Constraining the near-surface response to lithospheric reorientation of the Alps: Integrating structural, thermochronometer, and numerical modelling along AlpArray geophysical transects

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Project Report

Changes in the deep lithosphere (e.g., slab break-off or a switch in subduction polarity) potentially result in orogen-wide structural reorientations and changes the pace and location of exhumation and Earth surface processes. In this project we combine bedrock thermochronology and balanced cross sections with thermo-kinematic modelling to reconstruct the cooling and exhumation history along geophysical profiles crossing the Central and Eastern Alps. Existing across-strike, orogen-wide balanced cross sections are verified and improved, if not consistent with the thermochronologic data. This method will yield reliable information about the structural and kinematic evolution of the Alps since continental collision. Observed changes in the structural and kinematic architecture will be diagnostic for deep lithospheric changes, for example, a switch in subduction polarity will likely shift the focus of active crustal deformation from the pro- to the retro-wedge side of an orogen.

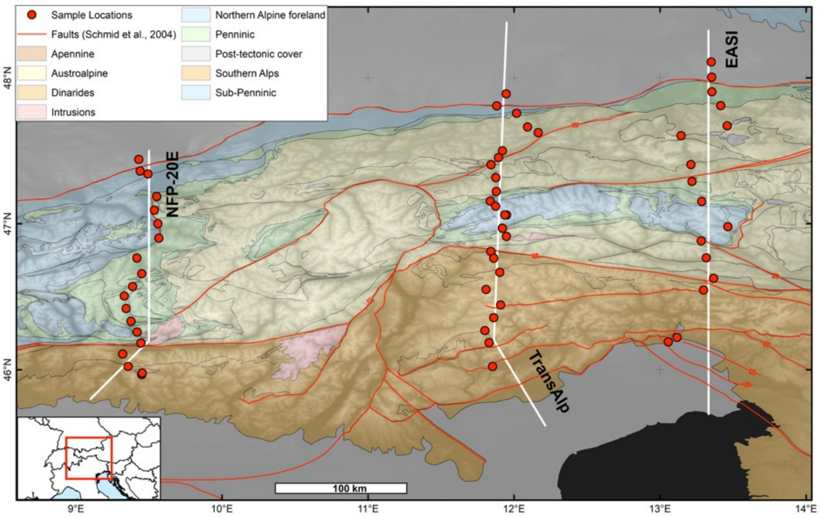
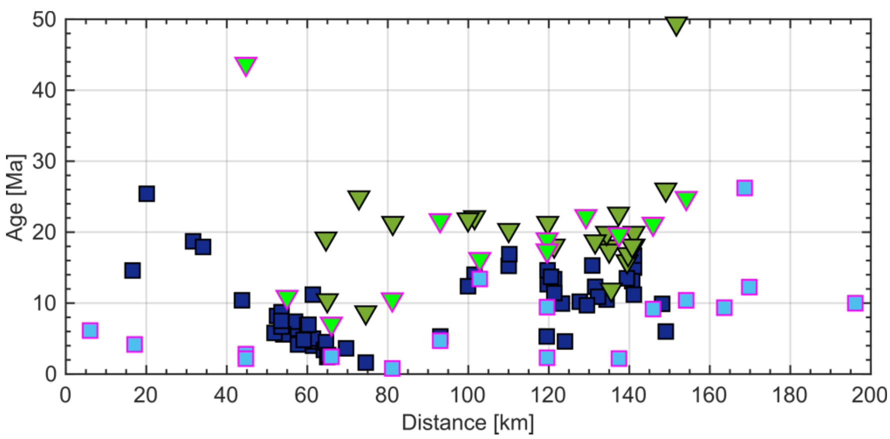


***Fig. 1**: Thermochronological sample locations along the studied geophysical transects.*

During field work in 2018 and 2019 we sampled 63 bedrock outcrops along the NFP-20E, TRANSALP and EASI geophysical profiles crossing the Central and Eastern Alps (Fig. 1). All of the samples have been processed and samples along the TRANSALP and NFP-20 have been dated with the apatite and zircon (U-Th)/He method (Figs. 2 and 3). Most thermochronologic ages along the NFP-20E profile are <30 Ma, with older ages in the Lepontine dome and younger ages towards the north in the Helvetic nappes and in the Bündnerschiefer east of the Aar massif (Fig. 2). Active tectonic uplift and exhumation therefore gradually shifted from the Lepontine dome in the south towards the Aar massif in the north at ca. 15-20 Ma.

***Fig. 2**: Low-temperature thermochronologic data along the NFP-20E profile (new ages outlined in magenta). See legend in Fig. 3 for symbology.*



Thermochronologic ages along the TRANSALP profile are generally young in the Tauern Window and older towards the north and south (Fig. 3). We used available semi-balanced cross sections to construct a thermo-kinematic model for the TRANSALP section. The kinematic field was integrated into a thermal evolution model to predict thermochronologic ages, which then were compared to observed ages (Fig. 3). We subsequently modified and revised the kinematic model, i.e. adding active structures at respective time steps, that are required to fit predicted and observed thermochronologic ages.

