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The North Anatolian Fault and lithospheric deformation in eastern Mediterranean: A seismic surface-wave study

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Deformation of the lithosphere in eastern Mediterranean shows complex lateral and vertical variations. The distribution of diffuse and localised deformation is governed by three-dimensional variations in the rheological properties of the rock within the lithosphere. Because the crustal and mantle deformation is generally three-dimensional, with strain patterns depth-dependent, it is difficult to determine the deformation mechanisms from surface observations alone. Anisotropic fabrics within and beneath the lithosphere present a record of deformation at depth. Such fabrics can be determined from anisotropy of seismic surface waves.

We measure phase velocities of surface waves using seismic stations in eastern Mediterranean and infer depth-dependent orientations of anisotropic fabrics in the crust and mantle. We also use the measurements to determine isotropic-average shear-velocity profiles, indicative of temperature within the lithosphere and, therefore, of its mechanical strength.

The shear associated with the westward motion of Anatolia is localised at and near the North Anatolian Fault (NAF). The lithosphere gets warmer and thinner from the Black Sea (north of NAF) to central Anatolia (south of NAF). This confirms that the fault is localised near the transition between the mechanically strong and weak lithospheric blocks. The ductile lower crust and mantle lithosphere beneath NAF show E-W, fault-parallel, distributed flow within an at least 100 km wide zone. The underlying asthenosphere flows in a different, NE-SW direction, towards the retreating Hellenic Subduction Zone.

Although the movements of both the lithosphere and asthenosphere may be driven by the same processes (primarily, the trench retreat), the motion of lithospheric blocks is different from that of the asthenosphere; it is influenced by boundary conditions and lateral variations in the mechanical strength of the lithosphere.