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The crustal structure along the 1999 Izmit/Düzce rupture of the North-Anatolian Fault

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Deformation along continental strike-slip faults is localized onto narrow fault zones at the surface, which may slip suddenly and catastrophically in earthquakes. On the other hand, strain in the upper mantle is more broadly distributed and is thought to occur by continuous ductile creep. The transition between these two states is poorly understood although it controls the behaviour of the fault zone during the earthquake loading cycle.
To understand the structure of and strain distribution across the North-Anatolian Fault Zone (NAFZ) we deployed temporary seismic stations in the region of the 1999 Izmit (M7.5) and Düzce (M7.2) earthquakes. The rectangular array consisted of 66 seismic stations with a nominal station spacing of 7 km and seven additional stations forming a semi-circular ring towards the east (Dense Array for Northern Anatolia – DANA). Using this very dense seismic dataset and a combination of established (e.g. H-k stacking and common conversion point migration) and novel (scattering migration and scattering inversion) seismic processing techniques allows unprecedented resolution of the crustal structure in this region.
This study resolves sharp changes in crustal structure across and along the surface expression of the two branches of the NAFZ at scale lengths less than 10 km at mid to lower-crustal depths. The results indicate that the northern NAFZ branch depth extent varies from the mid-crust to the upper mantle and it is likely to be less than 5 km wide throughout the crust. We furthermore resolve a high velocity lower crust and a region of crustal underthrusting that might add strength to a heterogeneous crust and may play a role in dictating the variation in faulting style and postseismic deformation in this region of the NAFZ. The results are consistent with a narrow fault zone accommodating postseismic deformation in the lower crust, as opposed to a broad ductile region below the seismogenic region of the fault.