Imaging the Alpine crust with ambient-noise tomography: linking surface observations to deep structures

PI: Emanuel D. Kästle (FU Berlin)

This project addresses Theme 1 „Reorganisations of the lithosphere during mountain building“ by imaging the current crustal structure underneath the Alps, focusing on the region covered by the Swath D station network. This part of the orogen is still subject to many open questions, such as the geometry of the Adriatic plate which is sometimes depicted as a rigid indenter and sometimes as a flexible material, able to subduct along a very narrow arc in three directions (under the Apennines, Alps and Dinarides). Driven by the movement of the Adriatic plate, around 20 Ma ago a major change in the tectonic evolution of the eastern Alps is inferred to have happened, sometimes referred to as “Neogene revolution”. It affects the lateral movement along the Giudicarie fault, the exhumation of the Tauern window, the lateral escape of the upper crustal layers in the eastern Alps and is still ongoing as evidenced from the seismically active areas in northeastern Italy and Slovenia. Studying the structural imprints of this Neogene Revolution will enable us to better understand the active forces driving plate tectonics, the mechanical behavior of continental plates, and the formation and collapse of orogens. The aim of this work is to image the shear-velocity structure of the entire Alpine crust with a focus on transition from the central to eastern Alps, covered by the Swath D network. By doing so, the following questions will be addressed:

A. Does the Giudicarie Fault offset the entire crust and can it be mapped into the mantle? Answering this questions helps to understand the importance of the fault, whether it forms the boundary between central and eastern Alps, and whether it accommodates differential shortening between these two domains. It would therefore also be a potential candidate for the boundary between a southward directed subduction of Europe in the west and a northward directed subduction of Adria in the east.

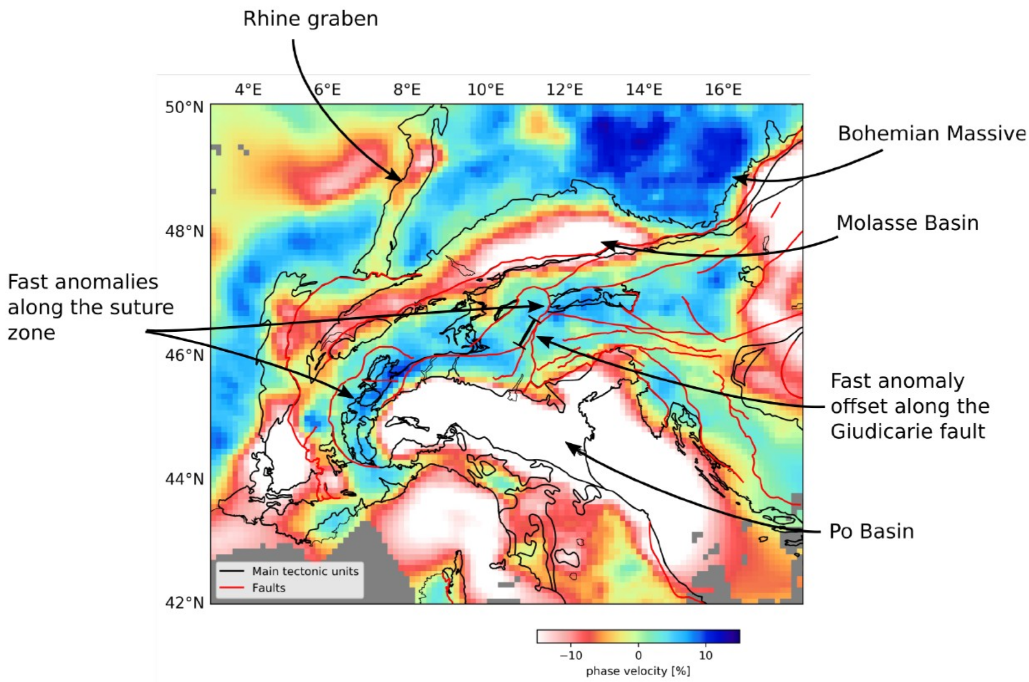

Figure 1: Rayleigh-wave phase-velocity map at 4s period (sensitive to 2-6 km depth) overlain by the outlines of the major tectonic units (black lines) and faults (red lines). The map is based on AlpArray data from 2016 and 2017.

