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Introductory Chapter: New Advances and Challenges

Angelo Paone and Sung-Hyo Yun

A volcano is a peculiar system where the evolution must be determined. Since a volcano is a complex and chaotic system, any volcanological information have to be taken in fully consideration in a broad volcanic model. Such task is not easy and many active and quiescent volcanoes must be watched attendally, and each volcanological parameter has to be studied and evaluate its influence on the broad hypothetically volcanic model at the unisono. This method could be a difficult endeavor, but it is worth to try.

1. Forecasting volcanic eruption

A major issue in the study of active volcanoes is the link between eruption history, the changes in magma compositions and volumes observed on the surface, and the nature and the time scale of magma differentiation processes underground [1, 2]. It is the latter which determine the timing and the style of eruptions, and which are therefore fundamental to models of how particular volcanic systems behave and evolve, and hence determine hazard mitigation. The immediate targets are those volcanoes that are active, have a history of devastating eruptions, and are in highly populated areas. To make best use of the latest analytical technology, it is also important to work on a well-studied volcano with an established stratigraphy and rock composition. Studies of volcanic samples, experimental investigations, and theoretical modeling are providing insights into the dynamics of magmatic systems and how the plumbing system evolves with time, giving a physical framework with which to interpret volcanic phenomena. All the volcanic processes evolving before and during an eruption lead to the variation of geochemical and geophysical parameters [3]. Hence, computational and analytical facilities, instrumentation, and collection of comprehensive observational, geophysical, geochemical, and petrological datasets associated with recent volcanic activity have enormously improved our view on how volcanoes work [4]. Many active volcanoes have been studied in terms of volcanic forecasting using only some of these techniques. The challenge is to try to employ a volcanological methodology where the main chemical, petrologic, physical, and geophysical parameters are linked all together in order to build a framework where the history of magma ascent velocities, the time scales of magma differentiation, the past and present situation of the magmatic conduit, and the present state of degassing must be considered simultaneously. Such conceptual scenario can be commensurate with monitoring quiescent volcanoes, thus forecasting volcanic eruptions. The papers presented in this International Volcanological Special Issue consider the characteristic features of a single volcano and/or a province of volcanoes on earth, in terms of a future volcanic activity. The technical methods used are wide and innovative as well as traditional concerning the knowledge presented for each paper and therefore worth to study. In this book by the title “Forecasting Volcanic Eruptions,” we collect some example of

less known volcanic systems and other well-known volcanic system such as Somma-Vesuvius volcano. Lar et al. [5] study the Jos and Biu Plateaux volcanic provinces occupying the northeastern half of Nigeria, bordering the Cameroon volcanic line, scattered with conspicuously visible number of dormant volcanoes with no reported activity. The several incidences of volcanic eruptions along the close-by Cameroon volcanic line are pointers to the possibility for the reactivation of any of the dormant volcanoes in Nigeria. Mandal [6], on the contrary, acquaints with the Indian plate that experienced the Deccan volcanism at 65 Ma when it moved over the Réunion hotspot, which has altered lithospheric structure below the Kachchh rift zone (KRZ). To quantify the influence of Deccan volcanism on the crust-mantle, Mandal [6] focuses on the delineation of the upper mantle structure below the KRZ, through the modeling of crust-corrected P-residuals and P-wave teleseismic tomography. The reduction in seismic velocity in the upper mantle could be explained by the presence of trapped carbonatite/partial melts related to the Deccan volcanism. The influx of volatile CO₂ emanating from the carbonatite melts in the asthenosphere might be generating lower crustal earthquakes occurring in the KRZ. Furthermore, Hwang [7] illustrates the evolution of the Guamsan caldera associated with the Guamsan Tuff and rhyolitic intrusions. The Guamsan Tuff consists of dominant ash-flow tuffs with some volcanic breccias and fallout tuffs. The breccias comprise block and ash-flow breccia near a vent and caldera-collapse breccia near a ring fracture. The lower member of the ash-flow tuffs is produced from pyroclastic flow-forming eruptions with any ash-cloud falls on the flow units, whereas the upper member is formed by many ash-flows from boiling-over eruptions. The rhyolitic intrusions are divided into intracaldera plug and ring dikes. The volcanic activities in the caldera exhibit the volcanic processes along a caldera cycle together with eruption types during 63.77–60.1 Ma. The activities began with pelean eruption that occurred with block and ash-flows from lava dome collapse, progressed through expanded pyroclastic flows and ash-cloud falls by pyroclastic flow-forming eruptions from a single central vent, and transmitted with non-expanded ash-flows from boiling-over eruptions along multiple ring fissure vents. Then the caldera collapse induced any translations into multiple ring fissure vents from an earlier single central vent. The boiling-over eruptions were followed by effusive eruptions along which rhyolitic magma was injected as a small plug and ring dikes with some lava domes on the surface [8–10].

