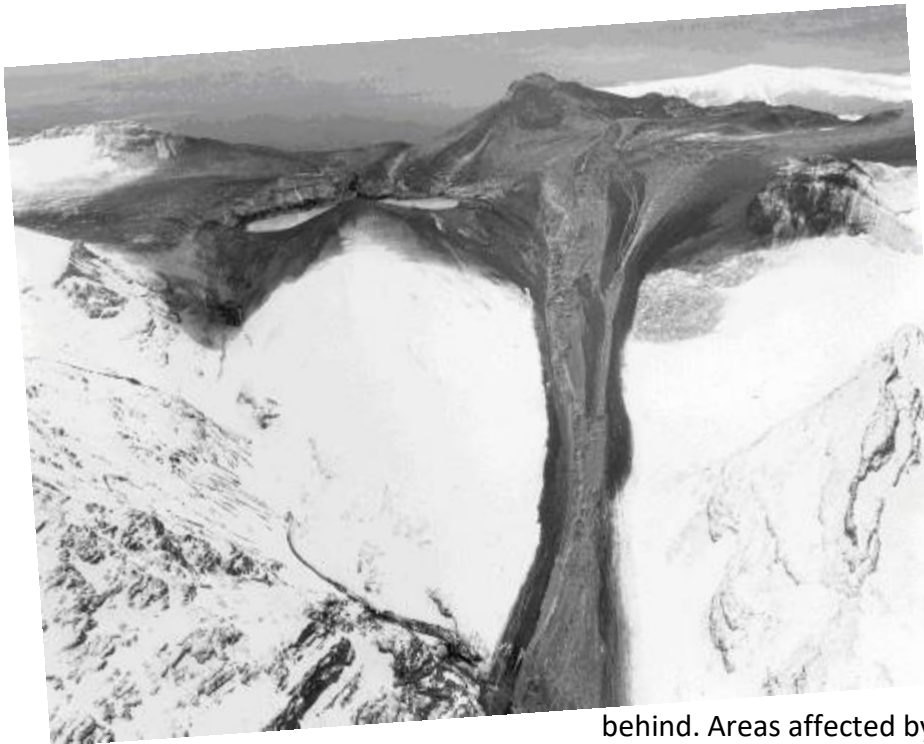


Pyroclastic flows cause damage by burial and by incineration, and because of their speed and gas content can also cause impact damage and asphyxiation. These flows are common at stratovolcanoes, since they are associated with andesitic and rhyolitic magmas.

Lahars: Mud and Debris Flows

Lahar is an Indonesian term for a hot or cold mixture of water and rock, flowing down the sides of a volcano, like a giant river of mud. When moving, lahars look like a mass of wet concrete that carries debris ranging from mud to rocks over 10m wide. Lahars vary in size and speed. Small ones less than a few meters wide and a few

centimeters deep may flow a few meters per second. Large ones hundreds of meters wide and meters deep can flow several tens of meters per second, much faster than a human can run, giving people no chance to outrun them and burying everything in their path. Large lahars can travel hundreds of kilometers down valleys. Because of their high density (how thick they are), these mudflows can cause a lot of damage.



These are particularly dangerous on volcanoes that have glaciers on top, as the eruption instantly melts the ice, causing a massive mud slide, much like what happened during the Mt. St. Helens eruption in 1980.

Can we predict when a volcano will erupt?

Scientists can often find clues about past eruptions by studying the deposits left

behind. Areas affected by lava flows, debris flows, tephra, or pyroclastic flows can be mapped, making disaster planning more effective. In addition to this type of long-range forecasting, scientists are becoming more and more skilled at spotting the warning signs of an eruption.

Still, a number of barriers remain. It's very difficult to pinpoint exactly when an eruption will happen. Often, moving magma doesn't result in an eruption, but instead cools below the

surface. Monitoring potential eruptions is expensive. With many volcanoes erupting only every few hundred or thousand years, it's not possible to monitor every site. Volcanic eruptions don't occur without warning, however.

Seismicity

Seismic activity (small earthquakes and tremors) always occurs as volcanoes awaken and prepare to erupt. Some volcanoes normally have continuing low-level seismic activity, but an increase can signify an eruption. The types of earthquakes that occur and where they start and end are also key signs.

Volcanic seismicity has three major forms: short-period earthquakes, long-period earthquakes, and harmonic tremor. Short-period earthquakes are like normal fault-related earthquakes. They are related to the fracturing of brittle rock as the magma forces its way upward. These short-period earthquakes signify the growth of a magma body near the surface. Long-period earthquakes are believed to indicate increased gas pressure in a volcano's "plumbing system." They are similar to the clanging or gurgling sometimes heard in your home's plumbing system. Harmonic tremor occurs when there is sustained movement of magma below the surface.

Patterns of seismicity are complex and often difficult to interpret. However, increasing activity is very worrisome, especially if long-period events become dominant and episodes of harmonic tremor appear.

Gas Emissions

As magma nears the surface and its pressure decreases, gases escape. This process is much like what happens when you open a bottle of soda and carbon dioxide escapes. Sulfur dioxide is one of the main volcanic gases, and increasing amounts of it usually herald the arrival of more and more magma near the surface. For example, on May 13, 1991, 500 tons of sulfur dioxide were released from Mt. Pinatubo in the Philippines. On May 28--just two weeks later--sulfur dioxide emissions had increased to 5,000 tons, ten times the earlier amount. Mt. Pinatubo erupted on June 12, 1991.

On several occasions, such as before the Mt. Pinatubo eruption, sulfur dioxide emissions have dropped to low levels prior to eruptions. Most scientists believe that this drop in gas levels is caused by the



sealing of gas passages by hardened magma. Such an event leads to increased pressure in the volcano's plumbing system and an increased chance of an explosive eruption.

