Slabs in the Alpine region: inferences down to 300 km depth from surface wave tomography and receiver functions

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Mountain building in the Alps is driven by a complex interplay between (i) subduction of oceanic lithosphere and/or continental mantle lithosphere and (ii) exhumation of crustal material. A major challenge represents passive seismic imaging of the various slab segments crucial for shaping the Alpine orogen. AlpArray and Swath-D provide the necessary dense station distribution for high-resolution surface wave tomography using earthquake and ambient noise data as well as for detailed P-to-S and S-to-P receiver function analyses.

Absolute shear-wave velocity models of the crust and upper mantle down to 300 km depth have been obtained from stochastic particle-swarm-optimization inversion of a large data set of more than 200,000 Rayleigh wave phase velocity curves (4 -300 s period). This allows for imaging the slabs and their connection to the forelands with a lateral resolution of about 50 km to 75 km in the Alpine area.

Moreover, about 300,000 P-to-S and about 80.000 S-to-P receiver functions have been obtained for the wider Alpine area. The common conversion point stacks of the P-to-S and S-to-P waveforms, concentrated in the Eastern Alps, provide high resolution images of the crustal structure as well as velocity discontinuities in the mantle at the interface between the European, Adriatic, and Pannonian domains. Moho topography indicating the tops of slabs as well as negative velocity gradients in the mantle beneath the Moho have been imaged. Thermochemical modelling provides evidence that the bottom of the negative velocity gradient causing S-to-P conversions is located close to the lithosphere-asthenosphere boundary. These conversions are thus hinting at the geometry of the bottom of mantle lithosphere and slabs, respectively.

Beneath the northern Apennines, Adriatic lithosphere is subducting nearly vertically southwards down to at least 200 km depth as supported by the spatial distribution of a few intermediate-depth earthquakes. A short Eurasian slab subducting eastwards down to about 150 km depth and a slab gap beneath are present beneath the western Alps. Interestingly, the Eurasian slab is almost colliding with the east-west oriented Adriatic slab beneath the southwestern Po Basin. An attached Eurasian slab subducting to at least 250 km depth is imaged beneath the central Alps, whereas beneath the eastern Alps a short Eurasian slab is found down to only about 150 km depth. A short slab of continental mantle lithosphere is also present beneath the northern Dinarides. It is extending towards the Alps east of the Guidicaria fault. Broken-off Eurasian or Adriatic lithosphere may be indicated by high-velocity anomalies at depth larger than 250 km beneath the south-eastern Alps and the Adriatic Sea. Next, digital slab interface models are to be set up accounting for the various geophysical observations in order to create realistic input models for numerical geodynamic forward modelling of observed deformation rates.