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Pressure–volume equation of state for pyrope–almandine solid solutions

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Garnet is a key phase of Earth's upper mantle and one of the most abundant solid inclusions in diamonds. The pyrope component ($Mg3Al2Si3O12$, Py) of garnet found in diamonds of peridotitic and eclogitic origin can be as high as about 79 and 43%, respectively and the almandine component ($Fe3Al2Si3O12$, Al) is about 11 and 33%, respectively. Thus such garnets are largely Py-Al-rich solid solutions (Stachel and Harris, 2008). To determine the depth of formation of diamond-inclusion pairs, precise and accurate thermoelastic parameters for both the diamond and the solid inclusion phase are necessary (e.g. Izraeli et al., 1999; Howell et al., 2010; Nestola et al., 2011; Howell et al., 2012). We are presently investigating the pressure–volume equation of state for a series of synthetic garnets along the binary pyrope–almandine by X-ray single-crystal diffraction using a diamond anvil cell up to a maximum of 8 GPa pressure. We have completed measurements on two crystals of composition $Fe3Al2Si3O12$ and $Fe1.20Mg1.80Al2Si3O12$. The equation of state coefficients obtained by fitting a third-order Birch-Murnaghan to the pressure–volume data show that an increase in the pyrope component in garnet causes a slight decrease of the isothermal bulk modulus, KT0, by about 3%, whereas the first pressure derivative term does not vary. Applying our results to obtain the pressure of formation of a natural diamond-garnet pair, and assuming a garnet composition close to $Fe1.20Mg1.80Al2Si3O12$, we obtain a pressure of encapsulation (or formation if garnet and diamond are syngenetic) of garnet in diamond between 6.5 and 7.0 GPa.

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