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Felsic melt migration via porous flow – a numerical modeling approach

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Melting of the continental crust and subsequent melt transport has been most thoroughly described in the case of metasedimentary rocks. In these rocks segregation and migration of melt occur either through an interconnected network of veins and melt-rich layers (leucosome) or in form of diapirs. For these rocks, porous flow of melt at grain scale is mostly regarded only as a transient stage of separation of melt from the solid rock.

An entirely different style of melting and melt transport occurs in the case of felsic metagneous rocks. We use the example from the Bohemian Massif, the eastern European Variscan belt, where metagneous migmatites were studied in large detail. Here, melt did not segregate from the solid rock but migrated pervasively along most of the grain boundaries and equilibrated with the host rock. This equilibration resulted in formation of a continuous sequence of texturally, geochemically and compositionally different migmatites.

The question arises, what are the conditions and driving forces for this unusual behavior. We attempt to address this question by means of numerical modeling of two-phase flow (i.e. flow of porous solid matrix and melt), using the open-source finite-element ASPECT code (aspect.geodynamics.org). Most previous numerical studies of this process were either purely generic or focused on the melting of the mantle. In order to study this process in crustal conditions, we set up a 2D crustal-scale thermo-mechanical model that includes melting and freezing. We investigate the role of material properties (viscosity, solidus and liquidus temperatures, solid matrix permeability, melt composition) and thermal and velocity boundary conditions, as well as the effect of grid resolution. The results are discussed in terms of realistic parameter values and possible styles of melt migration and deformation of the matrix.