Leaflet No.

The Republic of the Union of Myanmar
Ministry of Natural Resources and Environmental Conservation

Case Study of Effectiveness of Volcanic Hazard

Thin Han Htet Su
Assistant Geologist
Department of Mines

March, 2026

Contents

List of Figures

Case Study of Effectiveness of Volcanic Hazard

Thin Han Htet Su
Assistant Research Officer (Geology)
Mining Department

Abstract

Fifty to sixty volcanoes erupt each year worldwide. Volcanoes generate a wide range of hazards from eruptions that vary in chemical composition, gas content of lava and eruption styles. These natural phenomena are unpredictable and uncontrollable. A volcanic hazard is any potentially dangerous volcanic phenomenon or process that may cause loss of lives or injuries, extensive property damage, health impact, environmental degradation and socio-economic disruption. This paper examines the effectiveness of volcanic hazard assessment, according to observation indicators, founded two stages of effects: immediate consequences during eruption (primary effects) and long-term outcomes afterward (secondary effects). Volcanic activity impacts communities in both positive and negative ways, however, advances in technology have greatly improved the ability to detect volcanic changes accurately and enhance safety and to mitigate disaster risks. The objective of this study is to aware the effectiveness of volcanic hazards. This research contributes to a better understanding of volcanic hazard assessment in relation to underlying geologic conditions and can serve as a reference for related research volcanic hazards.

Keywords: *Disaster, Geologic Conditions, Lava and Gas Emission, Risk Management, Volcanic Activity, Volcanic Eruption, Volcanic Hazards*

မီးတောင်ပေါက်ကွဲမှုအန္တရာယ်၏ အကျိုးသက်ရောက်မှုများကို လေ့လာတင်ပြခြင်း

သင်းဟန်ထက်စု၊ လက်ထောက်ဘူမိဗေဒအရာရှိ
သတ္တုတွင်းဦးစီးဌာန

စာတမ်းအကျဉ်း

ကမ္ဘာပေါ်တွင် နှစ်စဉ် မီးတောင်ပေါင်း ၅၀ မှ ၆၀ ခန့်ထိ ပေါက်ကွဲလျက်ရှိပါသည်။ မီးတောင် များသည် ၎င်းတို့၏ ချော်ရည်များထဲတွင် ဓာတ်ငွေ့ပါဝင်မှုနှင့်ဓာတုဖွဲ့စည်းမှုများ အပေါ် မူတည်၍ ဘေးအန္တရာယ်များ ဖြစ်ပေါ်စေနိုင်ပါသည်။ ထိုသဘာဝဘေးအန္တရာယ်မျိုးကို တိကျစွာ ခန့်မှန်းနိုင်ခြင်းနှင့် ထိန်းချုပ်နိုင်ခြင်းမရှိသေးပေ။ မီးတောင်ပေါက်ကွဲမှု အန္တရာယ် သည် လူ့အသက်များကို ဆုံးရှုံးစေခြင်း၊ ထိခိုက်ဒဏ်ရာရရှိစေခြင်း၊ ကျန်းမာရေးထိခိုက် စေခြင်း၊ ပစ္စည်းဥစ္စာများ ပျက်စီးစေခြင်း၊ လူမှုအကျိုးစီးပွားထိခိုက်စေခြင်းနှင့် ပတ်ဝန်းကျင် ထိခိုက်ပျက်စီးစေခြင်းစသည်တို့ကို ဖြစ်ပေါ်စေပါသည်။ ဤစာတမ်းသည် မီးတောင် ပေါက်ကွဲမှုကြောင့်ဖြစ်ပေါ်လာသော အကျိုးသက်ရောက်မှုများကို လေ့လာတင်ပြထားခြင်း ဖြစ်ပြီး လေ့လာတွေ့ရှိချက်များအရ အကျိုး သက်ရောက်မှုဖြစ်စဉ် အဆင့် ၂ဆင့် ရှိကြောင်း တွေ့ရှိရပါသည်။ ထို့ပြင် အချို့သောအကျိုးသက်ရောက်မှုများသည် ကောင်းကျိုးကို ဖြစ်ပေါ် စေသကဲ့သို့ အချို့သည်ဆိုးကျိုးကိုလည်း ဖြစ်ပေါ် စေပါသည်။ နည်းပညာတိုးတက်လာသည် နှင့်အမျှ မီးတောင်များ၏ ပြောင်းလဲမှု ဖြစ်စဉ်များကို ပို၍တိကျစွာ တိုင်းတာ နိုင်လာပြီး ဘေးအန္တရာယ် ဖြစ်ပေါ်စေမှုကိုလည်း လျှော့ချလာနိုင်သည်ကို တွေ့ရှိရပါသည်။ ဤစာတမ်း ပြုစုရခြင်း၏ ရည်ရွယ်ချက်မှာ မီးတောင်ပေါက်ကွဲမှုအန္တရာယ်၏ အကျိုးသက်ရောက်မှုများကို သိရှိစေရန်ဖြစ်ပါသည်။ ဘူမိဗေဒဆိုင်ရာ အခြေအနေများကြောင့် ဖြစ်ပေါ်သော မီးတောင် ပေါက်ကွဲမှု အန္တရာယ်၏ အကျိုးသက်ရောက်မှုများကို သုံးသပ်ရာတွင် ဤသုတေသနအား ကိုးကားမှုအနေဖြင့် ပြန်လည်အသုံးပြု နိုင်မည်ဖြစ်ပါသည်။

