The Science Behind Volcanoes

A **volcano** is an opening, or rupture, in a planet's surface or crust, which allows hot magma, volcanic ash and gases to escape from the magma chamber below the surface.

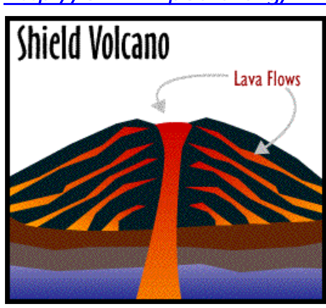
Volcanoes are generally found where tectonic plates are diverging or converging. A mid-oceanic ridge, for example the Mid-Atlantic Ridge, has examples of volcanoes caused by divergent tectonic plates pulling apart; the Pacific Ring of Fire has examples of volcanoes caused by convergent tectonic plates coming together. By contrast, volcanoes are usually not created where two tectonic plates slide past one another. Volcanoes can also form where there is stretching and thinning of the Earth's crust in the interiors of plates, e.g., in the East African Rift, the Wells Gray-Clearwater volcanic field and the Rio Grande Rift in North America. This type of volcanism falls under the umbrella of "Plate hypothesis" volcanism. Volcanism away from plate boundaries has also been explained as mantle plumes. These so-called "hotspots", for example Hawaii, are postulated to arise from upwelling diapirs with magma from the core–mantle boundary, 3,000 km deep in the Earth.

Erupting volcanoes can pose many hazards, not only in the immediate vicinity of the eruption. Volcanic ash can be a threat to aircraft, in particular those with jet engines where ash particles can be melted by the high operating temperature. Large eruptions can affect temperature as ash and droplets of sulfuric acid obscure the sun and cool the Earth's lower atmosphere or troposphere; however, they also absorb heat radiated up from the Earth, thereby warming the stratosphere. Historically, so-called volcanic winters have caused catastrophic famines.

4 Types of Volcanoes

1.) **Shield Volcano** *(largest volcanoes)*

- **Profile:** large size and gentle slope, resembles a warriors shield
- **Lava:** highly fluid lava eruptions, travels far and spreads quickly and thinly
- **Viscosity:** low viscosity magma
- **Silica Content:** 50%
- **Rock Type:** basalt, high levels of sodium, potassium and aluminum
- **Examples**: Hawaiian Islands: Mt. Kilaeua, Mauna Loa, Galapagos Islands
  http://en.wikipedia.org/wiki/Shield_volcano



2.) **Stratovolcanoes** *(most common type, some are also composite volcanoes)*

- **Profile**: steep profiles and slopes, and periodic explosive eruptions
- **Lava:** thick, viscous lava and rock rubble

- **Viscosity:** intermediate viscosity
- **Silica Content:** 60-64%
- **Rock Type:** andesite
- **Examples**: Mount St. Helens, Mount Fuji, Krakatoa & Vesuvius—destroying town of Pompeii and Herclaneum in 79 AD
  http://en.wikipedia.org/wiki/Stratovolcano

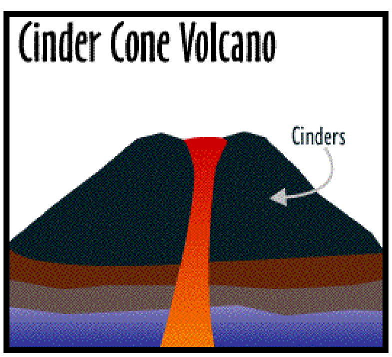
Mt. Fuji, Japan

3.) **Cinder Cones**

- **Profile:** steep conical hill made of tephra (pyroclastic debris), bowl-shaped crater at summit, common on flanks of shield and stratovolcanoes
- **Lava:** first explosive eruption, then quiet, oozy lava

with small amounts of gas

- **Viscosity:** intermediate-high viscosity
- **Silica Content:** 63-68%
- **Rock Type:** dacite, andecite
- **Examples**: Lava Butte, Oregon; Mount Fox, Australia
  http://en.wikipedia.org/wiki/Cinder_cone



