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2D Numerical modelling of fluid and melt transport above slabs with finite differences and marker-in-cell techniques

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Subducting slab dehydration and resulting aqueous fluid percolation triggers partial melting in the mantle wedge and is accompanied with the further melt percolation through the porous space to the region above the slab. This problem is a complex coupled chemical, thermal and mechanical process responsible for the magmatic arcs formation and change of the mantle wedge properties.
We have created a two-dimensional model of a two-phase flow in a porous media solving a coupled Darcy-Stokes system of equations for two incompressible media for the case of visco-plastic rheology of solid matrix. We use a finite-difference method with fully staggered grid in a combination with marker-in-cell technique for advection of fluid and solid phase. We performed a comparison with a simple benchmark of a thermal convection in a closed bottom-heated box to verify the interdependency of Rayleigh and Nusselt numbers with a theoretical one.
We have also demonstrated the stability and robustness of the algorithm in case of strongly non-linear visco-plastic rheology of solid including cases with localization of both deformation and porous flow along spontaneously forming shear bands.
Also we have checked our model for the forming of localized porous channels under a simple shear stress (channelling instability).
We have included simple melting into the model as a function of pressure and temperature. Currently we elaborate on the setting of subduction setup of the model and expanding the system of equation for the high-porosity limits and stabilizing of the system under conditions of high porosity contrasts.
Current work includes implementation of solid elasticity, fluid/solid compressibility and realistic melting of subducted and mantle rocks in our numerical model as a function of water content and composition as well as of pressure and temperature (currently done). Also we plan to perform porosity waves benchmarking (Connolly and Podladchikov, 1998).
Ultimate goal is to simulate in a realistic self-consistent manner fluid and melt generation and transport in subduction zones including fluid/melt focussing phenomena above slabs.