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# Thermal cracking of Westerly granite: from physical to numerical experiment

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Laboratory experiments provide some of the most comprehensive constraints on rock properties such as permeability, porosity, and rheology. However, in most cases such experiments are performed on length and time scales that are much smaller than geological scales. Upscaling, physically sound methods for extrapolation, of the obtained constitutive laws is therefore a matter of hot debate. Here, we present a numerical approach for the upscaling of the porosity evolution due to thermal cracking of Westerly granite. This project draws upon actual laboratory step-heating experiments of Westerly granite observed with high-resolution 3D synchrotron tomography (see Fusseis and others:" Formation of secondary porosity in 4D Synchrotron X-ray tomography experiments").
First, we use tomography time-series data to calibrate numerical simulations at the laboratory scale. In effect, the real-world sample is discretised and "heated" numerically. The software is an implicit Lagrangian finite-element code (Abaqus Standard) using elastoplastic rheologies in coupled temperature-displacement analysis. To minimize computational costs, indirect feedbacks, namely temperature-dependent functions of density, coefficient of thermal expansion, specific heat capacity, Poisson's ratio, and Young's modulus, are pre-calculated with Perple_X (Connolly 2005) and implemented as table input. Direct feedbacks are computed in the framework of thermodynamic equations and solved for explicitly. Next, we repeat the above numerical experiments for simplified stochastic models of the actual sample at the laboratory scale. Finally, we generate stochastic numerical models on increasing scales to determine the scale at which rock properties remain constant regardless of the specific microstructure. This empirical homogenization allows the derivation of constitutive laws which can be employed for large-scale simulations.
In this contribution, we will briefly outline this workflow and present first results for steps one and two.

References:
Connolly, J. A. D., Computation of phase equilibria by linear programming: A tool for geodynamic modeling and its application to subduction zone decarbonation. Earth and Planetary Science Letters 236 (1-2), 524 (2005)