Case Study of Effectiveness of Volcanic Hazard

1. Introduction

In this case study, I emphasize the effectiveness of volcanic hazard that is reviewed from reports of Wright, T.L and Person, T.C, Living with volcanoes, U.S Geological Survey Circular in 1992. Nature is beautiful but it can also be dangerous. Hazard is any agent that can cause harm or damage to humans, property of the environment. Natural Hazards which are event that cause great loss of life or property of damage or both. In the past few decades, killed several million people with an average worldwide annual loss of life of about 150,000 people. Natural Hazards are basically natural processes.

Geological Hazards is one of several types of adverse geologic conditions, which cause damage or loss of property and life. They have two types. These two types are sudden phenomena and slow phenomena. The sudden phenomena include earthquake, landslide, and volcanic eruptions. The slow phenomena consists of flooding, sand dune migration, and geyser.

Volcano produce a hazards, depending on the chemical composition and gas content of lava. Fifty to sixty volcanoes erupt each year worldwide. Eruptions often occur in populated areas of the world, causing loss of life and economic damage.

Several hundred million people on earth live close to volcanoes (Figure 1) and as the human populating grows, more and more people are living on the flanks or sides of active or potentially active or volcanoes. The western United States, including Alaska, Hawaii, and Pacific Northwest, has also many active volcanoes. Densely populated countries with many active volcanoes such as Japan, Mexico, Philippines and Indonesia. Mud volcano (Minbu township, Naga Pwat Hill), and Mt. Popa volcano are famous in Myanmar. They erupted violently in the past.

Figure 1. Volcanoes is located near large city

2. Objectives

The objective of this study is to raise awareness of volcanic hazards by studying the effectiveness of hazard assessment methods, distinguishing between primary and secondary effects, highlighting the role of technology in improving detection and safety and contributing to a deeper scientific understanding of volcanic activity for future research.

3. Materials and Methods

For case study view, I studied volcanic effects by using remote sensing tool (Satellite Sensors), drones, thermal cameras and seismometers and to observe by using monitoring method with these combination tools that reported in Stephen A Nelson, 2019, Tulane University, Natural Disaster. Circular Combining these tools are contributed my research to monitor hazardous zone, lava flow movement, gas emission, ash plumes (tephra), volcanic earthquake (tremors) and thermal anomalies. Each tool offers unique insights and works best when integrated with others.

