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Modeling of self-consistent lithosphere subduction dynamics using a composite rheology.

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Our research1 is concerned with the 4D evolution of Western-Mediterranean subduction systems from ~30 Ma until the Present. Slab rollback is an important geodynamic process in this evolution which strongly affects the development of surface geology. Nowadays it is observable in GPS motions and slab morphology associated with long standing rollback is visible in mantle tomography models.

We have started our project with 2D numerical simulations of self-consistent slab rollback under different initial conditions. We investigate the factors controlling slab behavior such as age of the subducting plate, initial angle of the subduction, different mantle and low-viscosity zone rheology and far-field influences on in the overriding and subducting plate.

We perform our experiments in a 2D Eulerian mesh, which allows for large deformation of the slab during subduction. Using a pressure condition we have implemented open right and left boundaries which prove to minimize the effect of the boundaries on the flow pattern around the subducting slab, i.e. as compared to using of free-slip impermeable or periodic boundary conditions. We use a composite rheology consisting of diffusion and power-law creep. The top of the subducting lithosphere consists of a low-viscosity upper crust (1019 Pas) which represents sediments or otherwise weakened crust and which is defined on particles that are advected by the flow.

The second part of our research is devoted to investigating the influence of different boundary conditions on the subduction process. We investigate open boundaries, constant inflow/outflow velocity and closed boundaries. Open boundaries are implemented by putting the tangential velocity component on the boundary to zero at the same time compensating for the lithostatic pressure by prescribing a normal stress on the boundary. The normal component of the velocity on the boundary is not prescribed.

We have found that these different boundary conditions e.g. closed box or constant inflow leads to results that are strongly influenced by the boundary. Return flow near the slab due to a closed boundary can potentially lock the subduction while in case of a constant inflow/outflow boundary condition widening of the subduction gap occurs allowing for influx of mantle material. Open boundaries show a much reduced influence on the evolution of slab morphology and allow for experiments with small aspect ratio of the modeling domain while a large aspect ratio (boundaries far away) is required with other boundary conditions.

So far our experimental results focus on the evolution of subduction dependent on far field plate motion effects, the age of the subducting lithosphere and its viscosity structure, and with focus on the boundary conditions used. Subduction evolution is monitored with the dip angle of the slab, the speed of rollback or slab advance, acquired depth of the slab tip, and slab flattening. The overall goal of our research project is to simulate slab rollback in 3D, followed by the application to Western-Mediterranean subduction systems.

1) Our research is part of the EUROCORES TOPO-EUROPE, particularly of project TOPO-4D