

The high-pressure, single-crystal elasticity of pyrope, grossular, and andradite

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ABSTRACT

High-pressure Brillouin scattering experiments were conducted on three natural, single-crystal garnets with near end-member compositions: pyrope ($\text{Mg}_3\text{Al}_2\text{Si}_3\text{O}_{12}$), grossular ($\text{Ca}_3\text{Al}_2\text{Si}_3\text{O}_{12}$), and andradite ($\text{Ca}_3\text{Fe}^{3+}_2\text{Si}_3\text{O}_{12}$). Acoustic velocities of the samples were measured from the samples at pressures to 10 GPa in a diamond-anvil cell with a methanol-ethanol-water pressure medium. Elastic stiffness constants (C_{ij}) and their pressure dependencies ($\partial C_{ij}/\partial P$) were calculated, as were aggregate elastic moduli (K_S and G) and their respective pressure derivatives. The Cauchy relations changed with pressure for both grossular and andradite, suggesting that assuming these are constant is not valid for extrapolation to high pressures for these and possibly other minerals. The variation in $\partial K_S/\partial P$ and $\partial G/\partial P$ was sensitive to composition and required a complex mixing model for extrapolation of end-member elasticity values from garnets of intermediate compositions.