3.1 Study of Analysis of ash plumes and gas emission

Monitoring effects of volcanic eruption by satellite sensors give in order to detect possible changes and to track ash plumes, gas emissions. Volcanic eruptions produce different ash plume types and release various gases.

The various types of ash plumes are vertical columns, umbrella clouds, bent-over plumes, collapsing columns. Vertical column type is a vertical cloud of hot ash and gases rising tens of kilometers into the atmosphere. In strong eruptions, it can penetrate the stratosphere. Umbrella cloud type is founded when the plume reaches neutral buoyancy, it spreads horizontally, forming a mushroom-like shape. Bent-over plume type is a strong winds tilt the ash plume sideways, dispersing ash over wide areas. Collapsing column type is founded if the plume becomes too dense, it collapses down the volcano's slopes, creating pyroclastic flows.

The various types of gases are water vapor, carbon dioxide, sulfur dioxide, hydrogen sulfide, and halogens. Volcanoes emit gases before, during, and after eruptions. Major types include water vapor (H_2O); the most abundant volcanic gas, driving explosive eruptions. Carbon dioxide (CO_2); greenhouse gas; high concentrations can be deadly in valleys. Sulfur dioxide (SO_2); forms of acid rain and sulfate aerosols, which can cool global climate. Hydrogen sulfide (H_2S); toxic gas with a "rotten egg" smell. Halogens (Cl, F); chlorine and fluorine gases can combine with ash to form corrosive deposits. These forms depend on eruption strength, wind, and magma composition. Monitoring plume dynamics and gas composition helps predict eruption impacts and mitigate hazards.

Ash plumes disrupt aviation, damage infrastructure and cause respiratory issues. Gas emissions affect climate, air quality, and ecosystems.

3.2 Study of Analysis of hazardous zone and Lava flow movement

Second Monitoring by using drones capture hazardous zone and lava flow movement through fly over dangerous areas. Collecting data from drones contribute to draw hazard mapping by use historical data and satellite imagery to identify high-risk zones, high-resolution maps of lava flows and thermal zones. They can also monitor eruption intensity and assess lava hazards.

3.3 Study of Analysis of temperature changes and tremors

Thermal cameras monitor temperature changes in vents, lava flows, and fumaroles. Thermal cameras fixed at safe strategic observation points. It can use the way that handheld or drone-mounted cameras for mobile surveys. Deploy seismometers around the volcano to detect earthquakes and tremors which often precede eruptions and to measures seismic waves caused by magma movement. They can analyze seismic waveforms to identify volcano-tectonic and long-period events.

Combining these data from all sources founded model magma movement, assess eruption risk, and understand environmental impacts (Figure 2). This research will provide a robust, multi-instrument approach to volcanic monitoring, enhancing both scientific understanding and public safety.

