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Two-/three-dimensional thermo-mechanical modeling of Cenozoic lithospheric deformation in the Himalaya-Tibet-Pamir-Tien Shan orogen

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The Pamir-Hindu Kush region located in the western syntaxis of the Himalaya is the locus of a large number of intermediate-depth earthquakes and an almost vertical high velocity zone, seen in seismic tomography. The seismicity is not clearly related to oceanic subduction and forms an S-shaped zone between north-western Afghanistan and the eastern Pamir. In depth, the earthquake hypocenters are forming what some authors interpret as a V-shaped pattern which supports the model of two converging subduction zones. However, other models propose a single but highly contorted Indian slab or even a Rayleigh-Taylor instability due to a higher density in the lithosphere compared to the asthenosphere.

As part of the TIPAGE project (TIen Shan - PAmir GEodynamic program) our aim is to find lithospheric scale models constrained by all TIPAGE observations as well as to find controlling factors for the extreme Cenozoic shortening in the Pamir-Tien Shan orogen. In our current modeling approach, we use the finite-element codes SLIM2D and SLIM3D which are allowing coupled thermo-mechanical treatment of deformation processes. These codes are capable of highly nonlinear elasto-visco-plastic rheology including diffusion, dislocation and Peierls creep mechanism and allowing self-consistent generation of faults. They incorporate free surface boundary conditions and are equipped with petrological routines for gabbro-eclogite, coesite-stishovite phase transitions.

We run several 2D cross-section models in order to explain the high velocity zone below the Pamir-Hindu Kush and the seismicity which distinguishes the region from the rest of the Himalaya. In a typical model setup India has two parts: the 'inner part' which comprises 35-45 km thick continental crust and relatively thick cratonic mantle lithosphere; the 'outer part' has 25-30 km thick crust and a less depleted, more ocean-like lithosphere. Inside of Asia we place an "inclusion" of thicker cratonic lithosphere, like that of the Tarim (Tadjik) block and vary only the initial distance between the outer part of India and the Tarim (Tajik) block.

Our hypothesis is:
The high velocity zone below the Pamir - Hindu Kush is the last remaining and hanging undetached part of the semi continental - oceanic 'outer India' shelf and has only survived due to mechanical locking with delaminated mantle lithosphere of the Tarim (Tadjik) block.

Since the 2D cross-section models are ignoring strike-parallel relations they miss 3D effects e.g. stress concentration around the tip of the advancing Indian plate. Hence we run low resolution 3D models in order to incorporate these effects. Setup for these models are the 2D cross-sections. Calculations are conducted in a $\sim$3200km x 1400 km x 400 km (N-S, E-W, depth) domain with an assigned velocity at its southern boundary. Modeling in 3D is excessively time-expansive, limiting the amount of finite elements to $\sim$200.000 all together.

Results of the 3D models will help us to proof or disproof the hypothesis we stated above.