CAT 360

Catastrophe Risk from Every Perspective

The CAT 360 is a quarterly newsletter that features articles developed by our Research and Development Team and covers topics that relate to Catastrophe Modeling, Natural Perils and Information Technology on a global basis. Please feel free to contact the editors if you have any questions or comments regarding any of our publications.

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Volcanoes: Nature's Fury

The bestselling novels and blockbuster movies are testament to the fact that volcanic eruptions capture the public imagination. Yet they are also one of the most misunderstood natural perils.

Travelers around the world could not have anticipated that a natural phenomenon would leave them stranded for weeks. But that is precisely what happened with the eruption of Eyjafjallajokull in Iceland during April this year. The major European airports ground to a halt, with more than 100,000 flights cancelled, costing the airlines an estimated $200m a day and affecting ten million travelers around the globe. The total global economic cost of the eruption is expected to be in the billions.

For most, this was the first time a volcano had directly affected their lives. But volcanic eruptions have affected humans since the beginning of time. While this eruption may have come as a surprise to the average person, volcano experts were well aware of the volcanic activity in Iceland and the potential for a strong eruption, like the one that occurred in mid April. This article will investigate volcanic activity around the globe, summarize some of the more famous historical eruptions, consider the hazards from eruptions and look at some of the potential benefits society can gain from these events.

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A brief history of volcanic activity

There are around 500 active volcanoes globally, but this does not include volcanoes that lie beneath the sea, which brings the total to over 5,000 active at this time. When one thinks about volcanic activity, a couple of

Some volcanic eruptions have been so intense that they have temporarily affected the earth's temperature. Climate scientists have long studied the impact of volcanoes, even hypothesizing that a colossal eruption or series of

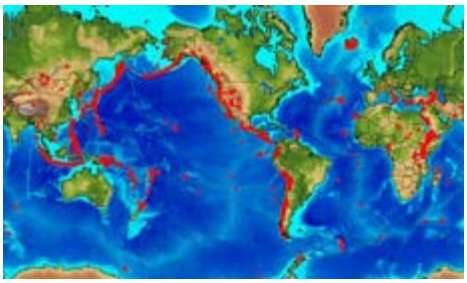
famous eruptions come to mind, such as Mount Vesuvius in Italy that buried the city of Pompeii in 79 AD and the violent eruption of Krakatoa in 1883, which destroyed 165 villages and towns. These events were glamorized in the movies and media, giving the perception that great violence and destruction accompanies a volcanic eruption. But this is not always the case.

Another myth is that volcanoes mostly occur in exotic locations. However Russia is the country with the most volcanic activity, closely followed by the US. In fact, the most active volcano in the world is Kilauea volcano on the Big Island of Hawaii, with Mount St Helens in Washington State not far behind in second place.

Volcanic activity occurs on every continent of the globe. Volcanoes are not randomly placed and can usually be found near fault boundaries. Many land volcanoes are located in convergent subduction zones, such as Mount St Helens, or at divergent plate boundaries where fissure, sea-mount and shield volcanoes occur. In some cases, volcanoes are located where there are intraplate hotspots beneath the earth's crust, such as those located in Hawaii.

eruptions 63 to 65 million years ago could have contributed to the extinction of the dinosaurs by dramatically altering the global climate. Ash and dust clouds, along with a potpourri of gases released into the atmosphere, can absorb the sun's rays causing the atmosphere to cool.

The eruption of Krakatoa, Indonesia in August 1883 is one example of a climate changing event. This eruption had an Explosivity Index of 6, which is equivalent to 200 megatons of TNT — about 13,000 times the yield of the Little Boy bomb (13 to 18 KT) that devastated Hiroshima, Japan in 1945. The following year, the average temperature dropped 1.2 degrees Celsius.



*Map of Worldwide Volcanoes - **www.usgs.gov***

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The deadliest volcanoes

While Eyjafjallajokull disrupted worldwide travel and is projected to cost the airline and travel industry over $1.7bn, it will probably not go down in history as a significant volcanic eruption. Prior to modern instrumentation and detection methods, eruptions would occur with little warning, killing thousands of people living in the volcanoes' shadow.

