



Evidence for dry carbonatite metasomatism in the oceanic lithosphere from peridotite xenoliths of Samoa and Lanzarote

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Water in Earth's mantle affects processes like magmatism and plate tectonics. Experiments show that CO₂-rich fluids lower the water solubility in olivine [1], implying that CO₂-rich melts/fluids may dehydrate the lithosphere during metasomatism. To test this hypothesis, we report water concentrations (by polarized FTIR) of olivines, orthopyroxenes (OPX) and clinopyroxenes (CPX) from Savai'i (Samoa) and Lanzarote (Canary Islands) peridotite xenoliths with evidence of carbonatite metasomatism.

Savai'i peridotites are highly depleted harzburgites and dunites with spinel Cr# (Cr/(Cr+Al)) ranging from 0.4 to 0.76 (estimated degree of melting: 19±1.5% [2]). Strong Light Rare Earth Element (LREE) enrichments with Ti and Zr depletions in OPX and CO₂-rich fluid inclusions (via Raman spectroscopy) are consistent with carbonatite metasomatism. Olivine, OPX and reconstructed bulk rock water concentrations (0.67-3.8, 17-89 and 4-26 ppm H₂O, respectively) are low and show no apparent relationship with extent of carbonatite metasomatism. Calculated water concentrations of melts in equilibrium with Savai'i OPX (OPX/melt partitioning of water ~0.0063 to 0.011 [3]) are, on average (0.54±0.32 wt% H₂O), lower than host Samoan lavas (0.63 to 1.5 wt% H₂O [4]), despite the LREE enrichments in OPX.

Lanzarote peridotites are also highly depleted (degree of melting from spinel Cr#: 17±1.8% [2]). Water concentrations are low in olivines (1.7-5.3 ppm H₂O) and variable in pyroxenes (OPX: 42-103 ppm H₂O; CPX: 105-301 ppm H₂O), and show no apparent correlation with indicators of carbonatite metasomatism. Both Savai'i and Lanzarote peridotites show negative correlations between water and degree of melting (i.e. Mg/(Mg+Fe), Cr#), suggesting melt depletion rather than metasomatism may have influenced their water concentrations. Calculated water concentrations of melts in equilibrium with Lanzarote CPX (average 1.9±0.75 wt% H₂O; CPX/melt partitioning of water ~0.011 to 0.012 [3]) are similar to those for Western Canary lavas (average 1.8±0.31 wt%; CPX/melt partitioning of water ~0.016 to 0.021 [3]) inferred from their CPX phenocrysts [5]. However, calculated Ce concentrations in such melts (352 to 378 ppm; CPX/melt partitioning of Ce ~0.07) are an order of magnitude greater than the lavas, and similar to carbonatites. This leads to H₂O/Ce to be an order of magnitude lower in the inferred melts (26 to 57) than estimates for Western Canary lavas (~280±150). These low H₂O/Ce ratios may suggest H₂O loss from CPX during ascent, but the lack of strong water diffusion gradients in Lanzarote minerals does not support this. Instead we hypothesize that carbonatite metasomatism resulted in greater enrichment of Ce over H₂O. Assuming carbonatite magmas are water rich, this implies a lower partitioning of water between minerals and melts during metasomatism, as suggested by experiments. Our data suggests carbonatite metasomatism does not result in significant re-hydration of the lithosphere, in contrast to silicate metasomatism as previously observed in Hawaiian peridotites [6].

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