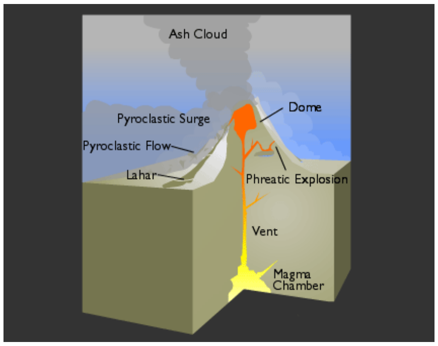
Cinder Cone at Little Lake, California

4.) **Lava Domes**

- **Profile:** rough, circular mound-shaped protrusion (a structural element in many stratovolcanoes)
- **Lava:** slow extrusion, extremely thick viscous lava, does not flow far from

the vent

- **Viscosity:** highest viscosity
- **Silica Content:** 68-77%
- **Rock Type:** Rhyolite
- **Examples**: inside the crater of Mount St. Helens, Mono-Inyo Craters in Eastern California http://en.wikipedia.org/wiki/Lava_dome




Lava Dome inside crater of Mt. St. Helens

Types of Rock

1.) Andesite

- Intermediate Temperature *(1742-2192 F)*
- Intermediate Viscosity
- Moderate Flow Rate
- Higher quartz content, lighter in color than basalt

2.) Dacite, Rhyolite

- Low Temperature *(Rhyolite: 1292-1652 F; Dacite: 1472-2012 F)*
- High Viscosity
- Low Flow Rate
- Fine-grained, white, pink or gray rock, high in quartz and feldspar

3.) Basalt

- High Temperature *(1832-2280 F)*
- Low Viscosity
- High Flow Rate
- Dense, black, massive rock, high in calcium and iron-magnesium, low in quartz content

Source: http://www.1000sciencefairprojects.com/Science-Experiments/Viscosity-and-Volcanoes.php

Features and Erupted Material

Viscosity: The resistance of a material (usually a fluid) to flow. Example of comparison would be the higher resistance to flow of cake batter compared to water.

Lava Flow: Lava flow is thin at the tope of the cone, while lava pooled at the base is very thick. When eruptions end, erosion processes start on the cooled lava, including glacier erosion, flowing water, rockfall, and landslides. The volcano will only grow in size if the amount/volume of lava erupted is more than the amount that is lost to erosion.

Volcanic Gases: Most gases originate in the mantle and are transported to the crust and surface by complex interactions with magma and rocks along the way. In general, gases are dissolved in the magma. At shallow depths, as pressure on the magma decreases, gases leave the magma. The gases can interact with surrounding rocks or continue to the surface.

The most common volcanic gases are: Water Vapor (H2O), Carbon Dioxide (CO2), and Sulfur Dioxide (SO2). Gases can be both dissolved in the magma chamber and also emitted from volcanoes at the surface. It's the dissolved gases cause volcanoes to erupt.

A magma chamber contains high pressure and dissolved gases. The density contrast between the magma and the surrounding rock causes more buoyant magma to rise. As the magma rises, the dissolved gases start to come out of the liquid and form bubbles. As the bubbles grow and increase in volume, it causes the magma to became more buoyant and ascend closer to the surface, allowing the overlying pressure to decrease and produce magmatic foam. When the pressure in the bubbles is greater than the pressure of the overlying rock, then the chamber will burst causing a volcanic eruption.

The viscosity, temperature and composition of the magma determine whether the explosion is explosive or effusive.

Source: Volcano World http://volcano.oregonstate.edu/volcano-factoids

Silica: Influences lava viscosity and overall shape of the volcano. Silica molecules form a strong bond that permits entrapment of volcanic gases and promotes explosive volcanic eruptions. Low-silican magmas allow rapid escape of gases and low-explosivity eruptions. Other factors that control magma viscosity include the temperature, gas, water content and the amount of crystals in the magma.

Color: Color and texture of lava vary considerably depending on cooling conditions. Lava rocks at high temperatures appear red to orange in color but cool quickly to shades of red (due to oxidation) and gray.

Sound: Witnesses of slow-moving, partially cooled lava flows report sounds similar to breaking of glass and pottery, caused by the splintering of the cooled outer skin of the lava flow. In contrast, the passing of a pyroclastic flow is eerily quiet. Some people say this is because its sound energy is absorbed within the billowing ash cloud.

Smell: Observers of lava flows report a slight sulfur smell in the air and the odor of burning vegetation.

Texture: Lava at Mount Rainier is not as fluid as lava at the volcanoes on Hawai'i, where lava flows sometimes resemble hot molasses, nor is it as viscous as lava at Mount St. Helens.

