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Phase transitions under differential stress: Deviatoric stresses or pressure?

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We performed deformation experiments for the Calcite-Aragonite system in a (Griggs-Type) solid medium deformation apparatus, using different sample geometries. The confining pressure (σ_3) was maintained below the Calcite-Aragonite transition while the first principal stress (σ_1) exceeded the transition pressure, changing with sample strength. Thus, the bulk sample pressure, $P_{3D} = (\sigma_1 + 2\sigma_3)/3$ was closely varying around the transition pressure.

Light microscopy, Raman spectroscopy and electron backscatter diffraction (EBSD) show systematic, strongly heterogeneous patterns in the distribution of the phases, grain-sizes and deformation. These result from stress, strain and pressure variations within the sample. To better understand different mechanisms contributing to the phase transition and grain size reduction, the local distribution of first order parameters as pressure, stress and strain must be known.

We performed numerical modelling in order to quantify the stress, pressure and strain distribution within the deforming sample. The numerical results are compared to the stress distribution, as inferred from grain size, and finite strain. These show a good fit with modelling results using a viscous power law rheology. As the distribution of stress and strain in the numerical model matches the experiments, the modelled pressure is expected to depict the experimental conditions as well.

Finally, patterns of modelled pressure, stresses and strain are compared to experimentally produced phase-transition patterns. From this comparison the confining stress (σ_3) can be excluded as being a driving force for the phase transition. However, the discrimination between local σ_1 and local pressure (defined like P_{3D}) still needs better quantification regarding experimental measurements.