

Subsolidus hydrogen partitioning between nominally anhydrous minerals in garnet-bearing peridotite

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ABSTRACT

Hydrogen distribution between nominally anhydrous minerals (NAMs) of a garnet-lherzolite under subsolidus conditions has been investigated. Separated NAMs from a garnet-peridotite from Patagonia (Chile) are annealed together (olivine, orthopyroxene, clinopyroxene, and garnet) using a piston-cylinder at 3 GPa and 1100 °C using talc-pyrex cell assembly for 10, 25, and 100 h. The talc-pyrex assembly provides enough hydrogen in the system to re-equilibrate the hydrogen concentrations at high pressure. The three coexisting nominally anhydrous minerals (NAMs, i.e., olivine, orthopyroxene, and clinopyroxene) were successfully analyzed using FTIR. The resulting hydrogen concentrations exceed significantly the initial hydrogen concentration by a factor of 13 for olivine and a factor of 3 for both pyroxenes. Once mineral-specific infrared calibrations are applied, the average concentrations in NAMs are 115 ± 12 ppm wt H₂O for olivine, 635 ± 75 ppm wt H₂O for orthopyroxene, and 1214 ± 137 ppm wt H₂O for clinopyroxene, garnet grains are dry. Since local equilibrium seems achieved over time (for 100 h), the calculated concentration ratios are interpreted as mineral-to-mineral hydrogen partition coefficients (i.e., Nernst's law) for a garnet-peridotite assemblage. It yields, based on mineral-specific infrared calibrations, $D_{\text{Opx/Ol}} = 5 \pm 1$, $D_{\text{Cpx/Ol}} = 10 \pm 2$, and $D_{\text{Cpx/Opx}} = 1.9 \pm 0.4$. While $D_{\text{Cpx/Opx}}$ is in agreement (within error) with previous results from experimental studies and concentration ratios observed in mantle-derived peridotites, the $D_{\text{Px/Ol}}$ from this study are significantly lower than the values reported from mantle-derived xenoliths and also at odd with several previous experimental studies where melt and/or hydrous minerals co-exists with NAMs. The results confirm the sensitivity of hydrogen incorporation in olivine regarding the amount of water-derived species (H) in the system and/or the amount of water in the coexisting silicate melt. The results are in agreement with an important but incomplete dehydration of mantle-derived olivine occurring at depth, during transport by the host magma or during slow lava flow cooling at the surface. The rapid concentration modification in mantle pyroxenes also points out that pyroxenes might not be a hydrogen recorder as reliable as previously thought.

Keywords: Olivine, pyroxenes, hydrogen, partition coefficient, upper mantle