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American Volcanoes: Mt. St. Helens and Kilauea

Julie Wirts, Coley Dale

In researching volcanoes, scientists attempt to determine why volcanoes act the way they do. The study of volcanoes is necessary so that one can learn the contrasting elements of volcanoes throughout the world. We picked the volcanoes Mt. St. Helens and Kilauea, because these volcanoes exemplify how differently various volcanoes can behave. The reasons for the disparity in eruptions can be attributed to the location, architecture and shape, magma composition, and plate tectonics of each volcano. Kilauea, in Hawaii, is located on an ocean hot spot, from which plumes of hot mantle rock rise to be stored in the oceanic crust before erupting. Kilauea is made of basaltic magma, which typically results in temperate eruptions. Gas from the basaltic lava escapes easily increasing the fluidity of the lava. The runny lava can escape easily from the vents, and the resulting gentle lava flows create a volcano classified as a shield volcano. This type of volcano is very predictable and poses little threat to society. Mt. St. Helens, in Washington State, is formed along a subduction zone, in which hot molten rock rises up through the lithosphere and erupts at the surface as andesitic lava. The lava within these volcanoes is very viscous and has a difficult time erupting. Pressure is built up within the volcano, resulting in a large explosion. The fall-out from these huge explosions results in a tall cone shaped volcano commonly called a stratovolcano. These eruptions are hard to predict, leading to a potentially dangerous situation for people and communities. This type of volcano can cause a great deal of destruction from the force of its eruption. Thus by looking at the characteristics of a volcano, one can determine its potential for destruction on the Earth.

Through the study of Mt. Kilauea and Mt. St. Helens, one can examine two U.S. Volcanoes that contrast in a number of ways. Specifically, one may examine the force of the eruption, the geographical location, the architecture and shape, the magma composition, and the effects of the two volcanoes on the Earth's environment during their most active moments. Looking at the volcano's shape, a volcano is classified as a Shield, Strato, or Caldera volcano. One may use the results of the volcano investigation to categorize other volcanoes throughout the world. Mt. Kilauea and Mt. St. Helens are great examples of how different volcanoes can be. While Mt. Kilauea has proven to be relatively peaceful during its active period, Mt. St. Helens' eruption in 1980 showed a tremendous amount of force, and caused a vast amount of damage and destruction. One can conclude that while both mountain structures can be a called a volcano, Mt. Kilauea and Mt. St. Helens are also natural formations of considerable disparity.

Mt. Kilauea, found in Hawaii, is a prime example of a shield volcano. It is a volcano that forms under an ocean and is made of pillow basalt. It is located on one of the Earth's many hot spots in the ocean, where plumes of hot mantle rise from the boundary between the core and lower mantle, bringing basaltic magma to the earth's surface. Hot spot volcanoes erupt without the aid of plate tectonics that occur in convergent and divergent boundaries. They form above plumes of hot mantle rock that rises from the core-mantle boundary. The plumes are formed when heat from the earth's core warms the base of the mantle, causing the mantle to become buoyant and move upwards. When the hot rock of the plume rises to the base of the lithosphere, decompression causes the rock of the plume to partially melt and create a mafic magma. The magma rises through the lithosphere, pools in a chamber in the crust and then erupts at the surface to form a volcano (Marshak, 2001). As the plate moves over the mantle plume, the volcano moves off the hot spot. It becomes inactive and a new volcano forms over the hotspot. Because of this trend one sees seamount and island chains of active and inactive volcanoes

(Marshak, 2001). It is one of the most active volcanos on earth, and over 90% of its surface is covered by lava less than 1000 years old.[1] Lava flows on Kilauea are moderate, sending streams of lava smoothly down the sides of the mountain. They generally occur around the summit and rift zones of the volcano.[2] Because the viscosity of the lava is so low, the volcano is unable to form a large cone shaped mountain. The lava spreads out rather than up, and giant shield like volcanoes are created. More viscous lava would enable the volcano to grow upwards through the layering of thick cooled off magma. Sometimes Kilauea lava eruptions are more explosive, and lava fountains spout up in the air to heights of 470 meters[3]. The lava then accumulates in lava lakes around the vent from which the lava was ejected.

