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Water in upper mantle pyroxene megacrysts and xenocrysts: A survey study

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Abstract

Water content, mineral chemistry, and oxidation state of clino- and orthopyroxene xenocrysts and megacrysts were investigated by Fourier transform infrared (FTIR) spectroscopy—including focal plane array (FPA) detector mapping, Mössbauer spectroscopy, and electron microprobe. Various tectonic settings, ages, and modes of emplacement are represented by 23 samples from 6 areas (Massif Central, France; Letseng, Lesotho; Colorado, U.S.A.; Kakanui, New Zealand; Oahu, Hawaii; and New South Wales, Australia). The xenocrysts are from both garnet and spinel peridotites—including lherzolite and harzburgite varieties—and one sample of clinopyroxenite. Water contents vary between ~10 and 600 wt ppm. Samples from Massif Central, Colorado, Kakanui, and Hawaii have high water contents: 180–600 wt ppm. The samples from Lesotho and New South Wales have considerably lower amounts: ~10–300 wt ppm. Water contents of xenocrysts and megacrysts from New South Wales vary within a narrow range (clinopyroxene: ~50 wt ppm, orthopyroxene: 15–20 wt ppm), whereas the water content of the Lesothian samples scatter considerably. No significant correlations are observed between water content, mineral chemistry, or oxidation state of the samples. FPA mapping reveals homogenous distribution of water in the pyroxene lattice. The results are compared to available literature and research on water diffusion in natural mantle pyroxene. Altogether, the data suggest that water in pyroxene found in fresh peridotite xenoliths partly reflects the water content of the mantle source region. On the other hand, variable mineral chemistry and water contents of megacryst pyroxenes indicate processes such as magmatic equilibration, magma mixing, and contamination.

Keywords: Mantle water, pyroxene, mantle xenoliths, megacrysts, FTIR spectroscopy, FPA detector analysis, Mössbauer spectroscopy