The historical record indicates that about one million people have been killed by volcanic eruptions over the past 2,000 years. Most of these deaths occurred in just a few eruptions. The rich soil surrounding volcanoes explains why the death toll from historical events has been so high. The potential for cultivation has drawn high population densities to volcanoes' slopes or surrounding lowlands despite the ever-present threat of eruption.

In the 20th century, the 1902 eruption of Mont Pelée on the island of Martinique in the Caribbean killed around 25,000

Tambora in 1815 and Krakatoa in 1883 — were the most deadly on record, causing 120,000 deaths. In 1792 the eruption of Unzen Volcano on Kyushu, Japan killed around 15,000. The eruption of Vesuvius in 1631 near Naples in Italy killed about 6,000 people, while the infamous 79 AD eruption that destroyed Herculaneum and Pompei is thought to have led to over 10,000 deaths.

The city of San Salvador in El Salvador in Central America lies close to a lake, which was produced from a massive eruption around 300 AD. According to estimates it would have displaced or killed thousands to hundreds of thousands of people and changed the course of civilization by benefiting the Mayans living in the Pete'n and Yucata'n areas.

The following table is a list of the deadliest volcano eruptions in history. Note that there have been few deadly volcanoes during the past decade as worldwide monitoring can detect

people, while the Nevado del Ruiz Volcano in Colombia in 1985 killed another 25,000. In the 19th century, two eruptions in Indonesia — imminent eruption threats, providing enough warning to evacuate populations at risk.

Date	Volcano	Location	Deaths
April 10-12, 1815	Tambora	Indonesia	92,000
August 26-28, 1883	Krakatoa	Indonesia	36,000
May 8, 1902	Mount Pelee	Martinique	28,000
November 13, 1985	Nevado Ruiz	Colombia	23,000
August 24, 79 A.D.	Vesuvius	Italy	10,000+
May 21, 1792	Unzen	Japan	14,500
1586	Kelut	Java	10,000
June 8, 1783	Laki	Iceland	9,350
May 19, 1919	Kelut	Java	5,000
December 15, 1631	Vesuvius	Italy	6,000
April 24, 1902	Santa Maria	Guatemala	4,000
August 12, 1772	Papandayan	Java	3,000
January 27, 1951	Lamington	New Guinea	3,000
March 28, 1982	El Chichon	Mexico	1,880
August 21, 1986	Lake Nyos	Cameroon	1,700
January 10, 1977	Nyiragongo	Congo	70+

A photo of the 2007 eruption of Krakatoa. This volcano is best known for the 1883 eruption which is among the most violent volcanic events in modern times. www.seeindonesianow.com

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Volcanic hazards

The ash clouds that resulted from Eyjafjallajokull are the most notable hazard from recent times, however there are many other threats from a volcanic eruption including:

Gas release - While water vapor is the most abundant gas emitted, carbon dioxide, sulfur dioxide, hydrogen sulfide, hydrogen, carbon monoxide, hydrogen chloride, hydrogen fluoride and helium are all part of the noxious mixture of gases released during an

and progressively smaller fragments are carried away from the vent by the wind. Volcanic ash, the smallest tephra fragments, can travel thousands of kilometers downwind from a volcano. Imagine what it would look like if several inches of talcum powder covered everything in sight. This is literally what happens when very fine tephra falls onto a community.

Directed blast - Directed blast material is expelled into the atmosphere by

eruption. The gases that pose the greatest hazard to the population and agriculture are sulfur dioxide, carbon dioxide and hydrogen fluoride. These gases can produce acid rain, deplete the ozone layer and contaminate the soil. There have been instances where high concentrations of carbon dioxide gas proved to be lethal to people, animals and vegetation.

Lava flow - These are streams of molten rock that flow from an erupting vent. Lava is released from either non-explosive activity or explosive lava fountains. Lava flows literally destroy everything in their path, with temperatures that range between 600°C to 1,200°C (1,100°F to 2,200°F). Fortunately most flows move slowly, allowing people to move out of harm's way. It is a different story with property however, as everything in the path of advancing lava flows will be knocked over, surrounded, buried or ignited and decimated by the extremely hot temperatures. Not only is the property destroyed when this occurs, but the developed land is rendered useless as well.

