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Elasticity of single-crystal low water content hydrous pyrope at high-pressure and high-temperature conditions

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Abstract

The elasticity of single-crystal hydrous pyrope with ~900 ppmw H_2O has been derived from sound velocity and density measurements using in situ Brillouin light spectroscopy (BLS) and synchrotron X-ray diffraction (XRD) in the diamond-anvil cell (DAC) up to 18.6 GPa at room temperature and up to 700 K at ambient pressure. These experimental results are used to evaluate the effect of hydration on the single-crystal elasticity of pyrope at high pressure and high temperature (*P*-*T*) conditions to better understand its velocity profiles and anisotropies in the upper mantle. Analysis of the results shows that all of the elastic moduli increase almost linearly with increasing pressure at room temperature, and decrease linearly with increasing temperature at ambient pressure. At ambient conditions, the aggregate adiabatic bulk and shear moduli (K_{S0}, G_0) are 168.6(4) and 92.0(3) GPa, respectively. Compared to anhydrous pyrope, the presence of ~900 ppmw H_2O in pyrope does not significantly affect its K_{S0} and G_0 within their uncertainties. Using the third-order Eulerian finite-strain equation to model the elasticity data, the pressure derivatives of the bulk [$(\partial K_S/\partial P)_T$] and shear moduli [$(\partial G/\partial P)_T$] at 300 K are derived as 4.6(1) and 1.3(1), respectively. Compared to previous BLS results of anhydrous pyrope, an addition of ~900 ppmw H_2O in pyrope slightly increases the $(\partial K_S/\partial P)_T$, but has a negligible effect on the $(\partial G/\partial P)_T$ within their uncertainties. The temperature derivatives of the bulk and shear moduli at ambient pressure are $(\partial K_S/\partial T)_P = -0.015(1)$ GPa/K and $(\partial G/\partial T)_P = -0.008(1)$ GPa/K, which are similar to those of anhydrous pyrope in previous BLS studies within their uncertainties. Meanwhile, our results also indicate that hydrous pyrope remains almost elastically isotropic at relevant high *P*-*T* conditions, and may have no significant contribution to seismic anisotropy in the upper mantle. In addition, we evaluated the seismic velocities (v_P and v_S) and the v_P/v_S ratio of hydrous pyrope along the upper mantle geotherm and a cold subducted slabs geotherm. It displays that hydrogen also has no significant effect on the seismic velocities and the v_P/v_S ratio of pyrope at the upper mantle conditions.

Keywords: Hydrous pyrope, single-crystal elasticity, high pressure and high temperature, Brillouin light scattering, upper mantle