A Study on Volcanoes and Risk Assessment

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Abstract

Volcanic hazard assessments are generally based upon the assumption that the future activity of a volcano will be similar to past activity, in terms of style, size and frequency of eruption. Such information on past activity may be obtained from historical records, and from the examination, interpretation and risk assessment dating of ancient deposits which permit the elucidation of a volcano's evolution. As with other natural hazards, the level of rapid production of first-pass volcanic hazard maps. Combined with GIS-based digital techniques, such hazard maps may be presented in forms more easily volcanoes. The potential therefore exists for major loss of life and damage to property and infrastructure, especially where large urban areas occur in proximity to dangerous volcanoes. As population pressures intensify, hazardous areas are likely to become increasingly developed, so raising the level of risk.

Keywords: Volcanic Hazards, Risk assessment, Mitigation

1. Introduction:

Volcanic eruptions produce a number of different hazards, including lavas, pyroclastic falls, pyroclastic flows, pyroclastic surges, lateral blasts, debris avalanches, volcanogenic tsunamis, mudflows and floods and gases. A basic premiss of volcanic hazard assessment is that hazard impact is generally related to the size of the eruption and proximity to the volcano. There are exceptions to this rule, as exemplified by a number of snow-capped Andean volcanoes that produce catastrophic floods and mudflows which have on several occasions devastated distant urban areas. Such a catastrophe befell the Colombian city of Amaro in 1985, where several thousand people were killed by mudflows generated by a relatively small eruption which partly melted the summit ice cap of Nevadodel Ruiz, some 50 km from the city. Whilst such dramatic volcanic disasters are well-publicised, even relatively benign activity such as prolonged periods of degassing and light ashing can have substantial adverse effects. Studies undertaken by the BGS of VolcánIrazú near the Costa Rican capital of San José indicate that a prolonged but relatively small eruption in 1963-65 caused health volcanic risk may be reduced by disaster prevention, preparedness and emergency response measures. Hazard assessment underpins all of these activities and is fundamental to sound land-use planning, which offers the most effective means of reducing volcanic risk in the longer term. As part of the United Kingdom's contribution to the United Nation's International Decade for Natural Disaster Reduction (IDNDR), the BGS was commissioned by the Department for International Development (DFID) to investigate the role of volcanic hazard maps in development planning and to develop a methodology for the rapid production of first-pass hazard maps. Experience from past volcanic crises and disasters have shown that problems exist in the uptake and utilization of volcanic hazard information by civil authorities. To improve this interface non-geoscientists need to be involved in the process of hazard assessment and should be educated in the nature and effects of the hazards. As described above, better visual presentation methods for hazard
maps are also advantageous, although probably the most effective means of communicating the potential impact of volcanic eruptions problems. Vulnerability may be defined as the degree of loss to a given element or group of elements, such as people, property or economic activity, resulting from the occurrence of a hazard of a given magnitude, and expressed on a scale from 0 (no damage) to 1 (total loss).

Volcanic risk for a given hazard zone and specified period of time may be estimated as: It involves a great deal of laborious data gathering. As a result, very few volcanic risk assessments have been undertaken, and those that have been attempted have been restricted to the risks imposed by selected volcanic hazards on specific elements, such as estimates of human casualties or numbers of collapsed roofs due to ash-loading. Nevertheless, specific risk assessments of such key elements are sufficient to act as indices which demonstrate to planners and politicians in understandable terms the impacts that might be expected and how these may be mitigated within the framework of land. Vulnerability may be assessed empirically or analytically. The empirical approach assesses vulnerability by examining the adverse impacts of vulnerability hazard probability of the element at risk.

Value may be expressed either as value use planning. Whilst it has been demonstrated that the methods exist for producing effective and cost-beneficial hazard and risk assessments, the greatest hazardous volcanic phenomena during previous disasters. The analytical approach is particularly applicable to assessing the built environment, by numbers of people or in monetary terms in the case of constructions or economic activity. In theory this is a relatively simple process, although in practice it challenge remains to convince politicians and administrators that such assessments are worth putting into action in the first place.

About sixty volcanoes erupt every year worldwide. Large eruptions endanger life and settlement areas of millions of people living on the slopes or on the foreland of active volcanoes. Volcanoes with a high hazard potential are located mainly in third world countries (Latin America, Southwest Pacific). In these countries, eruptions are becoming increasingly risky because of rising population density and intense infrastructural interweaving in the areas surrounding volcanoes. However, compared to other natural disasters, such as earthquakes, the destructive potential of volcanic eruptions is lower, as eruptions are often predictable. Thus mitigation of volcanic hazards is feasible, reducing damage considerably provided that hazard and risk potential have been assessed correctly. To do so, detailed knowledge is needed about the structure and history of the respective volcano, eruption mechanisms, etc. Apart from the numerous destructive effects of volcanic activity, the positive effects, such as fertile soil, geothermal energy, or the picturesque scenery, should not be forgotten.

