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Single inclusion piezobarometry confirms high-temperature decompression path for Variscan granulites

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The identification and chemistry of inclusions trapped in host minerals during growth of the host phase have long been used to infer P-T points on metamorphic paths. The determination of the remnant pressure on the inclusion, e.g., using data from X-ray diffractometry, birefringence analysis or Raman spectroscopy, provides an alternative method of barometry using elasticity theory. A remnant pressure in an inclusion is developed because the inclusion and the host have different thermal expansion and compressibilities, and the inclusion does not expand in response to P and T as would a free crystal. Instead it is restricted to expand only as much as the host mineral, and this constriction in volume can result in inclusions exhibiting over-pressures when the host is studied at room conditions. This concept has been known for a long time, but satisfactory quantitative modelling of inclusion-host systems based on non-linear elasticity theory and precise thermal-pressure euqations of state has only recently come available (Angel et al., 2014, 2015), even though it is still restricted to elastically isotropic minerals.

No mineral is elastically isotropic, but garnets and diamond are almost so. Calculations show that diamonds trapped as inclusions in host silicates at P and T within the stability field of diamond should exhibit zero pressure when the samples are recovered to room conditions. However, some diamond inclusions in garnets in granulites are reported to exhibit significant residual overpressures (e.g., Kotková et al., 2011). This indicates that the inclusion was elastically re-equilibrated (e.g., by plastic flow in the garnet host) at high temperatures and lower pressures in the stability field of graphite, consistent also with the observed partial inversion of diamond to graphite. In this case, the elastic analysis of the diamond-in-garnet inclusions provides qualitative independent evidence that the Variscan granulites underwent pressure reduction at high temperatures. The extension of single inclusion piezobarometry to elastically anisotropic minerals will allow quantitative analysis of diamonds trapped in other minerals such as kyanite.

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