Magma injection process in monogenetic volcanoes: the El Hierro eruption, Canary Island, Spain: applications to eruption forecasting

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A new submarine eruption started in October 2011 on El Hierro, Canary island. The eruption was preceded by three months of seismic unrest related to internal magma movements. Several magma injection processes have been identified from the beginning of the unrest but only a few have culminated with a new vent opening. These successive injection processes are being monitored with the available high quality GPS deformation and seismic data.

An injection model (De la Cruz-Reyna and Yokoyama (2011), and a cumulative seismic energy model proposed by Yokoyama (1988) were adopted after the volcanic unrest was detected in July 2011. The former is used to assess the spatial susceptibility of new-vent formation, and the latter to forecast the probability of volcano-tectonic earthquakes exceeding magnitude 4 occurring as a consequence of the magma displacements.

Using the GPS deformation data in real time, a new pressure source is assumed using a Mogi model, and a conical region of likelihood for new vent opening is calculated from the abovementioned injection model as the surface of maximum shear stress resultant from the superposition of the Mogi pressure source and the lithostatic pressure. The intersection of the conical region with the known fracture system on the surface defines the points of maximum probability of vent opening. At the beginning of each injection process the volcano-tectonic seismic energy accumulates at a constant rate and is mostly released by earthquakes with magnitude lower than 2.0. However, when the volcano-tectonic cumulative seismic energy reaches about 1011 Joules, the injection process accelerates producing earthquakes with magnitudes higher than 4.5, thus increasing the probability of a new opening.

To the time of this submission, six distinct injection processes have been identified, but at least two opened vents to the surface of the crust. The first one produced a submarine serretian eruption south of the island. Another one produced a second deep-sea eruption north of the island which remained undetected on the surface except for the characteristic seismic tremor signal.