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2D Numerical modelling of fluid and melt transport above slabs

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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 melting process according to the model of Katz (1) where melting degree is a function of pressure, temperature, composition and water content. We have expanded our system of equation for the high-porosity limits and stabilized it for the case of high porosity contrasts.
Current work includes implementation of non-liner viscous rheology and elaboration on the setup of self-initiating subduction. Also we have developed a full complexity system of equations for visco-elastic case and currently are working on numerical implementation of it.
Later we plan to include solid elasticity and fluid/solid compressibility.
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.

References

[1] Katz, R.F., M. Spiegelman, and C.H. Langmuir (2003), A new parameterization of hydrous mantle melting, Geochem. Geophys. Geosyst., 4(9), 1073.