Tephra: fragmental material produced by a volcanic eruption regardless of composition, fragment size or emplacement mechanism. Also referred to as pyroclasms (airborne), and pyroclastic flows (on ground) and rocks. Tephra can stay in the stratosphere for days to weeks following an eruption. It can also reflect light and heat from the sun back into the atmosphere. Tephra mixed with precipitation can also be acidic and cause acidic rain and snowfall. Tephra is made up of ash (fragments of pulverized rock, minerals and volcanic glass), volcanic blocks (a mass of molten rock), and lapilli (little broken up pieces of molten or semi-molten lava ejected from eruption).

<u>Other Types of Volcanic Rock</u>

If a **rhyolite** lava flow cools quickly, it can quickly freeze into a black glassy substance called **obsidian**. When filled with bubbles of gas, and usually with explosive eruptions, the same lava will form **pumice**. If the same lave is allowed to cool slowly…it will form a light-colored, uniformly solid rock called rhyolite.

Pumice most commonly forms with rhyolite lava flows, though it has formed from dacite and andacite flows as well.

Pumice is so lightweight, it will float on water

Obsidian has been used for centuries in many countries for things such as weapons and art.

Utah Volcanoes

1.) **Sheild Volcanoes**: **Cedar Hill, Box Elder County (1,150,000 years old)**

Sheild volcanoes started to erupt about 12 million years ago after plate motions and resulting crustal forces changed. Compressional forces had eased and the crust started to stretch between the Wasatch Rang in Utah and the Sierra Nevada Range in California. This extension created splintered zones in the Earth's crust where magma rose to the surface creating shield volcanoes and cinder cones.

2.) **Stratovolcano**: **Mount Belknap, Tushar Mountains, Paiute County & Monroe Peak on the Sevier Plateau.**

Stratovolcanoes erupted in western Utah between 40-25 million years ago. At this time Utah was closer to a continental-oceanic plate boundary, where the oceanic plate was subducting undearneath the North American continental plate.

Now active volcanoes are located in the Cascade Range of Washington, Oregon and California.

3.) **Cinder Cone**: **Diamond Cinder Cone, Washington County (27K years old)**

4.) Santa Clara, North of St. George, *Dormant*

The Santa Clara volcanic field is volcanic area north of St. George in SW Utah, which has been active since abaout 4 million years ago. It contains numerous cinder cones and lava flows. The Santa Clara lava flow was erupted from 2 young cider cones above Snow Canyon about 10-20,000 years ago and is one of the youngest lava flows in the Colorado Plateau/Basin and Range region. The almost unvegetated lava flow extends 16 km to the south down Snow Canyon, excavated through rocks of the colorful Navajo Sandstone.

5.) Kolob Volcano, Zion National Park, *Extinct* (*probably*)

Kolob is a volcanic field in Zion National Park, Utah. It contains a chain of cinder cones and lava flows, the youngest one being the cinder cones in Diamond Valley. Other famous features of the area include the Kolob Canyons, Kolob Plateau, and Kolob Arch.

6.) Markagunt Plateau Volcano, Dixie National Forest, *Dormant*

The Markagunt Plateau volcanic field, located east of Cedar Breaks National Monument in SW Utah, is a group of cinder cones and lava vents on Markagunt Plateau. The youngest cinder cones are located near Panguitch Lake in the north and Navajo Lake in the south. Volcanic activity on the eastern Markagunt Plateau began about 5 million years ago and has been continuing up to the last eruption, which occurred only about 1,000 years ago. The date was obtained by dendrochronology, i.e. by counting the growth rings and thus, the age, of the oldest trees on the flow. A common maximum age of 900 years for the oldest present trees (big gnarled junipers (/. scapularium)) was found, which suggests the age of the flow being only about 1000 years old, if the first trees appeared to grow 100 years after the flow was emplaced.

Eruptions in the Markagunt Plateau field have produced basaltic flows at Miller Knoll, Cooper Knoll, and Henry Peaks, Duck Creek, at Bowers Flat, in Black Rock and in the upper Rock Creek valleys. The oldest episodes of volcanic activity produced silica-rich trachytic, andesitic and rhyolitic lavas, and were followed by extensive basaltic lavas occuring in 2 different ages. Several lines of NE-SW-trending cinder cones occur within the volcanic field. The most recent cinder cones were formed near Panguitch Lake in the north and Navajo Lake in the south. Navajo Lake formed when a thick, blocky flow from a nearby vent dammed Duck Creek. Young lava flows, many of which are fissure fed, have distinct margins and covered or diverted stream drainages, which have for the most part not been reestablished across the flows.