Landslides - This is a rapid down slope movement of rock, snow and ice. Landslides range in size from small movements of loose debris on the surface of a volcano to massive failures of the entire summit or flanks of a volcano. Volcanic landslides are not always associated with eruptions; heavy rainfall or a large regional earthquake can trigger a landslide on steep slopes. Volcanoes are susceptible to landslides because they are composed of layers of weak, fragmented volcanic rocks that tower above the surrounding terrain. Some of these rocks have been altered to create soft, slippery clay minerals by hot, acidic ground water inside the volcano. At least five large landslides swept down the slopes of Mount Rainier during the past 6,000 years. The largest recorded volcanic landslide occurred at Mount St Helens on May 18, 1980.

Tephra - This is a term for fragments of volcanic rock and lava, regardless of size, that are blasted into the air by explosions or carried upward by hot gases in eruption columns. Such fragments range in size from less than 2 mm (ash) to more than 1 meter in diameter. Large-sized tephra

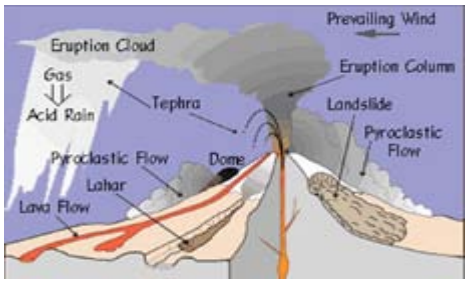
means of an eruption column. The bottom of this column, where material is ejected from the vent, is known as the gas thrust zone. The convective thrust zone sits above the gas thrust zone and it is in this zone that pyroclastic material is lofted toward the top of the troposphere. When the eruption column meets the stratosphere, the material extends into a mushroom shape, eventually dropping to the ground. The area affected by the eruption column and fallout material, is called the blast zone.

In a directed blast that erupts from the side of the volcano, such an eruption column is not produced. A directed blast can occur as a result of depressurization triggered by an earthquake-initiated landslide, such as at the Mt St Helens 1980 event. The effect of a directed blast can be seen for several miles from the volcano as it will destroy everything in its path. The temperature of materials ejected from the blast cloud can be as hot as 300°C.

Earthquakes - The question, "Do earthquakes cause volcanoes?" has been asked many times. The short answer is "no." There are different earth processes responsible for volcanoes. Earthquakes may occur in an area before, during and after a volcanic eruption, but they are the result of the active forces connected with the eruption and not the cause of the volcanic activity. While these phenomena are not geologically related, they are quite often associated with each other.

Tsunamis - A tsunami is a sudden displacement of water generated by seismic activity. Tsunamis travel at very high speeds through deep water as low broad waves, building to great heights as they approach the shallow bottom of shores. Most are caused by fault displacements on the sea floor, but many have been caused by volcanic action. The eruption of Krakatoa in 1883 produced tsunamis that killed 36,000 people. The pyroclastic flow generated by this eruption displaced the water that initiated the tsunamis.

typically falls back to the ground on or close to the volcano



Volcanic Perils - www.usgs.gov

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Volcano damage effects

Destruction of property - The destruction of property by lava flows is the most publicized characteristic of volcanic eruptions in media reports. Property in the path of a lava flow will almost certainly be destroyed. Lava flows generally move at a walking pace, and rarely pose a direct threat to human life. However, they have the capacity to completely engulf entire villages and towns, destroying everything in their way.

In recent times, man has tried to influence the flow of lava. This was attempted in Italy during an eruption of Etna in 1992 with moderate success and experimentally in Hawaii in 1975-76 for the lava flows emanating from Moana Loa. Using massive barriers made of concrete, the flow of lava was diverted or slowed to a point where the cooling effect prevented catastrophic damage to buildings in the flow's path. But the question remains as to how effective these measures would be in a larger eruption.

