

Here Comes Da Boom:
The Effect of Volcanoes on the Four Spheres of the Earth

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As we all know, volcanoes are some of the most violent and dangerous forces of nature. They have the ability to alter the landscape of an area, the hydrosphere, the atmosphere, the biosphere, and the geosphere. As a result of their destructive power, it is necessary that scientists and potential victims are made aware of the repercussions of a volcanic explosion.

For our project, our group will focus on various volcanoes with an emphasis on volcanoes from Hawaii, Italy, and Costa Rica. This will include a brief review of the formation and structure of volcanoes. We will also focus on how these volcanoes affect the biosphere, atmosphere, hydrosphere, and geosphere. We will compare the effects of various volcanoes on their surroundings, which are dependent on their shape, structure, and formation. We will include pictures and details from first-hand accounts concerning volcanoes in Hawaii, Costa Rica, and Italy. This will enlighten the class with a student's perspective of the effects and consequences of these natural disasters.

Although the volcanoes may not be geologically located near everyone, all people are affected by them, for volcanoes have an influence on the earth's hydrosphere, atmosphere, biosphere, and geosphere. Kilauea and Mauna Loa, Hawaii's two most active volcanoes, are continuously altering the atmosphere and hydrosphere with their addition of sulfur dioxide and the biosphere with the enormous amounts of lava. The volcanoes Arenal and Irazú of Costa Rica are both a blessing and a curse to the country because they affect the hydrosphere and biosphere by cyclically producing fertile lands and destroying them. In Italy, Mount Vesuvius and Mount Etna pose threats to the population due to unpredictable and dangerous eruptions. All of these volcanoes have the potential to change their surroundings, and it is vital that humans work to understand them if we are to benefit from them.

Section I

The Volcanoes of Hawaii

The Hawaiian Islands formed as a result of hot spots. Plumes of magma rise from the mantle to the surface of the earth at the Hawaiian hot spot while the Pacific Plate slides above them. The islands, composed mainly of basalt, formed after volcanoes arose above the hot spots and then were carried away from their place of origin as the plate moved (Lindemann). The hot spot is currently located under the Big Island of Hawaii which is at the southeast end of the chain. The islands towards the northwestern end of the chain formed first and are therefore more apt to erosion, extinction, and submersion (Decker and Decker 92-95). Although the entire island chain is composed of volcanoes, we will discuss only Kilauea and Mauna Loa, the two active volcanoes of Hawaii (Wright, Takahashi, and Griggs 1).

Mauna Loa Volcano

Volcanoes have affected Hawaiians for hundreds of years in various ways. The shield volcano Mauna Loa, the earth's highest volcano with a height of 4170 meters above sea level, is one of the five volcanoes located on the Big Island of Hawaii (Francis 27). A shield volcano has a gentle slope and usually emits fluid basaltic lava through a central vent. The layers of fluid lava have accumulated to form a barren landscape, but many Hawaiian plants and animals have adapted to survive in this type of environment

(Minicola and Rubin). Hawaiian volcanoes produce two types of lava: a'ā and pahoehoe. A'ā lava usually has a very rough surface; whereas, pahoehoe has a smooth and shiny surface (Wright, Takahashi, and Griggs 132). Plants are more likely to recuperate from an eruption of a'ā lava because it contains more cracks than pahoehoe; therefore, it is easier for the plants to receive sunlight and rainfall and for soil to accumulate (“Learning Objective”).

Kilauea Volcano

The shield volcano Kilauea is also located on the Big Island of Hawaii and measures 1200 meters above sea level (Francis 27). It is Hawaii's most active volcano (Wright, Takahashi, and Griggs 1). During the past 1500 years, lava from this volcano has covered more than ninety percent of its land area (Wright, Takahashi, and Griggs 139-140). In 1955, Kilauea erupted for the first time since 1840. The eruption resulted in earthquakes, tilting, and the destruction of land used for agriculture (Wright, Takahashi, and Griggs 86). After the eruption of 1959, ash covered an area of 500 ha, which was later referred to as the “Devastation Area” because of its horrendous effects on the vegetation. The majority of the wildlife in this area was destroyed (Smathers and Mueller-Dombois 1). Plant survival depends on three factors including: the depth of the volcanic debris, the size of the plant, and the plants ability for regrowth. Herbaceous plants have a high survival rate after eruptions because they have storage organs underground (Smathers and Mueller-Dombois 89).