7.) Black Rock Desert Volcano, South Central Utah, *Dormant*

The Black Rock Desert volcanic field of a group of small volcanic fields in south central Utah, at the eastern margin of the Great Basin. It is the youngest volcanic area in Utah and contains both Utah's youngest known rhyolite dome (0.4 million years old) and its youngest lava flows, the roughly 660-year-old Ice Springs lava flows, located at Ice Springs, 15 km west of Meadow. These lava flows extend 4 km north and west from Black Rock Station.

The broader Black Rock Desert volcanic field includes several smaller lava fields and eruptive centers:

- **Deseret volcanic field** consists of basalt lava flows capping a small plateau about 8 km SW of the town of Deseret.
- **Pavant volcanic field** consists of a prominent cinder cone, Pavant Butte (Sugarloaf Mountain) located about 25 km west of Holden, Utah. The field contains mainly pahoehoe basalt flows around and to the south Pavant Butte, a large 270 m high tuff cone. The field contains many lava tubes.
- **Kanosh volcanic field** includes the Black Rock volcano itself, a dissected cinder cone with basalt lava flows at its base.
- **Tabernacle volcanic field**, located about 8 km northwest of Meadow, is the smallest of the volcanic fields in the Black Rock field and covers an area of about 12 km2. It contains basaltic flows erupted from the base of Tabernacle Hill, a small tuff cone in the center of the field.
- **Ice Spring volcanic field** is the youngest of the field, located about 15 km west of Meadow, and covers an area of 20 km2. The field contains 3 large and several smaller craters: Cresent crater (500 m diameter), Miter crater (300 m), and the collapsed cone of Terrace crater (300 m).
- **Cove Fort volcanic field**, located southwest of Cove Fort. Cove Fort crater is a reddish cinder cone about 1 km in diameter. A basalt lava flow extends 20 km SW of the crater.

8.) Binghman Canyon Mine (Kennecott Copper Mine)

The Bingham Canyon Mine, also known as the Kennecott Copper Mine, is an open-pit mining operation extracting a large porphyry copper deposit southwest of Salt Lake City, Utah, USA, in the Oquirrh Mountains. The mine is owned by Rio Tinto Group, an international mining and exploration company headquartered in the United Kingdom. The copper operations at Bingham Canyon Mine are managed through Kennecott Utah Copper Corporation which operates the mine, a concentrator plant, a smelter, and a refinery. The mine has been in production since 1906, and has resulted in the creation of a pit over 0.6 miles (0.97 km) deep, 2.5 miles (4 km) wide, and covering 1,900 acres (770 ha). It was designated a National Historic Landmark in 1966 under the name Bingham Canyon Open Pit Copper Mine.

The Bingham Canyon orebody is a porphyry copper deposit, formed by a quartz monzonite porphyry intruded into sedimentary rocks. It has the concentric alteration pattern and mineralogic zonation typical of porphyry copper deposits.

The oldest rocks at Bingham Canyon--sandstones, quartzites and limestones—were originally deposited as sediment by the shallow seas that covered the region 300 million years ago (in the late Paleozoic Era). Much later, between 60 and 135 million years ago, extensive folding and faulting of the sediments created the Oquirrh Mountains.

Thirty to 40 million years ago, massive igneous intrusions initiated the process of mineralization. Extreme pressure forced superheated, mineral-rich solutions into fractured intrusive and adjacent sedimentary rock. Upon cooling, the mineralized solutions deposited enormous quantities of metals throughout a broad section of igneous and sedimentary rock that is now known as the Bingham Stock.

Bingham Canyon is not presently a source of notable mineral specimens. The Bingham Stock is a porphyry deposit, meaning that copper minerals—primarily chalcopyrite—are present in very low grades and disseminated throughout the granite-like host rock as tiny grains, seams and fracture coatings.

9.) Bald Knoll Volcano, Southern Utah, Dormant

Bald Knoll is the youngest of a group of basaltic cinder cones on the SW part of the Paunsaugunt Plateau in southern Utah, between the southern end of Bryce Canyon National Park and the western margin of Grand Staircase-Escalante National Monument. The Bald Knoll cinder cone probably erupted only a few thousands years ago. It has an intact crater, which has produced a massive youthful-looking lava flow that traveled about 12 km to the SSE. Buck Knoll and Black Knoll are 2 other cinder cones to the west, located on the western side of Kanab Creek.