Mantle flow under the Central Alps: Constraints from non-vertical-ray SKS shear-wave splitting

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The association of seismic anisotropy and deformation, as e.g. exploited by shear-wave splitting measurements, provides a unique opportunity to map the orientation of geodynamic processes in the upper mantle and to constraint their nature. However, due to the limited depth-resolution of steeply arriving core-phases, used for shear-wave splitting investigations, it appears difficult to differentiate between asthenospheric and lithospheric origins of observed seismic anisotropy. To change that, we take advantage of the different backazimuthal variations of fast orientation $\phi$ and delay time $\Delta t$, when considering the non-vertical incidence of phases passing through an olivine block with vertical b-axis as opposed to one with vertical c-axis. Both these alignments can occur depending on the type of deformation, e.g. a sub-horizontal foliation orientation in the case of a simple asthenospheric flow and a sub-vertical foliation when considering vertically-coherent deformation in the lithosphere. In this study we investigate the cause of seismic anisotropy in the Central Alps. Combining high-quality manual shear-wave splitting measurements of three datasets leads to a dense station coverage. Fast orientations $\phi$ show a spatially coherent and relatively simple mountain-chain-parallel pattern, likely related to a single-layer case of upper mantle anisotropy. Considering the measurements of the whole study area together, our non-vertical-ray shear-wave splitting procedure points towards a b-up olivine situation and thus favors an asthenospheric anisotropy source, with a horizontal flow plane of deformation. We also test the influence of position relative to the European slab, distinguishing a northern and southern subarea based on vertically-integrated travel times through a tomographic model. Differences in the statistical distribution of splitting parameters $\phi$ and $\Delta t$, and in the backazimuthal variation of $\delta \phi$ and $\delta \Delta t$, become apparent. While the observed seismic anisotropy in the northern subarea shows indications of asthenospheric flow, likely a depth-dependent plane Couette-Poiseuille flow around the Alps, the origin in the southern subarea remains more difficult to determine and may also contain effects from the slab itself.