Complex magmatic systems beneath monotonous basaltic shield volcanoes in the Galápagos Archipelago

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The Galápagos Archipelago is one of the most volcanically active regions on Earth, with eruptions typically occuring every ~2 years. Most volcanoes in the archipelago produce monotonous basaltic lava, with very little variability in the compositions of erupted liquids on millenial timescales. This has been interpreted to result from thermal and compositional buffering of the liquids as they ascend through steady-state crustal-scale magma systems. However, previous geochemical studies have largely relied on whole-rock data, which preclude detailed interrogation of the depths of magma storage or compositional heterogeneity within the sub-volcanic systems. Here, we undertake a microanalytical study of lava, tephra and cumulate nodules ejected during recent eruptions at Fernandina (in 1968) and Wolf (in 2015) volcanoes, placing new constraints on the architecture and dynamics of Galápagos magmatic systems.

By integrating robust petrological geobarometers with geophysical (InSAR) observations, we demonstrate that erupted magmas are largely sourced from lower crustal reservoirs (>6–9 km), with small amounts of melt stored at shallower levels (~1 km). Furthermore, mineral compositions record crystallisation from chemically diverse melts, ranging from primitive basalt to andesite, and extending to more evolved compositions than their carrier liquids. We infer that evolved magmas are not erupted at the surface because they have mixed with a much larger volume of basalt ascending from depth. Hence, our data support a model of sub-volcanic systems containing heterogeneous liquids within multiple discrete storage regions, rather than thermally and compositionally steady-state crustal-scale magma reservoirs. This suggests that even volcanoes that persistently produce homogenous basaltic lavas may be fed by magmatic systems containing pockets of silicic melt, and that the monotonous composition of erupted material may instead reflect the dynamics of magma storage and ascent.