B. Which part of the the eastern Alpine crust is involved in the eastward extrusion of the Austroalpine nappes? The processes, which started around 20 Ma ago, evidently affects only part of the upper crust, which would require a (sub-) horizontal detachment fault at unknown depth.

C. What drove the Tauern window exhumation and what is the role of the Adriatic plate in creating this structure? Three alternative geometries for the sub-Tauern crustal structure have been proposed in the literature (Lüschen et al. 2004, Schmid et al. 2004). This project will concentrate on distinguishing between the options of a rigid, Adriatic lower crustal, or even mantle-derived, indenter or stacking of European upper crust. The contrasting velocities (lower crust vs. upper crust; crust vs. mantle) are expected to be high enough to be imaged with the ambient-noise method, as shown in previous works (Kästle et al., 2018).

D. How does the Moho structure along the Europe-Adria boundary look like? It has been shown that with a good station coverage, the ambient-noise method delivers reliable 3D Moho depth estimates. By comparing the downbending of either of the two Moho boundaries, the hypothesis of Adriatic subduction under the eastern Alps will be tested.

E. How does the regional evolution in the area covered by the Swath D network relate to the wider Alpine tectonic history? From imaging the crustal structures also beyond the area covered by Swath D, it will be possible to better identify the unique structural properties of the eastern Alps and it will help to explain why the three domains (western, central and eastern Alps) differ significantly in topography, uplift rates, arcuation, magmatic activity and seismic activity.

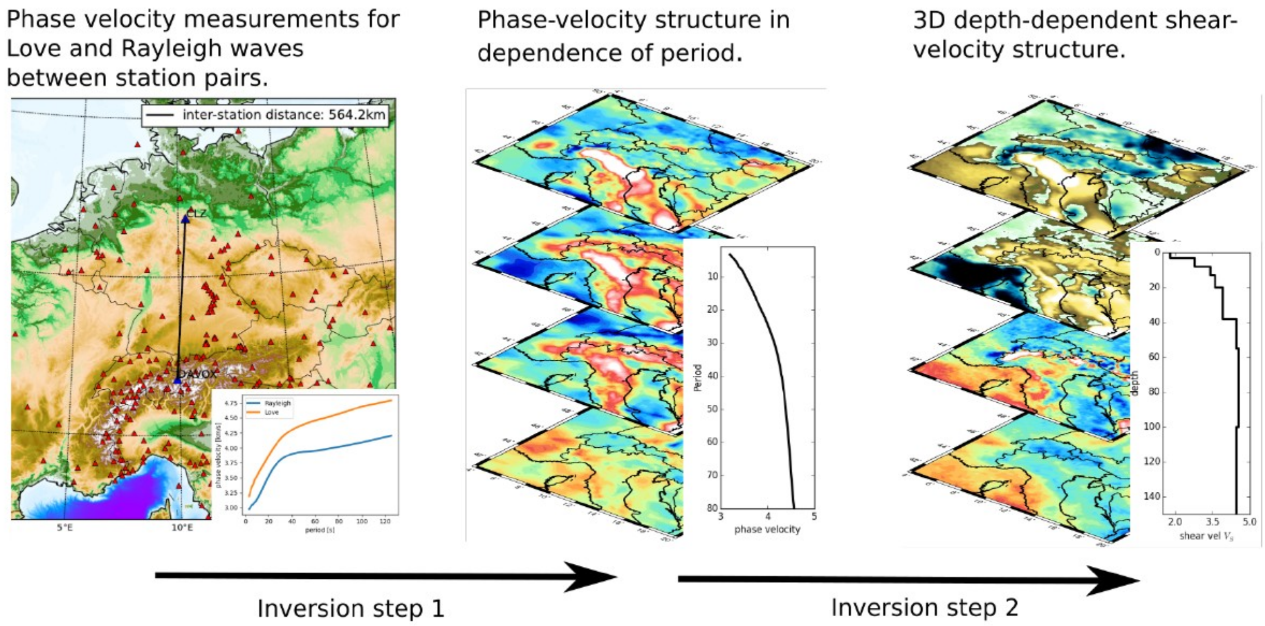

Figure 2: Typical workflow for ambient noise based seismic tomography.

References

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