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Melt emplacement induced stresses

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Transport of melt into and through the lithosphere has an essential influence on it's state, evolution and properties. Rock deformation, physically seen as viscous flow, acts on a long time scale compared with the rapid ascent of melt originating in the asthenosphere. In our numerical models the short time scale transfer of melt is replaced by melt extraction and emplacement at a given depth zone above the source region. New findings reveal probably consequential stresses in the high viscous lithosphere.

Thermo-mechanical physics of visco-plastic flow is approximated by Finite Difference Method with markers in an Eulerian formulation in two dimensions. The equations of conservation of mass, momentum and energy are solved for a multi component and two phase system: fluid and matrix. The full compaction formulation is used. The high Prandtl number approximation is applied, elasticity is neglected, and rheology is temperature-, stress- and depth-dependent. In consideration of depletion and enrichment melting and solidification are controlled by a simplified linear binary solid solution model. Extraction and emplacement of melt is accounted for.

A continental rift scenario serves to define a model comprising asthenosphere and lithosphere under extensional conditions. A temperature anomaly generates deep melt intruding the lithosphere on its way up. We focus on the early phase of melting, forming a first plume and releasing some melt. Above a fraction limit melt extraction induces underpressure at its origin region attracting ambient melt and contracting the matrix. A melt fraction minimum develops in the inital batch. In the emplacement zone above sudden dilatation, immediate freezing, increase of enrichment and heating takes place. The dilatation of the rock matrix generates relative high stresses if it's viscosity is high. The behaviour is not intuitively comprehensible. Results are compared with numerical solutions of Compaction Boussinesq Approximation.