The Impacts of Volcanoes on Guatemala and its People

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ABSTRACT

Volcanoes are natural landforms caused by tectonic processes. They profoundly influence the physical, climatic, and cultural areas within their proximity. Although they can be considered hazards that have the potential to destroy whole communities, they also serve as sources of fertile soil and protection and have great cultural and religious significance in some communities. Guatemala has the highest density of active volcanoes anywhere on earth. The way that the people of Guatemala, including the Mayan people, have dealt with volcanoes over the years is very fascinating and interesting. As much harm can come from these pillars of destruction, many good things also come from them, including some of the best farming soil in the world. This project investigated the impacts of these volcanoes on the physical and cultural geography of this area. The results indicated that Guatemala knows how to deal with natural disaster better than most around the world.

INTRODUCTION

People have settled in areas frequently devastated by natural disasters throughout human history. San Francisco is one of the most populated cities in the United States, yet it receives earthquakes almost daily. The rainy season in India regularly brings in hurricanes, yet India's population keeps booming.

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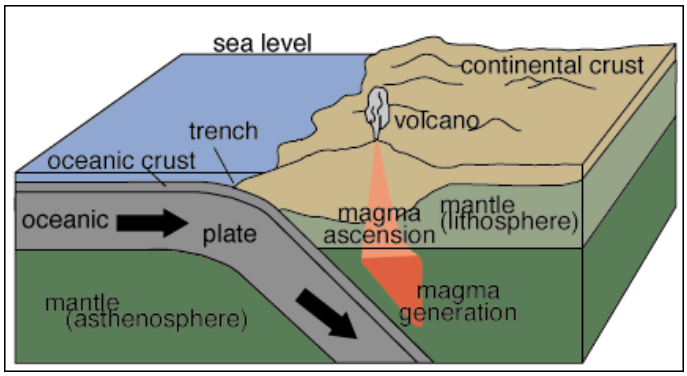

Figure 1. The subduction process (Plate tectonics)

TECTONIC PROCESSES

Plate tectonics move underneath the ground and sit upon magma (underground lava). That is how we have the arrangements of our land masses today, which is much different from what it used to be, which we call "Pangaea.". Pangaea was one land mass over 180 million years ago, during the Jurassic period. Slowly, after millions of years, the plates drifted apart. They separated enough to form oceans and seas and many different bodies of water. The figure above shows the process of subduction, which occurs when one plate rides over the top of another plate, causing breaks and cracks within the plate. Subduction allows magma to rise and flow to the surface. Some of these plates even ran into each other, making mountain ranges like the Rockies, the Alps, and even the Himalayas.

Guatemala lies above the intersection of the Caribbean and the Cocos plates, which

are moving into each other at a very slow rate. This intersection is causing a crack in the mantle. This mantle shoots up and out the top of the folding of the plates, which after millions of years have formed into huge mountains, which we call volcanoes. Guatemala is part of the Ring of Fire, which is a crudely shaped circle of earthquake and volcanic hot spots circling the Pacific Ocean.

HISTORY

While it is not certain, most historians agree that Mayan civilization started in Guatemala about 4000 years ago. The Mayans are considered to be the most developed peoples of their time. They had a vast trade route set up and

traded materials such as seashells, fish, cotton, and macaw feathers. City centers were set up which involved kings, temples and plazas. For about the next 2500 years, the Mayan community grew and flourished. The Mayans came up with their own writing system, calendars, and even a monarchy. An unknown event happened in Teotihuacan around 600 A.D. which destroyed the main city, and with this destruction much of the civilization started a spiral downward. Then in 1511, the Mayans encountered Europeans for the first time in the form of Gonzalo Guerrero, a Spaniard whose boat was shipwrecked off the Yucatan coast. Six years later Hernandez de Cordoba starts a war against the Mayans, bringing with him new diseases and sicknesses that were alien to the Mayans. Since this time, Mayans have become a big part of the Guatemalan population, comprising of about half of the total population (Rymer).

LAVA AND TEPHRA

It is important to discuss lava flow and tephra fall when dealing with volcanic eruptions. This idea is quite simple: Extremely hot lava flows over the crop, burning it and killing it instantly. Lava, which reaches temperatures of 2,000°F (1,093.3°C), has been known to start fires as it flows down the mountainside. Hot lava flowing down at 125 miles an hour down the side of a hill, wiping out and burning everything in its path 40 meters wide is a natural disaster in of itself. The damage that could be done is horrendous. In addition, high temperature gradients in the air above the lava create very high winds which can uproot full grown trees. Even though lava flow can last as short as 10-15 seconds or as long as several days, the damage can last far longer than that.

