Geophysical Research Abstracts
Vol. 15, EGU2013-5779, 2013
EGU General Assembly 2013

Constraining the rheology of the lithosphere through joint geodynamic and gravity inversion

Boris Kaus, Tobias Baumann, and Anton Popov

Johannes-Gutenberg University Mainz, Geophysics and Geodynamics, Institute of Geosciences, Johannes Gutenberg University Mainz, Germany (kaus@uni-mainz.de)

In order to understand the physics of the lithospheric deformation and continental collision we need to have better constraints on its rheology and in particular on the effective viscosity of various parts of the lithosphere. Typically, rheology is determined from laboratory experiments on small rock samples, which are extrapolated to geological conditions – an extrapolation over 10 orders of magnitude in deformation rates. These laboratory experiments generally show that small changes in the composition of the rocks, such as adding a bit of water, can dramatically change its viscosity. Moreover, it is unclear which rocktype gives the best mechanical description of, for example, the upper crust and whether a small sample is even appropriate to describe the large scale mechanical behaviour of the crust (or whether this is rather controlled by heterogeneities such as fault zones and batholiths). So the viscosity of the lithosphere is probably the least constrained parameter in geodynamics and might vary over maybe 10 orders of magnitude.

The concept of the effective elastic thickness is often used to make statements about the mechanical strength of the lithosphere. Whereas there is general agreement that the concept of EET works will in oceanic lithospheres, there are huge discrepancies in the EET for active collision belts in continental lithospheres, partly because the (mechanical) lithosphere at those locations is unlikely to be a thin elastic plate floating on a viscous mantle, but is rather multi-layered.

Ideally, we thus need a new independent method that allows constraining the effective rheology of the lithosphere directly from geophysical data, which is the aim of this work. Our method uses the fact that geodynamically the controlling parameters of lithospheric deformation are its effective viscosity and density structure (which can both be depth-dependent). By performing a forward simulation with a lithospheric deformation code we can model both the gravity signal as well as the velocity field at the surface and in the mantle. These synthetic models can be compared with observations (GPS surface velocity and gravity anomalies). By appropriately parameterizing the rheology of the lithosphere we can define an inverse problem that is tackled with a Monte Carlo inversion method. For a simple setup we can demonstrate mathematically that this joint geodynamic-gravity inversion approach results in a unique solution (as opposed to inverting for gravity alone which is a well-known non-unique problem). We will show an application of our method to a 2D cross-section of the India-Asia collision system. Moreover, we will show results for salt-tectonics in which we performed full 3D inversions and were able to determine the 'best-fit' parameters with uncertainty bounds.

Combining dynamic forward models with observational constraints and inverse models is a promising research direction that will likely teach us more about the physics of the Earth.

Acknowledgements

Funding was provided by the ERC under the European Community's Seventh Framework Program (FP7/2007-2013) / ERC Grant agreement #258830