Presentation materials to EGU2020-9714
TS7.6: The Alps and neighbouring mountain belts (Apennines, Dinarides, Carpathians): a multidisciplinary vision (AlpArray)

Neogene Exhumation History along TRANSALP: Insights from Low Temperature Thermochronology and Thermo-Kinematic Models

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Summary

The study is driven by the need to understand the late stage evolution of an orogen by bridging observations across the lithosphere. The AlpArray project across the European Alps provides a unique opportunity to integrate new high-resolution seismic data with data that respond to changes in the upper lithosphere and the surface, for example reflected by low-temperature thermochronology. Here we present new apatite (AHe) and zircon (ZHe) helium data densely spaced along the TRANSALP geophysical transect in the Eastern Alps (**Figs. 1** and **2**). In combination with previously published thermochronology data, these feature a clear ‘nesting’ of reset ages across the Tauern Window. In order to better explain this characteristic age distribution, we additionally conducted thermo-kinematic modelling, integrating structural models along TRANSALP using cross-section balancing in MOVE™ (**Fig. 3**) with thermal modelling of the upper lithosphere using PECUBE. The resulting thermal solutions allow us to predict thermochronologic ages that can be compared to the observed data set (**Fig. 4**). Our model results suggest that predicted age ranges are more sensitive to variations in convergence rates relative to temperature. The kinematic solutions, taking into account existing structural studies in the Northern Calcareous Alps, the Tauern Window and the Southern Alps, feature a gradual shift of fault activity from the north to the south since initiation of activity along the Sub-Tauern Ramp. Both, our new low-temperature data and thermo-kinematic models, producing predicted ages similar to the observed ones, suggest a slow and ongoing reversal in subduction polarity since the Middle Miocene (**Fig. 5**).

