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A numerical approach to test lithospheric cross-sections for geodynamic consistency

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Cross sections though active mountainbelts are usually constrained by a range of geophysical and geological data, but the resulting interpretations are not necessarily geodynamically consistent. To better understand the thermomechanical behaviour of such collision zones it is of major importance to combine knowledge about the geometrical, the density and the inferred viscosity structure of those zones. Constraints on the geometry can be obtained by reflection seismics, refraction seismics or seismic tomography. Constraints on the density come from gravimetrical methods. Effective rheological parameters of the lithosphere, however, are much less known. Laboratory experiments on creep of rocks, extrapolated to natural conditions, yield several orders of magnitude variation in the effective viscosity. Better constraining the effective viscosity of the lithosphere is however crucial, since variations in these parameters might result in drastically different lithospheric dynamics.

For this reason, we here develop and test an approach that employs 2D thermomechanical viscoplastic geodynamics codes. Rather than studying the long-term deformation of the lithosphere, as is typically done with such codes, we here focus on the present-day structure of the lithosphere. The main assumptions are: 1) the present day geometry of the lithosphere (in particular surface topography and Moho depth) is reasonably well known. 2) Far-field plate velocities are known (from plate models or GPS measurements). The lithosphere is then divided into several layers. By varying the effective viscosity and density of each of the layers, we can study the effects of changing these parameters on gravity, surface velocity, stress-distribution, and mantle flow. A comparison of modelled data with observations would thus -in principle- give geodynamic constraints on the rheology of the lithosphere. Before applying it to real data, however, it is necessary to study the theoretical power of the methodology. For this reason we here apply the method to snapshots obtained from synthetic (million-year timescale) forward runs.