Receiver Function mapping of mantle transition zone discontinuities beneath Western Alps using scaled 3-D velocity corrections

Dongyang Liu¹,², Liang Zhao¹,², Anne Paul³, Huaiyu Yuan⁴,⁵, Stefano Solarino⁶, Coralie Aubert³, Thierry Dumont³, Elena Eva⁶, Stéphane Guillot³, Marco G. Malusà⁶,⁷, Silvia Pondrelli⁸, Simone Salimbeni⁹, and Stéphane Schwartz³

¹Institute of Geology and Geophysics Chinese Academy of Sciences, State Key Laboratory of Lithospheric Evolution, BEIJING SHI, China (liudongyang@mail.iggcas.ac.cn)
²College of Earth and Planetary Sciences, University of Chinese Academy of Sciences
³Université Grenoble Alpes, Institut des Sciences de la Terre (ISTerre), 38041 Grenoble CEDEX 9, France
⁴ARC Centre of Excellence for Core to Crust Fluid Systems, Department of Earth and Environmental Sciences, Macquarie University, North Ryde, Australia
⁵Centre for Exploration Targeting, School of Earth Sciences, The University of Western Australia, 35 Stirling Highway, Crawley, Perth, Western Australia 6009, Australia
⁶Istituto Nazionale di Geofisica e Vulcanologia, Viale Benedetto XV 5, 16132 Genova, Italy
⁷Department of Earth and Environmental Sciences, University of Milano-Bicocca, Milan, Italy
⁸Istituto Nazionale di Geofisica e Vulcanologia, Via Donato Creti 12, 40128 Bologna, Italy

The Alpine orogenic belt is the result of the continental collision and convergence between the Adriatic microplate and European plate during the Mesozoic. The Alps orogenic belt has a complex tectonic history and the deformation in and around the Alps are significantly affected by several microplates (e.g., Adriatic and Iberia) and blocks, in particular the Apennines, Betics, Dinarides. The mantle transition zone is delineated by seismic velocity discontinuities around the depths of 410 and 660 km which are generally interpreted as polymorphic phase changes in the olivine system and garnet-pyroxene system. The subduction depth of the European plate and the origin of the mantle flow behind the plate plays crucial roles for our understanding of regional geodynamic (Zhao et al., 2016; Hua et al., 2017). Therefore, we use receiver function method to study the seismic features of discontinuities beneath the Western Alps to constrain the structure of subducted plate and study the geodynamic origin of the low velocity anomaly behind the subduction zone and its relationship with the high-relief topography.

This study uses data collected from 293 permanent and temporary broadband seismic stations (e.g., CIFALPS). Teleseismic events are selected from 30° to 90° epicentral distance with magnitudes (Mw) between 5.3 and 9.0. Data are carefully checked by automated and manual procedures to give a total of 24904 receiver functions. Both 1D velocity model of the IASP91 and 3D velocity model of the EU60 (Zhu et al., 2015) are used for time-to-depth migration. The results show that using 3D velocity model to image the two discontinuities may obtain a more accurate structure image of the mantle transition zone.
In the northern part of the study area, along the alpine orogenic belt, we find a localized arc-shaped thinning area with a depressed 410 discontinuity, which is attributed to hot mantle upwellings. The uplift is hardly seen on the 660 discontinuity, suggesting that the thermal anomaly is unlikely to be interpreted as a mantle plume. The uplift of the 410-km can be interpreted as the European plate subducting to the depth of the upper transition zone. The depression of the 660-km is likely attributed to the remnants from the oceanic mantle lithosphere that detached from the Eurasian plate after closure of the Alpine Tethys. Our results show a good agreement between the thinning area of MTZ and the area of topographic uplift, the mantle upwelling promotes the temperature increase which is conducive to the uplift of topographic.

Reference


Zhu H, Bozdag E and Tromp J. Seismic structure of the European upper mantle based on adjoint tomography. Geophys. J. Int. 2015, 201, 18–52