Interplay between tectonic and magmatic processes in orogenic crust: Insight from thermo-mechanical modeling

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Active tectonic shortening that is inherent feature of the orogeny is often associated with the intensive upper crustal magmatic activity. That means that the crust becomes heated even though crustal shortening (and thickening) itself leads to the cooling of the crust. The possible heating mechanisms include enhanced heat production in the thickened felsic upper crust, dissipation of mechanical energy (shear heating) as well as conductive and convective heat input from the lower crust and upper mantle. The way to quantify these mechanisms is numerical thermo-mechanical modeling. Our modeling studies focused at the Central Andean orogen [1,2] suggest that in that particular case, the most important factors were delamination of the mantle lithosphere and of the eclogitic lower crust that resulted in the intensive heat influx into the crust and the convective heat and mass transfer to the upper crust by the partially molten lower crustal rocks. We also show that neither radiogenic heat production in a thickening crust, nor shear heating due to tectonic shortening, or heat brought by intrusions of arc magmas into the mid-crust could heat the mid-crust in the Central Andes enough to explain geophysical observations and upper crustal magmatism. Based on new modeling examples we will also discuss rheological aspects of the intracrustal convection associated with the tectonic shortening and possible application of this mechanism for other orogens.

[1] Babeyko *et al.* (2002) *Earth Planet. Sci. Lett.* **199** 373-388.
[2] Sobolev & Babeyko (2005) *Geology* **33** 621-624.

Constraining rheology and water content in the upper mantle by modeling plate tectonics

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Are the current views on rheology and water content in the upper mantle consistent with plate tectonics? To answer this question we model present-day global convection in the Earth and test model predictions for different rheological models versus observed plate velocities. We use a finite element technique [1] to model the upper mantle with 3D visco-elasto-plastic rheology, and deeper a spectral modeling technique with present-day density distribution based on the subduction history [2]. Plate boundaries are defined as the narrow zones with the low friction in the upper 60 km.

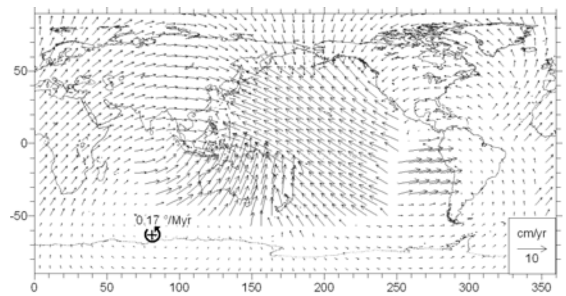

Figure 1: Best-fit model of plate velocities in the no-net-rotation reference frame and of lithosphere net rotation. Average effective friction at subduction zones is 0.02.

We show that dry olivine rheology for the upper mantle is inconsistent with observed plate velocities. However, models with dry lithosphere and wet asthenosphere with olivine water content of 500-1000 ppmH/Si and rheology [3] modified within experimental errors (power law stress exponent of 3.7-3.8), reproduce observed plate velocities and net rotation of the lithosphere very well (Fig 1).

[1] Popov & Sobolev (2008) *Phys. Earth Planet. Inter* **171** 55-75. [2] Steinberger (2000) *Phys. Earth Planet. Inter* **118** 241–257. [3] Hirth & Kohlstedt (2003) *Geophys. Monograph* **138** 83-105.