Pulsing evolution of a hotspot: constraining the scale of mantle heterogeneities

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Upwelling plumes bring a diverse range of deep mantle compositions from long-term storage to the Earth's surface, but the scale and periodicity of these heterogeneities is undetermined. We investigate the changes in mantle composition emerging from a plume through a period of 10 million years using high-resolution Pb isotopes of basaltic and felsic volcanic rocks from the Canary hotspot. Magmas are found to progressively track a discrete isotope trajectory for ~1 My, before taking ~0.3 My to transfer to a parallel trajectory, where tracking then continues. Each isotope trajectory reflects a pulse of mantle emerging from the plume stem with a distinct $^{208}Pb^{*}/^{206}Pb^{*}$ and consistent Th/U. During a pulse, $^{206}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ changes progressively, along the trajectory, reflecting the gradual incorporation of a component with either higher or lower U/Pb and Th/Pb.

Basaltic and felsic magmas on Tenerife show a coordinated response to this plume heterogeneity, indicating crustal processes do not interfere with the over-riding Pb isotope pattern. However, felsic volcanics have a more sluggish reaction to changes in mantle composition, taken to reflect the averaging effect of their slower-throughput and larger-volume magma reservoir, which blends and stores the products of consecutive mantle pulses. This time-integration of felsic magma, combined with their tight age-constraints, record progressively changing mantle in a more effective way than the basaltic magmas.

Pulses with distinct $^{208}Pb^{*}/^{206}Pb^{*}$ could represent the upwelling of 50-100 km-high columns within the plume. Each of these reflects a volume of mantle that has retained a consistent Th/U since processing through a subduction system at ~1.4 Ga. $^{206,207,208}Pb/^{204}Pb$ variation within these pulses represents a finer-scale heterogeneity and is consistent with the variable removal of Pb at that time.