Ground Deformation

Swelling of the volcano signals that magma has accumulated near the surface. Scientists monitoring an active volcano will often measure the tilt of the slope and track changes in the rate of swelling. An increased rate of swelling--especially if accompanied by an increase in sulfur dioxide emissions and harmonic tremors--is almost a sure sign of an impending event.

Demonstrate the ground deformation and volcanic prediction by doing the following:

Materials

- Plastic film canisters with lids (black cylinders with gray lids are best) typically free from photo processing services (or medicine containers orange with white lids)
- Water (or vinegar)
- Small cups
- Alka-seltzer (regular strength) tablets, cut into halves and quarters
- Lots of paper towels for clean up

Procedures

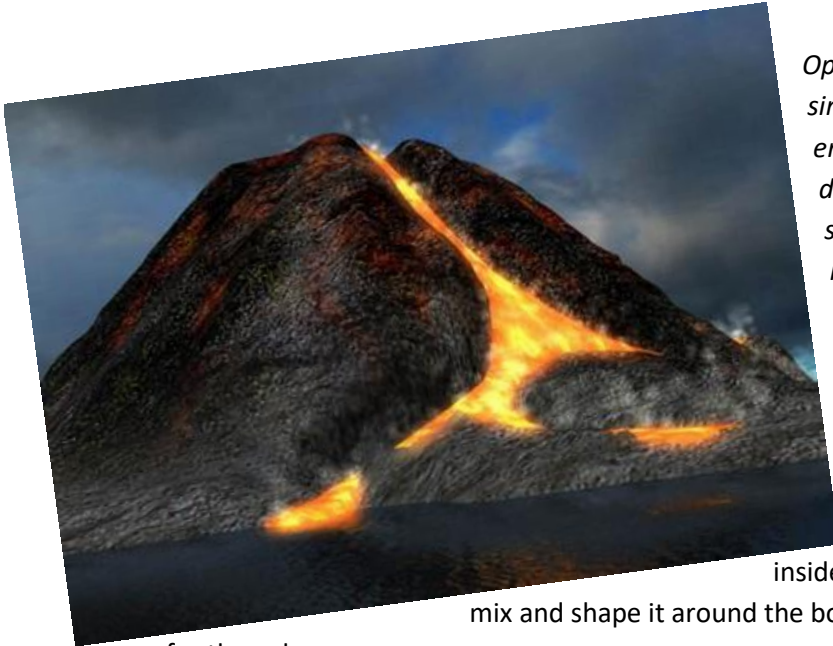
1. Put about 20 ml of water into canister (Don't have to be exact.)
2. Add quarter tablet of alka-seltzer and quickly put on cap.
3. Observe what happens for about 2 minutes.
4. Repeat using half of an alka-seltzer tablet. (Watch out!)
5. Repeat using half of a tablet and lid with perforations that allow gas to escape.

Results and Discussion

1. *What happens?* The lid on canister containing a quarter tablet will balloon upwards as the pressure increases, then deflate as it decreases, or it may possibly pop off gently. The lid on the canister containing a half of a tablet will bulge and then blow off surprisingly violently, rising several feet in the air or travelling laterally 5 or 6 feet. The perforated lids will not blow off.
2. *Why?* There is not enough gas generated by one quarter of a tablet of alka seltzer to build sufficient pressure to blow the lid off. However, the gas generated by a half of an alka seltzer tablet is plenty to blow the lid part way across the room, as long as the lid is put on quickly and firmly so that no gas escapes. Students can use the ballooning of the lid prior to its blowing off to predict when the lid will blow off.
3. *How is this like a volcanologist studying a volcano?* This is analogous to volcanologists predicting when an eruption will occur based on the measurable bulging of a volcano. If the gas is allowed to escape gradually through holes in the lid, the gas pressure from the

dissolving alka seltzer will not build up to the point where it exceeds the confining pressure of the lid, and the lid will not blow off

Volcano Models



for the volcano.

Option: As the class is ready, perform a simple baking soda & vinegar volcanic eruption from a volcano model. After you discuss volcanos, open the volcano model, so that the class can see what is going on inside the volcano.

Dough Method:

Place your soda bottle in the center of your aluminum roasting pan. Make sure the top is secure on the bottle. You don't want any dough to get placed

inside the soda bottle. Take the chosen dough mix and shape it around the bottle. This creates the cone shape desired

Easy Poster-board Method

<http://www.stormthecastle.com/how-to-make-a/how-to-make-the-easy-volcano.htm>

Here is what you need per volcano:

- 1 sheet of poster-board
- 1 solid piece of sturdy cardboard or wood (This is to sit the volcano on and it can be posterboard or a piece of corrugated box).
- 1 bottle -almost any size is ok from 20oz soda bottle to a snapple bottle
- Paints or markers/crayons and other things to decorate it any way you like
- Some Masking tape, but clear tape will work too
- a few sheets of newspaper

Take your bottle and place it upside down on the posterboard and draw a circle around the mouth.





Now cut the poster-board just like in the picture at left. It ends up with a slot from one side and the circle cut out.



Now grab both ends of the slit and fold one end right over the other to form a cone. Put some tape on it so it stays a cone shape. This is the cone of your volcano.



Trim it with scissors so it is a nice cone shape and the right size for your bottle. Trim it in small increments, taking a little bit off at a time so you don't over trim it.

Now trim the top of the cone so it fits nice and snug over the bottle.

