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Equation of state of almandine and implications for diamond geobarometry

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In the framework of a wide research project focused on mineral inclusions in diamonds we have investigated the compressibility of almandine. Garnet is an important phase of the Earth upper mantle and is one of the most abundant inclusions in diamonds. Garnets can be found in both eclogites and peridotites with an average composition showing about 33% and 10% of almandine component, respectively. In order to obtain information about the depth of formation of diamond-inclusion pair precise and accurate thermoelastic parameters for both the diamond and the inclusion are strongly necessary (e.g. [1-4]). In this work we have determined the pressure – volume equation of state of a pure synthetic garnet almandine, $Fe_3Al_2Si_3O_{12}$, by single-crystal X-ray diffraction up to about 7 GPa. The equation of state coefficients obtained by fitting a third-order Birch-Murnaghan equation of state to the pressure – volume data gave the following results: V_0 = 1533.52(10) Å^3, K_0 = 172.5(1.5) GPa and K' = 5.8(5). Our results show a significant lower bulk modulus and a stronger higher first pressure derivative with respect to previous works (i.e. K_0 = 185 GPa and K' = 4.2, [5]). Applying our results to the calculation of the pressure of formation of an hypothetical diamond-almandine pair we obtain 6.7 GPa for a residual pressure of 0.5 GPa and an assumed temperature of 1400°C (see [3] for calculation details). The same calculation performed using older compressibility data [5] provides a pressure of formation of 7.2 GPa, corresponding to a difference of about 15 km. If we consider that our geobarometric calculation must take into account further thermoelastic parameters as the thermal expansion and the dK/dT this means that even for a unique composition we could have strong difference of depth of formation if the parameters are not measured with very high precision.

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