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Effects of hydration on thermal expansion of forsterite, wadsleyite, and ringwoodite at ambient pressure

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Abstract

Single-crystal X-ray diffraction has been used to measure the thermal expansion coefficients of forsterite, wadsleyite, ringwoodite, and their hydrous forms at ambient pressure, from temperatures as low as 133 K to as high as 919 K. Second-order polynomial fitting to $\ln(V/V_0)$ vs. T was applied to derive the expansion coefficients in the form of $\alpha = a_1 \times T + a_0$. The single crystal of anhydrous wadsleyite persisted up to 859 K. Hydrous forsterite was observed to dehydrate at 919 K, whereas hydrous wadsleyite started to dehydrate at 655 K. The crystal of ringwoodite with 0.20 wt% broke down at 911 K, and the two ringwoodite samples with 0.74 and 2.4 wt% H_2O, were observed to break down with an irreversible unit-cell expansion at 808 and 606 K, respectively. From room temperature to high temperatures in this study, the mean thermal volume expansion coefficients are 36.4(5) and 38.1(9) $\times 10^{-6}$ K^{-1}, respectively, for anhydrous and hydrous forsterite; 28.5(5) and 35.8(8) $\times 10^{-6}$ K^{-1}, respectively, for the anhydrous and hydrous wadsleyite; 30.6(9), 35.2(15), and 34.9(7) $\times 10^{-6}$ K^{-1} for the samples of ringwoodite with 0.2, 0.74, and 2.4 wt% H_2O, respectively. Thus, forsterite, wadsleyite, and ringwoodite all have larger thermal expansion coefficients in their hydrous forms than in their anhydrous forms.

Keywords: Thermal expansion, forsterite, wadsleyite, ringwoodite, single crystal