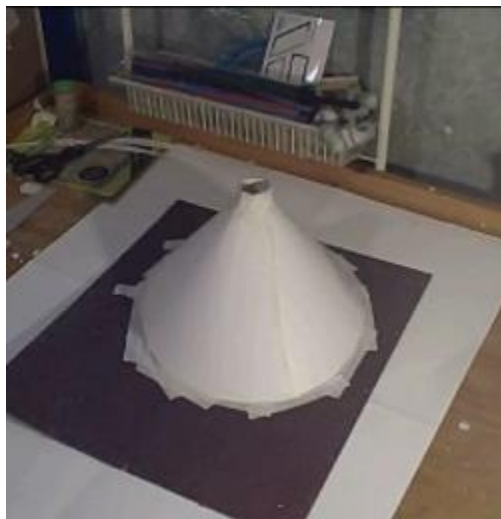




Tape the mouth of the bottle to the cone of the volcano. The bottle should sit flat on the table as does the cone. This is the basic shape of the volcano and it looks great. Remember, take your time and trim it in little strips at a time until it has a nice shape. This way you don't over cut it and have to start over.

Note: If you want to use crayons or pencils you should at this point, once you have the shape of the cone right, take all the tape off the volcano and lay the cone out flat - this way you can use crayons or pencils to decorate it like a volcano.

Flip the cone over and fill it with crumpled up balls of newspaper. The bottle is still there right in the middle under my hand. This newspaper will add strength and solidity to the form.



Place the cone down on your board and tape it firmly in place. Notice how it sits nicely and see how the bottle sticks out the top? This volcano looks great and you can use just about any kind of a strong flat surface to tape it down to. A piece of wood is good, or some strong corrugated cardboard. Even a couple of sheets of posterboard taped together would be ok.

Now you are ready to add some decorations and make it look real!



Here is completed volcano, all painted up and ready to go! Remember that you should paint red, yellow and orange at the top to simulate the flowing magma.

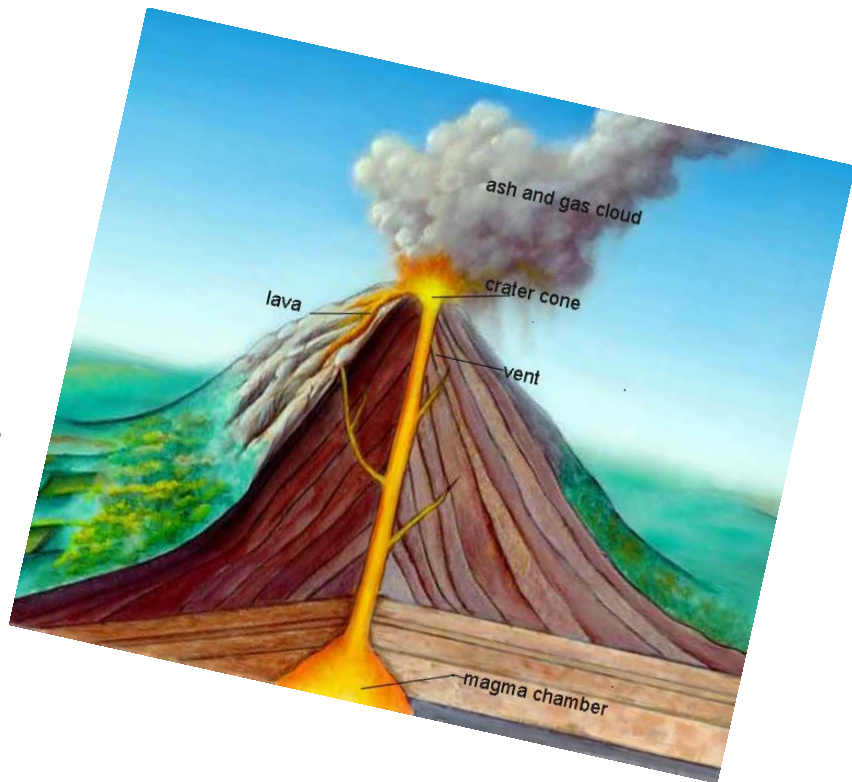
To Make this Volcano Erupt

It's always a good idea to have a few practice rounds to figure out the perfect ratio.

Take the bottle out of the volcano and put in 4 tsp. of red Jello powder and 2 tsp. of baking soda. Put the Volcano over the bottle so it is in place and ready to go. Pour the appropriate ratio of vinegar ($\frac{1}{4}$ cup of vinegar) right into the volcano bottle and watch it Erupt!!

Layered Volcano... Fun with Stratigraphy

If you have already done the baking soda and vinegar volcano continue on with this project teaching students about stratigraphy! It works with every age and is a great volcano project.



Materials:

- Short paper cups
- One sheet of poster-board (per group of four students)
- A marker
- Paper towels
- Clear straws
- at least 4 several different colors of Play-Doh
- and something to roll the dough flat
- Food coloring
- Vinegar
- Baking soda

Directions

1. Have children examine images of volcanoes and discuss what they know about volcanoes.

- What is a volcano?
- What are some things that come out of a volcano? (*lava, ash, water vapor, carbon dioxide, sulfur*)
- Where are some volcanoes on Earth located?
- Are there volcanoes on other planets? (*Nearly all the solid planets and moons have some volcanic activity in their history. Some, such as Earth, Venus, and Io are still active.*)
- How can you tell volcanoes and craters apart? (*Volcanoes have a central crater, raised rims, a circular central opening, and outer edges that are irregularly shaped though roughly circular. However, unlike craters, volcanoes do not have ejecta or an internal central peak. Furthermore, they are raised features while impact craters are low/deep.*)
- Does a single volcano form all at once or over a period of time, in stages? (*Over time*)
- What volcanic features provide hints that it formed in stages? (*Stacks of lava layers*)

2. Explain that teams will model lava flows from a homemade volcano. Invite them to examine the poster board with the attached cup (cup having been taped or glued to the posterboard). Ask: What does the cup represent? (*A volcano*)

3. Write the following questions on a board or chart paper so everyone can see them. The group will discuss them at the end of the activity, so teams should prepare answers as they work.