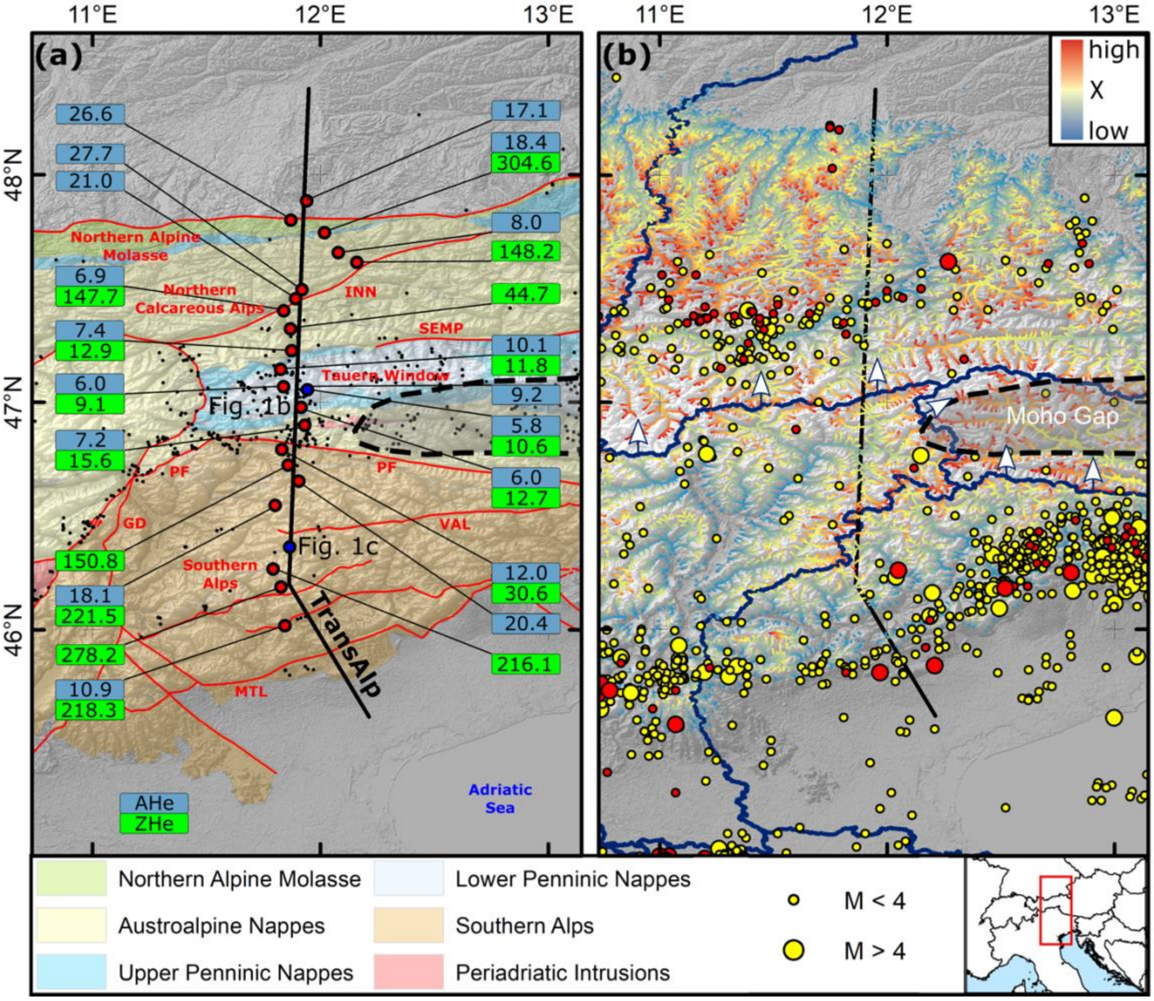

Figure 1. *Present-day to medium-term (million year) crustal responses to proposed lower lithospheric slab-reversal beneath TRANSALP in the eastern European Alps (Eizenhöfer et al., under review). (a) Simplified geological map with new (AHe and ZHe) low temperature thermochronology data (ages in Ma) and locations of published data (black dots). (b) Seismic activity recorded by the International Seismological Centre (yellow dots; ICS; Storchak et al., 2017) and the GEOFON Data Centre (1993) over the past ten years (red dots), and drainage divide migration trends based on χ-analysis along river profiles (Robl et al., 2017; Winterberg and Willett, 2019; major drainage divides outlined as bold blue lines; see Supplementary Text S3 for details). PF, Periadriatic Fault; VAL, Valsugana thrust; MTL, Montello thrust; INN, Inntal fault; SEMP, Salzach-Ennstal-Mariazell-Puchberg fault; GD, Giudicarie fault.*