Shield volcanoes are formed as lava continually piles on top of old lava fields, eventually increasing the size of the volcano. Kilauea, along with many other shield volcanoes, is made of basaltic magma, which typically results in temperate eruptions. Gas from the basaltic lava escapes easily increasing the fluidity of the lava. This tends to create a volcano that is more effusive than explosive. The runny lava can escape easily from the vents, rather than getting trapped in the volcanic structure and causing a huge explosion. It has been noted however, that Kilauea has erupted violently in the past. In 1790, a violent eruption killed many people gathered together in a war party. Footprints from the gathering still remain evident today.[4] Such eruptions are very rare, and Kilauea's shield-shape can be attributed to its gentle and moderate lava flows.

Figure 1: View of Pu`u `O`o from the north. (from: http://hvo.wr.usgs.gov/gallery/kilauea/erupt/2553023_caption.html)

Kilauea's first eruption is called the Pu`u `O`o -Kupaianaha, and began on January 3rd, 1983. Centered on the Pu`u `O`o vent, the volcano erupted every three to four weeks for a period of three years. The first stage of the Pu`u `O`o eruption was characterized by high fountains and extensive 'a' a flows, which are the "more viscous and crystalline of the two types of Hawaiian lava. `A`a flows from Pu`u `O`o typically 3-5 m thick and advanced at speeds of 50-500 m/hr."[5] Such flows eventually destroyed various structures and roads. There was considerable debris and fallout from the eruption's enormous lava fountains. A large 255-meter tall cone was created in the east rift zone, which can be seen in figure 1.

It should be noted that a great deal of the debris ejected from the volcano landed on the downwind side of the cone (the right side).[6] The eruption eventually shifted to another site, where there were less fountains and more continuous flows from lava lakes. The eruption was called Kupaianaha, where lava called pahoehoe (which is less viscous) ran in lava tubes to the ocean, which can be clearly seen in figure 2.[7]

The lava tubes are mostly underground, and in this photo one can see the low-viscosity magma through an opening in the tubes. In the distance steam is clearly evident. The steam is a result of the heating of the ocean-water from the deposited hot magma. After enough lava was steered towards the ocean, it started to created new beaches and expanded the Hawaiian land mass. The lava tubes started to break, and surface flows became commonplace during this 5 year eruption.[8] As the Kupaianaha eruption slowed down in 1991, a crater that had been formed in Pu`u `O`o, began to fill up with lava. Ultimately, the Kupaianaha site was inactive, and the Pu`u `O`o site once again became the center of activity. Flows continued for several years, all having the same characteristic lava tubes leading to the ocean. On occasion, (the greatest example being in 1998), the lava flows overtook the crater or the lava tubes and created surface lava flows. The Pu`u `O`o crater continued to flow lava until other sites along the mountain became increasingly active in the late nineties.[9] Very few houses and structures have been destroyed by the predictable lava flows. The volcano is of little threat to its neighboring residents, and is also a popular tourist attraction in Hawaii. By January 2001, the volcano has also created 207 hectares of additional landmass to Kilauea's southern shore.[10]

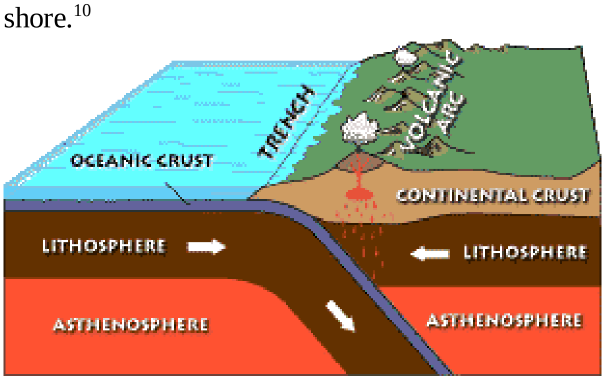

Figure 3: Diagram of a subduction zone. (from : http://www.aqd.nps.gov/grd/usgsnps/pltec/converge.html)

While shield volcanoes are relatively calm and safe, a stratovolcano, also called a composite volcano, is powerful and at times may be deadly. Located in Southwestern Washington, Mt. St. Helens is an example of a volcano that has produced highly explosive eruptions. The Cascade Range is home to several active volcanoes, but only St. Helens has had a significant eruption in the past twenty-five years. However, the eruption at Mt. St. Helens was relatively small in comparison to other volcanic activity throughout the history of the Earth. A strato volcano can cause a great deal of damage and destruction. They have distinctive features, which distinguish them from their calmer shield counterparts. The creation of this volcano involves convergent plate tectonics.