- Do all the flows occur on top of each other? (*Not always*)
- How do earlier flows influence the direction of later flows? (*Later flows may flow off to the sides of the earlier ones*)
- Does anything else influence the path of lava flow? (*Direction of flow out of the volcano*)
- Where does the oldest layer occur relative to later flows? (*On the bottom*)

4. Have teams: (1) Fill each of the four cups with approximately 1/8 cup of vinegar. (2) Add to each cup three drops of food coloring, making each cup of vinegar a different color. (3) Place one tablespoon of baking soda into the "volcano cup."

5. Have each team pour **one** of its cups of vinegar into the "volcano." The vinegar and baking soda will react and bubble over the edge of the "volcano." When the "eruption" has quieted, have the children use the markers to outline the edge of their "lava flow." Have them mop up the vinegar using the paper towels. (you can put the baking soda directly into your volcano instead of putting it in cups and then pouring it in the volcano, then pour the colored vinegar in, but don't skip the food coloring...you'll need it)

6. Have the children select a Play-Doh color to mark the first lava flow. They should flatten the Play-Doh into a thin sheet (about the thickness of a clip-board) and place it over the area they marked, covering any area where the lava flow extended.

7. Repeat the procedure three more times, using a different color of vinegar and Play-Doh for each lava flow. Remind the children to be gentle when placing layers of Play-Doh on top of each other; they should **not** smash the layers together.

8. Have the students sketch a map showing the distribution of the exposed part of the flows. Have them use graph paper, a ruler, and a north-south compass on their sheet, and mark each flow with a different color.

Ask them to label which flow came first (oldest), second, third, and fourth (youngest). Make sure older students include a scale, key, and direction indicator on their map.

9. Give children straws and have them "core" the lava flows.

- Can they core a location with all four flows? With only one? Two?
- What is the vertical order of flows (e.g., which is on the bottom, top, etc.)?
- What is the relative age of the flow on the bottom? (*Oldest*)
- Is the vertical order of the flows always the same? (*No, the model may have locations where a layer is missing*)
- Is the order always the same in terms of timing? (*Yes, older layers are always under younger units*)

The study of rock layering is called **stratigraphy**. One of the rules of stratigraphy is called the *principle of superposition*. It states that older rocks occur under younger rocks. In other words, the rocks on the bottom were laid down first and then covered by more recent deposits. Another rule of stratigraphy is the *principle of cross-cutting relationships*. It states that any feature (fault, crater, intrusion) must be younger than the rock that it "interrupts" because the rock was there first and the fault, crater, or intrusion happened after the rock was formed. You can't have a crack before a rock.



Cake Batter Lava!

In this activity older students will use cake batter to simulate surface lava flows. The experiment demonstrates many of the key features of many lava flows.

Real lava flows are complicated. They are characterized by a prominent lava channel confined between levees. Shear zones, places where one portion of the flow is moving faster than an adjacent portion, usually occur. Small flows of pahoehoe lava also become channelized, but on a much smaller scale than lava flows.

As cake batter is poured onto an inclined surface, the first and foremost thing to do is to observe the formation of distinct features in the flow. Levees form on the outer part of the flow. These are not quite the same as levees on lava flows because lava flows form up levees by overflowing the banks. Inside the levees the batter moves downhill. Ridges might develop in the flowing portions, which are comparable to large ridges in lava flows. The thickness of the flow varies with slope, time, position in the flow, and amount of batter poured. These variables can be tested by measuring width and thickness as functions of time, as described in the procedure.

Preparation

Review and prepare materials listed on the student sheet. Begin with a standard, boxed cake mix, preferably without pudding added. Mix the dry cake mix with water only. Smooth the mixture with a wire whisk to the consistency of thick cream.

The final mixture should be fairly uniform, with only a few lumps. If the mixture is too runny, then it will pour like water. In this case, add flour to the mixture. If it is too thick, then it will mound up (though that is interesting and somewhat resembles some very viscous lava flows). In fact, at the end of the experiment, you may choose to use a very thick batter for comparison purposes.

A baking sheet is an excellent surface to use for the experiment, though any smooth, surface will do fine, such as a wooden drawing board.

Draw a grid with 10-cm spacing onto a paper taped to the baking sheet or wooden board, then cover with plastic wrap.

Materials

- cake batter
- large mixing bowl, preferably with handle and pouring spout

- wire whisk large spatula
- large baking sheet or wooden drawing board with a 10-cm grid on it
- protractor with plumb line
- stopwatch
- "DataTables"
- tape measure or ruler

Procedure

1. Stir the mixture of dry cake mix and water in the bowl. A few lumps are acceptable.
2. Prop up one end of the board at an angle of about 15° (use the protractor and plumb line to determine the angle). Make sure the board does not sag.
3. Hold the bowl of cake batter about 10 cm down-slope from the high end of the board. This will help prevent batter from spilling accidentally onto the floor.

Keep the bucket about 10 cm above the board. Pour the batter slowly. It is important to keep the pour rate as constant as possible.

Start the stopwatch when the flow front passes the zero line.

4. Watch the flow as it goes downhill and spreads out, and record the time it reaches each 10 cm mark. How far behind the flow front does the distinct channel become apparent?
5. Record the time when you stopped pouring (the flow will continue to move). Fill in the "Data Tables."
6. Note the channel and levees as well as shear zones within the levees. Does the channel extend the entire length of the flow?

