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How to interpret upper mantle structure under the Eastern Alps?

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Recent controlled source seismic investigations, supplemented by potential field studies, have substantially improved our knowledge about the lithospheric structure of the Eastern Alps. Crustal structures due to collision and escape tectonics were imaged and an improved Moho map revealed the fragmentation of the mantle lithosphere into three blocks, the European plate (EU), the Adriatic micro-plate (AD), and a newly interpreted Pannonian domain (PA) comprising the mantle lithosphere below ALCAPA, Tisza, and the Dinarides. The EU, AD, and PA blocks compose a triple junction near the southeastern border of the Tauern window. Images of the upper mantle supplied by seismic tomography provide a better understanding of plate tectonic processes. These studies identified a slab below the EU-AD plate boundary, with its eastern termination near the triple junction. We interpret the European lithospheric mantle to be connected to this slab (East Alpine slab, EAS), and thus, identify it as former lower European lithosphere. Another interpretation has been proposed based on an apparent NE directed dip of the EAS resolved by teleseismic tomography carried out as part of the TRANSALP project. In this interpretation, the EAS is connected to the Adriatic mantle lithosphere thus inferring a subduction polarity flip near the Brenner normal fault terminating the Tauern window in the west.

However, we conclude that arguments based only on the slab geometry are not sufficient to determine the nature of the EAS. We suggest a plate tectonic model of the East Alpine collision and extrusion processes based on the structure of the lithospheric mantle and the slab geometry. We reconstruct the passive EU margin of the Penninic Ocean (Alpine Tethys) by restoration of the EAS to the EU plate. The Adriatic domain, including ALCAPA, represents the active margin. Collision of the Adriatic domain with EU starts at the southern end of the restored EAS. After subduction of the entire Penninic Ocean, the tectonic scheme changes significantly. The EU-ALCAPA plate boundary shifts from subduction to sinistral strike-slip, and the Periadriatic line (PAL), separating ALCAPA in the south from the Adriatic domain, becomes activated as a dextral strike-slip plate boundary. A stable triple junction (EU-AD-ALCAPA) is formed. Ongoing convergence between AD and EU forces ALCAPA to extrude to the east, and the triple junction moves along the PAL to the east. West of the triple junction, the PAL changes from strike-slip to subduction of EU under AD. This tectonic scheme continues during the Miocene. In the Quaternary, ALCAPA, Tisza, and the Dinarides merged to one (“soft”) tectonic block, the PA, and the PAL loses its significance as a first order tectonic structure. Our model explains the structure of the EAS and the lack of subducted continental lithosphere east of the triple junction. It supplies a mechanism that drives the eastward extrusion of East Alpine crust toward the Pannonian basin.