

The Causes of Volcanic Eruptions and How They Affect Our Environment

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Abstract. Volcanic eruptions often have an impact on the environment. In the context of the environmental problem of global warming, a large amount of carbon dioxide released by volcanic eruptions will aggravate the greenhouse effect, which has aroused widespread concern. This article first explains the volcano's cone-shaped structure with several craters, cones, and vents. Although each volcano is unique, most volcanoes can be separated into three major types, the first type is a cinder cone, the second type is a composite volcano, and the third type is a shield volcano. Furthermore, this article interprets the causes of volcanic eruptions by decompression melting, and crustal movement. In addition to this, the environmental impacts of volcanic eruptions from three different angles are explained in the article. The First is the environmental impact of volcanic eruptions at different latitudes. It not only examines the sea surface temperatures' responses to volcanic forcing but also mentions a phenomenon of wind (El Niño de Navidad) caused by volcanic. The second argument is the impact of volcanic eruption on climate. It explains the effects of volcanic dust, Sulphur dioxide, and greenhouse gases, these three main volcanic substances that contribute to environmental cooling, acid rain, and global warming respectively. The final point is the impact of volcanic eruption on the benefits and disadvantages of plant cultivation, hoping this article could raise awareness of volcanoes and global environmental problems and prevent them.

Keywords: Volcanic eruption, climate change, plants, earth science, ocean.

1. Introduction

Climate change can be extremely caused by the severe volcanic eruption in many time horizons. Although volcanoes are just openings or vents in the crust, their internal structure and the cause of the eruption are very complex. In addition, a volcanic eruption can lead to many climatic effects, for example, global warming and acid rain; a volcanic eruption produces a lot of gas such as SO₂, CO, HCL, CO₂, H₂S, etc. Those chemicals can be very valuable if used. Furthermore, volcanoes are scattered all over the world, they can take place in the water, on the land, and even under glaciers. Every volcano obtains an underlying central vent on the volcano's peak crater. The edifice, or cone-shaped structure, of the volcano, is formed due to the symmetrical collective of magma or pyroclastic substance surrounding the central vent system. The central vent links at depth to a lava sac, which is the major preserving place for the eruptive material. Several craters, cones, and vents appear on most of the volcanoes [1].

Just like biodiversity, volcanoes are diverse as well. However, most volcanoes can be classified into three main types of volcanoes. First of all, cinder cones can be the most common and familiar type in the world. Most of them are 100 to 150m tall. Each cinder cone usually is its edifice built up around a central vent. And they usually have low explosivity. Another common type of volcano is the Composite cone, which usually is a large volcano. These mountains usually have snow-capped summits that tower over the surrounding mountainous terrain. Intricate volcanoes could live actively for long centuries (even thousands of centuries) and keep erupting regularly for periods. Lastly, the Shield volcano is the type of the largest volcano on earth. As opposed to composite cones, they are broad volcanoes with gentle slopes. They are formed by repeated, intermittent bursts over long

periods of time (up to millions of years or even more), and most eruptions of the shield are just nonexplosive [2].

The main purpose of this article is to analyze the impact of volcanic eruptions on the environment. To begin with, this article briefly introduced the main causes of volcanic eruption and the eruption of the material. What follows is describing the environmental impacts of volcanic eruptions in different dimensions and the impacts of volcanic eruptions on climate and plants.

2. Causes of volcanic eruptions

A volcanic eruption is a phenomenon in which magma pours out of a crater onto the Earth's surface, accompanied by ash, dust, and various chemical gases that erupt into the atmosphere. There are many physical and chemical reactions behind this phenomenon.

2.1. Decompression and melting

The mantle convection can be caused by the unstable density and temperature in the Earth's interior or plumes, which form underground. As the hot rocky substance raises to the shallower layers of the mantle, the drop in pressure causes melting to occur. This molten material will cause the formation of magma pockets in the Earth's shallows. Magma will break through the crust along a weak point or fault as the pressure in the magma sac is greater than that in the stratum, thus leading to a volcanic eruption.

2.2. Principle of decompression melting

This type of melting is counterintuitive and will occur at shallower mantle locations as temperatures decrease. And that's because there's so much pressure deep in the mantle, and rock exists mostly as a solid deep in the mantle even though it's very hot. As the rock rises to the surface, the pressure on it decreases, so it expands and melts. At the same time, the temperature decreases by 0.5 degrees Celsius per kilometer as the depth of the rock becomes shallower, but the decrease in temperature has less effect on the rock than the decrease in pressure, and eventually, decompression and melting occur at the critical point, as shown in Fig. 1. Hawaii's lava is formed by melting under reduced pressure [3].

