Modelling overriding plate deformation and slab rollback in the Western Mediterranean

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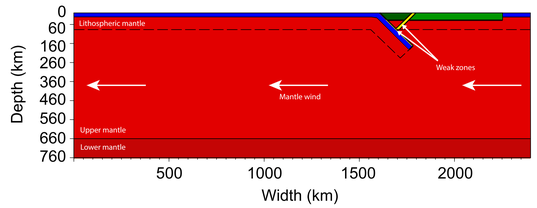
Problem formulation

Stagnation and reactivation of back-arc extension occurs in several (former) subduction systems, e.g. the Western Mediterranean and the Lau Basin. However, the cause of this stagnation and reactivation remains unknown. The aim of my MSc project was to study the effect of overriding plate rheology and velocity boundary conditions on the evolution of back-arc basins and rollback timing.

Model setup



- 2D cross-section through Western Mediterranean (see geological setting) with ASPECT *[1]*
- Prescribed velocities (subducting plate: 0.5 cm/yr, overriding plate: 0 cm/yr) and open vertical boundaries, free surface (top) and free slip (bottom)
- Compositional field per component
- Weak zones in overriding plate to simulate former faults and suture zones
- Mantle wind (1.8 cm/yr) to simulate toroidal flow around slab edges

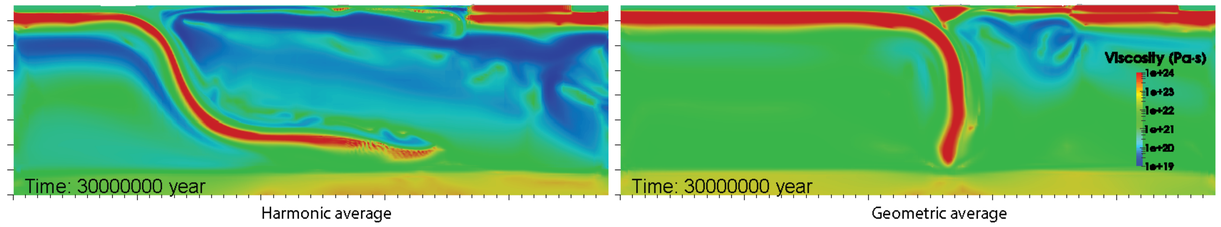
Conclusions

- The choice of the averaging scheme strongly influences the slab evolution
- The convergence velocity of the subducting plate strongly influences the trench motion and location
- A 3D model is needed to simulate the geological setting properly

Viscosity averaging schemes

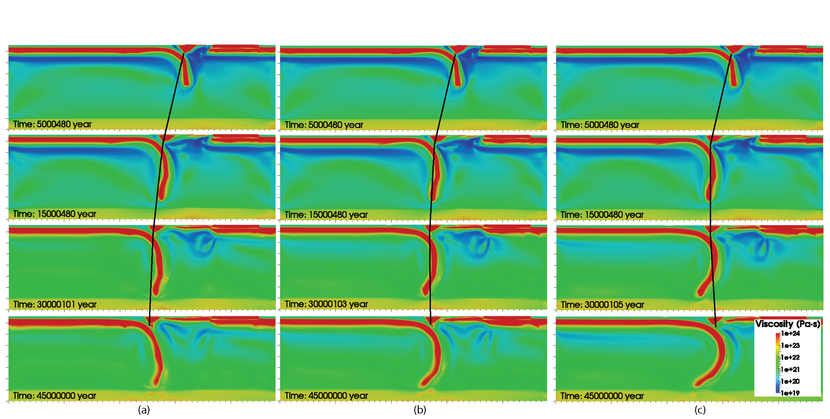
The choice of the viscosity averaging scheme has proven to have an important effect on the model evolution. The use of an harmonic averaging scheme, which is physically plausible, results in rollback and back-arc extension. However, the implemented high viscosity continental block accounting for Corsica and Sardinia vanishes through time due to numerical diffusion of its composition. The amount of rollback is more or less representative of the Western Mediterranean.

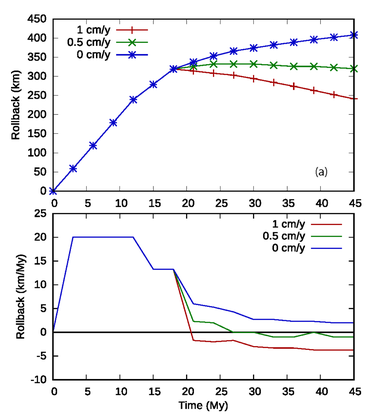
If a geometric averaging scheme is used, the continental block does not vanish, but an unrealistic amount of rollback and back-arc extension takes place. Usage of a geometric average has not resulted in simulating the present geometry of the Calabrian slab. Both averaging schemes yield unrealistic results, but the geometric average is preferred in the following models since the continental block does not disappear.



Trench rollback velocities

To test whether rollback stagnation and reactivation of back-arc extension occurs, the trench retreat velocity through time is monitored. To do this, the difference in location of the trench relative to the previous time step is measured. With initially prescribed boundary velocities and mantle wind, trench retreat occurs from the onset of extension in the overriding plate until 18 million years. When open boundaries are used and the convergence velocity is adjusted, the trench retreats or advances depending on the chosen velocity. The following figure includes 3 scenario's, where a, b and c correspond to convergence velocities of 0, 0.5 and 1 cm/yr, respectively.





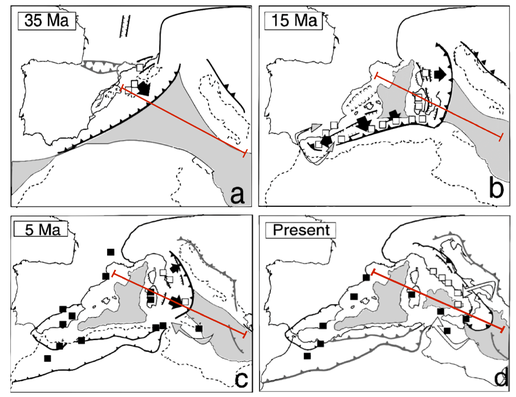
References

[1] Heister et al. In *GJI '17*

[2] Faccenna et al. In *Tectonics '04*

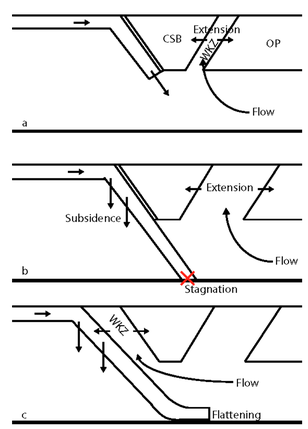
[3] Faccenna et al. In *EPSL '01*

Geological setting



Modified after [2]

Since 30 Ma, two-stage back-arc extension caused by rollback of the Calabrian slab has taken place in the Western Mediterranean. During the first stage (30-16 Ma) the Liguro-Provencal Basin opened. After a stagnation of 6 My the Tyrrhenian Basin opened (10 Ma-present). The continental block containing Corsica and Sardinia was left behind at its current location before the beginning of the second stage of rollback. The hypothesis for the two-stage extension of *Faccenna et al., 2001* is tested, which proposes that slab stagnation at the 660 discontinuity plays a major role in slowing down the rollback process.



Schematic overview of the stagnation process [3]