CONDUCTING HAZARD ASSESSMENT AT MONOGENETIC VOLCANIC FIELDS

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Volcanoes can cause significant losses of human lives and property and their impact can be important at local, regional and/or global scales depending on the size of the eruption. To evaluate and manage volcanic risk we need first to assess volcanic hazard, that is, identify how a volcanic system (i.e. an active volcano or volcanic area) has behaved in the past and then use this information to infer how it may behave in the future. Therefore, conducting volcanic hazard assessment for a specific region looks to answer questions like when, where and how the next eruption will be. This is part of a sequential process that involves compilation of geological and volcanological information, the characterization of past eruptions, spatial and temporal probabilistic studies, and the simulation of different eruptive scenarios to get significant and representative results.

At present, volcanic hazard is usually assessed in the form of event tree structures containing possible eruptive scenarios and probabilistic methods are applied to these structures to estimate the long-term and short-term probabilities for each scenario. Consequently, long-term forecasting is based on historical and geological data and theoretical models, while short-term forecasting is complemented with continuous monitoring data when an unrest episode has started. The complexity of any volcanic system and its associated eruptive processes, together with the lack of data that characterise many active volcanoes or volcanic fields, particularly those with long recurrences, make volcanic hazard quantification very challenging, as there is often not enough observational data to build a robust statistical model. A detailed knowledge of the past eruptive record (i.e. volcanic stratigraphy), the internal structure of the volcanic system, and of its tectonic controls, is fundamental to establish a reliable basis on which to build the hazard assessment structure, to determine the time constraints of the volcanic processes, and to correctly interpret volcanic unrest and precursory signals of future eruptive events.

Monogenetic volcanism represents, in comparison with polygenetic volcanism, the other end-member of volcanic systems and is commonly represented by volcanic fields containing tens to thousands of small volcanoes, each the product of a single eruption. They are usually mafic in composition and represent relatively small volume eruptions that produce cinder cones and lava flows, as well as occasional phreatomagmatic deposits due to the interaction between magma and surface water. Basaltic monogenetic volcanic fields are the commonest type of terrestrial volcanism and may be active for several millions of years with eruption recurrences ranging from several tens to several tens of thousands of years. The distribution of volcanic cones in basaltic monogenetic fields is clearly controlled by regional and local tectonics. The great variety of eruptive styles, edifice morphologies and deposits in monogenetic volcanoes are the result of a complex combination of internal (magma composition, gas content, rheology, volume, etc.) and external (regional and local stress fields, stratigraphic and rheological contrasts in substrate rock, hydrogeology, etc.) parameters that help characterize each volcanic system

The factors controlling the precursory activity in monogenetic volcanic fields are still poorly understood, which means that eruption forecasting in these systems is not very accurate. The fact that in monogenetic volcanism each eruption has a different vent suggests that volcanic susceptibility has a high degree of randomness, so that accurate forecasting is subjected to a very high uncertainty. Recent studies on monogenetic volcanism reveal how sensitive magma migration may be to the existence of changes in the regional and/or local stress field produced by tectonics or lithological contrasts (i.e., intrusion of magma bodies), which may induce variations in the pattern of further movements of magma, thus changing the location of future eruptions. This implies that a precise knowledge of the stress configuration and distribution of rheological and structural discontinuities in such regions is crucial to forecast monogenetic volcanism.

We use the Garrotxa Volcanic Field (NE Spain) and El Hierro and Tenerife (Canary Islands) as case studies to improve our understanding of the local 3D geology of monogenetic volcanic fields. We have used a combination of field geology and high precision geophysical techniques, including seismic tomography, gravimetry, self-potential and electrical resistivity tomography, in order to investigate the relationship between regional and local tectonics and the spatial distribution of monogenetic volcanoes in these volcanic areas, and how basaltic magma is transported from deep reservoirs to the surface in each of them.