The fall of tephra from the volcano must also be considered. Tephra is the explosion of any material from the volcano. Ash is the smallest size of tephra, followed by volcanic cinders (known as lapilli), and then volcanic blocks, which are the largest volcanic material. Tephra can travel a long way. In the Mt. St. Helen's eruption of 1980, the massive ash cloud grew to 80,000 feet in 15 minutes and reached the east coast in 3 days. Although most of the ash fell within 300 miles of the mountain, finer ash circled the earth for 15 days and continued to stay in the atmosphere for many years (Burton, 1983). Tephra can have many effects on the vegetation that it lands on. The damage to trees by tephra fall can be easily recognized. The tree will have lost almost all of its upper branches but still retain its lower ones. Higher branches will be weighed down with the weight of all the ash; in some instance, the intense heat literally melted the branch right off. Tephra, if hot enough, can also burn holes through leaves itself, making it look like swiss cheese. And even though there are many negative things that occur to agriculture during a volcano, the eruption can be beneficial, depending on one's viewpoint.

AGRICULTURE

Depending on when a crop is harvested, different long and short term effects will happen after a lava flow. A research project done in New Zealand by Neild et al. looked at crop emergence during tephra fall. A partial summary of what they found is as follows:

Table 1. Periods when crops are most at risk (Burton, 1984)

Pea: from emergence until end of flowering.
Squash: during the initial stages of growth and flowering.
Tomatoes: during seed emergence and flowering stages.
Sweet corn: during the early stages of growth.

Neild also found a lot of information based on the cereals, like grain and wheat. The timing, not just the amount of the ash fall, will affect the chances of survival of grain and cereal crops. For example, when corn is in a vegetative period during the first two months of growth, light ash falls are unlikely to affect the expected yield. Heavy ash falls, however, bury much of the plant and change the soil characteristics sufficiently to result in crop failure. Damaged stalks are also more susceptible to disease, which may also reduce yields. Corn requires many heat units for a crop to reach maturity. An eruption could delay crop maturity if sunshine hours were reduced during the eruptive period.

In examining Mount Fuego in Guatemala, some information can be gleaned. On May 29, 2006, an eruption occurred that sent lava about 125 meters in the air and down the side of the mountain, causing several minor avalanches. The eruption had devastating effects to any farmers in the area, since this is the time of year when seeds are emerging and initial stages of growth are starting.

Long term effects are a little different, however. Much debate and research has been done to figure out the best way to treat vegetation after an eruption. The hard part with volcanoes, though, is that every range, volcano, and eruption is different.

There are two more general strategies that can be broken down when looking at how to deal with tephra removal. The two strategies are 1) to let nature takes it course and wait for the vegetation to grow back itself, or 2) to try and use the flow and the ash to the farmers' advantage. The first idea is a strategy used more commonly for forests and areas not inhabited by humans. Eventually, the tephra crust is broken and grasses and small plants start to appear. The latter strategy, however, is one used for farmers of both sustenance and cash crops alike. The debate comes in when dealing with the tephra itself. Does tephra actually help with agriculture, or does it poison it and hurt the yields? Two methods have developed from this debate. The first is plowing ditches through the tephra to make room to plant the seeds directly in the soil. The ditches can be helpful in preventing soil erosion as not as much soil gets used up. Also, the rows in which the crops are planted can be changed year to year so that it is possible to plant the same crop more than one year in a row. This is a benefit to farmers in the region.

Table 2. Tephra thickness effects on crops (Burton, 1984).