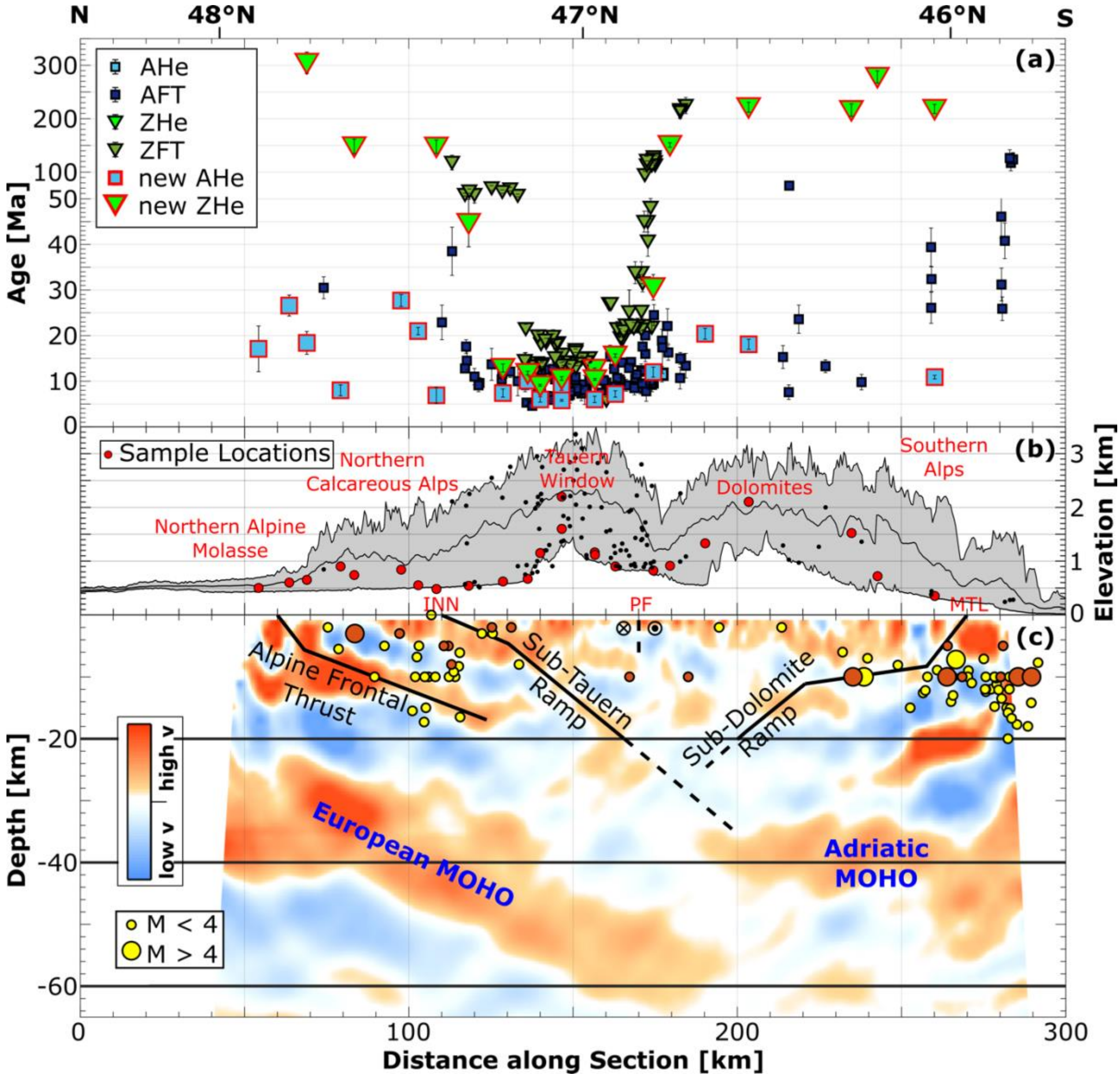

Figure 2. *Cross-sectional N-S view of a 20 km wide swath along the TRANSALP profile (Eizenhöfer et al., under review). (a) Distribution of new and existing low temperature thermochronology data. Dashed lines outline proposed age trends (light blue, AHe; dark blue, AFT; light green, ZHe). (b) Topographic swath profile with locations of samples and published data shown in (a). (c) Locations of the European and Adriatic Moho based on receiver function analyses (Kummerow et al., 2004), simplified structural geometry and depth of seismic activity (ICS; Storchak et al., 2017; GEOFON Data Centre, 1993). PF, Periadriatic Fault; MTL, Montello thrust; INN, Inntal fault.*

