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The 2011 El Hierro eruption confirms petrological models of magma transport at ocean islands

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A number of recent studies have investigated magma plumbing systems of La Palma and El Hierro (Canary Islands) and Fogo (Cape Verde Islands) by applying clinopyroxene-melt geobarometry and microthermometry of CO_2-rich fluid inclusions. The data indicate a remarkable bimodality of retrieved pressures, reflecting a multi-stage ascent history. Most clinopyroxene phenocrysts last equilibrated with the host melt at about 16-30 km depth, in the uppermost mantle, interpreted as the levels of major magma reservoir systems. In contrast, fluid inclusions in phenocrysts and xenoliths typically (re-)equilibrated at <15 km depth, interpreted as major intrusion levels within the lower crust where ascending magmas stagnate or move laterally. The bimodality was attributed to fluid inclusions re-equilibrating to changing ambient pressures much faster than clinopyroxenes. The petrological data show that temporary stalling of magmas within the crust beneath Atlantic ocean islands is the rule.
This model is corroborated by seismic data from the submarine eruption of El Hierro that began on Oct. 10th, 2011 (data courtesy of Instituto Geográfico Nacional, Madrid, Spain). The eruption was preceded by three months of ground deformation and seismic unrest with most hypocenters being located beneath the island at 7-15 km depth. Three weeks before eruption the seismic foci migrated southward and increased in depth and magnitude. The data are best explained by emplacement of sills and filling-up of a lower crustal storage system, corresponding to the intrusion level reflected by fluid inclusions. Once the eruption had begun, the seismic foci shifted to beneath the north of the island at 15-25 km depth. This shift indicates that a stable magma pathway with lateral transport within the lower crust had been established. Subsequent strong seismicity was most likely related to magma withdrawal from a reservoir system in the mantle and probably concomitant recharge. This is the reservoir system indicated by clinopyroxene-melt barometry. In summary, the results confirm the suitability of petrological methods for the investigation of magma plumbing systems.