Geophysical Research Abstracts
Vol. 19, EGU2017-1073-1, 2017
EGU General Assembly 2017

A new barometer from stress fields around inclusions

Diana Avadanii, Lars Hansen, David Wallis, and David Waters

Department of Earth Sciences, University of Oxford, Oxford, United Kingdom (diana.avadanii@univ.ox.ac.uk)

A key step in understanding geological and geodynamic processes is modelling the pressure-temperature paths of metamorphic rocks. Traditional thermobarometry relies on mineral assemblage equilibria and thermodynamic modelling to infer the pressures and temperatures of chemical equilibration. This approach requires the presence of specific mineral assemblages and compositions, which narrows its applicability. In this study we aim to develop a geobarometer based on mechanical interactions between inclusions and their host grains. Exhumation of minerals with inclusions causes heterogeneous residual stress fields due to the different, and often anisotropic, elastic properties of the inclusion and host. Recent studies measure residual mean stresses within inclusions using Raman spectroscopy and use those stresses as a barometer. In contrast, we map each component of the stress tensor around inclusions using high angular-resolution electron backscatter diffraction (HR-EBSD). This technique provides both higher spatial resolution and increased sensitivity to elastic strains relative to Raman spectroscopy. We focus on quartz inclusions in garnet, a common feature in metamorphic rocks. This assemblage also provides an opportunity to test our results with compositional thermobarometry. We analyse samples metamorphosed at pressures ranging from $\sim$ 300 MPa to $\sim$ 1600 MPa, as recorded by independent geobarometers. HR-EBSD reveals symmetric and lobate signals around inclusions, with elastic strains and residual stresses of the order 10^{-3} and $\pm 10^2 - -10^3$ MPa, respectively. We solve Eshelby's problem for the 'inhomogeneous inclusion' case to simulate the elastic strain/stress field around an anisotropic ellipsoidal inclusion surrounded by an isotropic, homogeneous, infinite matrix. This model calculates the stress disturbances caused by differential expansion of an inclusion and host subjected to decompression. We additionally account for differential expansion related to cooling by imposing an eigenstrain in the inclusion, according to the thermal expansivity of quartz. Thermal contraction in the host garnet is accounted for by modifying the macroscopic pressure. The simulations reproduce the general pattern of the elastic fields that we observe from HR-EBSD and account for different geometries of the inclusion. The simulations provide the basis for quantitatively relating the stress fields measured by HR-EBSD to the entrapment pressures of inclusions.