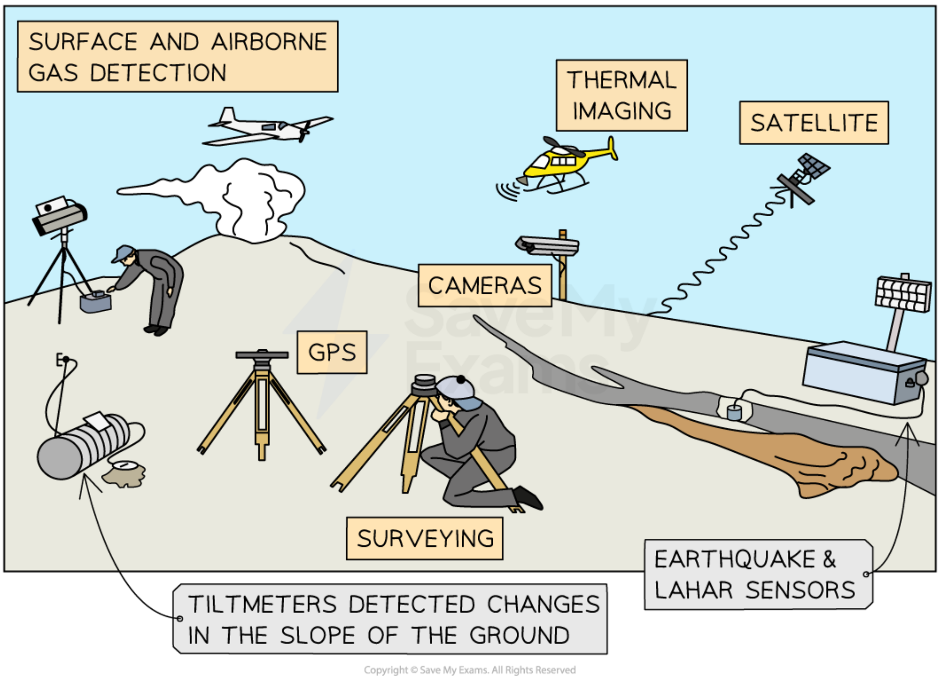

Figure 2. Study effectiveness of volcanic hazards by monitoring methods

4. Results

In this case study, after analyzing through above these ways and founded two stages effect of volcanic hazard. They can divided into primary effect and secondary effect. Primary effects are produced directly by the volcanic activity. Examples include lava flows, poisonous gases, pyroclastic activity and Tephra. Secondary effects are the result of primary effects. Examples include landslide, earthquake, tremors, lightning, climate changes and fire.

4.1 Primary Effect

4.1.1 Lava Flows

Lava flows can create many hazards. Lava is the molten rock expelled by a volcano during an eruption. The resulting rock after solidification and cooling is also called lava. It is rare for people to be killed by lava flows. When first erupted from a volcanic vent, lava is a liquid usually at temperature from 700˚C to 1200˚C. Lava can flow great distances before cooling and solidifying. The composition of almost all lava of the Earth's crust is dominated by silicate minerals mostly feldspar, olivine, pyroxenes, amphiboles, mica and quartz.

Pillow lava is the lava structure typically formed when lava emerges from an underwater volcanic vent or subglacial volcano or a lava flow enters the ocean. Lava fountain is a volcanic process in which lava is forcefully. The highest lava fountains recorded were during 1999 eruption of Mount Etna in Italy, which reached heights of 2,000 m. Lava deltas form wherever sub-aerial flows of lava enter standing bodies of water. It is associated with large scale, effusive type volcanism. Anything in path of a lava flow will be damaged. They can destroy buildings, forests, farmland, highway roads, river and streams (Figure 3). They usually advance sufficiently slowly to allow people and animals time to evacuate. In 2002, mobile lava flow destroyed about 13% of Goma city, 80% of its economic assets, parts of international airport runway and the homes of 120,000 people. Areas of recent lava flows continue to represent a hazard long after the lava has cooled.

Figure 3. Lava flow destroyed buildings

4.1.2 Poisonous Gases

Volcanoes emit gases (Figure 4) that are poisonous to living organisms. These poisonous gases are carbon dioxide, hydrogen chloride, hydrogen supplied, and hydrogen fluorite. Most of the gas released in an eruption is fatalities, health impacts and damage to vegetation and property. Toxic concentrations of hazardous volcanic gases rarely reach populated areas. The chlorinate vapor (H_2O), and relatively harmless. Volcanic gases can directly causes Fe, Sulphur and fluorine gases can kill organisms by direct ingestion. Carbon dioxide is not poisonous, but it displaces normal oxygen-bearing air, and is odorless and colorless. Because it is heavier than air, it collects in depressions and can suffocate people and animals who wander into collect in lake bottoms; in some situations, the water in those lakes can suddenly 'erupt' huge bubbles of carbon dioxide, killing vegetation, livestock and people living nearby.

