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Luminescence dating of offset terraces at the Elmali segment of the North Anatolian Fault (NE Turkey); Implications for long term geologic slip-rate

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The North Anatolian Fault (NAF) is 1500 km-long dextral strike-slip fault, starts from Karliova triple junction in the east and terminates at the Aegean Sea in the west with northward convex arc shaped geometry. In the 20th century, series of earthquakes which started by 1939 Erzincan (M=7.9) in the east and ended by August 17, 1999 Izmit (M=7.4) and November 12, 1999 Duzce (M=7.1) events in the west, caused many causalities and economic loss at settlements all along this zone. Geodetic short term slip rate is measured to be between 28.0±0.3 mm/yr and 24.2±0.3 mm/yr by GPS as snapshots of strain accumulation for a relatively short period of time. The geologic long term slip rates are determined, mostly from west and middle sections of the NAF, to be between 10 mm to 20.5±5.5 mm/yr, which are slower than the short term of elastic strain accumulation measured geodetically. This mismatch is also seen on many fault systems after the dating of many offset geological and morphotectonic structures at different parts of the Earth. These observations raise several fundamentally important questions about how strain accumulates and is released along major plate boundary fault systems. Are geologic slip rates averaged over thousands to millions of years compatible with short term geodetic rates, or do strain transients commonly occur? In addition, determination of geologic slip rates at many locations on the same fault zone helps to understand the uniformity of the slip rate or an existence of a gradient for the whole system. In this study, we undertook field and aerial photography research on one of the least known sections of the NAF, Elmali segment, at the NE Turkey. The NAF is extremely placed on a relatively narrow zone around Erzincan and 150 to 200 km west of it. However, more to the east, deformation extends to a wider zone of a width of around 10 km between the Yedisu basin and Karliova. Here, three different segments form a restraining double bend and are clearly defined physiographically along the Elmalı valley. The compressional nature of this restraining double bend structure creates an uplift, which is expressed by formation of fill terraces in alluvial fans as insets on the geomorphology of the region. We determined two locations, 5 km-apart each other, consist of dextrally deflected; Dinarbey and Kaynarpinar spots. An alluvial fan is incised by an active stream, which created two terrace surfaces, at the Dinarbey spot. Terrace risers, forming boundaries between two terraces and the recent floodplain, have recorded dextral offset of 67±5 m and 21±5 m with respect to each other. We used cylindrical metal pipes with 25 cm length and 5 cm diameter to sample the upper terrace both from the northern and southern blocks of the fault for Optical Stimulated Luminescence (OSL) dating. These samples yielded ages of 3273±567 yr BP and 3279±258 yr BP giving a slip-rate of 20.4±2.2 mm/yr for this section of the fault. Although, we see the same terrace formation at Kaynarpinar spot, it is not easy to reconstruct the net offset of terrace risers. The lateral erosion of the stream system modified the geometry of terrace risers not to have any piercing point for the measurement of the net offset. However, it is morphologically clear that 55±5m net offset of incised stream should have formed after the formation of the alluvial fan and before the formation of the upper terrace. At this spot, terraces and lower fan surface are sampled for luminescence dating, which is still in process.