These types of volcanoes are generally found along subduction zones, where one plate dives down below another one, usually along a coastline. Oceanic lithosphere subducts and sinks into the mantle. The oceanic lithosphere is made up of oceanic crust and underlying mantle material. When the plate sinks into the mantle, gaseous materials like water and carbon dioxide boil off the suducting plate and rise into the overlying hot mantle. This process generates hot

Figure 2: Skylight in lava tube. (from: http://hvo.wr.usgs.gov/gallery/kilauea/erupt/2553008_caption.html)

molten rock that rises up through the lithosphere and erupts at the surface as andesitic lava.

This process is clearly illustrated in figure 3, as the oceanic plate dives below the continental plate. An important aspect of a composite volcano is its conduit system. Magma from a reservoir in the Earth's crust rises to the surface. The volcano is formed through the accumulation of material erupted through the conduit. The volcano grows larger as lava, cinders, ash, etc, are added to its slope.[11]

The andesitic lava within these volcanoes is very viscous, and is unable to erupt with the same frequency and predictability as shield volcanoes.

Figure 4: Mt. St. Helens with bulge (http://pubs.usgs.gov/publications/msh/reawakening.html)

Because these volcanoes have a difficult time erupting, pressure is able to build up inside the volcano, resulting in a large explosion. Geologists often give the example of shaking up a carbonated drink, or soda bottle. When the cap is removed after shaking, the pressure built up inside the bottle creates an upsurge in the gas, and the gas escapes rapidly. The same process occurs within a composite volcano. The pressure in the volcano builds up because the gas cannot escape, and when the gas finally escapes the result may be a huge explosion.

The eruption of Mt. St. Helens on May 18, 1980 was a relatively small-scale eruption in comparison to other historical explosions, but the publicity and attention it received gave the volcano an aura of greatness. An earthquake noted the mountain's magma activity almost two months before the eruption actually occurred. "A magnitude 4.2 (Richter Scale) earthquake on March 20, 1980, at 3:47 p.m. Pacific Standard Time (PST), preceded by several much smaller earthquakes beginning as early as March 16, was the first substantial indication of Mount St. Helens' awakening from its 123-year sleep."[12] The usually inactive volcano had begun to show signs of activity, and an increasing amount of earthquakes indicated that an eruption was near. Other signs of activity included small outbreaks of steam and gas from the Volcano. Eventually, an outward growth, or a "bulge", grew on Mt. St. Helens as seen in figure 4. The bulge changed the shape of the mountain, and it grew at an alarming rate. Scientists documented the growth of the bulge and found that it had the potential to inflict serious consequences.

May 18th, 1980, a 5.1 magnitude earthquake occurred one mile beneath the volcano, causing an eruption to occur at 8:32 PDT. The earthquake triggered what is known to be the largest landslide in recorded history.[13] The whole bulge slid away as a result of the earthquake, and the landslide was the initial part of the eruption.

> *The series of slide blocks merged down slope into a gigantic debris avalanche, which moved northward at speeds of 110 to 155 miles an hour... At one location, about 4 miles north of the summit, the advancing front of the avalanche still had sufficient momentum to flow over a ridge more than 1,150 feet high... Covering an area of about 24 square miles, the debris avalanche advanced more than 13 miles down the North Fork of the Toutle River and filled the valley to an average depth of about 150 feet; the total volume of the deposit was about 0.7 cubic mile.*[14]

The catastrophic landslide left a large part of the mountain exposed, and the landslide caused a lateral blast of volcanic debris, the killing of 57 individuals and massive amounts of destruction. Because the interior of the mountain was exposed on one side of the mountain (due to sliding of the "bulge"), the eruption was a lateral blast rather than a vertical blast. The explosion had a velocity of 300 to 670 miles per hour, covered 230 square miles, and reached a distance of 17 miles northwest of the crater. Some areas reached temperatures of 660 degrees Fahrenheit.[15] There was also evidence of hot pyroclastic lava flows, formed by "the direct frothing over at the vent of magma undergoing rapid gas loss". This type of lava frothing is called pumice[16]. Mt. St. Helens destroyed countless trees, creating a flattened landscape around the Volcano.

