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Local stress distribution around garnet inclusions during hydration of granulite in the Bergen Arcs, Norway

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The importance of heterogeneous stress and pressure distribution within a rock has been established over the last decades (see review in Tajčmanová et al., 2015). During a hydration reaction, depending on whether the system is open to mass transfer, the volume changes of the reaction may be accommodated by removing material into the fluid phase that leaves the system (Centrella et al., 2015; Centrella et al., 2016). The magnitudes and the spatial distribution of stress and pressure that evolve during such processes is largely unknown.

We present here a natural example where a granulite is hydrated at amphibolite facies conditions from the Bergen Arcs in Norway. Granulitic garnet is associated with kyanite and quartz on one side, and amphibole-biotite on the other side. The first couple replaces the plagioclase of the granulite matrix whereas the second replaces the garnet. We use electron probe microanalysis (EPMA) and X-ray mapping to investigate the spatial and possible temporal relationships between these two parageneses. Gresens' analysis has been used to determine the mass balance and the local volume changes associated with the two reactions. The reaction to kyanite+quartz induces a loss in volume compared to the original plagioclase whereas the second reaction amphibole+biotite gains volume compared to the original garnet. The specific mass evolution associated with both reactions suggests a local mass balance probably associated with a single hydration event.

Using the methodology of Vrijmoed & Podladchikov (2015) we test whether the microstructure may be partly related to the local stress heterogeneity around the garnet inclusion. We evaluate the phase assemblage and distribution at chemical equilibrium under a given input pressure field that can be computed with the Thermolab software. By varying the input pressure field using the Finite Element Method and comparing the resulting equilibrium assemblage to the real data an estimate of the local stress and pressure distribution around the garnet inclusion is obtained. The differences of the equilibrium model with the observations are discussed.

References:

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