Geophysical Research Abstracts
Vol. 20, EGU2018-9652, 2018
EGU General Assembly 2018

Thermoelastic modeling of heterogeneous stress distribution around mineral inclusions

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Mineral inclusions are critical messengers from the Earth's interior and have been extensively analyzed to extract the pressure-temperature history in petrological studies. During exhumation accompanied with changes of confining pressure and temperature, differential expansion/contraction between inclusion and host occurs due to their different thermoelastic properties. Over (under)-pressure develops within mineral inclusions and can be measured with various analytical techniques, e.g. Raman spectroscopy and XRD. Most studies have focused on the pressure of mineral inclusions rather than the stress state within the surrounding host. However, as most minerals are elastically anisotropic, pressure variations are developed around mineral inclusions after exhumation. In this work, we model the stress distribution in mineral inclusion-host systems. Two 3D-thermoelastic models are presented based on both finite element (Milamin-based code (Dabrowski et al., 2008)) and finite difference methods. Both models are benchmarked with the Eshelby's solution for ellipsoidal inclusion and Mindlin's solution for spherical inclusion next to a stress-free surface (Eshelby, 1957; Mindlin and Cheng, 1950). The numerical models are applied to study heterogeneous stress patterns around anisotropic mineral inclusions. Our model indicate that GPa levels of shear stress and pressure variations may develope around quartz inclusion in garnet exhumed from eclogite facies conditions. The significance of elastic stress relaxation around an inclusion exposed to a stress-free surface is also investigated. This will allow a direct comparison between modeling results and analytical measurements on thin-section surface using e.g. high angular resolution EBSD (HR-EBSD) technique (Avadanii et al., 2017).

References

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