Transpression and transtension in the Eastern Alps (TATEA): Kinematics and age of a sinistral wrench zone

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How shortening, wrenching, and extension are related kinematically, interfered over time, and correlate with the lithosphere is a first-order geodynamic issue at the bifurcation of the Eastern Alps into the Dinarides and the Carpathians. We expect a temporal and kinematic change in deformation and exhumation occurring within the Niedere Tauern (NT). Only few structural studies of the NT exist; it is bordered by the sinistral SEMP Fault in the north, the dextral PLF in the east, and the sinistral MFS in the south (Fig. 1). In addition, the dextral PöF crosscut the NT. The kinematics of the MFS –whether thrust-related, extensional, or strike-slip dominated– are still debated. The westward transition into the Tauern Window is marked by flat nappe contacts whose tectonic significance and kinematic reactivation is unclear and objective of this proposal (Fig. 2).

The goal of TATEA is to establish a kinematic model for a Cenozoic wrench zone across the Eastern Alps, focusing on tectonics and geochronology of the middle–upper crust in the NT (Fig. 1). TATEA contributes to the MB-4D Research Theme 1: "Large-scale reorganizations of the lithosphere" and to the MB-4D Research Theme 2: "Surface response to changes in deep structure on different time scales". We address the question whether the Eastern Alps are the site of a reversal in subduction polarity and whether recent denudation and uplift rates reflect long-term, deep-seated processes imaged by AlpArray. A grid of low-temperature cooling ages across the NT will permit interpretation on processes of vertical rock motion resulting in Cenozoic exhumation. Dating of synkinematic minerals in bordering strike-slip shear zones and the nappe contacts to the Tauern Window will evidence lateral rock motion.

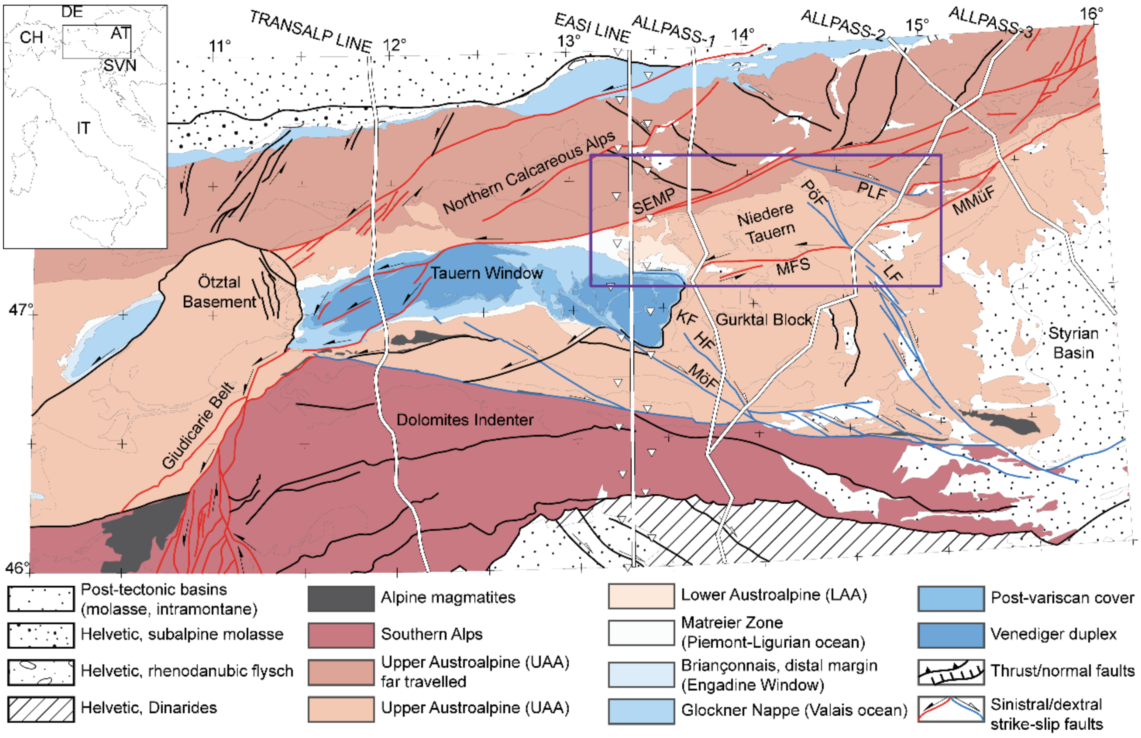

Figure 1. *Modified tectonostratigraphic map of the Eastern Alps after Bousquet et al. (2012a); purple frame marks the study area. White lines indicate the seismic sections of the campaigns TRANSALP, ALLPASS and EASI. Relevant Cenozoic faults: HF=Hochstuhl Fault, KF=Katschberg Fault, LF=Lavanttal Fault, MMüF=Mur-Mürz Fault, MFS=Murtal Fault System, MöF=Mölltal Fault, PLF=Palten-Liesing Fault, PöF=Pöls Fault, SEMP=Salzach–Ennstal–Mariazell–Puchberg Fault.*

Coeval shear zone activity and rock exhumation together with structural and kinematic linkages renders understandable long-term, deep-seated tectonic processes. These data will provide detailed rock trajectories recording late tectonic events (indentation, lateral escape) covering MB-4D Research Theme 3: “Rock trajectories and deformation during mountain building”. Geophysical studies indicate a current major change in the plate geometry beneath the eastern Tauern Window and the NT at ~11°E–13°E. We propose a combined structural and geochronological study to characterize this zone that coincides with the detachment of the European slab.

