Structural controls of monogenetic volcanism

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The factors controlling the precursory activity in monogenetic volcanic fields are still poorly understood, which means that eruption forecasts in these systems are 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) as a case study to improve our understanding of the local 3D geology of monogenetic volcanic fields. We have used a combination of high precision geophysical techniques, including gravimetry, self-potential and electrical resistivity tomography, in order to investigate the relationship between local tectonics and the spatial distribution of monogenetic volcanoes in the Garrotxa. Our results show that this volcanic field is underlain by low-density material, which partly can be interpreted as the roots of surface manifestations of volcanic activity. They also show that most of the eruptive fissures which have controlled the volcanic activity in this area for more than 300 ka correspond to NE-SW and NW-SE oriented tectonic structures. This suggest that ascent and eruption of magmas in this volcanic field has been controlled by the same regional normal faults bounding the horsts and grabens of the area and which seems to be related to the origin of magmas at the base of the lithosphere. This explains the high magma ascent velocities (0.2- 2m/s) found in these volcanoes, which together with the presence of mantle xenoliths and lower crust cumulates, suggest that some of the eruptive fissures and faults reached quite deep in the lithosphere. The occasional diversification of magma at the upper part of the crust towards secondary fractures of the same structural system seems due to stress barriers caused by the presence of intrusive bodies from previous eruptions and stratigraphic discontinuities in the substrate.