Figure 5:Trees blown down by the lateral blast (http://pubs.usgs.gov/publications/msh/lateral.html)

At first glance, one might assume that figure 5 is nothing more than a close up of a pine tree, but in reality it is a field of blown over trees. The blast flattened trees and destroyed everything in its path. There were three areas the explosion affected, covering more than nineteen miles outward from the Volcano. The Direct Blast Zone was around 8 miles in radius, and about everything in this area was destroyed and carried away by the lava. The next area was called the Channelized Blast Zone, which extended about nineteen miles from the mountain. The most distinctive characteristic of this zone is that one can see the strength of the explosion. The "parallel alignment" of collapsed trees shows the direction and power of the lateral blast. The last zone is known as the Seared Zone, because trees in this area were not destroyed, but many turned brown from the gasses, heat, and force of the explosion.[17] In figure 6, one can clearly distinguish the three zones, as they are all marked distinctively. The direct blast zone is the inner-most circle, while the channelized blast zone is the middle area. The seared zone makes up much of the perimeter of the affected area around Mt. St. Helens.

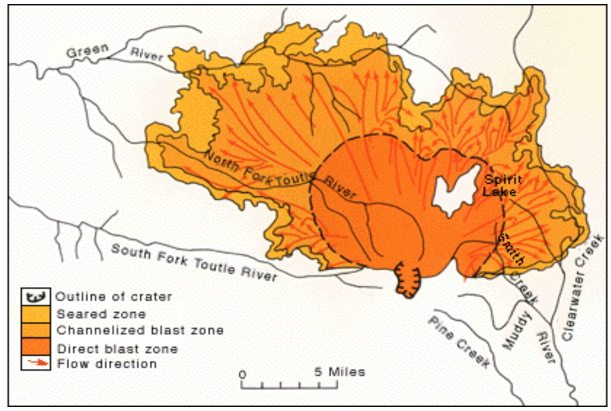

Figure 6: Map of affected area (http://pubs.usgs.gov/publications/msh/lateral.html)

After the initial blast, ash and fallout rained down on the Pacific Northwest and parts of Montana. St. Helens discharged 540 million tons of ash over 22,000 miles.[18] Other dangers resulting from the violent eruption included mudflows, caused by the melting of glaciers and snow atop Mt. St. Helens. These flows (lahars) contain sediment and debris, often destroying anything in its path.

> *The mudflows in the Toutle River drainage area ultimately dumped more than 65 million cubic yards of sediment along the lower Cowlitz and Columbia Rivers. The water-carrying capacity of the Cowlitz River was reduced by 85 percent, and the depth of the Columbia River navigational channel was decreased from 39 feet to less than 13 feet, disrupting river traffic and choking off ocean shipping.*[19]

Such mudflows deposited sediment in rivers and streams, and reduced the amount of water that rivers, lakes and streams could contain. This volcano's explosion is much greater than that of Mt. Kilauea. One cannot assume that all volcanoes are the same, because each structure has is own unique characteristics. Studying these two volcanoes can help scientists to classify volcanoes and determine the potential danger of various volcanoes on the Earth.

Through the study of Mt. St. Helens and Mt.

Kilauea, one is able to gain a better understanding of the various types of Volcanoes located on the Earth. It can be concluded that not all volcanoes are the same, and they can be categorized as a shield, strato, or caldera volcano. In classifying a volcano, one must take into account such factors as the force, geographic location, after effects, magma composition, and architecture and shape of each volcanic structure. Mt. St. Helens and Mt. Kilauea are two volcanoes that contrast in a number of ways. Through the examination of the characteristics of these two structures, an idea can be formed of how to classify various volcanoes on the Earth and determine their threat and potential danger to the environment.

References and Footnotes

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