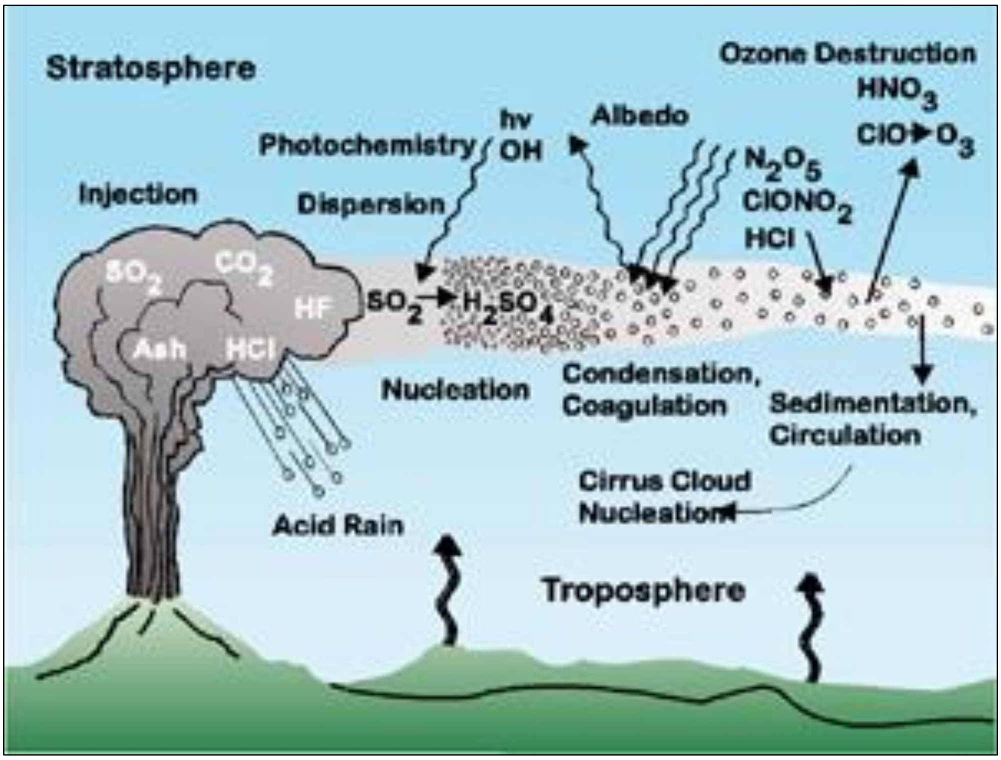

Figure 4. Gases and ash can influence climate patterns

4.1.3 Pyroclastic Activity

Pyroclastic activity is one of the most dangerous aspects of volcanism. Pyroclastic rocks are bombs, blocks, lapilli and ash (Figure 5). Volcanic blocks and bombs travel only a matter of hundreds of meters to kilometers from the vent, depending on the force with which they were ejected. Pyroclastic debris sometimes contains blocks the size of car. Finer lapilli and ash may be sent kilometers into the atmosphere and distributed by wind. Pyroclastic flows are concentrated avalanches of volcanic rocks, ash and gases that are typically confined to valleys, and pyroclastic surges are more dilute turbulent clouds of ash and gases that can rapidly spread across the landscape and even travel uphill or across water. Volcanic ash eruption create several hazards. First, vegetation including crops and trees may be destroyed. Second, surface water may be contaminated by sediments, resulting in temporary increase in acidity of the water. Third, structural damage to building may occur, caused by increased load on roofs. Fourth, health hazard such as irritation of the respiratory system and eye are caused by contact with the ash and associated caustic fumes.

Figure 5. Types of pyroclastic rocks

4.1.4 Tephra

Tephra is a volcanic hazard due to large blocks and bombs that are ejected from the volcano (Figure 6). When a volcano erupts it will sometimes eject material such as rock fragments into the atmosphere. This material is known as tephra. Tephra produces a wide range of hazards (Figure 7). Ash can disrupt electricity, television, radio, and telephone communication lines, bury roads and other manmade structures, damage machinery, start fires, and clog drainage and sewage systems. Mount Pinatubo, Philippines view of World Airways DC-10 airplane setting on its tail because of weight of June 15, 1991 ash, in Cuba Point Naval Air Station (Figure 8).