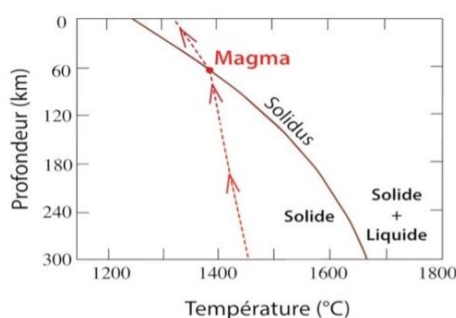


Figure 1. The relationship between provender and temperature

2.3. Plate tectonic activity

Most of the volcanoes are related to plate tectonic activity. Strong pressure will generate enough heat to melt nearby rocks and form magma as one plate slides under another. The mass of rock (magma) remains unchanged, but the volume increases and the density decreases. Thereby, due to the buoyancy, lighter magma uplifts to the surface of the earth. If the magma density, or inner pressure, is lower than that of their surroundings, the magma will erupt.

2.4. Chemicals released

The most important gas in volcanic eruption is carbon dioxide, in addition to sulfur dioxide, hydrogen sulfide, water vapor, hydrochloric acid, chlorine, bromine, sulfuric acid, aerosol, and so on.

Huge amounts of CO₂ emissions will aggravate the greenhouse effect; gases such as sulfur dioxide, hydrogen sulfide, and sulfuric acid will produce acid rain; sulfur compounds in volcanoes are usually formed by the combustion of sulfur-containing substances.

3. Environmental impacts of volcanic eruptions

3.1. Environmental impacts of volcanic eruptions at different latitudes

As mentioned above, when volcanoes erupt, they produce sulfate aerosols that inject into the lower part of the stratosphere, which reduces incoming solar radiation reaching the surface and absorbs long-wave radiation from the surface. However, the researchers suggest that in the eastern equatorial of the Pacific, after the volcano erupts, some low-latitude volcano trends to warmer. But some high-latitude volcanoes tend to be colder. In addition, El Niño de Navidad is a wind phenomenon that is a warm stream of water in the central and east-central equatorial Pacific Ocean, which can keep some places dry, wet, and warm. It showed that El Niño can affect the weather significantly.

The response of the SST to volcanic forcing has been studied, and from latitude 10°S along the equator in the north, tropics, and between March (year 0) and March (year 3) after the March 2012 volcanic eruption. A temporal profile of anomalies at latitude 10°N was shown. The composite pattern of mean zonal winds of 850 hPa heading south. In particular, the westerly anomaly began to appear in August after the northern eruption. Westerly winds also strengthened, resulting in an increase in positive SST the following year after weakening in the first winter. In tropical volcanic eruptions, the western anomaly begins in April of the first year, and the warm SST anomaly peaks in the winter of the first year. In the western Indo-Pacific, the central and eastern Pacific have not El Niño-like response for the first 8 months, with significant temperature drops compared to northern eruptions. Moreover, warm sea surface temperature anomalies are mostly confined to the eastern Pacific and are large in magnitude [4].

Fig. 2 shows the preliminary paths of SST anomalies in the western and eastern Pacific after three types of volcanic eruptions. The eastern Pacific tends to cool in the first few months after a volcanic eruption. The decreasing trend of net radiation flux in the eastern Pacific is greater than that in the western Pacific, and shortwave radiation plays a leading role [5].

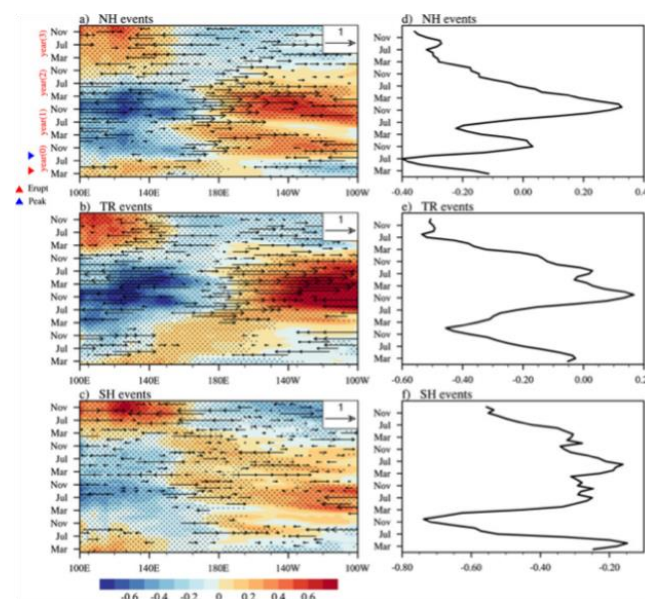


Figure 2. The preliminary paths of SST anomalies in the western and eastern Pacific after three types of volcanic eruptions [5]