Health issues - The release of dangerous and potentially deadly gases poses a significant threat to people, animals and vegetation in volcanic regions. There were 57 direct human fatalities from the eruption of Mt St Helens in 1980, and it is estimated that up to 7,000 big game animals perished during the event. Many of the deaths were caused by suffocation due to the ash in the atmosphere and subsequent death of wildlife was caused by starvation and disease, due to the sudden environmental change which greatly affected the food chain.

Transportation and travel - The airborne ash plumes from Eyjafjallajokull closed air space in Europe for almost one week in April, and continued to cause intermittent major airport closures over the next month (at the time of writing). While no direct property damage was incurred, this event cost the airline and travel industry an estimated $1.7bn (according to the International Air Transport Association), due to canceled flights and vacation reservations around the world.

Naples, Italy during the 1944 eruption of Mt Vesuvius - www.geology.com

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Volcano risk mitigation

Mitigating the hazard from a volcanic eruption is not only important during an event, but is most critical prior to an event. Education, preparation and effective communication systems are three areas that a community can focus on when preparing for any catastrophic event, not just a volcanic eruption. A well-prepared community will have a far greater chance at minimizing losses

- Land-use planning - The topographical features can influence the flow of lava and the landslide potential. Community regulators in a volcanic region should prohibit or severely limit the development of land that is threatened by a volcanic eruption;
- Contingency planning - All

compared to a community that only reacts once an event has occurred.

Lessons learned from modern day catastrophic events (such as Hurricanes Andrew and Katrina, the Indian Ocean Tsunami and recent earthquakes in Haiti and Chile), show that prior preparation is a key factor in minimizing loss to life and property. Before an event, the following measures can be employed in an attempt to manage volcanic hazard:

- Risk analysis - An analysis of the region will identify areas most at risk, helping authorities to target communities most likely to be affected by an eruption;
- Volcanic surveillance - Modern monitoring equipment can detect changes in a volcano that could potentially lead to an eruption. This can help to provide enough lead time to evacuate residents closest to the eruption zone;
- contingency plans should include alternatives for transportation routes, supply chains, power and communication systems.
- Event procedures - Plans should be established and disseminated throughout the community;
- Public education - Education will lessen the psychological and physical affect on the public. A community that is fully aware of the impacts of a volcanic eruption is more likely to react properly in taking steps to minimize loss; and
- Personal protective gear - Goggles, breathing masks, protective clothing, flash lights and battery powered radios are a few of the items individuals should have in their possession, as an emergency situation can occur very quickly.

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Potential benefits from volcanic activity

While the bulk of this article has looked at the negative impact of volcano eruptions, there are a number of beneficial side effects from these natural catastrophes. These include:

- Fertile soil - Very rich soil is deposited in the aftermath of an eruption as ash and minerals are washed into the surrounding slopes. This rich soil can be used in the agricultural production of fruits and vegetables, plants which flourish in this environment.
- Valuable minerals - Volcanic material is a plentiful source of precious gems and minerals including opal, gold, silver, copper and zinc among others.
- Water reserves - During an eruption, gases including carbon dioxide and oxygen are released. When these two gases mix together, water vapor is produced, helping to boost water supplies.
- Geo thermal power - Experts are now attempting to harness the energy of volcanoes and hot springs, citing possibilities to supply alternative energy to thousands and possibly even millions of homes.

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Conclusion

Earthquakes, hurricanes, flooding and tsunamis have dominated the media in recent years, but volcanic activity remains a real and imminent threat to significant population centres around the world. Modern technology has given us the ability to predict when volcanic activity is about to occur, minimizing the impact on human life. However, as the in Java, Indonesia according to Munich Re), there still exists the potential for a significant volcanic event. For example, the clean-up costs for ash debris in a densely populated urban environment potentially can run into the tens of billions.

A community at risk of an eruption can

eruption of Eyjafjallajokull and its impact on the travel industry has demonstrated, the direct (lava flow) and indirect (ash clouds) effects of an eruption can be devastating.

While most historic volcanic events have had limited direct exposure to the insurance industry (the most costly event occurred between 2006 and 2007 be best served by its pre-event preparation, helping to minimize or eliminate the loss of life. In the near future, technology may be developed to tap the incredible energy within an active volcano, turning what is an otherwise frightening hazard into usable energy for communities around the world.

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