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Research paper

Slip rate of the Aksay segment of Altyn Tagh Fault revealed by OSL dating of river terraces

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A B S T R A C T

The slip rate of Altyn Tagh Fault (ATF) was studied near the Aksay segment (39°24.572′N, 94°16.012′E), China, based on dating the terraces of a river passing through the ATF. Two river terrace risers were offset by the ATF and the fault displacements were recorded. Average slip rate of the Aksay segment of the ATF was estimated using the offset of terrace risers divided by the corresponding ages. The ages of the terraces were determined by optical dating of the loess deposited on the river terrace. Our results demonstrated that: (1) The optically stimulated luminescence (OSL) ages of loess can be used to constrain the terrace ages in the study area. (2) The average slip rate of the Aksay segment of the ATF in the last 6 ka is about 12 ± 1 mm/yr, given specific geomorphic assumptions discussed in the text. (3) In this situation, rather than the lower terrace age, the upper terrace age should be used in slip rate calculation as it is closer to the riser offset duration.

1. Introduction

As one of the largest strike slip fault in Eurasia (~1600 km), the active Altyn Tagh Fault (ATF) acts as the major boundary separating north Tibet and the Tarim Block (Tapponnier and Molnar, 1977; Ge et al., 1992). It defines the northern edge of the Tibet Plateau and forms a remarkable linear-structure on satellite images (Fig. 1). It has been regarded as either a localized lithospheric boundary fault (Molnar and Tapponnier, 1975; Avouac and Tapponnier, 1993; Peltzer and Saucier, 1996) or a by-product of the thickening and deformation of strain in the viscous crust and lithospheric mantle that consequently leads to strike slip motion (Houseman and England, 1986; England and Molnar, 1997). To understand the general tectonics of Indo-Asian collision zone, the kinematics of this major boundary fault must be recognized. As one of the most important single structures accommodating Indo-Asian convergence, kinematic features of the ATF such as its total offset, history, and slip rate are of vital importance to the understanding of intracontinental geodynamics (Tapponnier et al., 2001; Yin et al., 2002). Estimating its shortening amount and slip rates are keys to understand kinematics within the Indo-Asian collision zone (Ge et al., 1992; Ding et al., 2004).

The slip rate of ATF has been heavily disputed for over two decades. Previous studies can be summarized into two groups with different slip rates: the fast group (Peltzer and Saucier, 1996; Tapponnier et al., 2001) and the slow group (Houseman and England, 1986; England and Molnar, 2005; Zhang et al., 2007). Based on landform reconstructions, mainly from river terrace sites, the fast group suggested that long-term average slip rate is about 18–27 mm/yr (Meriaux et al., 2004, 2005; Xu et al., 2005). To the contrary, mainly based on GPS observations, the slow group suggested a slip rate of about 7–10 mm/yr (Bendick et al., 2000; Wallace et al., 2004; Zhang et al., 2007). Recent works also reported a similar slow rate from paleoseismic studies (e.g. Washburn et al., 2001, 2003) and river terrace studies (Cowgill et al., 2009). However, the major issue with the GPS record is that it only has decadal data and may have difficulties when extrapolating to a millennial scale. It was noticed that the neglect of transient deformation during the earthquake cycle in models of geodetic data can systematically underpredict or overpredict the slip rate (e.g. Hilley et al., 2009).

One of the difficulties in determining the ATF slip rate using the offset of a terrace riser is the selection of the terrace. Since there is only one scarp between two terraces, the choice of terrace ages (upper or lower) to represent the age of riser offset could be

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ambiguous. Because of this discrepancy the slip rate can vary by a factor of 1.2 to about 5 for the same site (Cowgill, 2007). This issue has been addressed in previous studies (e.g. Zhang et al., 2007) and it was suggested that different conclusions can be made for the same site even using the same chronological data. To avoid this problem, we studied streams deflected by the ATF and dated the loess deposited on stream banks instead of using river terraces, near old Aksay town (yellow rectangle in Fig. 1b). It was suggested that deposition of loess is related to the active fault. A slip rate of ~11 mm/yr in the Holocene is estimated for the ATF along this segment (Chen et al., submitted for publication).

