Non-thermal equilibrium two-phase flow : A new approach of melt migration in super-solidus regions

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Melt migration in super- and sub-solidus regions of the lithosphere has been successfully modeled respectively as two-phase flow of melt within a compacting matrix and as dikes propagating through the hosting solid rock. However, the evolution of melt transport processes at the transition from super- to sub-solidus regions remains poorly understood. While migrating towards the surface, melt pathways merge and widen, and melt transport conditions evolve from thermal equilibrium to disequilibrium. The development of such a thermal disequilibrium may influence melt transport by acting on melt and matrix properties (e.g. viscosity), helping for melt focusing in larger pathways, and stabilizing initiating dikes. Although it may be key for understanding melt transport evolution when approaching the transition from super- to sub-solidus regions, thermal disequilibrium has never been considered in super-solidus melt migration two-phase flow models.

Following the formulation from Schmeling et al. (2017), we propose a non thermal equilibrium two-phase flow model of melt migrating through a compacting matrix. The melt and the matrix are considered as two continuous phases whose heat conservation equations are coupled through a heat exchange term that accounts for the melt-matrix interfacial area density, the thermal boundary layer thickness, and the melt and matrix thermal properties and temperature difference. We detail the influence and evolution of this heat exchange term for melt transport processes and geometries varying from melt tubules in a granular matrix to widening melt channels. First results evidence that thermal effects become significant when the melt focuses into channels, and could play a significant role when approaching the super to sub-solidus transition. Having two separated heat equations for the melt and the matrix also raises questions on the way melting/freezing latent heat, melting rate and viscous dissipation are considered, that we discuss here.