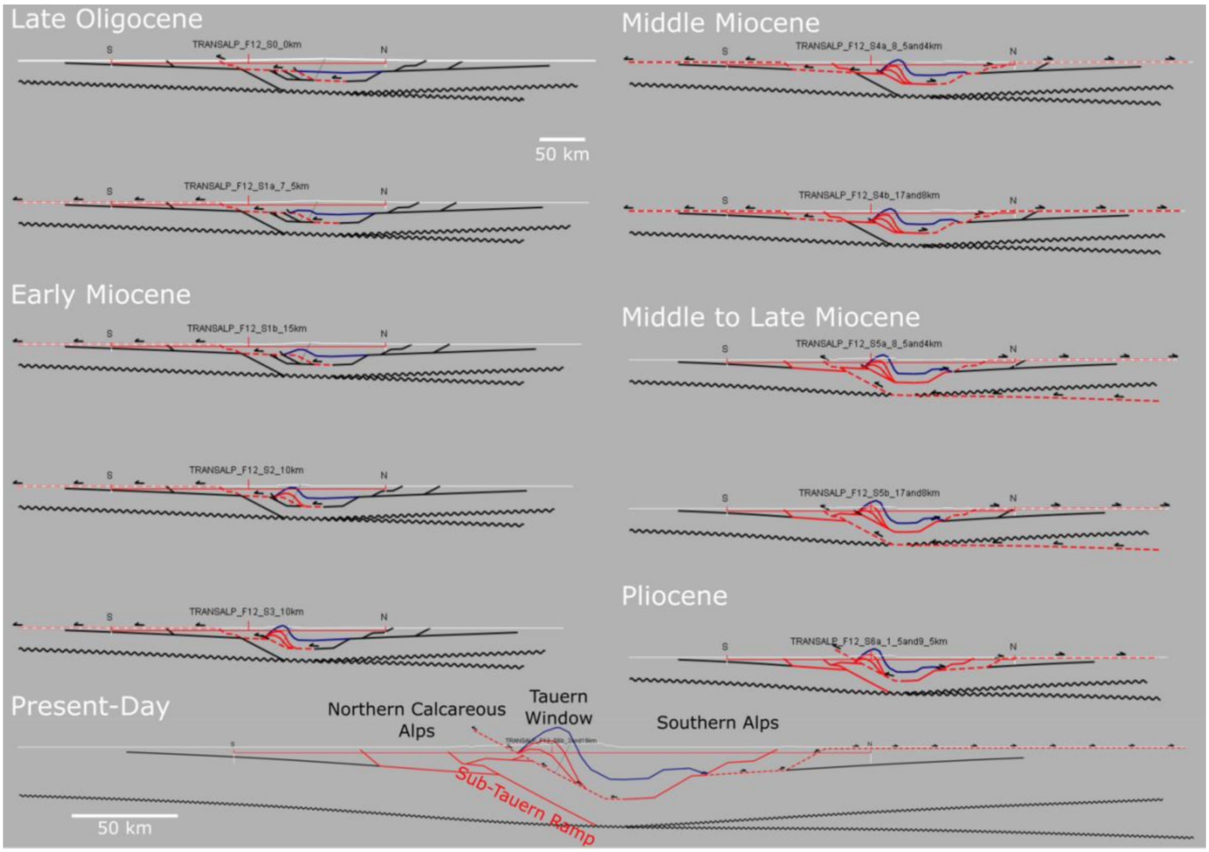

Figure 3. *Proposed upper lithospheric, MOVE™ kinematic solution along the TRANSALP geophysical transect since the Oligocene (Eizenhöfer et al., in prep.). The Late Oligocene to Early Miocene is characterised by rapid exhumation and structural duplexing within the future Tauern Window. The Middle Miocene features lateral growth of the orogen followed by activity along the Sub-Tauern Ramp in the Middle to Late Miocene. Since the Pliocene upper lithospheric deformation is centred in the Southern Alps. Dashed red lines, active faults; white lines, modelled topography; red lines previously active faults; blue line, ~20 km depth marker at model start; wavy lines, slip horizons (without specific geologic meaning); no vertical exaggeration.*