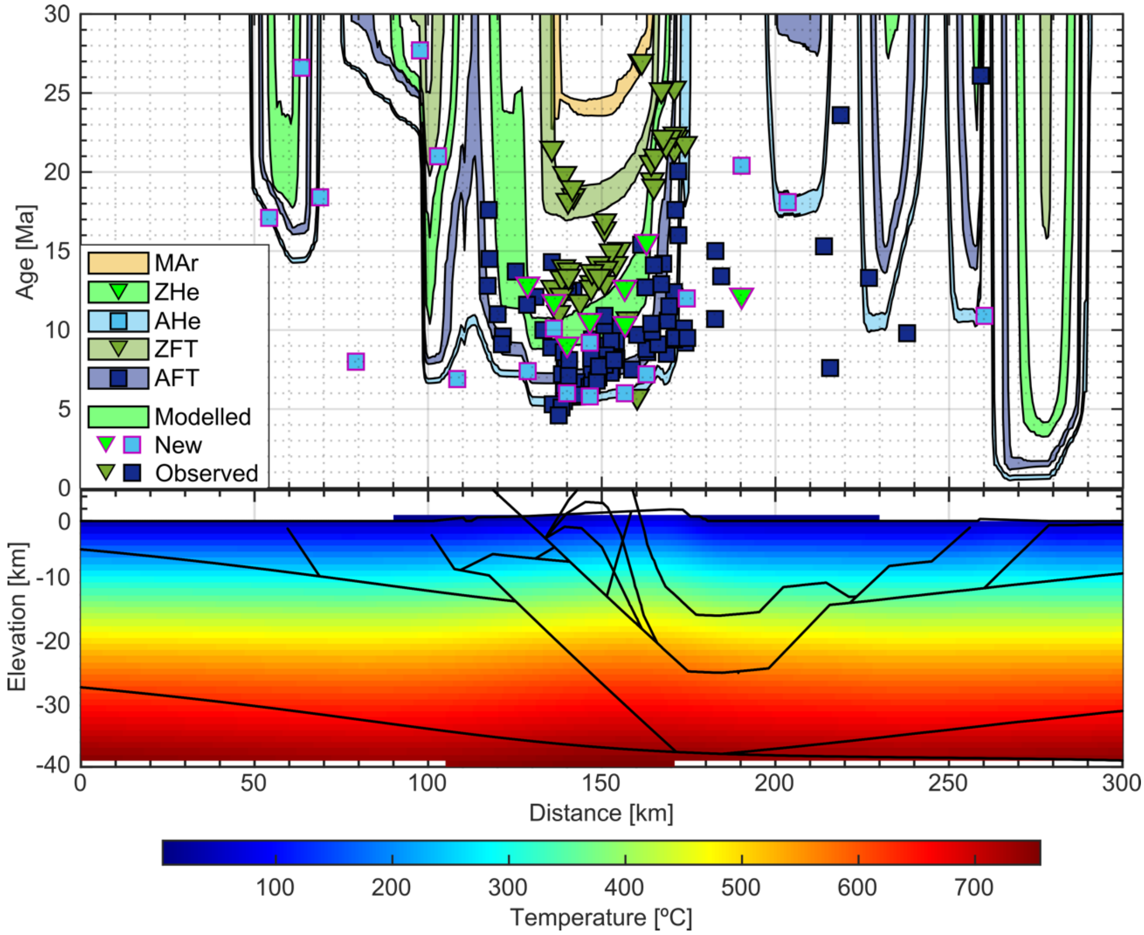


Fig. 3*: Observed and modelled low-temperature thermochronological ages along the TRANSALP profile (top) and corresponding thermo-kinematic model (bottom).*

The main conclusions for the TRANSALP section are that (i) the available structural and kinematic data are in accordance with the thermochronologic record, (ii) the steep age gradient near the Periadriatic fault (at ca. 175 km in Fig. 3) can be explained through internal duplexing within the Tauern Window and displacement along the Sub-Tauern Ramp; active reverse faulting along the Periadriatic Fault is not required, and (iii) model and observed data suggest a general shift from pro-wedge to retro-wedge deformation, potentially related to a switch in subduction polarity post 30 Ma.

Our study does shed new light on research themes 1, 2 and 3 of the original 4D-MB proposal providing insights into the crustal and surface response to reorganization of the lithosphere. Our preliminary results suggest crustal reorganization related to a switch in subduction polarity.

Publications

Eizenhöfer, P.R., Glotzbach, C., Büttner, L., Kley, J., Ehlers, T.A., (under review). Turning the Orogenic Switch: Slab-Reversal in the Eastern Alps Recorded by Low-Temperature Thermochronology. *Geophysical Research Letters*.

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Eizenhöfer, P.R., Glotzbach, C., Büttner, L., Kley, J., Ehlers, T.A., (2020). Neogene Exhumation History along TRANSALP: Insights from Low Temperature Thermochronology and Thermo-Kinematic Models. *EGU General Assembly Conference Abstracts*, EGU2020-9714.

Glotzbach, C., Eizenhöfer, P.R., Kley, J., Ehlers, T.A., (2020) Structural thermochronology along geophysical transects through the Alps. *EGU General Assembly Conference Abstracts*, EGU2020-6781.

Eizenhöfer, P.R., Glotzbach, C., Büttner, L., Kley, J., Ehlers, T.A., 2019. Structural Thermochronology along the NFP-20E, TransAlp and EASI Profiles: Understanding the Role of Slab Break-Off on the Neogene Structural and Exhumation History of the Alps. *EGU General Assembly Conference Abstracts*, 21, EGU2019-7808.