Tephra fall thickness (mm)	Effects on Crops	Tephra fall thickness(mm)	Effects on Crops
>2000	All vegetation killed	**30**	Some cherry damage; some plants unable to push through tephra crust
1000-1500	Most vegetation killed, some recovery	**25**	Sugar cane prostrated in patches; branches broken off young breadfruit trees; damage to sweet potatoes, yams
200	Rice paddy destroyed	**20**	30% loss of lentils; 5-15% loss of winter wheat, barley, peas, grass seed; mandarin oranges, mulberry tree crop and vegetables considerably damaged
150	Coffee trees severely damaged	**15**	Loss of first alfalfa cutting' grass hay windrowed before tephra fall not usable
100	Some branches break under tephra load, palm fronds broken	**10**	Breadfruit, apples, cotton balls dropped; cotton stems broken down; 20-4-% scarring on blueberries; banana, spring wheat; mulberry; tobacco and vegetable crops somewhat damaged; hay crop loss 25-30% because of prostration
50	Banana plants damaged, "forced ripening" of some crops	**<10**	Strawberry plants flattened increasing berry rot; minor damage to corn and hay; some burned leaf and salt damage of blueberries
40	50% loss of lentils; 15-30% loss of wheat, spring barley, peas, hay		

The other method would be to mix the tephra right into the soil. Tephra (especially ash) has the ability to retain lots of moisture. When mixed with the soil, it is able to hold more water for the crops. The tephra-soil is also full of many different nutrients. Tephra has glass particles in it at the time of eruption from the volcano, and the decomposition of the glass is helpful to the soil. The main difference between these two types of choices would be amount of labor involved. The first choice would be a lot less labor intensive, as it is not pertinent to remove all of the tephra. The latter involves having to plow a whole field many times over. Remember, tephra deposits can get as deep as 10 meters depending on how close to the volcano it falls. Even as much as three inches can have devastating effects, depending on where it falls. So just imagine how much labor is actually going into clearing room for agriculture on a whole field covered in tephra! This is why there is a big difference between the two different types of "living" with the tephra.

HOMES AND BUILDINGS

Personal housing, as well as buildings that make up the infrastructure of a city, also constitute a huge loss during a volcano eruption. Even without volcanoes, Guatemalan cities are starting to be overrun and over crowded. Earthquakes, hurricanes, and the "Scorching of the Earth" has washed away the homes of many families and caused them to look elsewhere for shelter. The Scorching of the Earth refers to the thirty year period starting in the late 1950s during which Guatemala was under civil war (Woodward, 2006). The civil war caused military leader Carlos Castillo Armas, to burn and destroy anything of value to those who stood in his way. Many families had to evacuate their homes and their family's land, which was handed down within families from generation to generation. In 1995, government studies estimate that 60% of the housing shortage corresponds to what is known as a "passive deficit," which includes all housing that lacks essential services. These basic services include electricity, running water and/or potable water, and sewer systems. In addition to the deficiencies, or complete lack of services, the often precarious nature of the dwellings and the materials used in their construction are additional factors. Generally, in squatter settlements, houses are made of wood, cardboard, or mud, with zinc sheets serving as the roof. Squatter settlements are generally shared by more than 600,000 families, whose housing conditions don't even meet minimum standards. (Hoft, 2002). As previously discussed, volcanoes can cause horrific damage due to how hot and how fast lava can flow, (2000°F and 125 mph, respectively) as well as the amount of tephra, which can reach above and beyond 20 meters. Housing, obviously, cannot withstand this natural disaster. Volcanoes in their own right have been known to take down entire cities, most notably Kalapana, and Kaimū, Hawaii in 1990. Guatemalans are not sure how they are going to replace their houses that were destroyed and how they will be able to move on. Most Guatemalans cannot afford to rebuild their homes time and time again. The homes that they can rebuild are not very sturdy and can be washed away if it rains too much.

Politics, family life, GNP, and modes of transportation are all critical factors that must be evaluated if one is to figure out the best way to rebuild half a city or even several homes. There are several measures being taken already that have helped somewhat. From Houses To Homes (FHTH)-Guatemala is a non-profit group that tries to build homes for the people in the country. The group, directed by Joe Collins, is a year long venture involving up to 120 volunteers. In the span of a month, Collins and a group of volunteers try to build two houses, with costs at $1500 a house, every year (From Houses to Homes, 2007). The houses are simple with a cement floor, cinderblock walls, and a corrugated iron roof. There are many groups like the FHTH in Guatemala helping to rebuild and give hope to new families. The object of these groups is to put the people back on their feet. From there they can get a job, rebuild schools and businesses, roads, and stores.

