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CHEMISTRY AND MINERALOGY OF EARTH'S MANTLE

Quantification of water in majoritic garnet†

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Abstract

Majoritic garnet, characterized by an excess of silicon (>3 Si per formula unit), is considered one of the major phases of the Earth's transition zone from 410–660 km depth. Quantifying the H_2O content of nominally anhydrous mantle minerals is necessary to evaluate their water storage capacity from experiments and modeling the Earth's deep water cycle. We present mineral-specific infrared absorption coefficients for the purpose of quantifying the amount of water incorporated into majorite as hydroxyl point defects. A suite of majoritic garnet samples with varying proportions of Si, Fe, Al, Cr, and H_2O was synthesized at conditions of 18–19 GPa and 1500–1800 °C. Single-crystals were characterized using X-ray diffraction, electron microprobe analysis, secondary ion mass spectrometry (SIMS), IR, Raman, and Mössbauer spectroscopy. We utilize SIMS and Raman spectroscopy in combination with IR spectroscopy to provide IR absorption coefficients for water in majoritic garnets with the general mineral formula $(Mg,Fe)_3(Si,Mg,Fe,Al,Cr)_2[SiO_4]_3$. The IR absorption coefficient for majoritic garnet in the OH stretching region is frequency dependent and ranges from 10 470 ± 3100 $Lmol^{-1}cm^{-2}$ to 23 400 ± 2300 $Lmol^{-1}cm^{-2}$.

Keywords: IR spectroscopy, water in nominally anhydrous minerals, transition zone, integral molar absorption coefficient, SIMS, high pressure, Raman spectroscopy