Thermo-mechanical subduction modeling with ASPECT
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Introduction

We have investigated the coupling between the earth's mantle and lithosphere in a subduction and rollback setting in the Western Mediterranean. The research presented here is the work of a master project of a year.

The project consists of two parts:
1) Development of a general subduction model for ASPECT.
2) Application of this model to the Western Mediterranean subduction and rollback setting.

ASPECT

ASPECT (Advanced SOLvers for Problems in Earth's Core-Flow, Knitrocki et al., 2012) is a new and modern modeling code mainly designed for volcanology problems. It has, among others, the following advantages and properties:
1) Modern numerical methods: linear and nonlinear solvers, stabilization of transport-dominated processes.
2) Adaptive mesh refinement.
3) Built from the ground up for parallelism.
4) Waves to go from Q2 to Q8.
5) Built upon very well-established and supported libraries: deal.II, Trixi, and plkit.

Because ASPECT has been built as a mantle convection software, several large adaptations were required to enable the study of the coupling of the mantle and lithosphere. These adaptations have been partly done by Anne Glerum and partly by the developers of the code.

Part 1: General subduction modeling with ASPECT

Model setup

For this problem a 2D model is used. ASPECT works with compositional fields. These are fields with the same rheological properties and have a value of 1 inside the field, and 0 outside the field. Table 1 shows the material properties of the different compositional fields, and Figure 3 shows the grid domain with the starting distribution of the compositional fields.

The temperature field is defined by an adiabatic mantle temperature, a constant temperature (273 K) for the air, a linear lithosphere temperature (from 273 K to 3000 K) and a McKenzie (1970) temperature for the slab.

The viscosity field is defined by a visco-plastic rheology (diplastic: creep (creep) and plasticity). Boundary conditions: The bottom is fixed, the sides get a velocity and the top is open.

Model results

Part 2: Slab detachment and the influence of weak zones

Model setup

We now make a model to represent the western Mediterranean initial setting.

- The height has remained the same, but the model is now 1000 km long.
- The thickness of the crust of the subducting plate (oceanic) and overriding plate (continental) have been changed to 7 km and 28 km respectively.
- The density of the crust of the oceanic plate has been slightly increased to 3000 kg m⁻³ and 3100 kg m⁻³ respectively.
- A lithosphere weak layer is now placed in the overriding plate in subduct.

The Adaptive Mesh Refinement (AMR) in these models is dependent on the temperature, composition, strain rate and user defined areas.

Model results (work in progress)

Conclusions

- Realistic topography can be reached.
- To create blocky behavior like Sardinia and Corsica weakening is required. The question is what kind and what strength of weakening is required to initiate this behavior.
- The dependency of shear bands on resolution might also play an important role, because it can concentrate stress and strain, leading to the most efficient argparse for blocky behavior.
- Another lead to a possible cause for weakening in the overriding plate is backarc volcanism, which might initiate from the accumulated oceanic crust at the bottom of the overriding plate. This can be modeled by locally raising the temperature.
- The mantle flow might have an important role in strengthening the pull of rollback, but its exact role of the mantle flow needs more investigation.
- Influence of a weak zone in the overriding plate is unclear due to numerical problems.

References