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Formation of the arc of the Western Alps and Alps-Apennines transition in the light of new geophysical data on the lithospheric architecture around the Ligurian knot

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This study integrates new geophysical data on the lithospheric structure of the Western Alps with a wealth of geologic and tectonic data. Geological evidence suggests an evolution of the Western Alps in 3 stages: Stage 1 (85-35 Ma) is dominated by NW- to NNW-directed convergence of Adria with respect to Europe, leading to subduction in the Central Alps and sinistral transpression in the Western Alps; collisional stage 2 (35-23Ma) results in top WNW out of sequence thrusting along the Penninic front associated with some 240km of WNW-directed indentation of the Ivrea zone at the tip of the Adria plate into the Western Alpine orogen, substantially modifying its geometry in terms of post-nappe folding; stage 3 (23 Ma to recent) involves a change in subduction polarity in the Ligurian Alps and Apennines, linked to the modification of the southern part of the Western Alps in terms of oroclinal bending during rotational roll-back of the Adria plate around a pole of rotation ("Ligurian knot"). Initiated in Oligocene times this rotation created the the young Ligurian plate .

New geophysical data (controlled source seismology, local earthquake tomography and receiver functions) tightly constrain the geometry of the Moho around the triple junction area between Europe, Adria and the new Ligurian plate that came into existence at the expense of the European plate near its suture with Adria. Moreover, these new data constrain the 3D geometry of the geophysical Ivrea body associated with a wedge of subcontinental mantle belonging to the Adria plate that rose to the surface of the earth in parts of the Western Alps during Alpine convergence. The internal (eastern) top of the Ivrea mantle wedge is identical with the Adriatic Moho rising up to shallow crustal depth. Local earthquake tomography constrains the external (western) limit of the Ivrea mantle wedge for the first time. The Ivrea wedge's subvertical-to-steeply west-dipping interface with the Penninic nappes and the Alpine suture zone strikes oblique across major tectonic boundaries at the surface. In the northern part of the Western Alps it follows the Insubric line where wedging of the Ivrea body into the stack of the Penninic units is still minor (ECORS-CROP profile). Southwards, however, the Ivrea mantle, its top descending to mid crustal depth, wedges far SW-wards underneath Penninic units (profile Argentera-Dora Maira massif, even reaching external Briançonnais units at its SE end in the Ligurian Alps SE of Cuneo. Hence, oroclinal bending during stage 3 also affected the southern part of the Ivrea mantle wedge and is responsible for the southward continuously increasing amount of shortening on the internal side of the Alps, associated with underthrusting of this mantle wedge below Dora Maira massif. We argue that this stage 3 oroclinal bending and SW-directed "underthrusting" of the Ivrea wedge, associated with the counter-clockwise rotation and backthrusting of the southern Western Alpine supra-crustal flakes, is the result of NE to N-directed slab roll back of the Adria plate rather than plate convergence.