Investigating the post-collisional reorganization of the Eastern Alps using a 4D reconstruction

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In Neogene time, the Eastern Alps underwent a profound post-collisional tectonic reorganisation. This featured indentation of the Alpine orogenic wedge by the Adriatic upper plate, eastward lateral extrusion between conjugate strike-slip faults, and a shift from thrust propagation on the European lower plate to the Adriatic upper plate, accreting the eastern South Alps fold-thrust belt. The triggers and driving forces of this tectonic reorganisation remain hotly debated.

We present new sequentially restored orogen-scale cross sections along the TRANSALP (12°E) and EASI (13.3°E) transects, plus an E-W orogen-parallel section (46.5°E) to investigate the kinematic evolution of the Neogene tectonic reorganisation in 4D. These transects were affected by eastward lateral extrusion, and so we used a map-view reconstruction to restore out-of-section transport of rock at the onset of rapid extrusion (23 Ma), and the onset of thick-skinned thrusting in the eastern South Alps fold-thrust belt (14 Ma). We then compared our results with V_p LET and teleseismic models of the crust and upper mantle.

The geologic record reveals two phases of indentation in the Tauern Window: (Phase 1, 23-14 Ma) The Adriatic crust acted as a coherent indenter, with northward motion relative to Europe accommodated by shortening within the Eastern Alps orogenic wedge as well as sinistral motion along the Giudicarie Fault. Initially, upright folding of Penninic units, including the Venediger nappes, in the Tauern Window accommodated most shortening, but by middle Miocene time, eastward lateral extrusion of the entire metamorphic edifice and NCA was the primary mechanism accommodating N-S shortening. This shortening required ongoing subduction of the European lithosphere, ruling out previous models involving north-dipping Adriatic subduction. A purported detachment below the Venediger Duplex is inferred to have served as the base of the laterally extruding wedge, which comprised the previously subducted and exhumed European crust.

(Phase 2, 14 Ma-Present): Since the middle Miocene, the leading edge of the Adriatic indenter has been deforming, forming the thick-skinned South Alps fold-thrust belt. The onset of S-directed shortening is recorded by Langhian-Serravallian rocks beneath the Valsugana Thrust. In contrast, the Adriatic lower crust of the fold-thrust belt was decoupled and transported northwards into the orogenic wedge. In the TRANSALP section, the European lithospheric mantle currently extends beneath the orogenic wedge, whereas in the EASI section the subducted European lithosphere has detached. The Adriatic lower crust indented the deeply buried equivalents of the European Venediger rocks exposed in the Tauern Window. A high-velocity (6.8-7.25 km/s) bulge in LET models of the TRANSALP section images this indenter, and possibly includes accreted European lower crust.

We find that when the European slab detached beneath the Eastern Alps, shortening, exhumation, and lateral extrusion of the Eastern Alps orogenic wedge became increasingly important in accommodating Adria-Europe convergence. This culminated in the accretion of the South Alps which now forms the southern part of the orogenic wedge and primarily accommodates ongoing convergence. We note that in the E-W orogen-parallel section, a vertical gap within the slab anomaly, interpreted as a horizontal slab detachment, occurs east of the western boundary of the Tauern Window and the north projection of the Giudicarie Fault. Slab detachment (Handy et al., this volume) is an appealing explanation for the Neogene evolution by eliminating slab pull and redirecting the shortening into the south part of the orogenic wedge.

