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Numerical modeling of two-phase flow: Interaction of partial melt with active tectonics

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We investigate the behaviour of a two-phase system that involves partial melt percolating through a continental crust. The rock matrix, which consists of the crust and underlying mantle lithosphere, is being deformed tectonically and has a viscoelastoplastic incompressible rheology.

The numerical modeling approach is based on the assumption that the melt fraction is equal to the porosity of the rock and that porosity propagation reflects the compaction or dilation of the matrix framework due to both viscous and mechanical compaction mechanisms. Both compaction terms are connected to the local effective pressure, which is obtained as the difference between the bulk pressure over both phases and the fluid pressure.

The numerical setup involves a continental crust of 30-40 km thickness and the underlying mantle lithosphere. At the lithosphere-asthenosphere transition, we introduce a source region of partial melt, either uniformly distributed in the upper mantle or in the form of a diapir. The melt propagation then depends on the dynamic pressure evolution in the lithosphere and crust as they are being tectonically deformed in either extensional or compressional regime.

First results indicate that both the geometry and spatial evolution of melt propagation are strongly related to the regional stress field, and that brittle fault zones might form important conduits for the propagation of partial melt, especially through the lower crust. Where the partial melt reaches either mechanical barriers or neutral bouancy with respect to the host rock, regions of magma accumulation are formed.

We observe a tendency towards vertical geometries for extensional tectonics and towards horizontal geometries under compressional tectonics. These observations are consistent with theoretical predictions.

One possible application of this type of models is to further the understanding of the processes involved in, and the geometry and field relations expected from, the emplacement of hydrated slab melts into the overriding continental plate in a ocean-continent subduction zone.