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Magmatic complexity recorded in deep cumulates of Hawaiian and Galapagos volcanoes

MATTHEW L. M. GLEESON, JOHAN LISSENBERG, MARC-ALBAN MILLET AND CAMILLE LECEOUCHE

Cardiff University

Presenting Author: gleesonm@berkeley.edu

Ocean island volcanoes, formed through melting of deep-seated mantle plumes, provide insights into the chemical heterogeneity and dynamic nature of the Earth's mantle. However, recent work has shown that erupted lavas represent an incomplete, and potentially biased record of the chemical heterogeneity within a magmatic system, owing to the roles of magma mixing, recharge, and reactive flow. A more complete record of the primary chemical heterogeneity in the underlying mantle source might be provided by the composition of deep crustal cumulates if the role of crustal processing can be determined. In fact, recent analysis of crustal cumulates from mid-ocean ridge settings reveal that these samples contain far greater heterogeneity than their erupted counterparts, indicating the presence of short length-scale chemical heterogeneity in their mantle source.

Snapshots of the deep magmatic systems beneath ocean island volcanoes are provided by cumulate xenoliths, fragments of magmatic mush brought to the surface in volcanic eruptions. These xenoliths contain information about the short length-scale heterogeneity of upwelling mantle plumes and therefore the long-term evolution and dynamics of the Earth's mantle. In this study we focus on understanding the chemical heterogeneity of cumulate xenoliths originating from the Hawaiian and Galapagos islands. Our work utilises a multi-scale analytical approach, involving chemical mapping of entire samples alongside major, minor and trace element measurements of individual crystal phases/zones to provide a detailed petrological study of the magmatic history of these cumulates. In doing so, we assess the origin of chemical heterogeneity within these samples and gain greater textural and petrological context for further geochemical analysis.

Our data indicates that there is clear chemical heterogeneity in most Hawaiian and Galapagos xenoliths, with several magmatic episodes recorded in each sample. For example, multiple geochemical domains are observed in several of the Hawaiian cumulates, with both wehrlites and gabbros displaying evidence for channelised transport of a secondary melt phase through a cumulate mush system. Overall, our results indicate a complex magmatic history for these deep crustal cumulates. Through careful, sub-crystal scale analysis, this provides an excellent opportunity to extract information about the isotopic heterogeneity of the mantle source.