

Hafnium isotopic compositions of Abyssal Peridotites from the Southwest Indian Ridge

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We report Hf isotopic compositions of clinopyroxene mineral separates from abyssal peridotites from the 9-25° E segment of the Southwest Indian Ridge (SWIR). Peridotites from 15.4° E are plagioclase-free with low Na-Ti abundances and depleted chondrite normalized REE patterns in clinopyroxene (cpx) suggesting residual characteristics. The cpx show a limited variability and plot at the radiogenic end of the MORB field in Nd-Hf isotope space ($\epsilon_{Nd} \sim 13.1$, $\epsilon_{Hf} \sim 18.5$), consistent with the estimates for the DMM reservoir. However these peridotites are more radiogenic than spatially associated SWIR basalts, suggesting the presence of an enriched component in the source of these basalts. A regression line through these peridotites and co-located basalts in ϵ_{Nd} - ϵ_{Hf} space has a slope of 1.21 ($R^2 = 0.94$), similar to the slope of mantle array, suggesting that the enriched component must lie within the mantle array. The un-radiogenic extension of the regression line in ϵ_{Nd} - ϵ_{Hf} space passes close to the proposed local enriched endmember, similar to the Bouvet hotspot lavas. Assuming a Bouvet-like enriched composition in the source of the SWIR mantle, maximum 40% of the Hf budget in the basalts is contributed from the depleted peridotites (15.4° E), which translates to a maximum of 10% enriched component in the basalt source. In contrast, peridotites from 9.98° E and 16.64° E have relatively high Na-Ti contents, high LREE/HREE ratios and are often plagioclase bearing, suggesting re-fertilization. The cpx from both locations plot towards the un-radiogenic end of MORB field ($\epsilon_{Nd} = 4.8-7.9$, $\epsilon_{Hf} = 9.9-14.2$). They are however distinct in Nd-Hf space and overlap with their co-located basalts. The above data is consistent with variable degree of equilibration between these peridotites and local basalts. Model calculations show that 4% addition of local basalts-like melt to the most depleted (15.4° E) local peridotites can explain the Nd and Hf isotopic compositions of re-fertilized 9.98° E and 16.64° E peridotites, however, this estimate does not match the REE patterns of the re-fertilized peridotites. This could indicate that local melts have reacted with a protolith, which is a residue of variable degree of melting but has an Nd-Hf isotope ratio similar to 15.4° E peridotites.

The high Sm-Nd and Lu-Hf ratios of the depleted peridotites (15.4° E) combined with their DMM-like Nd and Hf isotopes suggest recent depletion of a DMM – type mantle, likely related to recent melting underneath the SWIR. This observation is in contrast to the recently reported highly radiogenic Hf isotopic compositions (ϵ_{Hf} up to 291) of abyssal peridotites from the Gakkal Ridge, which have been interpreted to reflect an ancient (> 1 Ga) depletion and melt-rock interaction processes. Our observation, together with Gakkal Ridge peridotites indicates that earth's mantle is more heterogeneous than basalts suggest and investigation of Nd-Hf isotopic compositions of abyssal peridotites from other areas will help us to better constrain the upper mantle composition.

Genesis of alkaline magmas by reaction of MORB-eclogite derived carbonated melt with lherzolite

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Ocean island lavas such as HIMU basalts are silica-undersaturated [1] and present evidence of recycled oceanic crust in their mantle source. Partial melts of neither volatile-free peridotite nor subducted oceanic crust (MORB-eclogite) can explain the degree of silica-undersaturation and high TiO₂ and high MgO, respectively of HIMU lavas. While reaction of MORB-eclogite derived, volatile-free melts with peridotite produce alkalic basalts at low melt-rock ratios [2], the reacted-melts are not low enough in SiO₂ and Al₂O₃ and high enough in FeO* and CaO to explain most of the HIMU lavas. Here we explore whether MORB-eclogite derived CO₂-bearing partial melts and volatile-free peridotite reaction can generate the required chemical attributes for primary HIMU-type magmas.

Reaction experiments were performed between lherzolite KLB-1 and two different MORB-eclogite-derived partial melts – (1) an alkalic melt with 8.5 wt.% CO₂ (G2CPM1; [3]) and (2) a basaltic andesite with 2 wt.% CO₂ (G2CPM2) – at 1375 °C, 3 GPa, a condition which is above the respective liquidii of both the melts but below the solidus of peridotite. The amount of melt, mixed homogeneously with peridotite, was varied from 8 to 50 wt.%. In all the experiments, the original melt underwent partial reactive crystallization, leading to CO₂-enrichment in the reacted melt in equilibrium with a residue of garnet lherzolite to garnet-bearing olivine websterite. Reaction of G2CPM1-KLB-1 produced reacted melts which, on a volatile-free basis, show a decrease in SiO₂ from ~37 wt.% to ~35 wt.%, Al₂O₃ from ~7 wt.% to ~6 wt.%, FeO* from ~17 wt.% to ~12 wt.%, Na₂O from ~6 wt.% to ~3 wt.% and increase in TiO₂ from ~6 wt.% to ~8 wt.%, MgO from ~15 wt.% to ~21 wt.%, and Mg# from ~62 to ~75 with decreasing melt-rock ratio. The reacted melts produced from 25-33 wt.% G2CPM2 have ~39 wt.% SiO₂, 8.5-9.5 wt.% Al₂O₃, >10.5 wt.% FeO*, 15.4-16.5 wt.% MgO, 9-10 wt.% CaO, and Mg# of 72-73.

We demonstrate that carbonated MORB-eclogite derived mildly alkalic melt evolves to more primitive, strongly alkalic compositions with variable melt:peridotite ratio. More importantly, an andesitic melt with only 2 wt.% CO₂ evolves to melts similar to melilititic, nephelinitic, and HIMU lavas. At a given MgO content, the reacted melts evolved from G2CPM2 are a better match for alkaline ocean island lavas in terms of SiO₂, Al₂O₃, FeO*, CaO, and MgO as compared to partial melts of carbonated peridotites and eclogites. We suggest that percolative flow of siliceous or mildly alkalic carbonated melts in a subsolidus peridotitic mantle is a widely occurring process, causing partial reactive crystallization of the original melts and leading to formation of primary alkalic magmas. The reacted melts have the potential to erupt as alkalic OIBs or to act as metasomatic flux to shallower source regions.

[1] Jackson and Dasgupta (2008) *EPSL* **276**, 175-186. [2] Mallik and Dasgupta (in press) *EPSL*. [3] Gerbode and Dasgupta (2010) *JPetrol* **51**, 2067-2088.