Eruptions from Hawaiian volcanoes greatly influence the biosphere. Although it is rare for animals and insects to have the ability to survive on a landscape composed of only barren lava, some species of spiders and crickets have evolved in such a way that they can thrive in these habitats. The spiders consume the crickets for nourishment, and the crickets live off of tiny debris that is carried by the wind across the lava. The replenishment of plants on barren lava flows depends highly on the abundance of seeds near the lava flow and the amount of water that comes in contact with it (“Volcano World”).

Kilauea has a tremendous effect on the earth's atmosphere. It alters the composition of the atmosphere, for it releases 1,000 to 2,000 tons of sulfur dioxide a day. The sulfur dioxide eventually forms particles as it reacts with other gases released by the

volcano. These particles, which tend to accumulate on the leeward side of the island, contribute to the formation of acid rain and the pollution in the atmosphere. The pollution caused by the eruptions of Kilauea is also a cause of the present drought on the Big Island because it inhibits the formation of raindrops (“Long-lasting Eruption”). In 1955, a man named Doty contributed evidence to the idea that volcanic pollution leads to droughts when he studied the lava in the humid climate on the eastern side of Kilauea. He noticed that blue-green algae appeared 3 months after the lava ceased to flow and cryptogamic and vascular plants appeared after 6 months, but after 14 months the plants died due to drought (Smathers and Mueller-Dombois 4-5). The gases emitted by Kilauea are also harmful to people. They can cause severe respiratory problems in humans (“Researchers” and Sutton et al.).

Comparing Kilauea’s and Mauna Loa’s Biosphere

In 1941, a man named Skottsberg compared vegetation growth of Hawaii’s two types of lava on Kilauea and Mauna Loa. Skottsberg studied the 1920 eruption of Kilauea that occurred during the summer in the Kau Desert and the 1919 eruption of Mauna Loa that occurred during the rainy season in the southwestern part of the Big Island. His data showed that plants recovered quicker and more diversely from the eruption in the wet climate, than they did in the dry climate. He also discovered that vascular plants recovered easier on pahoehoe lava, and cryptograms (mosses and lichens) recovered easier on a’ a lava (Smathers and Mueller-Dombois 4-5).

Section II

The Volcanoes of Costa Rica

There are several powerful and violent volcanoes located in Costa Rica, and we will be focusing on all four, one volcano-spawned beach, a volcano-originated island, and the impact that these regions have on the surrounding biosphere, hydrosphere and atmosphere.

Rincón de la Vieja Volcano

The first volcano we encounter is the Rincón de la Vieja Volcano, located in the Rincón de la Vieja National Park. This volcano is a 1,926-meter high composite volcano, formed thousands of years ago by several simultaneous eruptions . This chain contains

nine mouths, two of which are still active, and the other seven are in the process of extinction. There are two areas on the southern slope, called Las Pailas and Las Hornillas, which contain hot springs, mud-pots, and sulfur lakes. These formations are quite stereotypical of volcanic activity. The last notable activity from the volcano occurred between 1966 and 1970, which was not extremely violent, but included tremors and columns of ash. Most of the activity today includes phreatic eruptions (relating to ground water) and the emission of ash and gas. Lahars are produced by the displacement of the crater lake. Biologically, the national park includes four life zones, one of which is a pure cupey forest (hardwood) close to the summit. This area is especially interesting due to the rich diversity of wildlife that thrives despite the volcano being active. This diversity includes tapirs, three-wattled bellbirds, morpho butterflies, and a large growth of the purple orchid, the Costa Rican national flower (Boza 56). To gain a better understanding of the importance of this particular balance, I would recommend visiting <http://www.museumofconceptualart.com/nature/birdsounds/bellbird.html> (Vickers) to hear the unique call of the three-wattled bellbird, which is particular to this area.

Poás Volcano

The second volcano is Poás. Poás is a basaltic volcano, 2,708 meters high. It has been called “the world’s biggest geyser”, because it sporadically erupts steam and muddy water. It was last active in 1952 to 1954, with tremors, clouds of ash and incandescent rocks (Boza 62). Today, there are many active fumaroles in the crater’s interior, and it is known to give off steam often. Poás has a caldera in its center, and it is called Botos Lake. Within the national park, there are 4 habitats. This includes blueberry thickets, dwarf vegetation, and cloud forests (which are important to hydrology, as they store and filter drinking water for communities near and far) (Sheck 196). There is no vegetation around the crater lip, as the whole area is covered in ash (Rowland). There is a lack of wildlife here due to the volcano’s activity and lack of vegetation, but strangely enough, many birds, including hummingbirds and sooty robins, thrive (Boza 63).

