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Impact of potential weakening effects of mineral reactions in lithospheric scale geodynamic models

Lorenzo G. Candioti and Stefan M. Schmalholz
Université de Lausanne, Institut des sciences de la Terre, Lausanne, Switzerland

Geodynamic modelling involves processes acting on multi-physics scales, thus requires coupling of different physical processes such as mechanics, temperature and fluid flow. Rheological parameters used in creep flow laws are determined in laboratory experiments performed at very high deformation rates in order to obtain results in short time spans, and extrapolated to tectonic deformation rates. On short time scales, mineral reactions cannot be resolved, however, on geological time scales they potentially have a significant impact on the strength of the rocks. Current creep flow laws do usually not take into account weakening effects of mineral reactions. Nevertheless, such effects can be parametrised by additional scaling factors in the creep flow laws. Conducting numerical simulations of lithospheric deformation with systematic variation of the scaling factors can restrict the potential magnitude of the reaction weakening, because over-weakened creep flow laws can generate results, which are not in agreement with the geological and geophysical record.

We perform 2D thermo-mechanical numerical simulations of large-strain lithospheric extension including a several hundred meter thick asthenosphere. The results indicate that if the effective viscosity of the mantle lithosphere is too low, then buoyancy-controlled downward dripping of the mantle lithosphere occurs which should be observable in geophysical records, such as tomography. Varying the effective viscosity from flow laws, analysing the resulting lithospheric scale structures and comparing numerically calculated structures with geophysical observations allows, hence, narrowing down the range of possible flow law parameters and assessing the potential impact of reaction weakening on flow laws.