The geological question arising from geophysical observations is; what is the structural and temporal surface expression of this change in plate geometry? We hypothesize that the Cenozoic change from transpressional to transtensional kinematics within the wrench zone indicates the transition from an attached to a detached European slab. This change coincides with the (1) increasing occurrences of intramontane basins (Fig. 1), (2) with the predominantly dextral transtensive kinematics and (3) the generally younger (≤17 Ma) deformation ages compared to sinistral transpressive faults and shear zones in the western Eastern Alps (Fig. 2). We argue that this transition is an expression of the eastward changing tectonics along the mountain chain caused by the geometry of the plate boundary underneath. We will perform geochronology within the NT, using the ^{40}Ar/^{39}Ar in-situ, the fission-track and the (U-Th)/He methods. The combination of structural geology, unravelling the Cenozoic shear and fault zone evolution, and geochronology, dating deformation and exhumation are the tools of choice to establish a link between surface geology and the deep structure.

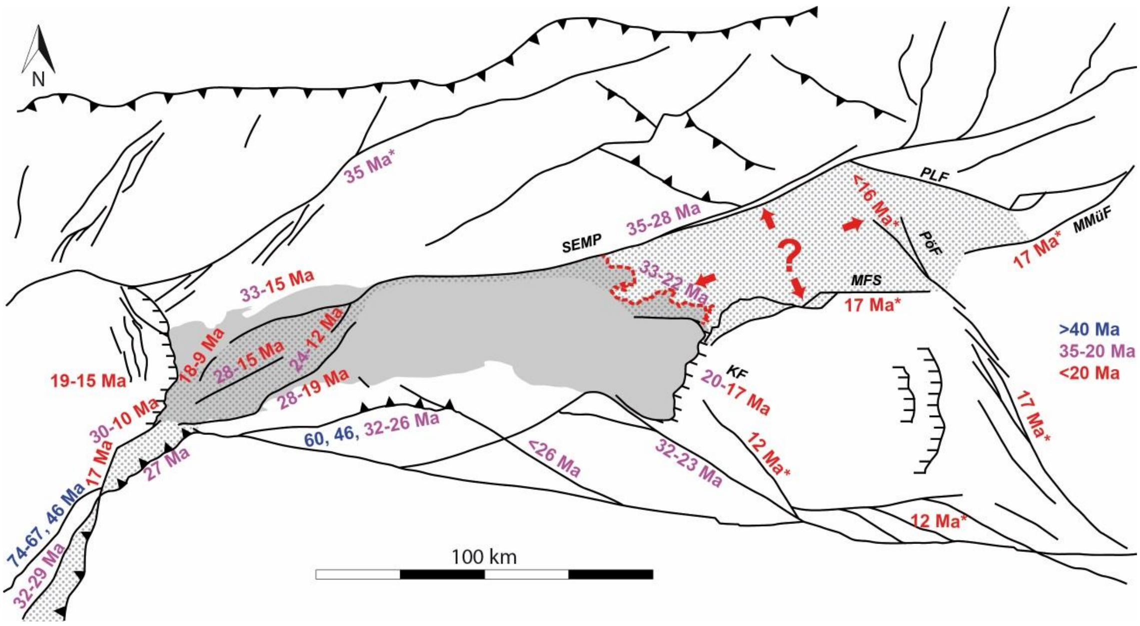

Figure 2. *Main Cenozoic fault and shear zones in the Eastern Alps and their deformation longevities, from dated synkinematic minerals, ^{40}Ar/^{39}Ar step-heating experiments on pseudotachylites, and formation ages of cross-cutting dikes from various studies. Dotted area: sinistral wrench zone. Red line: nappe contact between the Katschberg and SEMP faults, which is structurally unconstrained. Ages with an asterisk are for the oldest sediments within pull apart basins. Question mark indicates a 5 to 8 Myr gap in the NT.*

Major structural questions are: (1) Are the SEMP, PöF, KF and MFS linked (Fig. 1)? (2) Are there clear crosscutting relationships between these structures indicating a tectonic succession? (3) Are the nappe contacts of the NE tip of the Tauern Window overprinted or reactivated?

Major geochronological questions are: (4) what can be concluded from the distribution of cooling ages in the NT? (5) Is there a concentric cooling pattern, indicating exhumation by doming, or an oblique planar pattern, indicating extension related to one of the bordering faults? (6) What are the sample-specific cooling rates and do they show a regional trend? (7) Did the cooling rates change through time?