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A two- and three-dimensional numerical modelling benchmark of slab detachment

Cedric Thieulot (1,2), Anne Glerum (1,4), Bram Hillebrand (1), Stefan Schmalholz (3), Wim Spakman (1,2,4), and Trond Torsvik (2)

(1) Utrecht University, Dept. of Earth Sciences, Utrecht, Netherlands (c.thieulot@uu.nl), (2) Centre for Earth Evolution and Dynamics, Oslo, Norway, (3) Institute of Earth Sciences , University of Lausanne, Switzerland, (4) The Netherlands Research Centre for Integrated Solid Earth Science

Subduction is likely to be the most studied phenomenon in Numerical Geodynamics. Over the past 20 years, hundreds of publications have focused on its various aspects (influence of the rheology and thermal state of the plates, slab-mantle coupling, roll-back, mantle wedge evolution, buoyancy changes due to phase change, ...) and results were obtained with a variety of codes.

Slab detachment has recently received some attention (e.g. Duretz, 2012) but remains a field worth exploring due to its profound influence on dynamic topography, mantle flow and subsequent stress state of the plates, and is believed to have occured in the Zagros, Carpathians and beneath eastern Anatolia, to name only a few regions.

Following the work of Schmalholz (2011), we propose a two- and three-dimensional numerical benchmark of slab detachment. The geometry is simple: a power-law T-shaped plate including an already subducted slab overlies the mantle whose viscosity is either linear or power-law. Boundary conditions are free-slip on the top and the bottom of the domain, and no-slip on the sides.

When the system evolves in time, the slab stretches out vertically and shows buoyancy-driven necking, until it finally detaches. The benchmark is subdivided into several sub-experiments with gradually increase in complexity (free surface, coupling of the rheology with temperature, ...). An array of objective measurements is recorded throughout the simulation such as the width of the necked slab over time and the exact time of detachment. The experiments will be run in two-dimensions and repeated in three-dimensional, the latter case being designed so as to allow both poloidal and toroidal flow.

We show results obtained with a multitude of Finite Element and Finite Difference codes, using either compositional fields, level sets or tracers to track the compositions. A good agreement is found for most of the measurements in the two-dimensional case, and preliminary three-dimensional measurements will be shown.

Duretz et al (2012), Thermomechanical modeling of slab eduction, JGR, vol. 117.
Schmalholz (2011), A simple analytical solution for slab detachment, EPSL, vol.304, p45-54.