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Evolution and complexity of the seismogenic Düzce Fault Zone (Turkey) depicted by coseismic ruptures, Plio-Quaternary structural pattern and geomorphology

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We investigated the area struck by November, 12, 1999, Mw 7.1 earthquake that ruptured the Düzce segment of the North Anatolian Fault Zone (NAFZ), following, with a 3 months delay, the August, 17, 1999, Mw 7.4 Izmit earthquake. On the basis of 1:25.000 scale field survey and aerial photo interpretation we identified a simple and narrow 1999 coseismic fault trace and an older complex fault system, involving a wider zone of deformation.

By comparing the coseismic and older fault system, we recognized two different sections of the Düzce segment: a western section, where the coseismic fault trace has a staircase trajectory and reactivated part of the older fault system; an eastern section, where the coseismic fault trace shows a straight trajectory and cross-cuts the older and complex fault system. Our study suggests that the Düzce fault sections may represent different stages of the segment evolution. In fact, the collected data suggest the tendency of the fault to simplify its trace with time and to evolve from a complex towards a simpler mature trace, as a mechanically more favorable setting.

The western section of the Düzce segment splays out from a restraining bend of the Izmit segment of the NAFZ, and forms a releasing fault wedge. To investigate the potential for the mechanical interaction of these two segments within such tectonic arrangement, we computed the expected deformation field using a code based on standard dislocation theory and compared this synthetic surface deformation with the observed long-term morphology. Thus, we noticed that the present long-term landform

can be well interpreted as the result of 1999-type coseismic vertical deformation, repeating during several seismic cycles, and that the western section of the Düzce segment undergoes a lower normal stress that may justify its complexities and earlier stage of evolution.

We also performed a comparison of the surface data with the 1999 slip distribution at depth. This exercise highlighted how the projection at depth of the boundary between the western and the eastern Düzce fault sections, that we set from the surface analysis, separates a portion of fault plane characterized by a big single, large asperity, to the east, from a portion of plane with lower slip, to the west.

The peculiar arrangement of the Izmit and Düzce segments may control rupture propagation and fault loading. Under this light, the Izmit/Düzce release fault junction (1) could have delayed the propagation of the 1999 August Izmit rupture on the Düzce segment that ruptured on November 1999 along the asperity of its eastern section, and (2) may produce an unfavorable setting for the build up of asperities in the western part of the Düzce segment also in the future.