Tip: When the batter is flowing down the slope, look for areas near the edges where the flow rate is low or zero; these are the levees of the channel. The part in the middle that is moving faster is called the channel interior. You may try sprinkling red confetti onto the flow to get a better view of the relative movement between the interior and levees.

Using the **tape measure**, measure the length, width, and center depth of the flow and the channel width at each 10 cm mark. Fill in the "**Data Tables**."

8. Draw the outline of the flow using the grid as a guide.
9. When you are finished studying the flow, use the **spatula** to scrape the batter back into the bowl. The board should be clean and ready for the next procedure.

10. Now prop the board up higher to an angle of about 25° and repeat the experiment. The batter may flow off the end of the board this time, so make sure the flat underlying surface is washable or protected with plastic. How do the flow structures in this flat part compare to those on the slope?

11. Repeat all the measurements and fill in the "Data Tables."

12. How do the two experimental flows compare? Is the ratio of channel width to flow width the same?

Wrap-up

1. How do the two flows compare?

2. Is the ratio of channel width to flow width the same? Presumably the batter volumes were the same for both slopes, but the flow areas could be determined and multiplied by the average depths as an exercise just to check.

Extensions

1. Use a ruler with a grid to slice into the flow at each 10 cm mark to get cross sections.

2. Can you see the levee margins in the cross sections?

3. How do the cross sections change down the length of the flow?

4. Add more flour to the batter to see the behavior of a thick flow.

Gelatin Volcanoes

Purpose

For students to understand how and why magma moves inside volcanoes.

Magma is molten rock, including crystals and dissolved gases, found at depth in a planetary interior. When magma *erupts* onto the surface, the volcanic products make distinctive landforms including lava plains and *volcanoes*, depending on the details of the eruption. One of the most interesting things to consider about magma is how it moves up from underground reservoirs, called magma chambers, to erupt as *lava* on planetary surfaces. Does it travel in natural tubes or pipes? Or along fractures, cracks in the earth's crust? This experiment strikingly reveals the answer.

Magma leaves underground reservoirs through fractures in the surrounding rock. The fractures are either pre-existing or are created by the erupting magma. An active *dike* is a body of magma moving through a sheet-like, vertical or nearly vertical fracture.

An important aspect of magma flow not dealt with in the gelatin activity is the heat lost during eruption. Magma, ascending as a dike begins to cool and solidify and the flow may become localized in the dike. Such localized eruption of magma over a long period of time produces a volcano.

Stresses in the planet affect the orientation of dikes. Dikes open (widen) in the direction of least resistance. They propagate (grow longer and taller) perpendicular to the direction of opening.

Hawaiian shield volcanoes are characterized by concentrated regions of dike injections, called ***rift zones***. A series of experiments using gelatin models was conducted by researchers in 1972 to explain the growth and orientation of Hawaiian rift zones. The "Gelatin Volcanoes" classroom activity was inspired by this work.

This Activity

Follow the directions below for preparing the gelatin. Gelatin requires at least three hours of refrigeration to set. Use a warm water bath to free the gelatin from the bowl without getting water on the gelatin itself.

Unflavored gelatin is ideal for this experiment because of its transparency. Sweetened gelatin desserts also work. If you prefer the dessert variety, then use a flavor that is easy to see through, such as lemon. Another alternative is agar. Agar hardens at room temperature, eliminating the need for refrigeration, but it must be made so it is easy to see through.

Two-liter (or two-quart) capacity bowls work very well because the diameter allows enough space for multiple dike injections. This size is large enough for demonstration purposes. Smaller bowls, down to the size of margarine containers, have also been used successfully.

Gelatin, molded in bowls or bread pans, is used as transparent models of volcanic landforms. Colored water is used as the dike-forming magma. In this activity, dikes tend to propagate radially from the center of bowl-shaped casts of gelatin because the resistance to opening is the same in every direction. Dikes tend to parallel the long-axis of ridge-shaped (bread pan) casts of gelatin because the narrow dimension provides less resistance to opening than the long dimension. The dike opens in the narrow dimension and we see propagation in the long dimension. With a slow, steady injection rate, the colored water creates a dike and generally erupts from the flanks or ends of the gelatin casts.

Edge-on, a dike appears as a line. When the gelatin cast is sliced through with a knife, dikes appear as red lines in the vertical, cut edges.

Tips:

- Make sure a drip tray is placed under the gelatin to catch the colored water that drains out of the fractures. They will remain visible.
- Wear protective gloves to keep stains off hands.
- The colored water should not be injected too fast. Rapid injection drives the fluid straight up and creates an eruption but ruins the simulation of dike formation.
- When slicing the gelatin, choose a direction perpendicular to a dike to show its "line" shape on edge.



