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The Dynamics of 2D subduction models with power law rheology

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The subduction is an important driving mechanism of plate tectonics which is not well understood. With 2D models we investigate the possible dynamic evolution of the subduction process and especially the dynamics of the trench migration.

The models are calculated with the FD-code FDCON. We used temperature-, depth- and stressdependent rheology (non linear fluid) in the upper mantle and subducting plate. The constant viscosity of the lower mantle (linear fluid) is assumed 50 times higher than the average viscosity of the upper mantle. In addition to viscous rheology we adopted the Byerlee law in the subducting plate to mimic the brittle behavior of the plate and to decouple the lithosphere from the top of the model box. These different rheologies are advected with a tracer approach. The subduction is driven by the temperature differences between the lithosphere and the mantle. The temperature profile is approximated by the error function in the lithosphere with an adiabatic gradient in the mantle.

The power law rheology leads to a weak bending region near the trench. To prevent the slab from tearing for long plates we assumed a hot temperature anomaly under the left edge of the plate (ridge push force) to push the plate toward the trench. The initial subduction stage is characterised by the weak slab bending region, stretching of the slab and oceanward trench migration. After the slab reaches the lower mantle it slides for some Myr along the viscosity jump. The subducted part of the plate is less stretched due to the increased viscosity at the bending region. The trench retreat velocity is almost zero or the trench migrates continentward at very low speed. During the late subduction stage the lower part of the slab becomes deformed due to the decreased slab viscosity and interaction with the lower mantle. The flattening of the plate in the upper mantle causes the continuation of trench retreat in this stage.