2. Location Of Volcanoes:
Many volcanoes are located at the edges of lithospheric plates. Along the mid-ocean ridges (spreading zone), the plates are moving apart and new crust is being formed. Along subduction zones, plates collide and one plate is subducted beneath the other. Intraplate volcanoes are located in the interior of oceanic or continental plates.
Volcanoes range from small scoria cones to large stratovolcanoes and shield volcanoes. The morphology of a volcano depends on the eruption processes which are largely governed by the chemical composition and volatile content of a magma. For instance, the higher the percentage of
silica (SiO2) in a magma, the higher its viscosity and the more explosive the eruption. Highly liquid, basaltic lava builds shallow, broad shield volcanoes, whereas stratocones are formed by explosive and effusive activity of more viscous magmas. Hazard assessment of volcanoes must consider the morphology and environment. The products of volcanic eruptions include lava, fragments (tephra), and intrusions. Tephra is classified according to the grain size of fragments into ash "2 mm", lapilli "2-64 mm", and bombs or blocks ">64 mm". Attempts have been made to classify the intensity of a volcanic eruption, i.e., its volume and explosive power. Recently, the Explosive Volcanic Index has been used.

3. Types Of Dangerous Volcanic Activity:
The longer a volcano has been inactive, the greater, usually, the volume of the ejected masses and the more explosive the eruption. Long periods of dormancy between eruptions are characteristic for many volcanoes. The question of when to call a volcano extinct is not easy to answer some volcanoes become active again after thousands or hundreds of thousands of years. High-risk volcanoes are volcanoes that (1) erupt one or more times during one decade, (2) are poorly investigated or monitored, and (3) have dense populations inhabiting the area. Following the emptying of a large magma reservoir, the top volcanic structure collapses, and a caldera is formed. If magma encounters groundwater during its ascent toward the Earth's surface, an explosion-like evaporation or the water occurs, (phreatic explosion when only wall rock is fragmented; phreato-magmatic when new magma is involved). Such eruptions are often accompanied by base surges, currents of immense destructive power which consist of gases, and fragmented rock flowing horizontally and radially away from the eruption center.

4. Products And Hazardous Phenomena:
The principal products of volcanic eruptions may be grouped into several broad categories according to the type of material ejected and its mode of transport from the vents to its place of deposition: ash, falls, pyroclastics flows, lava flow and gas emission. Several other hazardous phenomena are directly associated with eruption. There are ground fracture, ground subsidence, debris avalanche, lahars, glacier bursts, volcanic earthquakes and tsunamis.
1. Lava flows are less dangerous to human life than to property, traffic, and communication because probable path, of lava flows can be roughly predicted, diversion measures, cool advancing front with water, or disruption of source or advancing front of lava flow by explosives may be taken in principle: however, such measures, often turn out to not be very successful. Highly viscous lava generally does not advance far, but commonly piles up above an active vent as a lava dome. Such domes can collapse repeatedly and generate dangerous hot block and ash flows and hot surges and blasts.
2. Poisonous, even lethal, gases can be ejected during the eruption of a volcano or can be released without a triggering eruption (e.g. Nyos). The gases are transported away from vent as acid aerosols, as compounds absorbed on tephra and as microscopic salt particles. Sulfur compounds, chlorine and fluorine react with water to form poisonous acids damaging to the eyes, skin and respiratory systems of animals even in small concentrations. Most volcanic gases are noxious and smell bad, but they can cause mass fatalities. The time available for early warning of gas release is extremely short, and intensified investigation on such gas eruption, as well as keen observation of the respective locations, are absolutely necessary.
3. Ashfalls during volcanic eruption generally do not directly endanger life, although the collapse of roof and houses under the ash load are not uncommon. Considerable damage may be caused, however, for agriculture and industry even at distances up to tens of kilometers from a vent. Many of the hazards of tephra falls can be mitigated with proper planning and preparation. This includes clearing tephra from roofs as it accumulates, designing roofs with steep slopes, strengthening roofs and walls, designing filters for machinery, wearing respirators or wet clothes over the mouth and nose.

4. Pyroclastic flows and low-density surges that are frequently associated with blast are extremely hazardous types of volcanic eruptions. Pyroclastics flows consist of a mixture of volcanic gases and ash and are generated during many volcanic eruptions. Some may be as hot as 900°C; they move swiftly with velocities of up to several 100 m/s. Early warning for this volcanic phenomenon is virtually impossible. A most dangerous situation develops if pyroclastic flows are generated on snow or glacier-covered volcanoes, causing the cover to melt. The only effective method of risk mitigation is evacuation prior to such eruption from areas likely to be affected by pyroclastic flows.

5. Lahars (volcanic mud and debris flows) are a common major volcanic hazard for people and property. Lahars likewise proceed very quickly and possess great destructive power. They develop either as a direct consequence of a volcanic eruption, if, for instance, crater lakes are blown out, or as a secondary event as a result of heavy rainfall during or after the eruption. Areas farther away may be warned several hours in advance. A sufficient monitoring of individual volcanoes, however, rarely is guaranteed. Small lahars can be diverted by barriers or by artificial channels which lead them away from valuable land or property, but in most cases the volume and force of the lahar is such that it beyond human power to control.