In addition, the graph shows changes in sea level pressure after each eruption. The corresponding sea level pressure is characterized by low sea level pressure in the eastern Pacific Ocean and high sea level pressure in the western Pacific Ocean (Fig. 3). Alternating current). However, after a stronger

and longer winter, sea level pressure changes, and two summers of tropical and northern volcanic eruptions occur. The southern volcanic eruption anomaly is relatively weak, and the eruption time is short, but the east-west sea level pressure gradient is still decreasing at zero in winter. To explain the east-west asymmetry of the sea level pressure field (Fig. 3), d-f represents the temporal variation of sea level pressure anomalies in the eastern and western Pacific.

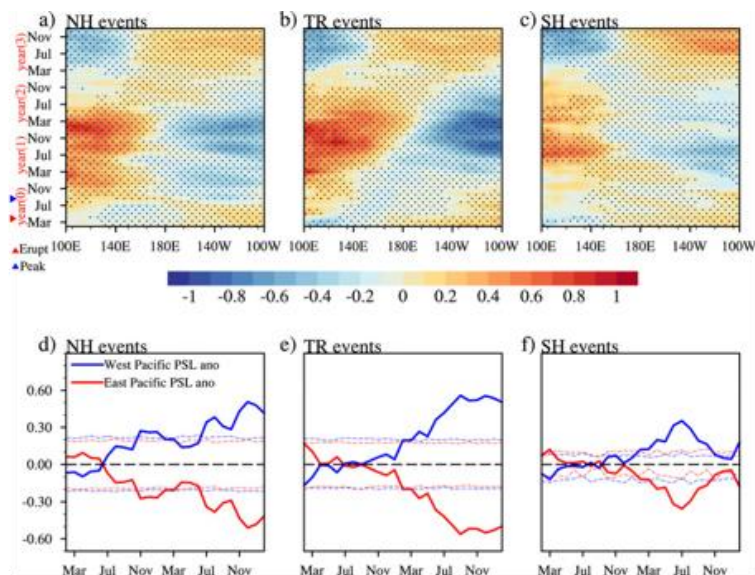


Figure 3. Changes in sea level pressure following volcanic eruptions [5]

About 5 to 10 months after tropical and northern eruptions, El Niño appears over the equator. At the peak of a northern eruption, the moderate sea temperature seems unusual. No El Niño occurred after the southern eruption. El Niño becomes even more pronounced when the tropical Pacific is removed from the background. The Nio-3 index peaks in the winter of the first year after the northern and tropical eruptions and occurs 4 months before the southern eruptions. After three eruptions, an unusual westerly wind of 850 hPa was observed. The north-south eruption in 2000 was westward. In tropical eruptions, the Western Anomaly appears early in the first year. Two years after the eruption, after all, three eruptions ceased, the anomaly transitioned to a La Niña-like state in the equatorial Pacific. After all types of volcanic eruptions, winds weaken in the equator and the western to central Pacific, and El Niño occurs in the eastern Pacific, resulting in unseasonably high temperatures [6].

3.2. The impacts of volcanic eruption on climate

The most important gas in volcanic eruption is carbon dioxide, in addition to sulfur dioxide, hydrogen sulfide, water vapor, hydrochloric acid, chlorine, bromine, sulfuric acid, aerosol, and so on. Huge amounts of CO₂ emissions will aggravate the greenhouse effect; gases such as sulfur dioxide, hydrogen sulfide, and sulfuric acid will produce acid rain; sulfur compounds in volcanoes are usually formed by the combustion of sulfur-containing substances.

