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Elasticity measurements of the unquenchable davemaoite: Clues to Earth's Deepest Mantle

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Davemaoite ($CaSiO_3$ perovskite) is a major lower-mantle phase and an important host for heat-producing and incompatible elements, yet its elastic and thermoelastic properties remain incompletely constrained because it cannot be quenched to ambient conditions. We report in situ high-pressure–high-temperature elasticity measurements of davemaoite, with composition expected in the subducted oceanic crust at deep lower-mantle conditions using synchrotron X-ray diffraction and Brillouin spectroscopy combined with CO_2 laser-heated diamond anvil cells. We also conducted isothermal compression experiments at high temperatures up to 100 GPa using resistively heated diamond anvil cell. Isothermal compression is critical because diffraction peak splitting across the tetragonal–cubic transition is subtle and difficult to resolve, particularly under conventional heating–cooling cycles where the expansion and contraction of the diamond anvil cell sample chamber, gasket, and pressure medium are unpredictable. By maintaining controlled isothermal conditions during compression, we obtained pressure-volume compression curve at different temperatures, and constrained the transition temperature of the cubic–tetragonal phase transformation. These results provide improved constraints on the thermoelastic properties and phase stability of davemaoite under deep lower-mantle conditions. Our findings refine interpretations of seismic velocity structure near the core–mantle boundary and offer new insights into the chemical heterogeneity and thermal state of Earth's deepest mantle.