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Hydroxyl in upper mantle minerals

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In order to evaluate the importance of nominally anhydrous minerals as a reservoir of mantle water, we used infrared (IR) spectroscopy to determine the structural hydroxyl (OH) contents of common minerals of upper mantle origin. Mineral-specific calibrations of the IR technique for quantitative analysis of hydroxyl (OH) were developed for garnet, clinopyroxene and orthopyroxene using carefully cleaned megacryst and lherzolite mineral samples, vacuum extraction of H and manometry. The new and previously published calibrations were applied to IR spectra of olivine, orthopyroxene, clinopyroxene, garnet and accessory minerals from mantle xenoliths to yield quantitative estimates of their structural OH contents.

Of the common nominally anhydrous minerals in peridotites, diopsidic clinopyroxene contains the greatest OH concentrations (100-500 ppm H_2O by weight). The highest clinopyroxene OH contents occur in a Cr-rich megacryst and in eclogitic omphacites. Orthopyroxene contains 50-450 ppm H_2O and is probably the most important reservoir of H in "anhydrous" peridotites. Most olivines and peridotite garnets contain less than 30 ppm H_2O. However, olivine and garnet megacrysts with concentrations in excess of 100 ppm H_2O, as well as OH-rich zircons, appear to reflect unusually hydrous environments. Peridotite water contents estimated from coexisting nominally anhydrous minerals range from 25 ppm in a spinel lherzolite from British Columbia to 200 ppm in coarse garnet peridotites from South Africa.

Concentrations of OH in the common "anhydrous" minerals suggest that these phases are petrologically significant hosts for upper mantle water, and may account for the water budget of the depleted upper mantle (MORB source region). Nominally anhydrous, OH-bearing minerals also provide a mechanism for the transport of water into deep regions of the mantle at subduction zones.