Non-characteristic slip history on the 1942 Erbaa-Niksar earthquake segment along the North Anatolian fault system, Turkey

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Amount of surface slip associated with large earthquakes is fundamental parameter to examine faulting behavior through earthquake cycles as well as to evaluate size and timing of future large earthquakes. Assumption of characteristic slip on the same fault or segment is still irreplaceable basis for long-term forecast on future large earthquakes generated by active faults. However, the assumption has been poorly verified by substantial field data, mainly because of difficulties to obtain past slip data and trade-off relationship between slip per event, recurrence interval and long-term slip rate with each uncertainty. In order to overcome these difficulties, we performed 3D trenching survey on the 1942 Niksar-Erbaa earthquake rupture to simultaneously reconstruct timing and slip associated with paleo-earthquakes.

The 1942 earthquake (M=7.0) ruptured for ~48-km-long section of the central portion of the North Anatolian fault system (NAFS) and produced right-lateral slip up to 2 meter (e.g. Barka, 1996). The 1942 event occurred three years after the Erzincan earthquake (M=7.9) which ruptured for ~380-km-section of the eastern NAFS, and the 1942 earthquake segment seems to have activated as barrier during the Erzincan earthquake (Kondo et al., 2006). Judging from historical earthquake records, the 1942 segment had likely ruptured as a part of the great Anatolian earthquake in AD 1668, which ruptured for ~650-km-section of the NAFS (e.g. Ambraseys and Finkel, 1988). These data suggest that the recurrence behavior of the 1942 segment is not simple and have varied from event to event.

The Ayvaz site for the 3D trenching survey is located on the eastern section of the 1942 rupture. Near the site, geomorphic expression of fault sag, fault scarplet on alluvial fan and mole-track structure is remarkable. The single fault trace extends perpendicular to general inclination of the fan surfaces around the site, hence, we expected buried channels for offset reconstruction were well preserved. We excavated several trenches from a few to tens meters in size; two fault-perpendicular trenches, two fault-parallel trenches and plan-view trench near the fault zone for offset measurement of a buried channel.

Fault exposures and alluvial fine sediments allow us to identify three paleo-earthquake events including the 1942 earthquake. The youngest event is recognizable as upward termination of faults inside of modern top soil. The penultimate event occurred before the deposition of depression-fill and after the deposition of sheet flood deposit alternating with sand and gravel beds. Another upward termination at deeper section indicates the occurrence of the untepenultimate event. Preliminary radiocarbon ages constrain the timing of the penultimate event between 300 and 1010 y.B.P., and the untepenultimate event between 1520 and 1720 y.B.P.

A distinct buried channel below the penultimate event horizon exhibits ~9-m-offset. Subtracting the 1942 offset yields ~7-m-offset associated with the penultimate event. The timing of the event suggests that this significant large offset resulted from the great 1668 Anatolian earthquake, probably larger than M=8 earthquake.

In addition, we excavated two small pits at the Delikli site, 1 km west of the Ayvaz site, to estimate ages of cumulative offsets. An erosional scarp on alluvial fan surfaces exhibits clear right-lateral offset of ~10 meter. Radiocarbon ages collected from the pits show that the erosional scarp and offset were formed after 380 y.B.P. Combining with the event chronology at the Ayvaz site and historical records, the cumulative offset was most probably produced by the 1942 and 1668 earthquakes.

These preliminary data imply that the amount of slip on the 1942 segment greatly varied during at least two recent earthquakes, in accord with the variance of the earthquake magnitude. We intend to reconstruct time-slip diagram for further discussion on the recurrence of large earthquakes.