Previous chronology studies on river terraces related to the movement of the ATF were mainly from cosmogenic radioisotopes (e.g. ^{14}C, ^{10}Be, ^{26}Al) dating methods. It is assumed that the deposited boulder's surfaces have not been changed or been covered since they were exposed to air after the terrace formation. Any possible

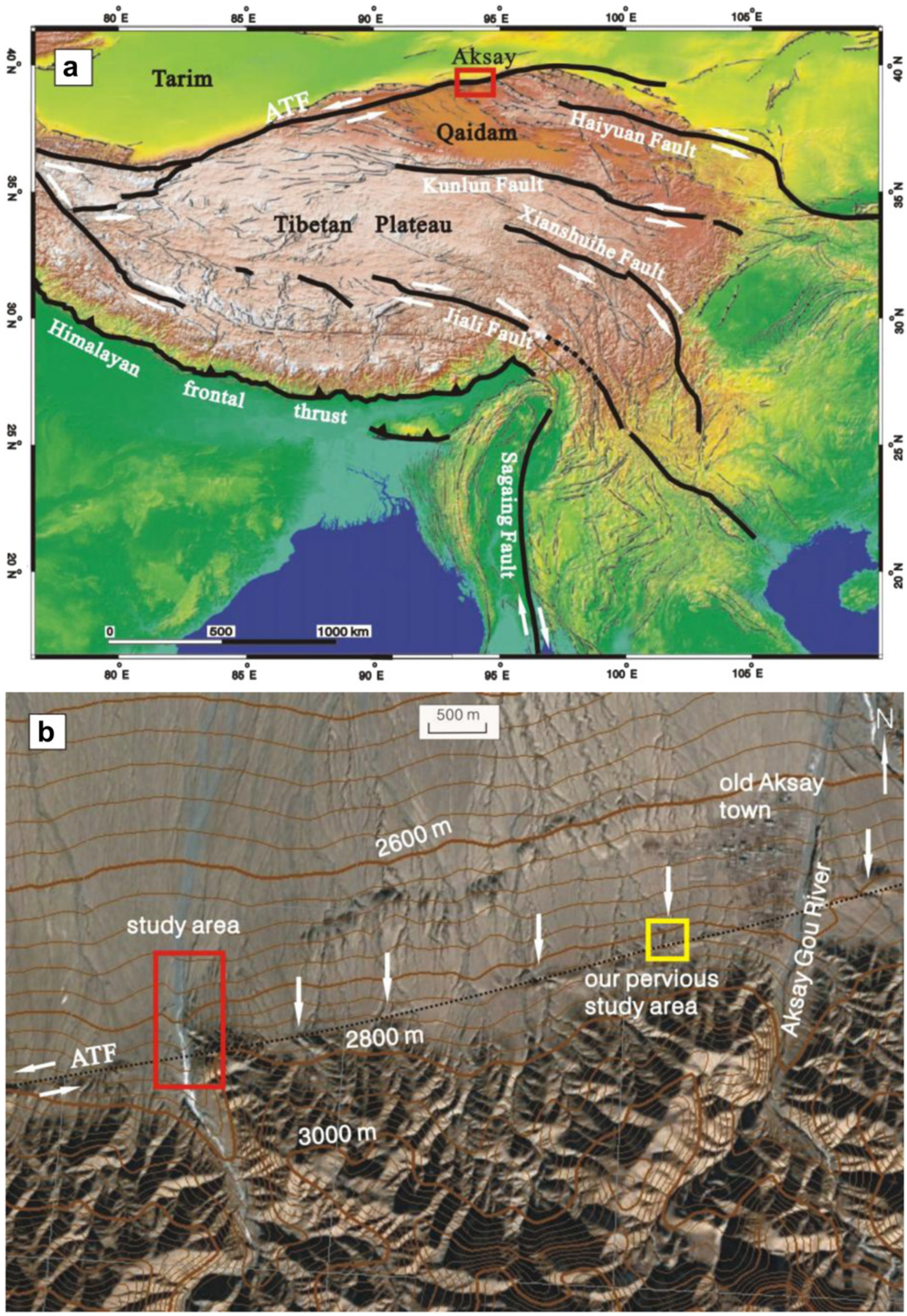

Fig. 1. (a): Schematic map of major faults in Indo-Asian collision zone, modified after Tapponnier et al. (2001). Red rectangle shows the Aksay area. (b): Topographic map (90 m Shuttle Radar Topography Mission data) of old Aksay displayed over satellite image. Red rectangle shows studying river while yellow rectangle shows our previous study site, i.e. deflected streams. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)