Water in Olivine from Different Host Rocks - Application of Proton-Proton scattering

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Despite of being nominally anhydrous, olivine incorporates trace amounts of water as hydroxyl defects. We determined the water content of olivine from different host rocks by applying a nuclear technique that is based on proton-proton scattering. This method, which is used here for the first time on olivine and the second time on a natural nominally anhydrous mineral, is very powerful to determine trace amounts of water. The olivine samples come from three principal rock types: spinel peridotite xenoliths, alpine-type peridotites, and ophiolites. The studied olivines differ in their H_2O contents by one order of magnitude; the results range from 4 to 51 wt.-ppm H_2O (= 10-117 atom-ppm H). The lowest contents are found in olivine from spinel peridotite xenoliths, the highest concentrations in olivine from alpine-type peridotite; the contents of the ophiolitic olivines are intermediate.
For comparison, 'quantitative' infrared spectroscopy was used to determine the water content of one olivine sample; the water contents obtained by spectroscopy and the nuclear technique are very similar. Additional 'qualitative' infrared spectroscopy was applied to all samples to ensure that the measured water contents stem solely from hydroxyl defects in the mineral structure (which was always the case) and not from hydrous impurities and alteration. The infrared spectra differ from sample to sample. Five of six olivines show absorption bands typical of hydroxyl groups associated with Ti defects. The relevant absorption bands are developed in olivines that differ by two orders of magnitude in their Ti contents. However, a correlation of water and Ti content is not indicated. One xenolithic and an ophiolitic olivine have spectral characteristics associated with Mg-site vacancies that are typical of mantle olivine. Another xenolithic sample shows an absorption pattern typical of olivine that either reacted with a basaltic melt or equilibrated at relatively low oxygen fugacity, respectively.
The question of whether the original water contents of the olivines studied were higher because they lost water due to decompression, remains unresolved. Most interestingly, the olivine water contents in alpine-type peridotite are higher than those in xenoliths. Olivine from alpine-type peridotite should lose more water due to uplift and decompression than xenoliths, because tectonic exhumation is by several orders of magnitude slower than the ascent of lavas. Hence, if the samples from the two different source rocks originally had the same water contents, xenolithic olivine should preserve more water. Apart from water loss during decompression, the low xenolithic water concentrations may reflect originally low contents in the mantle source, that possibly are a result of melt extraction.

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