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Geodynamic inversion to constrain the rheology of the lithosphere: What is the effect of elasticity?

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The concept of elastic thickness (T_e) is one of the main methods to describe the integrated strength of oceanic lithosphere (e.g. Watts, 2001). Observations of the T_e are in general agreement with yield strength envelopes estimated from laboratory experiments (Burov, 2007, Goetze & Evans 1979). Yet, applying the same concept to the continental lithosphere has proven to be more difficult (Burov & Diament, 1995), which resulted in an ongoing discussion on the rheological structure of the lithosphere (e.g. Burov & Watts, 2006, Jackson, 2002; Maggi et al., 2000).

Recently, we proposed a new approach, which constrains rheological properties of the lithosphere directly from geophysical observations such as GPS-velocity, topography and gravity (Baumann & Kaus, 2015). This approach has the advantage that available data sets (such as Moho depth) can be directly taken into account without making the a-priori assumption that the lithosphere is thin elastic plate floating on the mantle. Our results show that a Bayesian inversion method combined with numerical thermo-mechanical models can be used as independent tool to constrain non-linear viscous and plastic parameters of the lithosphere. As the rheology of the lithosphere is strongly temperature dependent, it is even possible to add a temperature parameterisation to the inversion method and constrain the thermal structure of the lithosphere in this manner. Results for the India-Asia collision zone show that existing geophysical data require India to have a quite high effective viscosity. Yet, the rheological structure of Tibet less well constrained and a number of scenarios give a nearly equally good fit to the data.

Yet, one of the assumptions that we make while doing this geodynamic inversion is that the rheology is viscoplastic, and that elastic effects do not significantly alter the large-scale dynamics of the lithosphere. Here, we test the validity of this assumption by performing synthetic forward models and retrieving the rheological parameters of these models with viscoplastic geodynamic inversions. We focus on a typical intra-oceanic subduction system as well as a typical scenario of subduction of an oceanic plate underneath a continental arc.

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