Constraining the near-surface response to lithospheric reorientation: Structural thermochronology along AlpArray geophysical transects

Dr. Christoph Glotzbach, Prof. Dr. Jonas Kley

Summary

This project follows the aim of the SPP MB-4D to reconstruct the 4D evolution of the Alps using a multidisciplinary approach. Our proposed research will make use of the refined geophysical understanding of the Alps gained by AlpArray. We will use an analytical / numerical modelling approach that integrates thermochronological data with structural-kinematic information ('structural thermochronology') from three orogen-scale balanced cross sections in the Central and Eastern Alps (NFP-20E, TRANSALP, EASI transects). Our approach will quantify the role of erosion, tectonics, and deep lithospheric changes for the evolution of the Alps. The study area overlaps and connects the activity fields (AF) AF-A (DSEBRA), AF-D (SWATH D) of the SPP MB-4D and will therefore strongly benefit from better resolution and understanding of the deeper underground gained by the AlpArray seismic network. This multidisciplinary approach will help to interpret the improved imaging of the deeper lithosphere from AlpArray (Research Theme (RT) 1-Reorganization of Lithosphere of the SPP MB-4D) by forward modelling restored balanced cross sections at lithospheric scale, thus linking surface deformation and exhumation histories with deeper, geophysically observed, structures. Expected outcomes of this innovative coupled modelling-data approach will be a high-resolution temporal and spatial (km-Myr-scale) exhumation history of the Alps that documents the erosional, near surface and deeper lithospheric controls on the Alps (RT 2 - Surface Response). Our project will initiate with existing upper-crustal structural data, and be refined when the deeper geometry of structures becomes available later in the project. Extracting the tectonic controls requires identifying and quantifying the activity of major faults. The proposed project will provide a long-term view of exhumation/erosion and fault activity, complementing studies focusing on the present-day motion pattern and seismicity (RT 4-Motion patterns and Seismicity of the SPP 4D-MB). Comparing these short- to long-term data will provide important information about the spatial and temporal continuity of the tectonic processes in the lithospheric evolution of the Alps.

Hypotheses tested and goals

The major goal of the proposed project is to quantify the surface and tectonic response to changes in the deeper lithospheric structure of the Alps. The expected impact on near-surface processes will be of large wavelength, low magnitude and associated with a time-lag and therefore requires a large scale approach with high spatial and temporal resolution (Fig. 1). We propose that a combination of structural, thermochronology and numerical modelling techniques will allow us to discriminate between the impact of lithospheric, crustal and near-surface processes. We will focus our project along major geophysical transects to make use of available geophysical data and detailed information on the present-day deep architecture of the Central and Eastern Alps. The proposed switch in subduction polarity occurred between the Central and Eastern Alps and therefore we concentrate our analyses on this transitional zone analysing (i) the NFP-20E transect in the Central Alps where S-ward subduction of the European slab occurs, (ii) the EASI transect in the Eastern Alps where N-ward subduction of the Adriatic slab occurs, and (iii) the TRANSALP transect located in the transition zone between the two configurations.

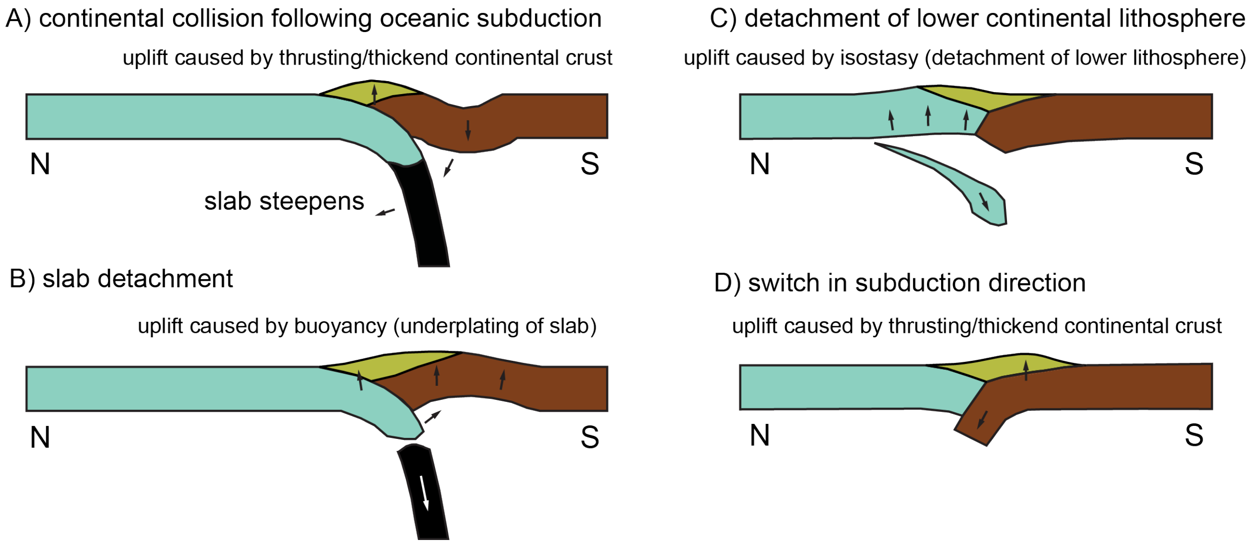

Fig. 1: Schematic figure showing the expected surface responses evaluated in this proposal and caused by: (A) slab retreat followed by (B) slab breakoff, (C) lower lithosphere detachment and (D) subduction polarity switch (modified from Bottrill et al. 2012; Handy et al. 2015). During initial collision rock uplift is caused by thrusting and thickening of continental crust, and a depression is formed in the overriding plate due to the flow of material caused by slab steepening (Bottrill et al. 2012). After slab breakoff the 'subducted' continental root rises buoyantly and leads to rock uplift in the overriding and subducting plates. Part of the subducted lower lithosphere may detach and lead to additional rock uplift of the former subducted plate. This may be followed by a switch in subduction direction and in response to rock uplift caused by thrusting and thickening, whereas subsidence (analogous to A) of the now overriding plate may not occur because of the buoyancy of the subducting plate.

Envisioned collaboration

This project will largely benefit from a better understanding of (i) the present and past crustal and the deeper lithospheric structure of the Alps and (ii) processes that impact cooling and erosion. We envision the following collaborations:

- Incorporate refined observations of the present and past crustal and lithospheric structure of the Alps gained by projects Friederich et al., Meier et al., Keppler et al., Gruetzner et al., Handy et al., von Hagke et al., Scheck-Wenderoth et al., Reicherter et al.
- Interpret thermochronological data taking into account the impact of fluid flow and climate change as studied in the projects of Luijendijk et al. and Mulch et al.