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Study on the Slip Rates of Yema River-Daxue Mountain Fault, Northeastern Margin of the Tibetan Plateau since Late Pleistocene

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The convergence between the India Plate and the Eurasian Plate has begun since 45 ± 5 Ma ago, which produced Qinghai-Tibet plateau, one of the most significant continental deformation zones. At present, the India Plate is still moving towards north with rate of 44-50 mm/yr, and the huge convergence quantity is accommodated by intra-continental deformation primarily within the plateau. The slip rate of the strike fault is one of the most important parameters that can indicate deformation and dynamic mechanism of the plateau. High slip rates often are taken to imply a fast lateral extrusion of rigid blocks and localized shear deformation between rigid blocks, and by contrast, low slip rates of faults are considered to be more consistent with distributed deformation caused by rotations of small blocks and crustal thickening. In the past few years, most of the studies were concentrated on the determination of slip rates of several major strike-slip faults, and the secondary strike-slip within Tibet aroused little attention. The eastern segment of the Altyn Tagh fault obliquely intersects with a series of the secondary strike-slip and thrust faults in Qilian mountain-Hexi corridor-Southern margin of Alashan platform. The reduced amount of its strike-slip rate turns into the left-lateral slip and shortening of the secondary faults. The Yema river-Daxue mountain fault located in the west segment of Qilian mountain, is approximately parallel to the Altyn Tagh fault, and is one of the vital faults that bear the reduced amount of strike-slip rate of the Altyn Tagh fault. In this work, according to the analysis on the displacement of the terrace riser and the corresponding active time, we estimate the slip rates of the fault from three selected sites, and then discuss the deformation characteristics of the Altyn Tagh fault and northeastern Qinghai-Tibet plateau.

1. Shibandun site is located on an alluvial fan of the northern margin of the Daxue mountain in middle-west segment of the Yema river-Daxue mountain fault. A gully developed 2 terraces, among which the riser of terrace II has been offset 25 ± 1 m, and the height of the scarp is 2.10 ± 0.1 m. We consider the sinistral displacement of the gully and terrace II begin accumulation after the formation of terrace I. Combining the ages of the samples collected from terrace II (16300 ± 1000 yr.BP) and terrace I (12600 ± 1000 yr.BP) and the corresponding displacement, we obtained that the estimated slip rate of the fault in this place is 2.00 ± 0.24 mm/yr and the shortening rate is 0.11 ± 0.01 mm/yr.

2. Dazangdele site is located on the diluvial fans east of Xiaogongcha, approximate 1 km in width, in the middle-west segment of Daxue mountain fault. A series of gullies with different depths crossing the fault were displaced 4-16 m due to the left-strike movement of the fault. We have surveyed the biggest gully, and gained that the sinistral displacement of the gully is 16 ± 1 m using bilateral risers as reference marks. We speculate that offset accumulation of riser began after the formation of the diluvial fan. Combined the age (5670 ± 35 yr.BP) of the diluvial fan and displacement, we estimate the left-slip rate of 2.88 ± 0.14 mm/yr.

3. Zhazihu site is located on the diluvial fan of Yema mountain where the fault spreads as 2-3 sinistral slip sub-faults. The fault formed a small pull-apart basin and a pressure ridge due to the left-strike motion. In this site, we investigated two gullies. The western gully develops 3 terraces, among which terrace II is sinistrally offset because of the movement of two sub-faults on both sides of pull apart basin. The riser displacements of terrace II are 5 ± 1 m in south side and 14 ± 1 m in north side, respectively, and then the total displacement of terrace II

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riser is 19 ± 1 m. Terrace III riser of the eastern gully is offset by the northern scarp where sinistral displacement is 23 ± 1 m. Combined sample age of terrace II, 7.7 ± 0.7 ka. BP, and displacement of 19 ± 1 m, we estimate that the left-slip rate of the eastern gully is 2.50 ± 0.36 mm/yr. Using the abandoned age of 8.3 ± 0.6 ka. BP of terrace III in eastern gully and the displacement of 23 ± 1 m, we obtain the slip rate of about 2.80 ± 0.33 mm/yr. Therefore, the average slip rate of the fault in Zhazihu site is 2.60 ± 0.50 mm/yr.

Through analyzing the slip rate of the fault in these three sites, we obtain that the ideal slip rate of Yema river-Daxue mountain is 2.84 ± 0.29 mm/yr.

The study area located in middle-west segment of Qilian block primarily develops two dominant active structures: one set is in NW-NWW orientation, and another is in NEE orientation. The two active structures undertake together the regional shortening deformation and the structural transformation of sinistral slip of the crust. Crust shortening and mountains uplift occur through a series of thrust fault. While, left-slip motion of eastern section of Altyn Tagh fault accommodates by Haiyuan fault and a range of sub-faults in Qilian mountain which forms a tendency of eastward movement of the whole Qilian block.

Sinistral slip rate of Altyn Tagh fault gradually reduces toward east in its east segment. Considering results of Zhao et al(2009) and Shao et al(2010), we speculate the reduction of slip rate from Subei West to Shibaocheng East is about 5 mm/yr, and there is other deformation in the basin, so our result is accordant with the reduction of 6 mm/yr indicated by Zhang et al(2007). It demonstrates indirectly a lower slip rate of Altyn Tagh fault.

The slip rate of Haiyuan fault, as one of major faults in northeastern margin of Qinghai-Tibet plateau, is about 4 mm/yr in east of Liuhuanggou. However, the fault is divided into several sub-faults in Qilian mountain at west

side of Liuhuanggou. The boundary slip of Qaidam block is accommodated by sub-faults in Qilian mountain due to the eastward migration of the block. Therefore, the sub-faults as segmented active borders of the block convert the motion of Altyn Tagh fault into Haiyuan fault.

Therefore, we can speculate that slip reduction between Subei West and Shibaocheng East in the east segment of Altyn Tagh fault is sectionally transformed about 4 mm/yr to Haiyuan fault along sub-faults in Qilian Mountain, and the rest of about 2 mm/yr is converted to the crustal thickening in Qilian mountain.

The analyses above show that part of the slip rate reduction of the Altyn Tagh transforms into crust continuous thickening in the end of the fault, and other part converts into the motion of Haiyuan fault that caused uplift of Liupan Mountain. Similar to east margin of the plateau, the movement of major strike fault in northeast margin of Qinghai-Tibet plateau primarily transforms into the uplift of the mountains, so does not extend to the outside of the plateau in large scale.

Key Words: slip rate, strike-slip fault, Yema river-Daxue mountain fault, Altyn Tagh fault, Northeast margin of Qinghai-Tibet plateau

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