Key Words

- magma
- dike
- eruption
- volcano
- lava
- rift zone

Materials

- Unflavored gelatin, 28 gm (one-ounce) box containing four packages
- Spoon

- Bowls or bread pans, either one 2-liter (or 2-quart) capacity, or smaller sizes
- Red food coloring, to mix with water in a glass to make "magma"
- Syringe for injecting magma, best to use a plastic variety found at pet stores for feeding birds
- Peg board, 40 x 60 cm, with 5-mm-diameter holes spaced 2.5 cm apart. Or you can use a large, disposable aluminum pan that you've punched holes into.
- Two bricks, 30 cm high
- Large knife to cut through the gelatin model
- Tray, for collecting drips
- Rubber gloves (optional) for protecting hands from food coloring

Procedure

1. Prepare gelatin for the volcano model by mixing two cups of cool water with four packages of unflavored gelatin in a large bowl. Stir for 30 seconds. Then add six cups of boiling water and stir until gelatin is dissolved. Transfer mixture to a 2-liter bowl, smaller bowls, or bread pans. Refrigerate gelatin at least three hours or until set.
2. Prepare "magma" by mixing water in a glass with enough red food coloring to make a very dark liquid.
3. Loosen the gelatin by dipping the bowl briefly in a larger bowl of hot water.
4. Transfer the gelatin upside-down to the center of the peg board and lift off the bowl. The gelatin cast will settle somewhat after being removed from the bowl. It should resemble a colorless to milky, shimmering volcano. There should be no cracks in the gelatin, but it's OK to proceed if one develops during unmolding.
5. Place the peg board on top of the two bricks or other supports.
6. Fill a syringe with red water. Remove air bubbles from the syringe by holding it upright and squirting out a small amount of water. Air tends to crack the gelatin.
7. Have students predict what will happen when red water is injected into the gelatin cast. What direction will it go? What shape will it take? Will it erupt through the surface of the gelatin? If so, where?
8. Then they will insert the syringe through a hole in the peg board into the center of the gelatin cast. Inject the red water slowly, at a rate of about 20 cc/minute, and watch carefully.
9. Have them describe how the experimental results compare with their predictions.
10. Have students refill and insert the syringe as many times as possible. Compare magma migration each time. Are there differences in the direction the magma takes when the syringe is inserted in different parts of the gelatin cast? Have them describe and explain what they see.
11. Looking directly down on the gelatin cast, have students sketch the positions and shapes of the magma bodies. Have students label their drawing "Map View."
12. Ask students to describe what they observed. (If the gelatin is fractured, the red dye will flow out of the fractures. If there are no fractures, the dye should flow out equally in all directions.)

13. Use a sharp knife to cut through the gelatin cast. Separate the pieces and examine the cut surfaces. Note the traces made by the magma bodies; these are similar to what we see in highway road cuts or cliff faces. Tell students that in the gelatin, just as in a volcano, the magma will follow the path of least resistance. When there is a fracture in the rock on the Earth's surface, the magma will flow out of the fractures. Otherwise, the magma flows in all directions
14. Sketch the positions and shapes of the magma bodies on a cut face. Label your drawing "Cross-sectional View."
15. Compare what you see in two dimensions on the cut face with what you see in three dimensions looking into the gelatin cast. Which view gives you more information. Why?
16. How and why does magma move through volcanoes?

