Single crystal elasticity of ice VII up to 35 GPa

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H_2O water, consisting of two hydrogen atoms and one oxygen atom, exhibits a rich and intriguing phase diagram with more than 15 phases. It has been long found that H_2O water transforms to ice VI at 0.9 GPa and then to ice VII at 2.2-60 GPa. Numerous reports suggest a structural transition of ice VII at ~10-20 GPa (Iitaka et al., 2015). We acquired Brillouin scattering data for ice VII using the time-domain thermoreflectance (TDTR) method (Chen et al., 2011; Hsieh et al., 2009), also indicating a structural transition of ice VII at 13-16 GPa at 300 K. Those data are, however, for the aggregates of ice VII crystals, instead of single crystals, impossible for us to determine the single crystal elasticity of ice VII. The single crystal elasticity of ice VII was only determined up to 8 GPa by Shimizu et al. (1995). Using externally-heated diamond anvil cells, we synthesized ice VII single crystals at high pressures and temperatures. Single crystal X-ray diffraction and Brillouin scattering measurements of single-crystal ice VII up to 35 GPa and at 300 K have been simultaneously at the Beamline 13-BMD of the Advanced Photon Source, Argonne National Laboratory. The newly acquired data permitted the determination of the equation of state and single crystal elasticity of ice VII. The single crystal elasticity results, concerted with Raman spectroscopic results and equation of state of ice VII at high pressures, help reveal the nature of the structural transition and its effects on the elastic properties of ice VII. The equation of state and sound velocities of ice VII are essential physical properties for the modeling of the structure of icy satellites of giant planets and for interpreting possible seismological signatures from the presence of high-pressure ices in the cold subducted slabs.

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