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Analysis of the spatial viscosity variation in the crust beneath the western North Anatolian Fault Zone

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Previously we showed by means of numerical experiments using a 3D visco-elastic model that the middle crust beneath the western North Anatolian Fault Zone (NAFZ) must have a relatively low viscosity within a zone of limited width ($< \sim 40$ km) and depth extent ($\sim$10 km, below the elastic upper layer). This weak zone is needed to satisfy GPS observations of relative displacement rates across the fault zone both before and in the months following the 1999 İzmit and Düzce earthquakes. Further testing of possible models for the viscosity structure in the ductile shear zone and in the surrounding crust is necessary however. In this study we further investigate the range of spatial viscosity variations in the crust beneath the western NAFZ that can satisfy the available geodetic data.

Previously we assumed that the weak ductile shear zone is centred beneath the main strand of the North Anatolian Fault on which the major earthquakes occurred in 1999. However, a low resistivity anomaly detected beneath the western NAFZ from magnetotelluric (MT) data is located between the northern and southern strands of the North Anatolian Fault [e.g., Tank et al., Phys. Earth Planet. Inter., 2005; Kaya et al., Geophys. J. Int., 2013]. The two strands of the fault bracket an allocthonous wedge of crust that potentially has different mean composition and physical properties. Displacement however is concentrated on the northern strand. These data motivate us to examine: (1) whether or not the fit to GPS data can be can be improved if the low viscosity zone is located between the two fault strands and (2) whether such an asymmetric model can predict a stress state that is consistent with the distribution of seismicity and the higher activity of the northern fault strand relative to the southern one.

Although the crustal viscosity is expected to decrease with depth, mainly due to increasing temperature, our previous calculations for the NAFZ did not constrain this aspect. In this study we also attempt to constrain the depth-dependence of crustal viscosity outside the low-viscosity zone beneath the western NAFZ using a simple two-parameter model based on exponential decrease of viscosity with depth.