Water Systematics in the Samoan Lithosphere

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Water in the mantle influences magmatism and rheology. Yet existing water contents in mantle xenolith phases show a highly variable water content distribution in the oceanic lithosphere [1,2]. Here, water concentrations in olivine and pyroxenes were determined by FTIR in harzburgite and dunite xenoliths from Savai'i (Samoa) to better constrain the processes that influence the variability of water contents in the oceanic lithosphere.

Savai'i peridotite spinel Cr# (0.30-0.75) and high Mg# (up to 0.927 in orthopyroxene) indicate high degrees of melt depletion (~12 to 21%, most samples > 18%). Water concentrations in olivine (0-3.8 ppm H_2O) and orthopyroxene (opx; 17-89 ppm H_2O, most < 38 ppm) are some of the lowest reported in oceanic peridotites, consistent with the lack of hydrous phases in Savai'i peridotites. Positive correlations with opx Al content and negative ones with spinel Cr# are consistent with partial melting having depleted the water in these minerals. However, these water concentrations are still higher than predicted by melting models. The two samples with the highest opx water concentrations (88-89 ppm H_2O) show evidence for both presence and absence of melt-rock reaction, but both have the highest Al contents in opx. Lack of water content variation in transects across olivine and pyroxene grains argues against significant diffusive loss of water during xenolith ascent. Two previously-analyzed Savai'i peridotites have similar opx water concentrations (99-118 ppm) [2] to the most water enriched opx analyzed here, and show evidence for carbonatite-metasomatism [3].

These data suggest that metasomatism may have "re-hydrated" parts of the Savai'i lithosphere. Yet, calculated water concentrations of melts in equilibrium with the opx (0.22-0.88 wt% H_2O) are lower than measured in Savai'i lavas (0.63-1.5 wt% H_2O) [4]. Therefore, either the metasomatic melts are unrelated to the host Savai'i lavas, and/or carbonatitic metasomatism decreases the water activity in the melt leading to lowered concentrations in the equilibrium minerals. The comparable and low water concentrations in carbonatite-metasomatized peridotite opx from the Canaries (42-103 ppm H_2O) supports the second scenario.

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