Depths of magma reservoirs at oceanic island volcanoes: the magmatic system of El Hierro (Canary Islands) during the 2011-2012 eruption inferred using satellite geodesy

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Starting from July 2011, anomalous seismicity was observed at El Hierro Island (Canary Islands, Spain). During the following three months, seismic activity increased both in number of events and in magnitude, while expanding over a larger area. In early October 2011 the process led to a submarine eruption, with some uncertainty about the location and timing of the opening of the vent(s). The site of the eruption was approx. 15 km from the initial and main earthquake loci, indicative of significant lateral migration. The submarine eruption finished in early March 2012. However, several additional pulses of magma seemed to occur in June-July, 2012; September 2012; and January 2013 as indicated by an increase in seismicity and intense ground deformation. The additional pulses has not yet produced an eruption, and seemed to follow different migration paths with respect to the previous periods. Here, we conduct a multi-frequency, multi-sensor interferometric analysis of space-borne radar images acquired using three different satellites (Radarsat-2, ASAR-ENVISAT and COSMO-SkyMed). Radar interferometry is used to measure the deformation that occurred from December 2009 to January 2013.

InSAR data fully captures both the pre-, co- and post-eruptive phases. Elastic modeling of the ground deformation is employed to constrain the dynamics associated with the magmatic and eruptive activity. Results indicate that El Hierro Island magmatic plumbing system is a much more complex system that previously thought. It is composed with at least three main stagnation levels, i) a petrologically-constrained level at 20-26 km depth, ii) a level at the moho, base of the oceanic crust at 8-12 km depth, and iii) a 4 km depth level at the base of the volcanic edifice, coinciding with the typical seafloor depth at El Hierro region. The existence of a dual crustal magmatic reservoirs seems a recurrent/representative feature at other (basaltic) oceanic island volcanoes. Our preliminary interpretation is that the depth of the "dual" shallow system might be controlled by the mechanical properties of the underlying lithosphere and the magma supply rates. In addition, this study represents one of the first geodetically-constrained active magmatic plumbing system model for any of the Canary Islands volcanoes, and one of the few examples of geodetic measurement of submarine volcanic activity to date.

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