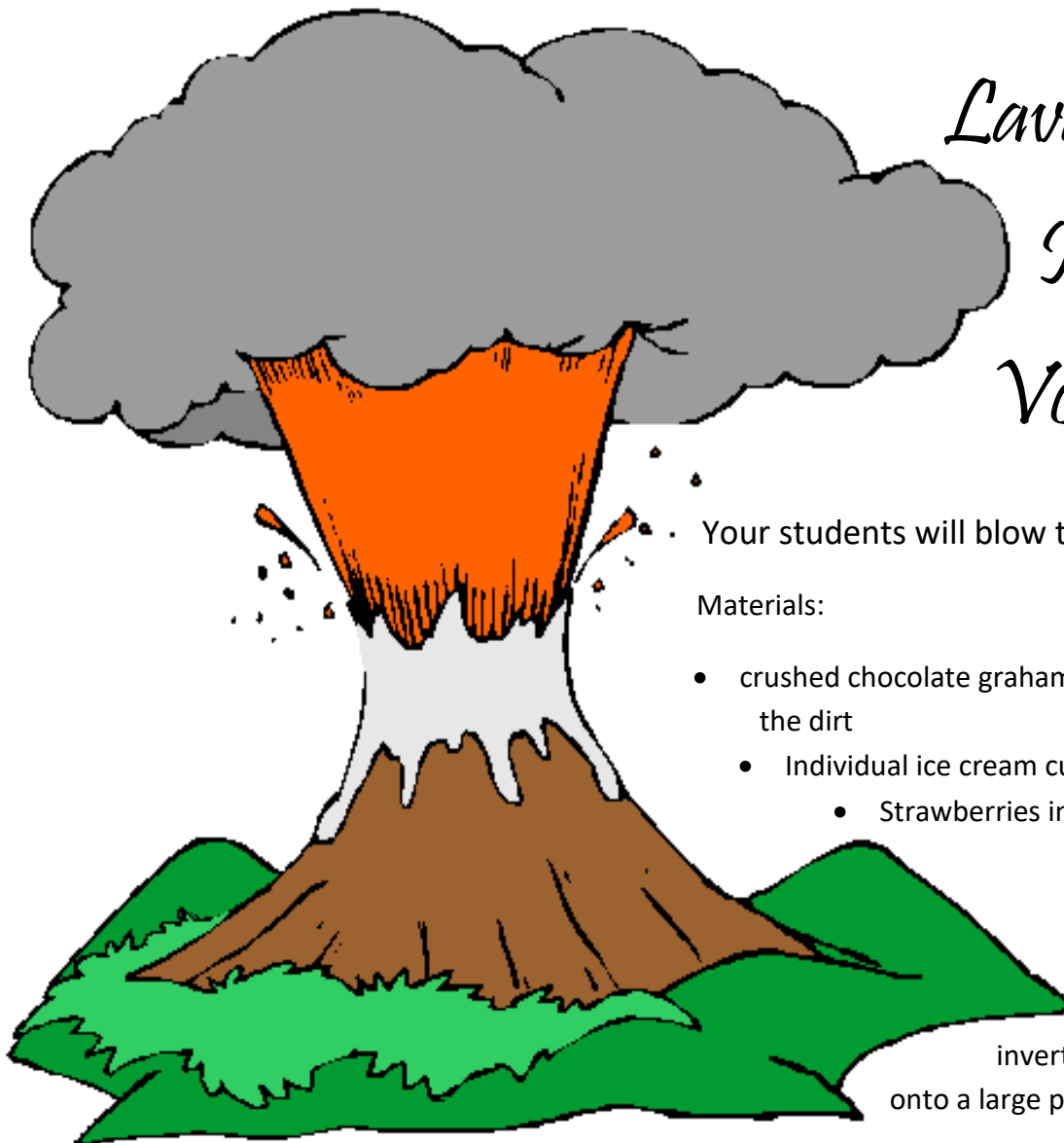
Extension

1. Repeat the experiment with an elongated model such as a bread pan. Before injecting the magma, try to predict what will happen. What effect does gelatin shape have on magma movement?

Tips: With small gelatin volcanoes you need to provide cracks along the top, so have the students cut small slits in the top of the volcano toward the sides. This way they can observe that the liquid will for sure flow into the present cracks, deepening them with time.

A larger volcano (2L bowl size) would be interesting for contrast, still allow each of the students to apply lava. This would allow the students to observe more long term changes with the shape of the volcano. Also, this would be a lot smaller mess!

Lava-Licious Ice Cream Volcano



• Your students will blow their tops!

Materials:

- crushed chocolate graham crackers or Oreos for the dirt
- Individual ice cream cups
 - Strawberries in syrup or other “lava” sauces

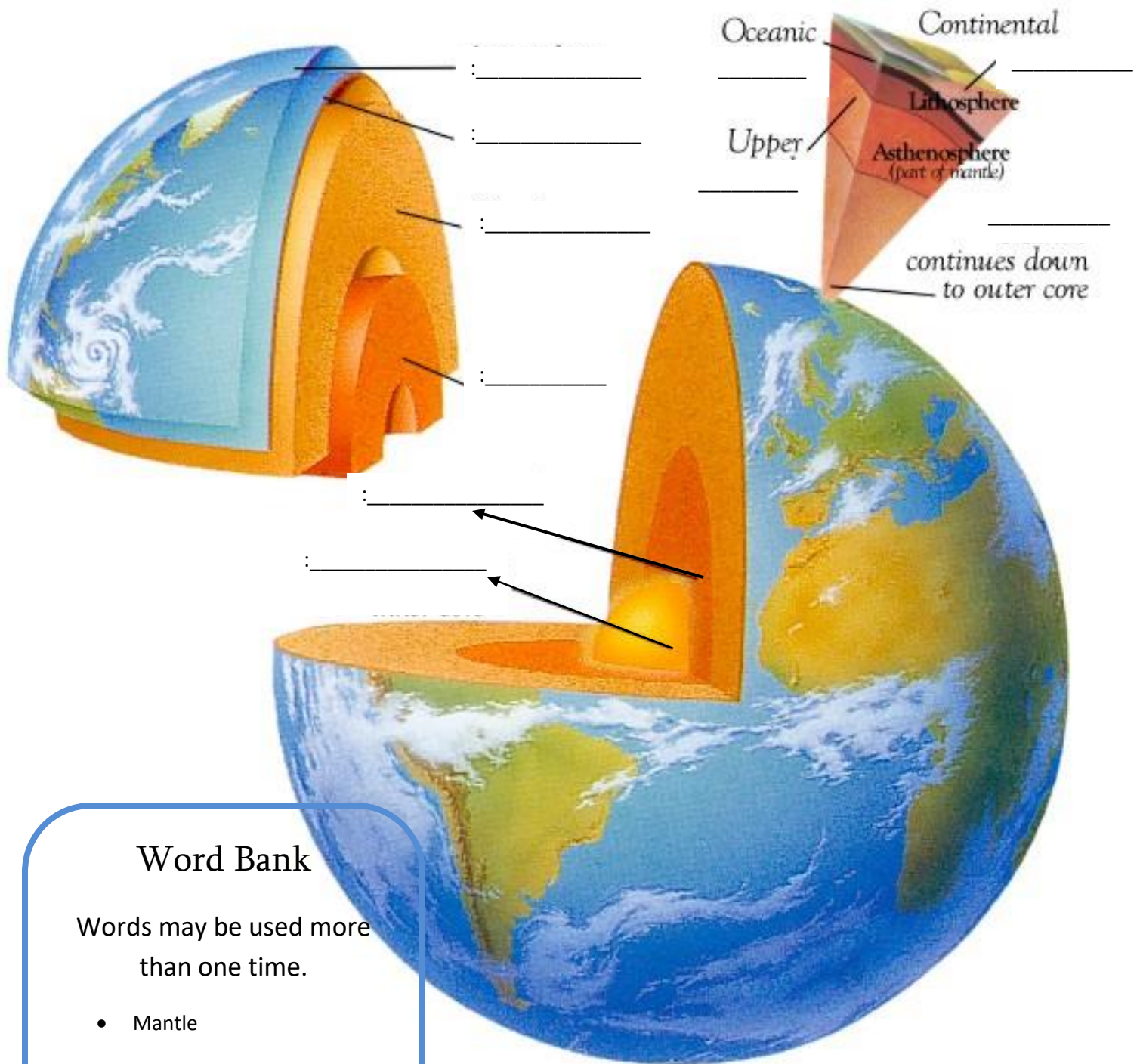
To create the volcano, have students simply invert their ice cream cup onto a large paper plate and cut or

peel away the container.

