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Can compaction, caused by melt extraction and intrusion, generate tectonically effective stresses in the lithosphere?

Herbert Wallner and Harro Schmeling
Institut für Geowissenschaften, Geophysics, Goethe University, Frankfurt, Germany (wallner@geophysik.uni-frankfurt.de)

Aim of our study is to deepen understanding the role of melt processes while the lithospheric evolution by means of numerical modeling. In the sense of plate tectonics, on the one hand, stresses are transferred by stiff lithospheric plates, on the other, lithosphere is deformed, broken, or modified in various ways. Melting often plays an important role but is not easy to model numerically due to all the interactions of physics, phase changes, non-linearities, time scales, petrology, heterogeneities and chemical reactions.

Here we restrict on a thermo-mechanical model of visco-plastic two phase flow with partial melting. Viscosity is temperature-, stress- and depth-dependent. Freezing and melting are determined by a simplified linear binary solid solution model. The fast melt transport through and into the lithosphere, acting on a short time scale, is replaced by melt extraction and intrusion in a given emplacement level. Numerical approximation is done in 2D with Finite Differences with markers in an Eulerian formulation.

A scenario of continental rifting serves for a model of lithosphere above asthenosphere under extensional conditions. An anomaly of increased temperature at the bottom produces a low fraction of melt initially in the asthenosphere. Above a porosity limit melt is extracted and leads to compaction at its origin which induces under-pressure attracting ambient melt and contracting the depleted matrix. In a higher, colder lithospheric level the emplaced melt extends the matrix, immediately freezes; an increase of enrichment and heating takes place. The dilatation of the rock matrix generates relative high compaction pressures if it's viscosity is high as in the uppermost mantle lithosphere. Local and temporary varying stresses provide deviatoric components which sometimes may be the origin of tectonic activity in nature.

Divergence terms of the full compaction formulation, responsible for viscous stress, are tested and reviewed. Quality and stability of the numerical solution for the irrotational potential are discussed.