EVACUATION

Most reactions by people in public office are usually determinant on the immediate danger of the town, as well as the town's perception of the danger. Some changes that might happen socially may occur only for a short time, maybe the length of the eruption itself, but some changes might be longer. Psychological trauma can endure for several months and years after the eruption and evacuation. Some changes maybe permanent, as when a family must relocate because their land is uninhabitable. Certain social affiliations, as well as age, can have a determining effect on human perceptions of the eruption itself. For example, middle-aged people have more accurate perceptions of the hazards than do younger adults. Some religions promote the idea of fatalistic notions, believing that the eruption is "God's Will" and serves as a type of punishment. Rural families usually have a more idealistic view of the situation than those who live more urban lifestyles (Burton, 1978). Evacuation and prayer in the event of an eruption were the most popular adjustments cited by the people interviewed. Awareness of the possibility of diverting the lava flow by wall construction was low (20%) given the serious and partial success during the 1960 Kapoho eruption (Murton and Shimabukuro, 1974). Being able to evacuate from the area is very important. Most evacuations are designed and generated by the government and city officials. These evacuations can vary among voluntary evacuations, forced evacuations, or spontaneous decisions. Numerous factors are usually involved when influencing those at risk to evacuate. For example, alternative accommodation, employment and food may (or may not) be provided for those moving. Forced evacuation – eviction-- is rare and hardly ever used. However, on March 1, 1970, a decree was issued to the people of Pozzuoli near Campi Flegrei. According to Hoffer (1982) 6000 people were evicted by the police and a further 30,000 evacuated on their own grounds. The eviction turned out to save several hundred lives as buildings collapsed due to the lava flow.

Most of the time, however, the people will react according to how their leader reacts. Interviews were conducted in early April of 1980 which helped determine the before and after perceptions of officials from a variety of federal, state, and local organizations. These interviews indicate that officials found it difficult to perceive an eruption and there was a high level of uncertainty about the volcano's future behavior. It seems that most officials

had a very poor perception of what might happen or of the risks to life and property (Blong, 1984). What exactly does this poor perception mean? If the officials are uncertain and uneducated about volcanic eruptions, the probability goes up that the people in the community would be uncertain and uneducated about volcanic eruptions. There is a strong feeling and attachment to a person's house and property. Many people own land handed down to them from generation to generation and some work their whole lives to obtain what little land they have. Guatemala ranks 94th in GNP at $1580, so it is safe to assume that the land they have is of utmost value to them and their family. Numerous factors may influence the willingness of those at risk to evacuate. For example, alternative accommodation, food, and employment may, or may not, be provided. In some cases political considerations may also be involved (Blong, 1984).

The number of people in the New Orleans' area that did not want to abandon their home and are working diligently to rebuild and clean up their communities is evident. Consequently, telling families that they must leave because everything they have worked so hard for is about to be covered by molten lava is difficult. The problems are exacerbated because volcanoes are so unpredictable in nature. The most important thing one can do is to inform and educate people on the dangers and reality of volcanoes.

R.W. Perry, a well known scientist who has done significant work in volcanism, came up with an evacuation plan including several steps. It is as follows:

Table 3. Perry's Evacuation Plan, 1979 (Burton, 1984).

1. Enforced evacuation is relatively inefficient; enforcement means convergence of enforcement officers and mass arrests of recalcitrants, when the aim is evacuation.
2. Voluntary evacuation often requires incentives.
3. Evacuation plans must be formulated and communicated to potential evacuees long before the hazard impact occurs. A warning should then stimulate recall of the evacuation plan.
4. Evacuation is dependent on effective communication and transportation.
5. Evacuation routes must be specified in warning messages and must remain clear until evacuation is complete.
6. Most potential evacuees seek confirmation of an evacuation order from neighbors, relatives, or officials.
7. Separation of family units during evacuation creates anxiety and attempts to return to the evacuated area.
8. A large proportion of evacuees do not use public shelter facilities, but stay with friends and relatives.
9. Evacuees worry about the security of their property.

