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Coupled thermodynamic and two-phase flow modelling of partially melting crust

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How magmas are formed, transferred and interact in the lower crust to form mid-crust plutonic belts remain a fundamental question to understand the chemical and mechanical evolution of continents. To assess this question we developed a 2-D two-phase flow code using finite volume method. Our formulation takes into account: (i) an extended Darcy's law for fluid flow with first order temperature- and fluid-content dependency for the host-rock viscosity and silica-dependent viscosity for the fluid, (ii) the heat equation assuming thermal equilibrium for both solid and liquid and temperature-dependent diffusivity, (iii) thermodynamic modelling of stable phases via a dynamic coupling with Perple_X, and (iv) chemical advection of both the solid and liquid composition. To model chemical interactions with the host rock during magma transport, the melt is assumed to be either in thermodynamic equilibrium or in thermodynamic disequilibrium, or as function of these two endmembers.

We applied our modelling approach to investigate the behaviour and composition of magma during lower crust melting. Our goal is to better understand the formation of felsic crust through melting, segregation and assimilation of lower crustal lithologies, applied to Archaean systems. Our preliminary results show the ascend of silica-rich magmas is slow, occurring on the timescale of millions of years, and is highly controlled by (i) the melting curve of the protolith and (ii) by its chemical degree of interaction with the host rock. The resulting transferred magmas are in good accordance with observed composition forming the grey gneisses of Archean terranes (i.e SiO_2-rich > 62%, Mg# = 40-50, Na2O $\sim$6%, MgO = 0.5-1%).