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Garnet Equations of State: a critical review and synthesis

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To interpret the remanent pressures, stresses and strains in inclusion phases in garnets as their entrapment conditions by the methods of elastic geobarometry we require accurate and reliable EoS. However, differences between published EoS even for the end-member garnets often prevent meaningful or reliable geological information to be obtained from the stress states of inclusions trapped within them.

We have therefore re-evaluated all published volume and elasticity data for the garnet end members grossular, pyrope, almandine and spessartine for internal consistency. A novel feature of our analysis is that we also developed a method to determine the consistency of these data with experimentally-measured heat capacities. All of the consistent data was then simultaneously fitted by least-squares to determine the parameters of Mie-Grüneisen-Debye thermal-pressure EoS in combination with 3rd-order Birch-Murnaghan EoS to describe the isothermal compression at 298 K. For grossular and pyrope garnets there is sufficient data to determine that the value of q used to define the volume dependence of the thermal Grueneisen parameter γ as q = d(ln γ)/d(ln V) has a value of q = 0.8(2). For other garnets, the data do not constrain the value of q. We therefore refined a q-compromise version of the Mie-Grüneisen-Debye EoS in which both γ/V and the Debye temperature are held constant at all P and T. For pyrope and grossular the two versions of the Mie-Grüneisen-Debye EoS predict indistinguishable properties over the metamorphic pressure and temperature range, and the same properties as the EoS based on experimental heat capacities. Final refined parameters are listed in the order V_0, K_{0T}, K', Debye temperature and γ_0:

Pyrope : 113.13 cm^3/mol, 169.3(3) GPa, 4.55(5), 771(28) K, 1.185(12)

Almandine: 115.25 cm^3/mol, 174.6(4) GPa, 5.41(13), 862(22) K, 1.16

Spessartine: 117.92 cm^3/mol, 177.57(6) GPa, 4.6(3), 860(35) K, 1.18(3)

Grossular: 125.35 cm^3/mol, 167.0(2) GPa, 5.07(8), 750(13) K, 1.156(6)

Files containing these EoS for use in the EosFit7 are available at www.rossangel.net and in the EntraPT software for elastic barometry calculations at www.mineralogylab.com.

The biggest change from previously-published EoS is for almandine for which the new EoS predicts

geologically reasonable entrapment conditions for zircon inclusions in almandine-rich garnets.

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