From plate tectonic reconstruction to 3D geodynamic models of the Alpine orogeny

PIs: Boris Kaus (JGU Mainz), Eline Le Breton (FU Berlin)

Motivation:
Using geological and geophysical data, it is possible to reconstruct the past motion of the plates involve in the Alpine orogeny and propose possible scenarios for their geological evolution. Those scenarios have not yet been tested for geodynamic consistency. Doing so is important as it will give insights into many additional parameters such as the rheology of the lithosphere, the occurrence of slab breakoff, and will show how reorganization of the lithosphere affects mountain building. Moreover, having dynamically consistent models will likely allow us to refine the reconstructions and perhaps even the interpretations of seismic tomography models.

Method:
In this project we will therefore perform 3D thermomechanical geodynamic simulations of the Alps starting with plate tectonic reconstructions, using a combined inverse and forward modelling approach. To make the problem tractable we start with reconstructions at 20 Ma based on the work of Le Breton et al. (2017) and adopt the rheology and geometry of the initial model setup using inverse models until they fit the velocity vectors predicted from plate tectonic reconstructions. This will show which rheologies are required to fit the data, but also how deep the slabs should be, with which angle they subducted at that time and what the impact of slab breakoff on surface-near processes was. Next, we will run the models in a forward manner for 20 Myrs to see whether the dynamics is consistent with the kinematics inferred by plate tectonic reconstructions. The models will include viscoelastoplastic rheologies and a free surface, and thus simulate the spontaneous occurrence of shear zones. Erosion is implemented in a simplified manner, which allows testing the interaction between surface and deep lithospheric processes.
We will subsequently put the starting point for the simulations further back in time.

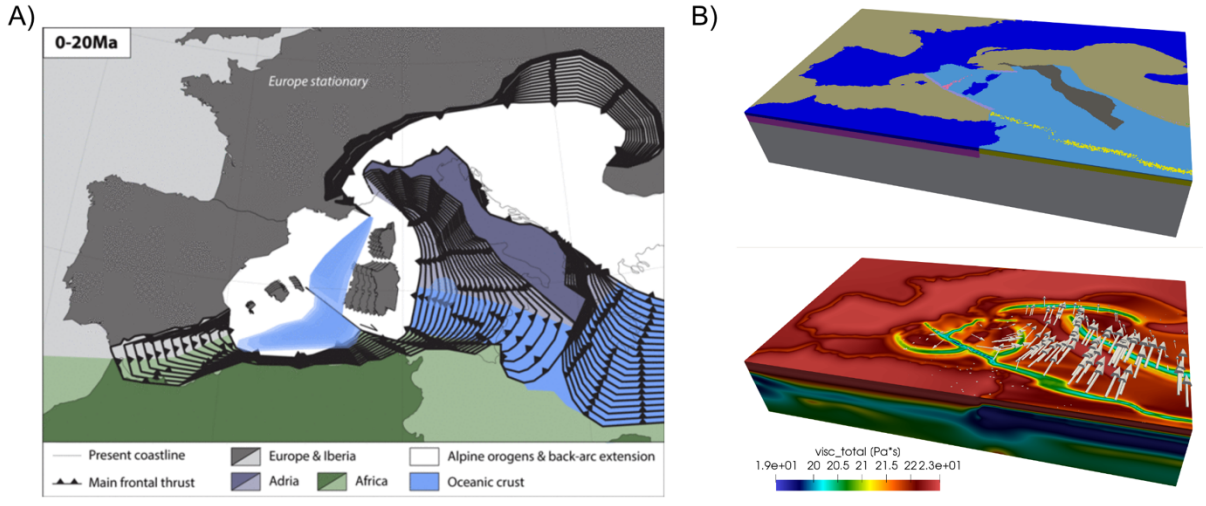

Figure: A) Plate tectonic reconstructions of the Alpine evolution over the last 20 Ma. B) Preliminary 3D geodynamic models in which the reconstruction @ 20Ma was used as starting point.

Funding requested: 1 PhD student