Geophysical Research Abstracts
Vol. 18, EGU2016-6174, 2016
EGU General Assembly 2016

Role of elasticity in stagnant lid convection

Vojtech Patocka (1), Paul Tackley (2), and Ondrej Cadek (1)

(1) Charles University, Geophysics, Czech Republic (patocka.vojtech@gmail.com), (2) Institute of Geophysics, Department of Earth Sciences, ETH Zurich, Switzerland

A present limitation of global thermo-chemical convection models is that they assume a purely viscous or visco-plastic flow law for solid rock, i.e. elasticity is ignored. This may not be a good assumption in the cold, outer boundary layer known as the lithosphere, where elastic deformation may be important. Elasticity in the lithosphere plays at least two roles: It changes surface topography, which changes the relationship between topography and gravity, and it alters the stress distribution in the lithosphere, which may affect dynamical behaviour such as the formation of plate boundaries and other tectonics features.

In the present work we study these effects in the context of stagnant lid convection. We use StagYY (Tackley, 2008) enhanced to include elasticity through adding advected elastic stresses to the momentum equation and replacing viscosity by the "effective" one (the method described in e.g. Moresi et al., 2002). First, a test example with a cylinder rising below the lithosphere (Crameri et al., 2012) is considered in various geometries and the effect of elasticity on the resulting topography and geoid is evaluated. Both free-slip and free-surface upper boundary condition is considered.

Second, comparison of stagnant lid convection models with and without elasticity is performed. It is shown that global characteristics of the convection do not change when a realistic value of shear modulus is employed and that the stress pattern in the lithosphere is very similar. The most important effect is that stresses build up gradually when elasticity is considered and thus the stress picture is more stable in the time domain in the elastic than in the viscous case. Viscoelastic lithosphere thus filters internal dynamics more effectively than a purely viscous one, responding only to features which stay stable for times comparable to its relaxation time. This effect is clearly recognizable only when free-surface upper boundary condition is considered. The role of viscosity cut-offs is discussed.