MENTAL HEALTH

There have also been some studies done on the mental health problems that are prompted by volcanoes. Unfortunately, no research on this topic has been done outside of the United States, so we must look at the 1980 eruption of Mount St. Helens. Research suggests that mental health problems following a volcano disaster are little different to those found after other natural disaster. Natural disasters are short-lived, and there is little problem in determining when the hazard impact has finished. Tornadoes last a few minutes, hurricanes a little more than a day, and flood waters usually recede within a week. Mount St. Helens, however, has presented a continuing at least to the people of the Toutle and Cowlitz river valley. So it may not be the eruption itself that is so irritating to the person, but the length of disarray. Many domestic abuse problems have been witnessed and recorded. Despite the orderliness and efficiency of the evacuation other problems arose as evacuation of material possessions proceeded 20 hours a day. Tempers flared as men watched their houses destroyed by the lava and falling pumice (Blong, 1984). In almost all instances, alcohol did not precipitate the problems. Flaring tempers and cases of domestic abuse were triggered simply by the amount of stress that this disaster puts on families.

What are the reasons for this extremely high stress, as compared to other natural disasters? There have been several different ideas on this topic. If we take another look at our young man who has inherited land from his father, we can see the pain in his face. There he is standing 150 yards away from his land, standing on his ridge,

watching his land get destroyed. The lava, which has gotten more viscous and slowed down since it was going down the mountain, is almost at a crawl. This has both its negative and positive attributes. First, evacuation is still possible after an eruption. The speed of the lava as it gets nearer and nearer can slow down so that it is possible to walk away and gain distance. But speed is not the lava's greatest asset. Rather, it is its ability to destroy. Ironically, it is possible to watch your land get destroyed while people can watch from a safe distance, and usually there is nothing that can be done. Imagine the stress anyone would experience being in this situation.

Stress can also be credited to the duration of the volcanic eruption. In addition to the lava being around for a long time, the effects of tephra can take years to reverse. Plants and trees must adjust to new settings and environments. The environment is given a lot of new stress to deal with, which in turn puts stress on the landowner.

The agricultural sector is the largest employer in Guatemala, making up over 55 percent of the job distribution. Much of this agriculture is actually due to the volcanoes. Taking a look at one volcano in particular might help with idea and conceptions of the importance of volcanoes in the area to keep the soils refreshed. Santa María is a major volcano in the region that has both provided and taken away resources for people. The volcanic eruptions that occur bring minerals as well as nutrients up from the earth. Eventually, these products of the volcano will break down to form a very rich soil that is the foundation for the agricultural business. On Santa María alone, there are crops of coffee, rubber, sugar cane and cardamom. Over 300,000 people live in the area and recently the area has adopted both geothermal and hydropower facilities. Whenever Santa María erupts in a major way, (such as in 1902) which volcanologists believe will happen again in our lifetimes, the impact on Guatemala will be profound. Many investments have been made in this region since and because of the 1902 eruption of Santa María. Given the geography of this area, the complexities of evacuation would be massive. The people of the region would have their life turned upside down. Worst of all, the agriculture that they depend so heavily on would be uprooted and destroyed. The Santa María still lets off steam every day, with the thick morning fog serving as a warning and reminder of what lays ahead (Burton, 1993).

FURTHER RESEARCH

A study needs to be done on the mental health of the people who are affected by volcanoes. With the density of volcanoes being so high, it would be easy to see people at different intervals following a volcanic eruption.

More research also needs to be done on the biological effects of tephra fall on crops, especially coffee beans. Coffee beans are so important to the Guatemalan community; it is important to know exactly what the tephra does to crops and their yields. Most coffee plantations can be found on the side of the volcano. This could help farming around all different areas, if they could make a demand for the tephra. It is not hard to fathom that the selling of tephra is not that far away from our future. The study needs to be done, however, to prove how important scientifically tephra is to crops.

CONCLUSION

Clearly, this is a complex topic. Volcanoes are disruptive and irrational at the same time. They are very destructive and can wipe out whole cities, causing people to move without ever moving back. They can destroy crops and kill livestock, burying the land under layers of ash. But at the same time, volcanoes give a great deal back. Crops on the mountainside of volcanoes help keep the economy afloat, as the people of Guatemala are dependent on it.

In conclusion, Guatemala would not be the same without its volcanoes. That is, these majestic, disastrous mountains have helped shaped the people in the area. Much can be learned and copied from the people here. Their ability to use the volcanoes to their benefit is one. Also, their ability to rebound after a disaster is something that can be copied and revised for the United States to use. In a culture shaped by the volcanoes they live side by side with, Guatemalans can be certain of one thing: No matter how bad or how terrible and destructive the next volcanic eruption is, they will bounce back and move on as a country. The Guatemalan people have already proven this time and again. The hard question to answer is: When will the next one be?

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