Irazú Volcano

Inside Irazú Volcano National Park lies “the deadly powder keg of nature” (Boza 66). Irazú Volcano is one of the most dangerous and violent volcanoes in Costa Rica. It reaches 3,432 meters high and it is composed of two craters (Sheck 188). The

extinguished mouth is called Diego de la Haya Crater. The western crater contains a lake in the bottom (caldera) which changes colors depending on the type of gas and chemicals being emitted at that time, depending upon activity. The beginning of the recent era of this volcano's activity was between 1962 and 1965, when it suddenly erupted super hot breccia and ash (Boza 67). After its initial violent rebirth, remnants can be found on the hill sides near it, where volcanic rocks pepper the landscape, and cross-sections would produce the memories of many floods which buried whole areas, mud flows, steam clouds, breccia and ash. Fumeroles that produce gases and vapors dot the northwestern slope. All of this activity produces rich agricultural soils, which the natives then use to produce great quantities of food, until the next great eruption, which will keep this area surviving on its cycle of destruction and rebirth (Sheck 188). The area around Irazú Volcano contains scarce animal life due to this cycle, and the only vegetation consists of twisted blueberry thickets (Boza 68).

Arenal Volcano

Fourth and our last volcano, Arenal is part of the central volcanic range. One of the smallest volcanoes in the country, it reaches only 1,657 meters above sea level, yet it is the most active and dangerous volcanoes to be found here. On average, it has 5-6 eruptions daily, though it has risen to 32 in a day! These daily eruptions include underground rumbling and ash columns. It is Costa Rica's youngest stratovolcano, and it was built by the eruptions of the older Chato volcano, and they were both active until about 3,500 years ago, when Chato became extinct. The recent active period began in 1968, and it has had strombolian type eruptions ever since, meaning they are moderate and frequent. The reawakening of Arenal was sudden and violent. At 7:30 AM, July 29, 1968, Arenal "Mountain" suddenly exploded, blowing "a huge hole out the side of the mountain killing 87 people and buried 3 small villages". It continued to erupt violently for days after that, destroying many lives and much of the property and livestock of the farmers living at the base and the on the slope (Arenal Eruptions).

To perhaps add a positive point amongst the devastation, the money made by the farmers was compensated for and surpassed by the tourists who come in flocks to see the volcano. This is part of the reason why Costa Rica's greatest economic moneymaker is their tourist business. This influences the biosphere inasmuch that people will move to

the areas where money is to be made, even if it means living next to a volcano. The hotels and most of the tourist spots are far enough away that an eruption should not put lives in danger, though some of the trails up the volcano are routinely closed due to unpredictable eruptions. There are warnings posted during these times that state quite clearly that to continue up the trail, you risk an encounter with a pyroclastic flow which “you cannot outrun”. More currently, on September 5, 2003, the volcano had a pyroclastic flow when one of the sides of a crater caved in and sent 4 consecutive flows down the volcano within 45 minutes (Volcano World). It is this type of danger that reinforces the influences of a volcano on the biosphere (destroying forests on the slope of the flow), the atmosphere (producing chemicals which will lead to acid rain), and indeed the hydrosphere (acid rain and chemicals infiltrating into Arenal Lake) around the volcano.

Tabacón Hot Springs

A perfect example of the influence Arenal has on the biosphere and hydrosphere of the surrounding areas is exemplified by the hot springs, a very catered-to-tourists area where water heated by the volcano flows down into a kind of paradise where visitors can swim. The water verges on 40 ° C and can become quite uncomfortable because it is so hot due to the magma. The sheer volume of vegetation is amazing, as most of it is natural, and is only landscaped to prevent overgrowth.

Curú National Wildlife Refuge

This refuge consists of three beaches, one composed of black sand. This sand is a remnant of the active volcanoes nearby which shaped the area. It contains a large amount of plant and animal life, both on land and in the ocean, and because it is a refuge, the volcanoes are a lot less of a threat, unless they all erupt at one time, which has been known to happen. It contains deciduous forests, semi-deciduous forests, a mangrove swamp, and littoral woodland. In addition, these life zones contain 115 species of bird (sighted), giant conch, lobster, monkeys, and chitons. As a note, the other two beaches are composed of white sand, a product of the ground coral reefs that surround the coast (Boza 31).

