Elastic geobarometry of multiphase inclusions

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Elastic geobarometry allows one to recover the PT entrapment conditions of a host-inclusion pair from measurements of the residual pressure of the inclusion which develops upon exhumation due to differences of its thermo-elastic properties from the host (Angel et al., 2015). At the present, calculations assume that the inclusion is a single phase. For a soft inclusion in a stiffer host, the volume change of a free inclusion crystal would be greater than that of the host, which leads to the inclusions being compressed into a smaller volume than expected and thus positive inclusion pressures. Conversely, an inclusion stiffer than the host should develop a negative pressure.

Rutile-in-garnet would be a good candidate for elastic geobarometry because of its common occurrence in high-pressure high-temperature (HP-HT) metamorphic rocks, its simple structure and chemistry and its broad PT stability field. However, recent work by Zaffiro et al. (2019) demonstrated that rutile trapped in garnet should always exhibit negative pressure upon exhumation because rutile is stiffer than garnet, making this pair unsuitable for elastic geobarometry.

Nevertheless, rutile inclusions in garnets from the Pohorje eclogite seem to challenge this thermodynamic prediction. Rutile inclusions show no Raman peak shifts relative to free crystals within the measurement error, despite there being strain birefringence in the garnet host around the rutile which indicates the relaxation of stressed inclusions. High resolution 3D Raman mapping on one of these rutile inclusions revealed the presence of tiny (2-3 µm thick) amphibole crystals located between the garnet and rutile, with the amphibole occupying about 25-30% of the volume of the inclusion. The presence of this amount of amphibole lowers the bulk modulus of the composite inclusion (rutile + amphibole) to less than the bulk modulus of the garnet, hence leading to pressurization of the inclusions upon exhumation. This study shows that careful characterization of host inclusion systems, linked to thermodynamic modelling, is thus necessary to interpret residual pressures ($P_{inc}$) in terms of entrapment conditions.

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References: