High-pressure single-crystal elasticity and thermal equation of state of jadeite

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Clinopyroxene (Cpx) is one of the major mineral phases in the Earth's upper mantle. Jadeite, the (Na, Al) end member of the upper mantle Cpx, is acoustically the fastest pyroxene among all pyroxene end members. In addition, it is also an important chemical end member of omphacite, which is the most abundant mineral in the subducted oceanic slab crust and delaminated continental lithosphere. Thus, studying its high-pressure elastic properties is of fundamental importance for understanding the recycling of materials into the Earth's interior. However, its single-crystal thermoelastic properties have never been experimentally determined at high-pressure conditions before. Therefore, in this study, we aim to provide the first experimentally determined single-crystal elastic properties and thermal equation of state of jadeite at elevated pressure-temperature conditions. Single-crystal jadeite samples from a natural jadeitite were double-side polished into pallets with thickness about 15 µm. We measured the thermal equation of state using X-ray diffraction experiments at 13BMC beamline, GSECARS, Advanced Photon Source up to 24 GPa at 300 K, 373 K, 500 K, and 700 K. Ruby and Au were used as pressure standards and Ne was used as pressure-transmitting medium. The face normals were measured at Hawaii Institute of Geophysics and Planetology, University of Hawaii at Manoa. The face normals of the polished crystal surfaces are close to (1, 1, 0), (0, 1, 0), and (0, 0, 1). Then we performed sound velocity measurements of the three samples up to 18 GPa under ambient temperature in the Brillouin spectroscopy laboratory at University of New Mexico. Two ruby spheres were placed near the sample as the pressure standards and Ne was used as pressure medium. For each sample, compressional and shear velocities were measured at a minimum of 13 different Chi angles along the 360° azimuth to avoid any geometrical error. The chemical composition was determined by electron microprobe analysis and normalizing the chemical analysis in terms of diopside and jadeite yields a simplified composition of $diopside_{3.2}jadeite_{96.8}$. A least-squares fit of the velocity-pressure data gives K_{s0}=138(3) GPa and G_0=84(2) GPa with ρ_0=3.302(5) g/cm^3. We utilized the obtained dataset and investigated the composition-dependent seismic properties of eclogite with different geological origins. Preliminary analysis indicates that the difference in Vp and Vs can be as large as 3%.