Geophysical Research Abstracts
Vol. 18, EGU2016-13569, 2016
EGU General Assembly 2016

Elastic geobarometry and the role of brittle failure on pressure release

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Mineral inclusions trapped in their hosts can provide fundamental information about geological processes. Recent developments in elastic geobarometry, for example, allow the retrieval of encapsulation pressures for host-inclusion pairs. In principle this method can be applied to any mineral-mineral pair so long as both the residual pressure on an inclusion (P_{inc}), and the equations of state for both host and inclusion are either known or determined (Angel et al., 2015). However, Angel et al. (2014) outlined some boundary conditions, one of which was that deformation in the host-inclusion pair has to be purely elastic. Thus this caveat would exclude from analysis all the inclusions that are surrounded by cracks, indicative of brittle deformation, which may result in partial or complete release of the P_{inc}. If however the effects of cracks surrounding trapped mineral inclusions could be quantitatively modelled, then the applicability of "elastic" geobarometry might be extended to a much larger number of inclusion-host pairs.

We report the results of a pilot experiment in which the stress states (i.e. the residual pressure) have been determined for 10 olivine inclusions still entrapped in 5 diamonds. Inclusion pressures were determined from the unit-cell volumes of the olivines measured in-situ in the diamonds by X-ray diffraction. The olivine equations of state were determined from the olivine compositions by in-situ X-ray structure refinement. Values of P_{inc} range from 0.19 to 0.53 GPa. In order to quantify the degree of brittle failure surrounding the inclusions, the same set of samples were also investigated by synchrotron X-ray micro-tomography (SRXTM at TOMCAT, Swiss LightSource). Preliminary results showed that at the spatial resolution of our experiments (pixel size of 0.34μm), 90% of the inclusions trapped in our set of diamonds were surrounded by cracks. The volume of the cracks has been determined from 3D reconstruction with an accuracy of about 4%. Our results show that crack intensity increases with increase in inclusion size. In addition, the residual pressure decreases with increasing inclusion volume (i.e. with increasing brittle deformation). However, the actual release in pressure can only be estimated knowing the composition and thus the exact equation of state of the infillings of the cracks.

This work is supported by ERC starting grant 307322 to Fabrizio Nestola and by the MIUR-SIR grant "MILE DEEp" (RBSI140351) to M. Alvaro.

References

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