Allow the ice cream to soften for a few minutes, then have the students use a spoon or butter knife to shape the mountaintop into a peak (or their favorite kind of volcano, a caldera will hold more yummy lava!)

Sprinkle on plenty of chocolate-cookie-crumb gravel/ash and spoon sliced strawberries in syrup over the top (or other type of lava). Make sure some flows down the sides.





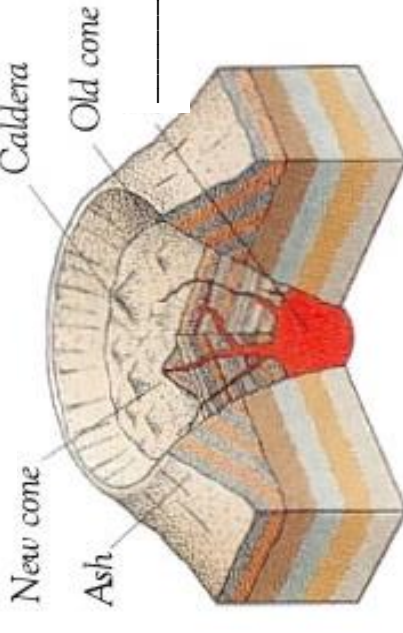
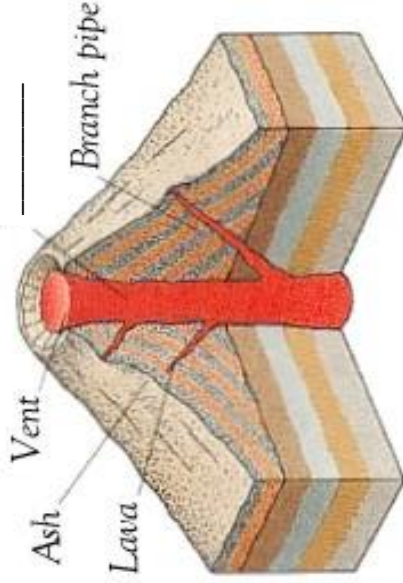
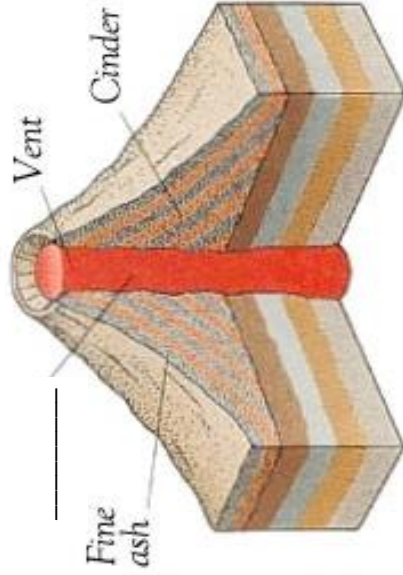
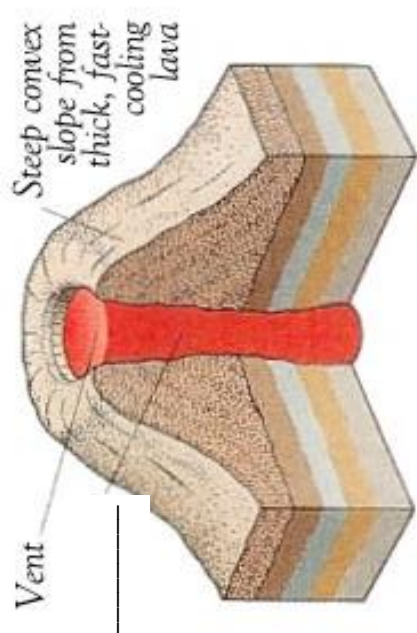
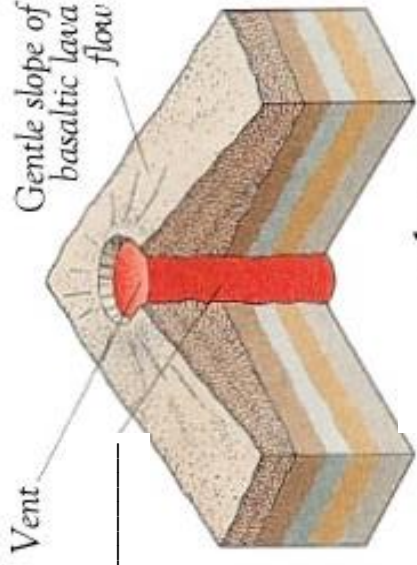
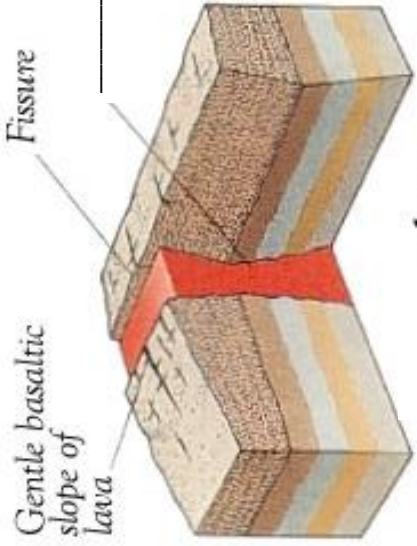
Word Bank

Words may be used more than one time.

- Mantle
- Outer Core of Molten Metal
- Atmosphere
- Crust
- Outer Core
- Solid Metal Inner Core

Name: _____

TYPES OF VOLCANO



Word Bank: Words may be used more than once.

- | | | |
|---------|------------|------|
| Magma | Ash-cinder | Dome |
| Caldera | Shield | |
| Fissure | Composite | |

