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Tracing the Relation Between Plume Volume Flux and Compositional Variations in the Hawaiian Plume from Helium Isotopes

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Hawaiian shield basalts exhibit some of the highest $^{3}He/^{4}He$ observed in ocean island basalts. High $^{3}He/^{4}He$ has been linked to the presence of an ancient, less-degassed component in OIB deep mantle sources. A global OIB helium data compilation (Harðardóttir & Jackson, 2025) suggests that high $^{3}He/^{4}He$ is limited to plumes with high buoyancy flux and may require a mantle source with lower proportions of recycled materials with low $^{3}He/^{4}He$. Along the Hawaiian Islands, volcanoes are divided into two geographic and geochemical trends, Loa and Kea. The Loa trend displays geochemical characteristics that reflect the presence of enriched, recycled material(s) in its source (e.g., Williamson et al., 2025). This study aims to investigate whether both recycled material(s) and a less-degassed mantle component can coexist within the Hawaiian plume source, examine their deep mantle spatial and temporal distributions, and decipher the relationship between plume flux variations and He isotopes from within a single hotspot chain.

Hawaiian He data exist for Kamaʻehuakanaloa (Lōʻihi), the Island of Hawaiʻi, East Maui, Oʻahu, and Kauaʻi, with the highest $^{3}He/^{4}He$ occurring at the oldest and youngest volcanoes of the chain (Kauaʻi, 5 Ma and Kamaʻehuakanaloa, 0 Ma). From Molokaʻi to West Maui, He isotopic compositions are relatively poorly constrained. We carefully selected ~27 samples from nine Hawaiian volcanoes to determine whether high $^{3}He/^{4}He$ is preferentially present in Loa- or Kea-trend volcanoes, and if high $^{3}He/^{4}He$ volcanoes show reduced contributions from recycled materials.

Preliminary results show no significant difference in $^{3}He/^{4}He$ between Loa and Kea trends, but there are distinct relationships between He and radiogenic Sr, Nd and Pb. Kamaʻehuakanaloa has the highest $^{3}He/^{4}He$ and does not overlap with the inferred centre of the Hawaiian plume, where magma flux is the greatest (DePaolo et al., 2001). Results imply that variations in recycled material in the Hawaiian source and potential differences in the plume flux might not fully explain the spatial variability in $^{3}He/^{4}He$ ratios across the Hawaiian Islands. Additional data and statistical analyses will better constrain the mechanisms governing high $^{3}He/^{4}He$ within the Hawaiian plume and the distribution of the less-degassed mantle component within its deep source region.