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Late Quaternary slip rate of the frontal thrust of the Qilian Shan , NE Tibetan plateau

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The Qilian Shan, with peak elevations >5500 m, seems to have been built largely during late Miocene time (e.g. Tapponnier et al., 2001) and continues to be seismically active (Hetzel et al., 2004), having produced the very large the Gulang earthquake in 1927 (M=8.0) (e.g., Zheng et al., 2005). Associated deformation is partitioned into thrust faulting on planes dipping south-southwest and north-northeast and large sinistral strike-slip faults oriented WSW-ENE to WNW-ESE, as well as second order dextral faults oriented NNW-SSW. The thickened crust of the Qilian Shan seems to be due to reverse faulting in a region that seems to have grown east-northeastward as the Altyn Tagh fault extended eastward (e.g. Burchfiel et al., 1989).
We constrain the slip rate of a frontal thrust of the Qilian Shan over millennial time scale by cosmogenic (10Be) exposure age dating of terraces offset by the reverse fault, combined with structural investigations, satellite imagery, topographic profiling, and exposure dating. We surveyed two terrace levels, and from each we took 6-7 samples in profiles dug to depths of two meters. These allowed us to constrain inheritance (equivalent to $\tilde{0}$-2 ka, for each) and to determine precise ages of abandonment of the terraces: 29.9 $\pm$ 7.8 kyrs for the upper terrace and 16.3 $\pm$ 4.4 kyrs for the lower one. Topographic profiles 4 km in length, with a determination of probable burial of the footwall by sediments, yield offsets of the surfaces of 96.4 $\pm$ 4.4 m and 40.1 $\pm$ 2.8 m.The average vertical rate is 2.8 $\pm$ 1.3 mm/yr, with a horizontal slip rate of $\tilde{2}$.5 $\pm$ 2.0 mm/yr.
The vertical and horizontal rates determined by this study contrast with slower rates determined farther north by Hetzel et al. (2004) on a similar thrust fault. Our results are consistent with GPS constraints, which show a NNE shortening direction across the Qilian Shan at a rate of 5.5 $\pm$ 1.8 mm/yr (Zhang et al., 2004). Slip on the studied thrust fault over millennial timescale account for a significant fraction ($\tilde{5}$0%), but almost surely not the entire geodetic shortening across the entire Qilian Shan. This rate, which is comparable to that of some of reverse faults in the Tien Shan, supports the image that Qilian Shan and the adjacent Hexi Corridor deform by slip on more than one major fault. Although the 1927 Gulang earthquake rupture seems to have stopped east of the reverse fault that we studied, clearly the shortening rate of 2.5 $\pm$ 2.0 mm/yr suggests that such earthquake might be rare on human time scales, but should recur at intervals of $\tilde{1}$000 years.

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