Switching pro- and retro-wedges and peripheral basins in the Eastern Alps - clues to a change in lithospheric structure?

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Classical models of mountain building feature foreland- and hinterland-basins, and thrust-and-fold belts that bound an asymmetric orogenic wedge. The Alps (**Fig. 1A**) do not fit this classical model. Although the Western and Central Alps are asymmetric with a pro-wedge in the north and greatest exhumation along S-directed backthrusts in the retrowedge (**Fig. 1B**), the Eastern Alps have most exhumation in their core and are marked by a striking change in thrust kinematics and basin development (**Fig. 1C**): Rapid infilling of the northeastern Molasse Basin and abatement of north-directed thrusting from 21-18 Ma in the north generally coincided with the onset of S-directed thrusting and formation of the Veneto-Friuliana basin in the south. Thus, the pro- and retro-wedges of the Eastern Alps appear to have switched in Neogene time.

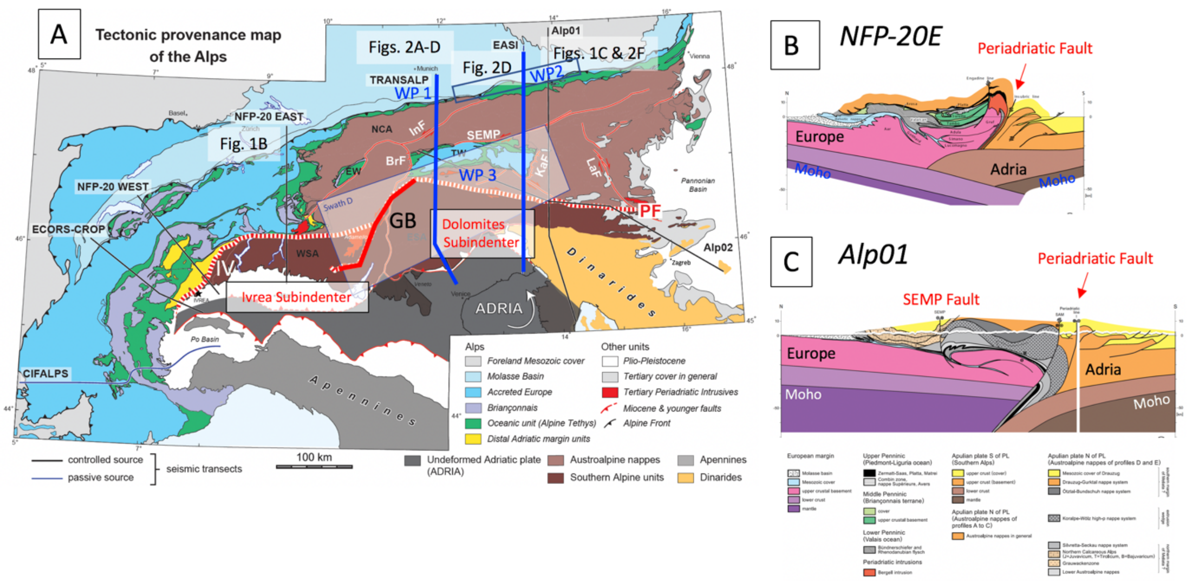

***Figure 1**: Tectonic map and cross sections of the Alps: (A) Map with location of dense seismic network Swath D (shaded area) and seismological transects in B and C (blue lines). Dashed red line – Periadriatic Fault System (PF) marking front of Ivrea (IV) and Dolomites Subindenters which are offset along the Giudicarie Fault (solid red line) and Giudiarie Belt (GB); Cross sections of the Central Alps (B) and Eastern Alps (C) with contrasting crustal structure and interpreted slab geometry. WP1 targets the TRANSALP section, WP2 targets the proximal margin of the eastern Molasse Basin including EASI and Alp01, WP3 integrates results along TRANSALP, EASI and ALP01, as well as along the eastern Molasse Basin. Map from 4D-MB website modified from Handy et al. 2010 and Schmid et al. 2004.*

Goals: This project seeks to identify the causes of this enigmatic switch in Neogene thrust kinematics and basin evolution. Specifically, the project will test two competing hypotheses: (A) indentation of the Adriatic Plate caused decoupling of the orogenic crust from its subcrustal roots, including the subducting slab; (2) the slab orientation in the Eastern Alps switched from S- to N-dipping with attendant changes in the levels of detachment.

