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Geophysical investigations along the North Anatolian Fault (Turkey): The contribution of GPR to the analysis of surface faulting

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The rupture behavior, related segmentation and propagation along major active faults are poorly understood. Are segment boundaries and associated slip distribution stable through time? Are segment-patches directly linked to individual large earthquakes or do they reactivate during moderate-sized events? Different approaches in paleoseismology may provide important information on past surface-rupturing earthquakes but trenching campaigns are time-consuming and expensive. The use of ground-penetrating radar (GPR) surveys may, however, offer decisive information by imaging surface ruptures in the shallow depth and complement paleoseismic investigations. The 1999 Izmit and Düzce earthquakes along the North-Anatolian fault produced a total of more than 180 km of surface ruptures that may help document past events in terms of chronology and amounts of co-seismic slip. We used 250 MHz shielded antennae and collected a total of 102 profiles at 10 sites distributed along the faults. Surveys consisted in a series of fault-perpendicular profiles to ensure a proper detection of major fault strands as well as fault-parallel profiles aimed at imaging and characterizing buried features and piercing points. At three sites of specific interest, we additionally collected 3D blocks of data to better visualize and assess the geometry of buried features. At the Nehirkent site (Sakarya segment of the Izmit fault), a young scarp of a river bank meander disappears when crossing the fault trace. Its buried counterpart across the fault is clearly visible in GPR profiles and shows 18.5 ± 0.5

m cumulative right-lateral offset. At the Cakirhaciibrahim and Beyköy sites (Düzce fault), the surveys led to the identification of promising well-delimited buried stream channels offset by the fault. However, since the very coarse nature of channel deposits was pointed out by high-resolution GPR signals, trenching operations were selective and limited to a single excavation at the Cakirhaciibrahim site. GPR surveys collected on surface ruptures of the 1999 Izmit and Düzce earthquakes led to the detection and characterization of buried drainage features serving as piercing points. Furthermore, GPR surveys may help constrain cumulative co-seismic slip along several sections of the fault, and orient future trenching operations in the field.