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Metasomatism-controlled hydrogen distribution in the Spitsbergen upper mantle

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Abstract

Hydrogen concentrations in minerals of peridotite xenoliths in alkali basaltic rocks from Quaternary volcanoes in northwest Spitsbergen were measured using polarized Fourier transform infrared spectroscopy (FTIR) to trace the effects of geologic processes on hydrogen distribution in the continental lithospheric mantle. The mineral grains show hydrogen profiles with lower concentrations at rims suggesting diffusive hydrogen loss during the entrapment and transport of the xenoliths in magma. However, hydrogen concentrations in the centers of the grains are uniform and appear to represent hydrogen abundances in the Spitsbergen upper mantle. The olivine, orthopyroxene, and clinopyroxene contain 1–10, 130–290, and 350–560 ppm H_2O, respectively. Hydrogen abundances away from metasomatic melt conduits recorded by Type 1 xenoliths are correlated with the concentrations of incompatible trace elements, indicating that hydrogen distribution is related to mantle metasomatism. By contrast, hydrogen near the melt conduits, recorded by Type 2 xenoliths, shows no regular correlations with incompatible trace elements (except Nb in clinopyroxene) and may be affected by fractional crystallization of amphibole in the conduits. Hydrogen contents decrease away from the melt conduits and are controlled by the interaction between the depleted host mantle and percolating metasomatic melts. Therefore, the metasomatic melt could have variably hydrated the Spitsbergen upper mantle via different processes. The H_2O/Ce ratios of the melt in equilibrium with clinopyroxene near the metasomatic melt conduits range from 93 to 218, i.e., within the oceanic island basalt (OIB) range. This is consistent with that the metasomatic melt could have been derived from OIB-type sources evidenced by the Sr-Nd isotope compositions of the xenoliths.

Keywords: Spitsbergen, lithospheric mantle, nominally anhydrous minerals, hydrogen content, metasomatism; Water in Nominally Hydrous and Anhydrous Minerals