Mixing in the Deep: Magma Plumbing in Space and Time at El Hierro, Canary Islands

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Understanding the architecture of subterranean magmatic systems feeding volcanoes is critical for accurate interpretation of surface monitoring data and, ultimately, eruption forecasting. At El Hierro, Canary Islands, a first historical eruption took place ~2 km offshore from October 2011 to March 2012 after three months of precursory seismicity and ground deformation. We analyzed the composition of the bulk lava, matrix glass, minerals and melt and fluid inclusions of a set of samples erupted in 2011–2012. Our detailed petrological analysis reveals that at least two distinct magmas initially supplied from reservoirs in the mantle underwent hybridization at 15–25 km depth, i.e., also largely within the upper mantle beneath El Hierro. Diffusion chronometry applied to zoned olivine crystals indicates that magma mixing began during the period of pre-eruptive seismicity and continued at depth for weeks after the eruption onset. Our data also capture a magma stagnation level at 10–15 km depth in the lower crust, consistent with subhorizontal propagation of an intrusion over ~15 km before rapid magma transit to the seafloor. The remarkable spatial and temporal correlation of petrological and geophysical data at El Hierro suggests that the observed seismicity records magma mixing and forceful intrusion, as well as subsequent reservoir dynamics. These results show that eruptions at El Hierro are controlled primarily by deep-seated processes, with little influence from shallow crustal levels, and have important implications for monitoring of renewed unrest at similar volcanoes elsewhere.