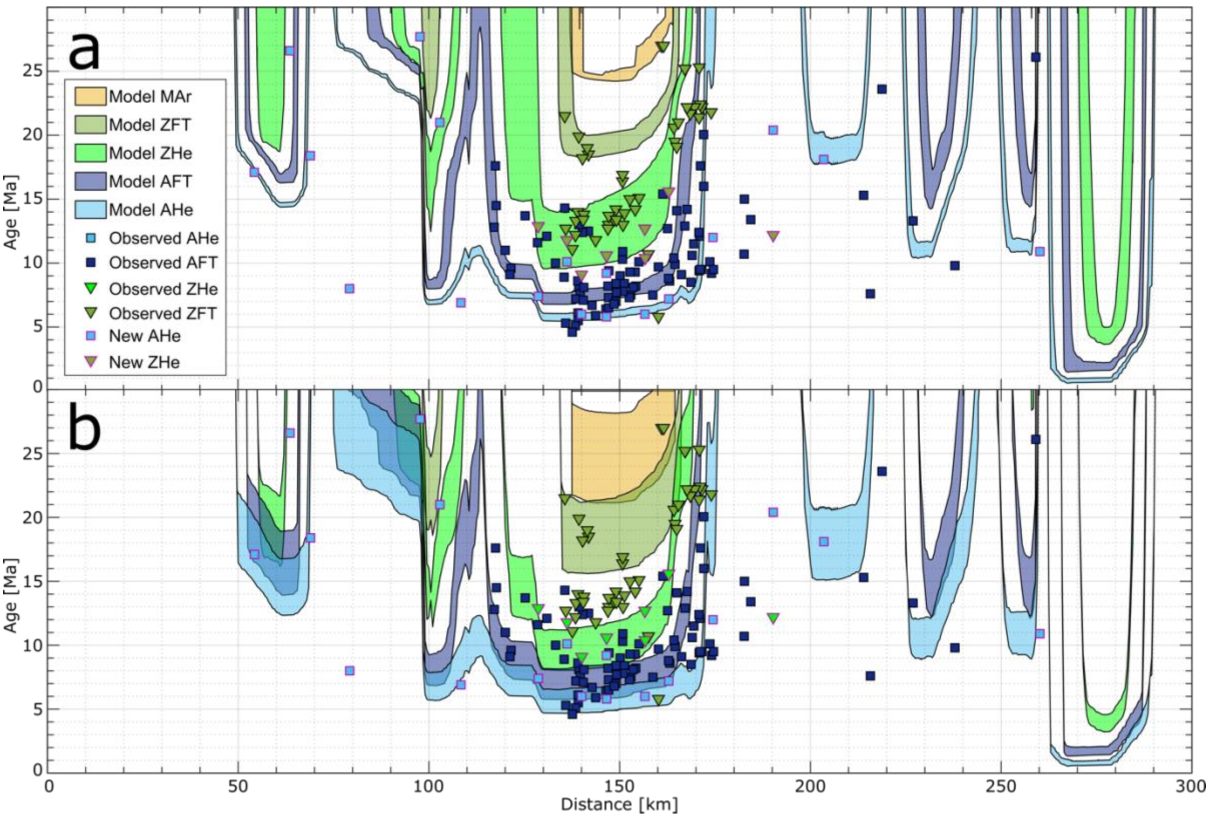

Figure 4. *PECUBE-predicted thermochronology age ranges based on MOVE™ kinematic solution shown in Fig. 3 (Eizenhöfer et al., in prep.). Predicted age ranges for (a) a crustal thermal heat production of A_0 = 3.0-4.0 µW/m^3, (b) convergence rates between 4-5 mm/yr in the Late Oligocene to Early Miocene and 3-4 mm/yr since the Middle Miocene.*

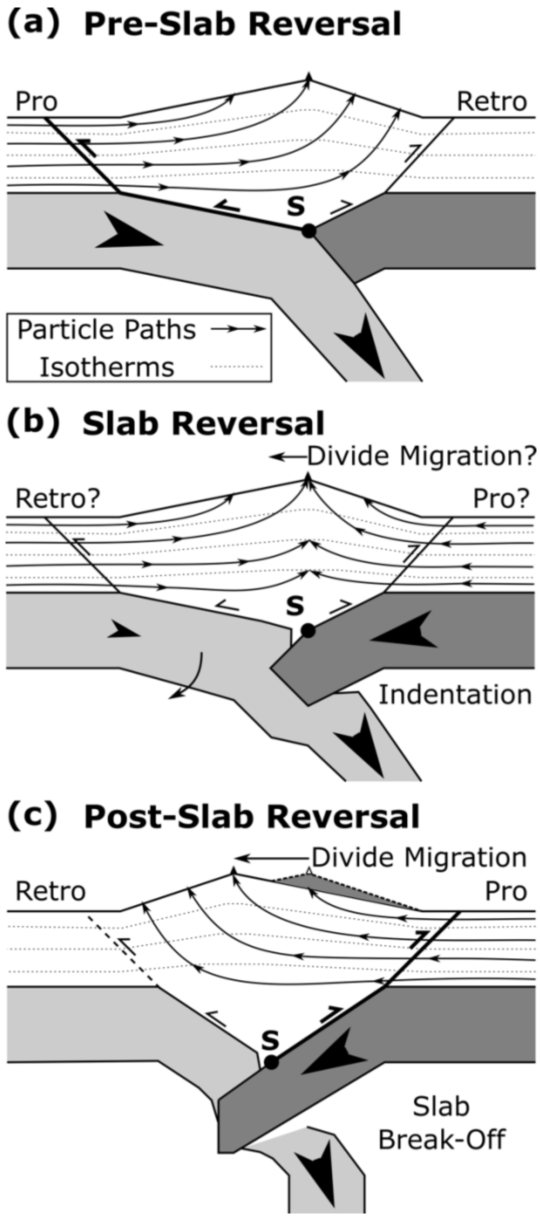

Figure 5. *Conceptual model for the stepwise evolution of lower lithospheric slab polarity reversal in a continent-continent collisional setting (following Pysklywec, 2001; Eizenhöfer et al., under review). (a) Initial doubly-vergent orogen geometry prior to slab reversal (Willett et al., 1993; Willett and Brandon, 2002; configuration along TRANSALP approximately during the Oligocene). (b) Indentation of retro-wedge lower lithosphere initiating polarity reversal and drainage divide migration (present-day configuration beneath TRANSALP). (c) Slab break-off and drainage divide migration after full slab-reversal (potential present-day configuration east of TRANSALP).*

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