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Stratification of seismic anisotropy in the Aegean lithosphere and relation to deformation

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The Aegean lithosphere has been strongly affected by subduction processes and extension due to roll-back of the Hellenic trench. We perform anisotropic array tomography using Rayleigh-wave dispersion measurements to map - for the first time - the effects of deformation and flow and the stratification of azimuthal anisotropy within the Aegean lithosphere.

In the lithospheric mantle beneath the Northern Aegean, S-wave fast-propagation directions are parallel to the direction of the present-day, North-South extension. This indicates coherent current deformation (stretching) within the entire thickness of the lithosphere. The Southern Aegean (the Cyclades volcanic arc and the Sea of Crete) is at present a nearly non-deforming block, and azimuthal anisotropy in the lithospheric mantle here is small or absent. Any fossil fabric - if present previously - must have been erased due to heating, presence of volatiles, or partial melting.

In the lower crust the pattern of azimuthal anisotropy is distinctly different from that in the mantle lithosphere. The change in orientation cannot be explained by extensive-dilatancy anisotropy, i.e. is not induced by cracks. Rather, fast-propagation directions beneath the Central and Southern Aegean are NE-SW, parallel to the direction of paleo extension in Late Miocene-Pliocene as indicated by tectonic reconstructions and structural analyses. Evidence for strong extension with the same orientation even before this time, in the Early-Middle Miocene, is provided by the formation of metamorphic core complexes throughout the Aegean which requires - according to tectonic and geodynamic models - the concurrent occurrence of pervasive, rapid ductile flow in the lower crust. Thus, fast-propagation directions point to frozen-in anisotropy caused by a large degree of alignment of lower-crustal anisotropic minerals in response to the

paleo strain in the last about 20 Ma.

Our study also demonstrates that the shear-wave splitting observed in the Aegean does not originate within (or only within) the lithosphere as has been suggested previously: the fast-propagation directions in the lithospheric mantle do not match the fast directions inferred from the splitting measurements, whereas anisotropy in the lower crust - although with similar fast directions - cannot account for all of the observed splitting signal. We infer that azimuthal anisotropy responsible for at least a large part of shear-wave splitting amplitude occurs below the lithosphere - within the asthenosphere or, perhaps, the subducting slab.