Coco Island National Park

Coco Island is proof of to what extent volcanoes can influence areas near and distant to them. It is a two million-year-old island produced from volcanic origins. It is the only outcrop of the Cocos Ridge, which is a chain of volcanoes that reaches from Costa Rica to the Galapagos Islands. The coastline is very jagged and it has a fractured terrain, which gives rise to many waterfalls. This demonstrates just some of the effect of the erosion on volcanic land and islands. Coco Island is home to 235 species of plants, 85 of birds, 3 of spiders, 2 of lizards, 200+ of fish, 57 of crustaceans, and more. It is also an important breeding ground to the red booby, black noddy, and white tern, all of which nest nowhere else in Costa Rica (Boza 54). This fact should serve to reinforce just how important the effects of volcanoes, even if they formed millions of years ago, have come to be so important in the modern world's biosphere and hydrosphere. Finally, just as Arenal Volcano is one of the most studied volcanoes in Costa Rica due to its unique characteristics, so the same holds for Coco Island and its influence on the biosphere.

Section III

Italian Volcanoes

In looking at how volcanoes affect the world's environment, one can take notice of the Italian volcano of Mount Vesuvius. Mount Vesuvius is a complex composite of older stratovolcano and a younger crater. Its oldest volcanic deposits date back 25,000 years. The recent volcanic activity of Mount Vesuvius is a result of the development inside of the Somma caldera. Its activity gives scientists a reason for calling this the Somma-Vesuvius complex ("Vesuvio (Vesuvius) Volcano").

Mount Vesuvius' most recent and obvious effect on the environment has been on the atmosphere. Scientists have discovered that ash plumes pose a major threat to aircraft in this area. This hazard has drawn attention from the scientific and local community for the past 15 years because of near fatal encounters with airborne volcanic ash in Indonesia and Alaska. This hazard has been an important issue to take into consideration ("Vesuvio (Vesuvius) Volcano").

Mount Vesuvius' Affect on Geosphere

Another interesting aspect of Mount Vesuvius is its effect on the geosphere. This unique structure is a complex that receives its lava flow from the caldera of Mount Somma. This volcano has recently been characterized by a series of eruptions, from ten eruptions in a period beginning in 1631 and ending in 1944. Within this period there have been small-scale and moderate-scale eruptions. Small-scale eruptions are those that have 10^6 to 10^7 cubic meters of eruptive debris. A mixture of explosive and effusive activity categorizes these eruptions. Moderate-scale eruptions are characterized by their explosive activity. They have 10^8 cubic meters of breccia and ash. Vesuvius has been considered a hazardously active volcano because of its eruptive history. The year 1944 marked the beginning of a quiescent period, which is a period of low activity. Vesuvius' history shows that the longer the quiescent period, the more violent its reactivation will be (“Vesuvio (Vesuvius) Volcano”).

Mount Etna

Another Italian volcano to take note of is Mount Etna. The Sicilian volcano is believed to have started its activity about a half a million years ago. It is said to have developed from regional tectonic uplift in the marine gulf around the area that is now Etna. It is currently one of the most fertile regions across the Mediterranean Sea. Etna can be used to describe how volcanoes interact with the biosphere (“Etna and Man”). The eruptions of the locally called, "Muntagna" or "the mountain" have a positive and negative effect on the biosphere. For example, the volcanism of this area has given it some of the most fertile land in the Mediterranean. But on the other hand, when eruptions occur, the lava destroys everything in its path. The human relationship with Etna is complex. The fertile land gives man a prosperous setting, but the threat of the eruption forces its inhabitants to find ways to protect themselves from lava flows (“Etna and Man”).

In conclusion, we have shown how the volcanoes of Hawaii, Costa Rica, and Italy constitute a major aspect of our universe. The volcanoes in these areas affect all four spheres of the earth above the crust. They contribute poisonous gases to the atmosphere, chemicals to the water supply, alter the landscape, and influence the evolution of many plant and animal species in the biosphere. If humans continue to increase their awareness

of the destructive and chaotic forces of volcanoes, we can learn to decrease their detrimental effects and increase their benefits in our world.

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