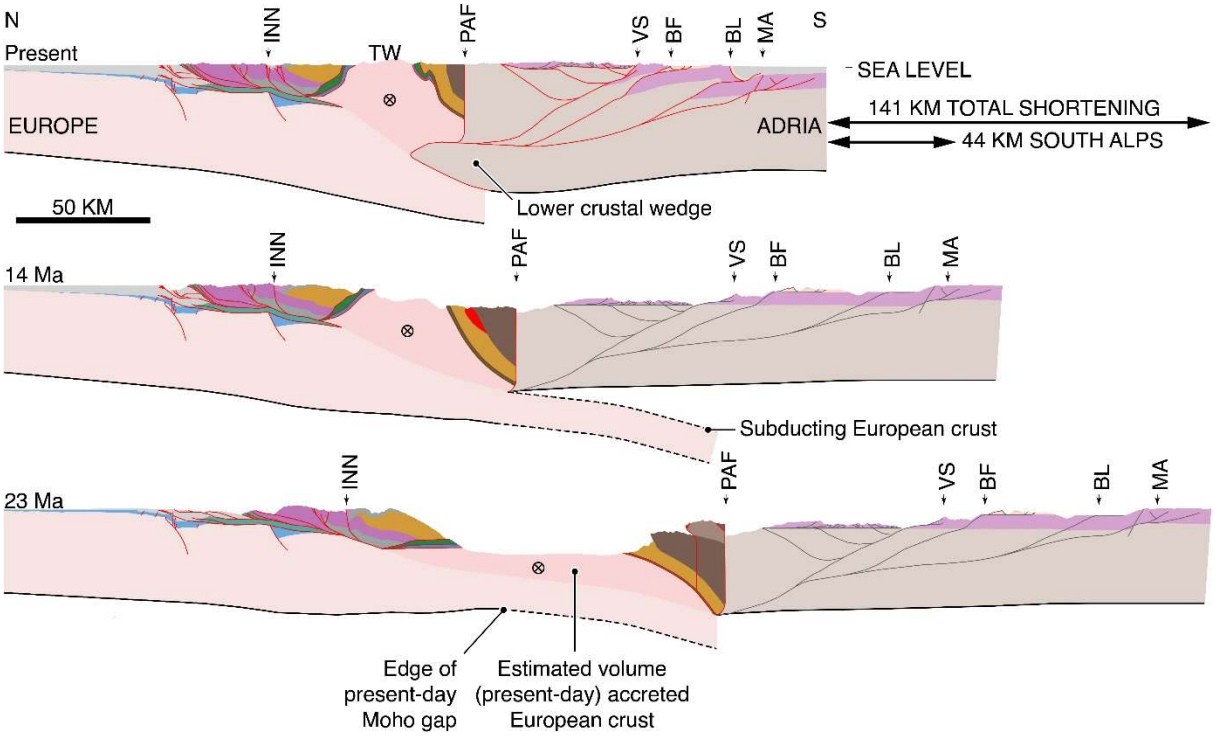

Figure 1A: Restored profiles along the TRANSALP section. Red = active faults during time slice.

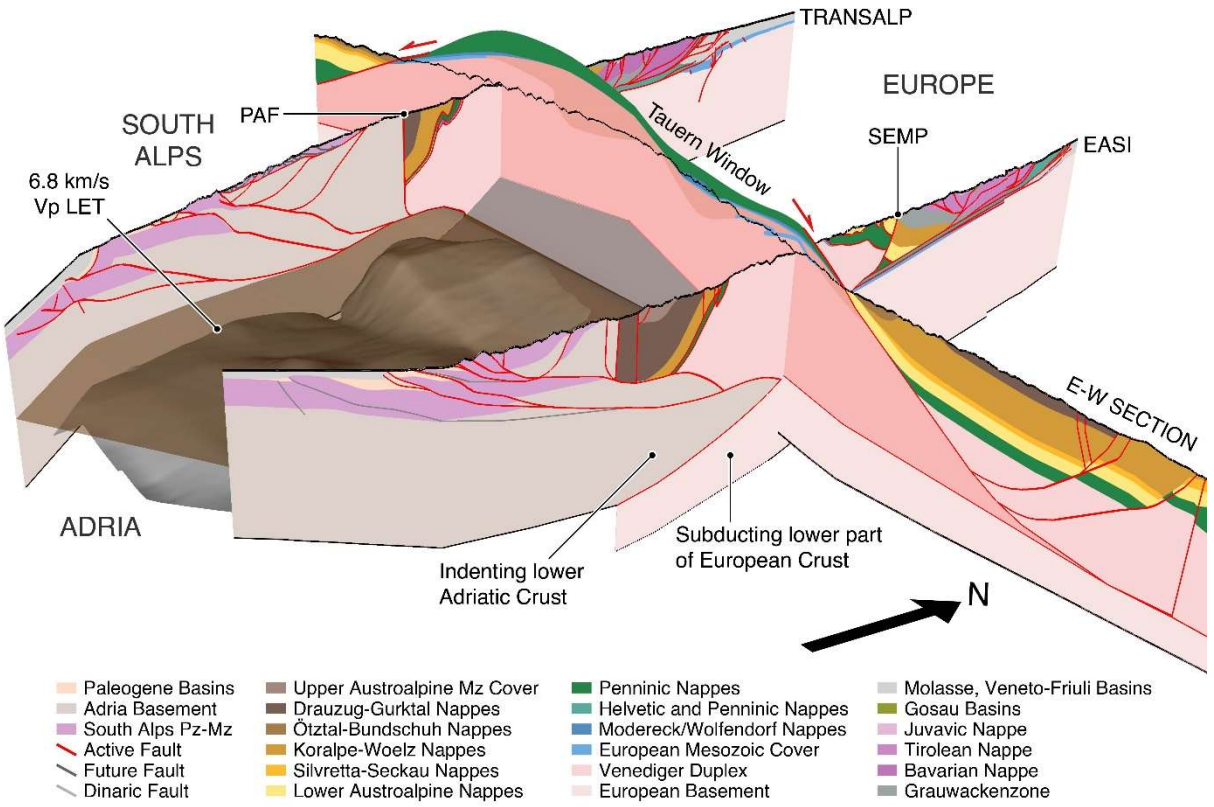

Figure 1B: Fence diagram showing the TRANSALP, EASI, and EW cross sections at the Present-day, and sequential restoration of the TRANSALP section.