Assessing shallow level interactions in OIB geochemical signature; Application to São Nicolau Island, Cape Verde

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Chemical and isotopic compositions of Ocean Island Basalts (OIB) related to plume melting in the Earth mantle can show large variations on a single island. These variations may reflect source evolution and/or interaction of plume-derived melts with their surrounding environment. Thus it is important to decipher the chemical fingerprint of each process to isolate the characteristics of the chemical signature of OIB related to the source composition and then to give insights into mantle chemical dynamics.

Several processes alternative to source vartiations are able to modify the plume-derived pristine chemical and isotopic composition of OIB. These include (i) post-eruption seawater interaction, which results in leaching of highly soluble elements relative to seawater (i.e. K, Rb, …), precipitation of secondary phases and input in some elements. This interaction also leads to changes in the $^{87}Sr/^{86}Sr$ isotopic ratio of basalts due to mixing with radiogenic Sr ($^{87}Sr/^{86}Sr$ of seawater ~0.7092); (ii) assimilation – fractional crystallization (AFC) processes, which occur in magma chambers and combine the effects of mixing with a chemically and isotopically different reservoir and fractional crystallization; (iii) plume-lithosphere interaction which corresponds to pure mixing of plume-derived melts with a non-convective mantle reservoir; and (iv) fractionation effects of partial melting and fractional crystallization.

New measurements of São Nicolau Island basaltic samples, Cape Verde Archipelago, (major-, trace-elements, Sr and Nd isotopes) provide evidence for these different types of interactions. Using a combined multi-elemental and multi-isotopic approach as well as numerical modeling of basic processes, the ascending history of São Nicolau magmas can be re-built, leading to an estimate of the chemical and isotopic composition of the Cape Verde plume melts.

Helium isotopic measurements from Raivavae and Rapa, Cook-Austral islands: New insights into the nature of the HIMU component

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Helium is a unique tracer of the chemical evolution of the Earth's interior. The presence of low $^{3}He/^{4}He$ ratios (< the MORB range of 7-9 R_A) found in HIMU ocean islands (high μ, where μ is the U/Pb ratio) are attributed to recycled oceanic crust. However, recycled crustal material should be essentially devoid of ^{3}He but have high concentrations of ^{4}He produced from the decay of U and Th. It is, therefore, somewhat surprising that the average helium isotopic ratios at HIMU ocean islands are as high as 6-7 R_A. Proposed explanations for the observed $^{3}He/^{4}He$ ratios include 1) an open system behavior of He characterized by extremely high He diffusivity of 10^{-4} cm^2/s [1]; 2) mixing between a composite plume, composed of a high $^{3}He/^{4}He$ component and a HIMU component, and depleted MORB mantle [2] and 3) derivation of He from recycled oceanic lithosphere [3].

To evaluate the above hypotheses and better constrain the origin of the $^{3}He/^{4}He$ ratios in HIMU basalts we have started an investigation of helium isotopic ratios in a suite of geochemically well characerterized samples (Sr, Nd, Hf, Pb, and Os; [4]) from Raivavae and Rapa, Cook-Austral Islands. Based on previous work [4], Raivavae lavas have a HIMU character while Rapa lavas have a enriched character. Our preliminary helium isotopic measurements indicate that Raivavae lavas have $^{3}He/^{4}He$ ratios down to 6.3 R_A, significantly more radiogenic than the MORB mantle. On the other hand, samples from Rapa, have $^{3}He/^{4}he$ ratios upto 11.2 R_A.

We observe good correlations between helium and other isotopic tracers (e.g., Os and Hf) which suggests that radiogenic helium at HIMU islands is carried by a mafic component. Further, combined He, Hf, Os data suggest that the EM- component sampled in Rapa lavas incorporates a FOZO/PHEM component, although in a volumetrically minor proportion. Hence, our new data aruge against models that attribute the EM- component solely to recycled sediments or continental lithosphere.

References

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