3.2.1 Volcanic ash or dust

After a volcano erupts, a large amount of volcanic ash erupts and accumulates in the atmosphere, blocking sunlight. Then the temperature drops. Large ash particles are ineffective because they fall to the surface immediately after an eruption due to gravity. However, when volcanic ash particles become smaller, they form volcanic ash clouds, which not only accumulate in the troposphere but also fall to the surface during rain and hail. Large amounts and high concentrations of volcanic ash can threaten human health, irritate eyes and skin, cause severe coughing, and even cause irreversible diseases in the lungs.

3.2.2 Sulphur dioxide

Sulfur dioxide has a greater cooling effect than volcanic ash accumulated in the atmosphere. Sulfur dioxide combines with water in the stratosphere to form sulfuric acid aerosols. Sulphuric acid aerosols

accumulate in the stratosphere and reflect large amounts of solar radiation back into space, thereby cooling the Earth's surface. What's more, acid rain also forms in the process. At the same time, sulfur dioxide will seriously threaten human health [7]. People who absorb large amounts of sulfur dioxide for a long time can cause respiratory problems such as asthma and even die from direct poisoning.

3.2.3 Greenhouse gases

Volcanic eruptions also release large amounts of greenhouse gases into the atmosphere. Among these are carbon dioxide, the most common, methane, the most powerful, and water vapor. Even without a major volcanic eruption, carbon dioxide is released into the atmosphere through soils, rock holes, and underground magmatic vents. Throughout human history, levels of atmospheric carbon dioxide have increased significantly after large volcanic eruptions, also contributing to the greenhouse effect and global warming. It's still a tiny amount compared to human emissions. Carbon dioxide emissions from volcanic eruptions account for less than 1% of carbon dioxide emissions from human activity. In addition, methane and water vapor emissions also contribute to global warming [8].

3.3. The impact of volcanic eruption on the plants

3.3.1 Negative effect

Most plants around the volcano will be killed by the hot erupted magma. The high temperature will burn the plants and cause a fire. Luckily, only the effect of fire will never wipe out those plants. Since most plants are resistant to fire, or can easily rebirth after burning, it has fewer negative effects than the following one. In addition to this, after a brutal volcanic eruption, there are ashes involving silicon dioxide erupted into the atmosphere and gathered high in the sky. Those ashes will last for almost three years before completely dissipating. The main effect of those ashes is blocking the sunlight. As a result, some solar energy from sunlight is reflected by the ashes and goes back to the universe, causing climate change on the earth like the decrease in temperature and the frustration of the precipitation. All of those play a crucial role in the growth of plants and crops. The lower temperature will let plants grow slowly and farmers may gain poor agricultural outputs. Moreover, the block of sunlight will reduce the role of photosynthesis, which also negatively affects the growth of plants [9].

3.3.2 Positive effect

After the volcanic eruption, some components of volcanic ashes and magma may deposit in the soil around the volcano. Those components will make the soil fatter, and more capable of planting crops and other plants. Moreover, there are valuable metals formed after the volcanic eruption, such as copper, gold, silver, lead, zinc, and so on [10].

4. Conclusion

Volcanoes, as an important part of the earth Volcano, are the most in four main areas of the earth, one is the Pacific rim, the Mediterranean Sea, the Atlantic ridge, and the volcanic belt in East Africa. In this paper, the basic structure of the volcano eruption of chemicals has been summarized and the influence of different dimension of volcanoes on the surrounding environment a few pieces are indispensable, whether short-term or long-term once eruptions are hard to avoid chemical is produced by the main damage to the environment, but because the dimension of regional temperature differences will also be different. For example, Health problems in the wake of the eruption include infectious diseases, respiratory illnesses, and traffic accidents linked to the slippery, hazy conditions caused by ash. Although the negative effect occupies most, there are still some benefits Volcanic eruption of volcanic ash to nearby soil with rich, it is not only the local farmers' scarce mineral fertilizer but also, the substance released could also form a chemicals layer to cool the earth. The causes of the volcanic eruption are also included that both decompression melting and hydration melting. People must use the principle of both causes to effectively assume the date and intensity of a certain volcanic eruption, thus protecting the surrounding area from getting damaged. Meanwhile,

it is also important to make precautions to deal with the following climate change around the next 2-3 years after the volcanic eruption, like the decreasing temperature should be considered as a problem that people grow fewer crops to reduce the loss. Hope the future will have more data to support our conclusion and to reduce the number of volcanic eruptions (in control) in addition to this it is expected that in the future scientists will be able to reduce the harm caused by volcanoes and use the advantages of volcanic eruptions for the benefit of society. For instance, using the characteristics of lowering the earth's temperature to combat global warming.

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