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Mantle origins of topography, volcanism and the North Anatolian Fault in Anatolia: constraints from seismic tomography, seismic anisotropy and crustal structure

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The eastern Mediterranean hosts, within the span of a few hundred kilometres, extensional, strike-slip, and collision tectonics above a set of fragmenting subducting slabs. Widespread Miocene-Recent volcanism and ~2km uplift has been attributed to mantle processes such as delamination, dripping and/or slab tearing/break-off. We investigate this complex region using a variety of broadband seismological techniques, with new P- and S-wave tomographic images in Kounoudis et al. (2020), seismic anisotropy constrained via an updated dataset of SKS shear-wave splitting observations in Merry et al. (2021), and crustal structure imaged by quality-controlled H-κ stacking of receiver functions in Ogden & Bastow (2021). Overall, seismic anisotropy and crustal structure are more spatially variable than previously recognised, and such variations correspond well with variations in mantle structure shown by the tomography. In general, Moho depth is poorly correlated with elevation, suggesting crustal thickness variations do not fully explain topographic differences, and residual topography calculations indicate the requirement for a mantle contribution to Anatolian Plateau uplift. Evidence for such a contribution exists in central Anatolia, where an imaged horizontal tear in the Cyprus slab spatially corresponds with volcanism, a residual topographic high, and a region of reduced splitting delay times and nulls, all consistent with upwelling of asthenospheric material through the tear. Anisotropic fast directions are consistent with flow through the imaged gap between the Cyprus and Aegean slabs, again correlating roughly with both volcanism and high residual topography. Slow uppermost mantle wave speeds below active volcanoes in eastern Anatolia, and ratios of P-to-S wave relative traveltimes, indicate a thin lithosphere and melt contributions. Elsewhere, there is more evidence for slab processes controlling mantle flow, with anisotropic fast directions diverted at the edges of imaged slabs and consistent with flow towards the retreating Hellenic trench in the Aegean. The North Anatolian Fault is revealed to be a deep, plate-scale structure: whilst there are no clear changes in Moho depth across the fault, deep velocity contrasts suggest a 40-60km decrease in lithospheric thickness from the Precambrian lithosphere north of the fault to a thinned Anatolian lithosphere in the south. Moreover, short-length-scale variations in anisotropy and backazimuthal variations in splitting parameters at the fault indicate fault-related lithospheric deformation, with seismic fast directions either fault-parallel or intermediate between the principle extensional

strain rate axis and fault strike, diagnostic of a relatively low-strained transcurrent mantle shear zone. Upper mantle structure thus exerts a strong influence on uplift, volcanism and deformation in Anatolia.

References

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