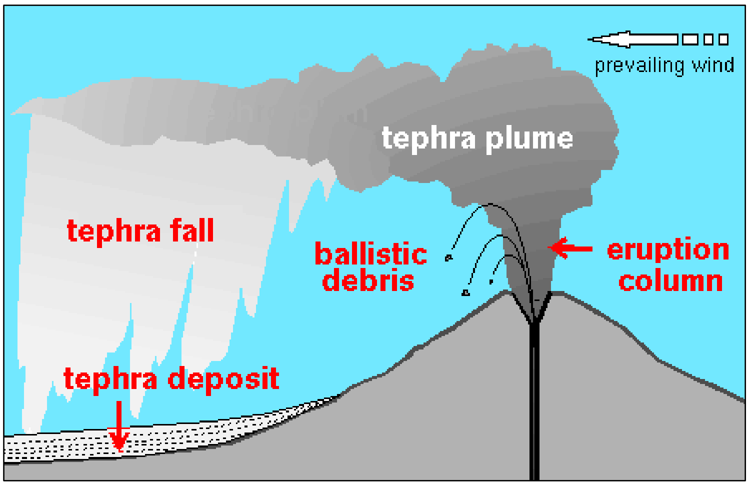

Figure 6. Tephra, large blocks and bombs are ejected from the volcano

Figure 7. Tephra falling from volcanic eruption make kill people

Figure 8. Damage of Airplane in Cuba Point Naval Air Station

4.2 Secondary Effect

4.2.1 Landslide, Earthquake, and Tremors

Volcanic Landslides can be caused by intense rainfall or regional tectonic earthquakes. Volcanic mountains tend to be become over steepened as a result of the addition of new material over time as well due to inflation of the mountain as magma intrudes. Over steepened slopes may become gravitationally unstable, leading to a sudden slope failure that results in landslides, debris slides or debris avalanches. Hurricane in 1998 triggered a major landslide on Casita volcano in Nicaragua, causing at least 3,800 fatalities. Landslides are common many volcanoes, whether or not. Earthquakes usually precede and accompany volcanic eruptions, as magma intrudes and moves within the volcano. They are typically small in magnitude (<M5) and relatively shallow, but they may be felt and may cause structural damage (Figure 9). They may be strong before a volcanic eruption as magma is forcing a path though the Earth's crust. Most volcanoes are in tectonically active environments prone to larger and more destructive earthquakes. Volcanic tremor, also called harmonic tremor, is a type of continuous rhythmic shaking of the ground that is generated by magma moving underground (Figure 10).