On the other hand, Vega [11] puts forward a new methodology in the case of volcanic risk computation. Most of the scientific-technical and economic efforts have been oriented mainly toward the evaluation of threats, with few methodological considerations for assessing vulnerability and much less risk. In other cases, the threat and vulnerability are evaluated independently, which logically presents many difficulties for the integral risk assessment. It is also easy to verify that many of the studies called “vulnerability assessments” are only physical and functional characterizations and diagnoses of vital infrastructure and population. These characterizations can hardly be interpreted in terms of georeferenced indexes and/or maps of vulnerability that represent the spatial and temporal exposure of the elements exposed to each threat.

These were the questions and the academic challenge that led the PIGA Group of research in politics, information, and environmental management of the Universidad Nacional de Colombia, under the direction of the undersigned and with the institutional support of the Ministry of Environment of Colombia and the Autonomous Regional Corporation of Tolima, to investigate and study the threats, vulnerabilities, and risks faced by the population, the constructed elements, and the ecosystems of the area of influence of the Cerro Machín volcano, located in the Department of Tolima, Colombia.

Consequently, a new equation for the determination of volcanic risk is generated and adjusted, based on the valuation of intrinsic threat indexes according to their

degree of intensity, duration, extension, and accumulation and of vulnerability indexes according to the degree of spatial and temporary exposure of the exposed elements (social, economic, institutional, and ecosystemic) and of their capacity of intrinsic and extrinsic response to the threats.

With these equations applied at the level of each pixel, and through the use of geographic information systems (GIS), the risk of damage is modeled and geospatially integrated for two analysis scenarios (start of crisis and eruption) of a possible eruption of the volcano Cerro Machín, which allows obtaining, according to the logical framework of the pre-established evaluation, both the total risk on each element exposed and the total risk generated by each threat.

As a final point, for each analysis scenario considered, the total risk maps as well as escape route maps and possible shelters for transient and/or final relocation of population and population centers are generated.

2. Volcanology at the centre of the people

Finally, Paone [12] shows how Somma-Vesuvius works with an outline on the state of the volcano. Somma-Vesuvius is a quiescent stratovolcano with a probability of Plinian-style volcanic reactivation. Its stratigraphy is well known in the last 40 ka BP. The volcanic products that are part of the Somma caldera are poorly studied. Conversely, younger products have been deeply studied together with the AD 79 Plinian eruption. The impact of a Plinian eruption has been studied and summarized. A simplified scheme is presented from what we can understand the volcanic hazard and risk that the volcano poses to the greater Neapolitan population. In the last 40 years, the demography around the Somma-Vesuvius volcano has increased; consequently, the volcanic risk has increased. It would seem that the Italian Civil Protection (ICP) has not influenced the population and the Italian authority with their massive work around Somma-Vesuvius (red zone). People still continue to build houses. Nowadays, the Somma-Vesuvius volcano does not seem to threaten people, or the people that live around Vesuvius are not afraid of the volcano. But as it is usual just in this moment that the work done and to be done must be spread to all Neapolitan people, working in the school to reach the family. People around Somma-Vesuvius tend to neglect the volcanic risk appearing around Vesuvius. So ICP, all must be much more attend about the behaviour of this Hazardous volcano.


Finally, any active or quiescent volcano must be studied by volcanologist very carefully and all the information must be passed to the people living around it in order to have the people at the centre of the Volcanology.

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