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Correlated lower crust and mantle deformation in the Tauern Window, Eastern Alps

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We study the coupling between crust and mantle in a convergent regime, by comparing measures of upper mantle deformation with indicators of crustal deformation. We use data recorded at 8 broadband stations located within the Tauern Window to determine seismic anisotropy measurements from shear-wave splitting, in particular the orientation of fast axes in the upper mantle. These are compared with kinematic indicators in the Tauern Window region of the Eastern Alps at outcrop scale. Our results show a striking parallelism between the upper mantle and crustal patterns, indicating vertical coherence of deformation all the way between the upper crust and the mantle lithosphere. The new findings suggest that the effect of the Adriatic indentation acts on the European lithosphere, not only at crustal but also at lithospheric mantle depths.

SKS splitting measurements and kinematic data deduced from exhumed crustal rocks reveal striking similar deformation patterns in the Tauern Window. Parallelism between crustal shear directions and anisotropic fast orientations exposes vertical coherence of deformation from the upper mantle to the crust. In the western part of the Tauern Window, NE-SW oriented orientations of fast anisotropy axes are in correlation with the kinematic data of orogen-parallel stretch; in the eastern part of the Tauern Window SE-NW oriented anisotropy is in agreement with the kinematic data as well; finally in the middle longitudes of the Tauern Window, both data sets show nearly E-W orientation. A simple rigid-plastic indentation model of a rigid indenter (Adriatic microplate) acting on the more strongly deforming European lithosphere qualitatively describes the most basic aspects of the observed deformation pattern, both for the crust and the mantle. Deviation of sinistral and dextral shear zones from the theoretical slip lines described in that model is presumably due to the effect of lateral extrusion that was/is contemporaneous with the indentation.

The general structure within the Tauern window indicates that exhumation of lower crust can be related to crustal scale folding due to north-directed shortening contemporaneous to orogen-parallel west-directed stretch within a transpressional regime, starting in a times range of 29 to 23 Ma.

If the anisotropic fast orientations can be interpreted as a combination of lower lithospheric alignments and the asthenospheric flow as a signature of present-day shear, and assuming coupled deformation of the lithosphere and the sublithospheric mantle, then this flow regime that initiated within the above mentioned time frame, is still active within the whole lithosphere beneath the Tauern Window area.