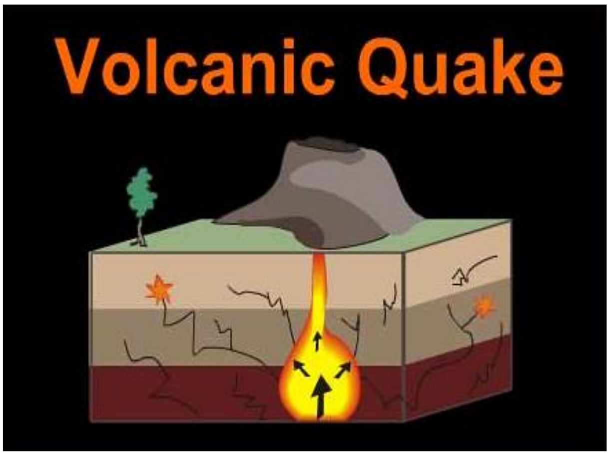

Figure 9. Volcanic quake

Figure 10. Continuous rhythmic shaking of the ground

4.2.2 Lightning, Climate Changes, and Fire

Lightning occurs during explosive eruptions in volcanic ash clouds and has caused a number of fatalities. Since large quantities of ash and volcanism can have a short-term effect on climate (Figure 11). In 1815, eruption of Tambora volcano in Indonesia, was the largest in recorded history. The year following the Tambora eruption (1816) was called the "year without summer". Snow fell in New England in July. Volcanic gases like SO2 also reflect solar radiation. Volcanic gases like CO2 greenhouse gases which help heat in the atmosphere. If airplane flights into the large volcanic ash clouds, it will cause dangerous. Sometimes, Lava flames cause house fire and forest fire.

Figure 11. Short-term effect on climate

5. Discussion

These primary effect and secondary effect are potentially dangerous volcanic phenomenon or process that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Volcanic hazards occur before, during and after volcanic eruptions. It is the related geophysical event will occur in a geographic area. It depends up on volcano type, magma composition, eruption style, scale and may occur in different combinations at different time. The major volcanic hazards create risks and disasters. There are two classes of volcanic hazards, direct and indirect. Direct hazards are forces that directly kill or injure people, or destroy property or wildlife habitat. Indirect hazards are volcanism-induced environmental changes that lead to distress, famine, or habitat destruction. Indirect effects of volcanism have accounted for approximately 8 million deaths during historical times, while direct effects have accounted for fewer than 200,000, or 2.5% of the total.

A volcanic risk is any potential loss or damage as a result of the volcanic hazard that might be incurred by persons, property, etc. or which negatively impacts the productive capacity/sustainability of a population. Risk not only includes the potential monetary and human losses, but also includes a population's vulnerability. The definitions of hazard and risk are not well-defined. When an eruption occurs, lava can spill over and can absolutely cause mass devastation. There are many dangers to volcanic eruptions, though this is a natural disaster that cannot be tamed or predicted. Volcanic hazards include primary effects and secondary effects.

6. Conclusion

Volcanic hazards remain among the most destructive natural phenomena, capable of producing both immediate and long-term impacts on human life, infrastructure and the environment. This case study demonstrates that while primary effects such as lava flows, poisonous gases, pyroclastic activity and tephra directly threaten communities and secondary effects including landslides, earthquakes, tremors, lightning, climate changes and fires can amplify devastation far beyond the eruption site. Modern monitoring technologies which are satellite sensors, drones, thermal cameras and seismometers have proven essential in detecting early warning signs, mapping hazardous zones and improving public safety. By integrating these tools, scientists can better understand magma movement, predict eruption risks and mitigate damage. Ultimately, the effectiveness of volcanic hazard assessment lies in combining scientific research, technological innovation and public awareness, ensuring that societies living near volcanoes are better prepared to coexist with these powerful forces of nature.

7. Acknowledgement

I wish to express my immeasurable gratitude to Director General U Kyaw Thet, Department of Mines, for allowing me to carry on the topic "Case Study of Effectiveness of Volcanic Hazard" and giving the opportunity to pursue an experience in the research conference.

I want to thank each person of my Department of Mines including Director U Khin Oo, Deputy Director Dr.Thant Swe Win and Assistant Director U Aung Kyaw Phyo for their help and invaluable advices. Because they are very knowledgeable creatures and always came with more insightful discussions on this paper.

Most importantly, I also would like to say a big "thank you" to everyone who ever joined me for helping and participating of their friendship, support and constant motivation.

8. References

Brilannica, 2020, Cambridge University Press. Chisholm, Hugh"*lava*" Encyclopoedia

Carlson D.H.C., C Plumber & Hammersley., 2011, *Physical Geology; earth revealed.9th*ed.,

Keller, Edward A. 2011, *Environmental Geology*, University of California, Santa Babara

Stephen A Nelson, 2019, Tulane University, *Natural Disaster,* EENs 3050

Wright, T.L and Person, T.C, 1992. *Living with volcanoes*, U.S Geological Survey Circular