6. Volcanic debris avalanches generated by sliding of larger portions of volcanic cones are common. These avalanches are highly mobile and may not only bury large tracts of land and dam streams to form lakes than can drain catastrophically and generate lahars and floods but also cause devastating tidal waves (tsunamis) if they advance into lakes or the sea. The only effective method of risk mitigation is evacuation prior to such debris avalanche or tsunamis (if expecting) from areas likely to be affected by this kind of phenomena.

Damage and hazard to human life, social structure, and property may not be induced only by direct effects of volcanic eruptions. Some of the most dangerous secondary phenomena are tsunamis, contaminated (e.g., fluorine-rich) ashes, or long-lasting aerosol clouds that can orbit the Earth for years after large volcanic eruptions. Aerosol clouds basically consist of condensed volcanic gases, mainly sulfuric acid. The emission of large quantities of SO2 and also possibly halogens into the stratosphere may lead to a temperature decrease on the Earth’s surface by increasing the global albedo and also can contribute significantly to the destruction of the stratospheric ozone layer. The correlation between volcanic hazards, destructive potential, and the erupted mass is not universal. In many cases, the destructive potential depends less on the mass and temperature of the erupted material than it does on the specific environment of the eruptive center, especially the degree of magma-water interaction and the energy of the initial blasts.

5. Prediction of Volcanic Eruptions:
The development of methods to predict volcanic eruptions is extremely important to provide for early evacuation of densely populated regions. Hazard and risk potential of volcanoes can be localized reasonably well, unlike some other types of natural disasters (earthquakes, storms).
Reliable predictions, to a minimum degree, however, are only possible for volcanoes that are well studied and sufficiently instrumented. A prediction based on the statistics of previous eruptions is too vague for specific and short-term prediction of an eruption. A forecast is a general announcement that a volcano will probably erupt in the near future (e.g., by qualitative signs of unrest). A prediction is a relatively precise statement that describes the part of a volcano that is likely to erupt, the time of the eruption, and the presumable type of eruption. Such predictions must be made public with utmost caution in order to gain credibility within the concerned population, thus enabling adoption of preparedness measures. Our increasing understanding of processes inside volcanoes and their measurable effects put predictions more and more on a deterministic basis. The careful analysis of the history of a volcano is the most important method in assessing the long-term probability of the occurrence of a specific eruption type and its eruptive energy. Volcanic eruptions are often announced years, months, days, or hours before (e.g., by harmonic tremors in the deeper conduit system). This microseismic activity commonly increases prior to an eruption and is characterized by relatively constant amplitudes and wave lengths that are possibly caused by the turbulent motion of the magma ascending to the surface from a magma chamber. The relatively slow ascent of viscous magma to the upper crust generates a surface expansion that can be measured with modern geodetic instruments. Temperature increases within a volcano as a result of ascending magma can be detected by infrared signals via satellite. Heat conductivity and the magnetic field are changing. An increase of SO2 emission, often has been observed before eruptions. The characteristic behavior of a volcano can be identified with the help of intensive monitoring by satellite.

6. Prevention And Mitigation Of Volcanic Hazards:
To prevent future disasters, or at least to reduce their extent, a series of measures must be taken before, during, and after a volcanic eruption. Various regional research centers especially in Latin America and South East Asia—should be established that have archives containing all relevant material and that can serve as centers for training of volcanologists, for public education, and for cooperation with other scientific institutions. The preparation of hazard maps helps to determine whether a volcano is potentially hazardous and to assess the risk. For that purpose, detailed knowledge about the history and characteristics of the specific volcano is indispensable, which requires, among other things, topographic and geologic mapping. Hazard maps show the pathways of eruption products to be expected for various eruption intensities. Monitoring of volcanoes by satellites has to increase in order to detect possible changes. Continuous monitoring is essential. When a volcano has been identified as potentially dangerous, ground monitoring (visual and instrumental) should be ensured. The public must be informed and educated on the results of volcanological studies and any possible dangers. This can be done through the use of brochures, lectures, or courses. For potentially dangerous volcanic regions, emergency plans must be worked out, particularly evacuation plans for the population in case of immediate danger. Disaster prevention exercises, as already carried out in Japan, are useful as well. A volcanic eruption cannot practically influenced by man. There are, however, limited possibilities to controlling several of its effects, such as barriers against lava flows or cooling lava with sea water. Smaller lahars can be channeled by artificial sabo dams. Another possibility to prevent the generation of lahars is artificial draining of crater lakes. Long-term regional planning can significantly reduce the hazard potential. Disaster reduction measures can contribute to mitigate the
impact of the volcanic eruptions. Fatalities and economic losses can be reduced if, associated with a well monitoring system, including Early Warning and land use planning, a culture of prevention is introduced within all levels of the society.

References: