Relationship between seismic structure and magma migration during the 2011-2012 El Hierro (Canary Islands) eruption

Antonio Villasenor[1], Carmen del Fresno[2], Carmen Lopez[2], Adelina Geyer[1], Joan Marti[1]

[1]Institute of Earth Sciences Jaume Almera, CSIC, Spain, [2]Observatorio Geofisico Central, Instituto Geografico Nacional, Spain

E-mail: antonio@ictja.csic.es

The submarine eruption in El Hierro island started on 10 October 2011 and was preceded by intense seismic activity that continued throughout the eruption and after it finished on March 2012. Seismicity was monitored by a 9-station seismic network that allowed to locate more than 10,000 earthquakes. The distribution of these earthquakes and stations is very suitable for studying the P-wave structure of the island down to 20 km with travel-time local-earthquake tomography. Using a subset of well distributed and recorded earthquakes we have obtained a three-dimensional P-wave velocity model of the island that is well resolved beneath its central and western part. The most prominent feature of this model is a high-velocity anomaly in the center of the island that at shallow depths coincides with the edifice of the Tanganasoga volcano. This anomaly dips to the south extending from the surface to 10 km depth, and seems to have great importance in the migration of magma that fed the 2011-2012 eruption. Two seismic zones converge at the base of this anomaly, while the seismicity inside the anomaly is very low. The first seismic zone dips very steeply (> 60 degrees) to the north and extends approximately to 25 km depth below the El Golfo area. The second zone dips more gently to the south below El Julan, reaching a maximum depth of 20 km, coinciding with the center of the inflation determined from GPS data. This seems to indicate that magma ascended from the south and/or north deep seismic zones reaching the base of the anomaly where its ascent was stopped. After this first period seismicity and presumably magma started to migrate south, always at the base of the high-velocity body, until it erupted 2 km offshore of the southern tip of the island. These results are consistent with thermobarometric and petrologic studies of young erupted rocks in El Hierro that suggest main fractionation of magma at 19-26 km depth, and also the existence of multi-stage ascent with small, isolated magma pockets where mixing of distinct magma batches may occur.