The hypotheses will be tested by using the structure and basin histories of the Alpine orogen as proxies for detachment level and subduction polarity. Specifically, such a switch is predicted to induce a change of the orogenic front from pro-wedge type (episodic advance by alternating in-sequence and out-of-sequence thrusting) initially in the north, to retro-wedge type (slower advance, alternating in-sequence thrusting and stagnation) initially in the south. This contrasting behavior is expected to be reflected in erosion rates in the orogenic hinterland and clastic deposition rates in the Molasse and Veneto Basins, respectively, north and south of the Alpine Orogen. The transition of the northern Alpine front from pro- to retro-wedge behavior is proposed to be manifested by stagnation of the thrust front at c. 21 Ma during prolonged subsidence of the Eastern Molasse Basin until 16 Ma. Along the southern Alpine front, retro-wedge behaviour may have changed to pro-wedge behaviour with the onset of Neogene thrusting involving the proximal Veneto Basin at 21-22 Ma. Basin subsidence until 16 Ma in the eastern Molasse Basin during continued activity of the orogenic front may be attributed to continued downward pull of the European slab following the main slab breakoff event at c. 30-35 Ma. Rapid infilling after 16 Ma may document rebound during tearing of the remaining part of the slab to the east, towards the Carpathians.

Methods: The project combines 3 work packages (WP) for seismology, structural geology and basin analysis (**Fig. 2**). WP1 (Bauer, Schwarz) will (re)process seismic data from the SWATH D and TRANSALP experiments to provide high-resolution images of the orogenic crust and key faults along the TRANSALP section. WP2 (Bernhardt, N.N.) will use industry seismics and surface exposures to reconstruct the Tertiary subsidence history of the eastern Molasse and Veneto Basins along and across their strike in order to establish the response of the basin to thrusting and slab events. WP3 (Handy, McPhee) will use these new images as well as those emerging from the EASI section and SWATH D to construct and balance new cross sections from the northern Molasse Basin to the Veneto Basin in the south.

Deliverables: (1) *seismology & structural geology*: a 3D image of faults beneath the Tauern Window area that partitioned strain during indentation and lateral escape; (2) *basin analysis & structural geology*: a 4D model of the northeastern Molasse Basin that documents advances and retreats of thrusting along the orogenic front, from the Central-Eastern Alps transition in the west to the Alps-Carpathians junction in the east; (3) combined *seismology, basin dynamics and structural geology:* an integrated 4D model of switching subduction polarity, from slab breakoff to indentation.

WP1 - Reflection Seismology K. Bauer + 1 postdoc	WP2 - Basin Analysis A. Bernhardt + 1 PhD	WP3 - Structural Geology M. R. Handy + P. McPhee

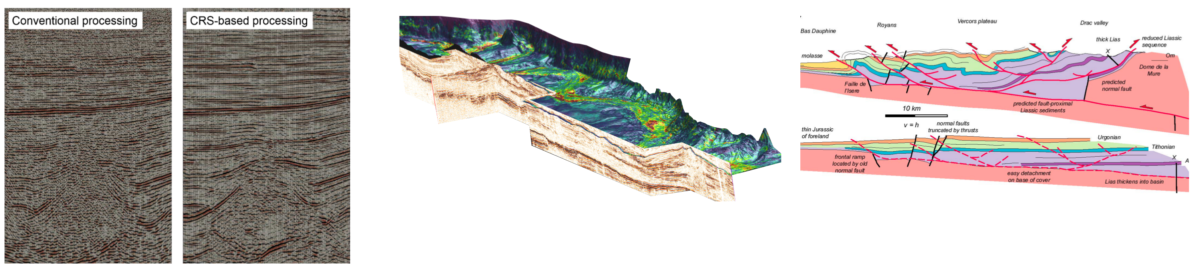

***Figure 2**: Work packages: WP1 - Conventional processing (left) and improved imaging (right) by multi-focussing and common-reflection-surface (CRS) stacking. In WP1, we propose CRS-based methods to reveal more detailed crustal structure along TRANSALP; WP2 - Detailed 3D seismnic image of part of the eastern Molasse. The 3D perspective visualizes an uplifted thrust sheet on a Middle Miocene channel; WP3 –tectonic balancing and restoration of geological-geophysical cross sections of the eastern Alps (locations in blue in **Fig. 1**).*