When the Kunlun fault began its left-lateral strike-slip faulting in the northern Tibet: Evidence from cumulative offsets of basement rocks and geomorphic features

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The E-W to WNW-ESE striking Kunlun fault, extending about 1600 km-long (between 86ºE to 105ºE), is one of large strike-slip faults in northern Tibet, China. As a major strike-slip fault, it plays an important role in the extrusion of the Tibetan plateau in accommodating northeastward shortening caused by India-Eurasia convergence. However, initiation time of left-lateral strike-slip faulting of the Kunlun fault is still largely debated, ranging from the late Eocene (34 Ma) to early Quaternary (2 Ma). It is well known that the growth of fault-bounded geologic structures and geomorphic features accumulate over time as a result of repeated large seismic events. Active strike-slip faulting causes a variety of geomorphic features, including linear valleys, offset streams, shutter ridges, sag ponds and pressure ridges. Offset or displaced stream channels and basement rocks are common characteristics developed along active strike-slip faults. Offset basement rocks and geomorphic features along the Kunlun fault are analyzed based on analysis of satellite remote sensing images and field tectono-geomorphic observations. These results indicate that stream channels at various scales show systematic sinistral offset along the Kusai Lake segement of the Kunlun fault zone. Largest cumulative offset of basement rocks is about 55 km in the Kusai Lake segment. Similarly, a series of pull-apart basins, such as the Kusai Lake, Xiugou, Alag Lake and Tusuo Lake pull-apart basins with ~40 to 60 km long and ~8 to 10 km wide developed along the Kunlun fault zone, which formed at releasing bend or extensional step-over as a result of long-term geomorphic development. In addition, restored geomorphic features, such as large-scale pull-apart grabens and pressure ridges developed along the splaying fault of the Kunlun fault system, also show about 30 km cumulative offset.

The 14 November 2001 Mw 7.8 (Ms 8.1) Central Kunlun earthquake produced a 400-km-long surface rupture zone. It is the longest rupture zone produced by a single intracontinental earthquake ever reported worldwide. This earthquake has also produced large coseismic left-lateral strike-slip displacements or offsets of typical geomorphic markers, such as small gullies, stream channel banks, and edges of alluvial fans, terraces as well as modern moraines as we observed in the field survey, generally ranging from 3-8 m. The ^{14}C dating data imply that the latest seismic event before the 2001 Mw 7.8 Central Kunlun earthquake occurred at 430 ± 50 yr B.P. near the Kunlun Pass in the Kunsai Lake segment. We estimate an average slip rate of 10 ± 2 mm/yr based on typical 4-5 m offset and 430 ± 50 yr recurrence interval of large earthquake. Similarly, we can calculate an apparent slip rate of 10± 1 mm/yr based on 275 ± 15 m lateral offset of stream channels and fluvial fans occurred about 27 500 yr B.P. to the east of the Kunlun Pass. Previous studies also inferred an average slip rate of 11.5 ± 2.0 mm/yr based on cosmogenic age dating data and terrace riser offsets along the Xidatan-Dongdatan and Dongxi-Anyemaqin segments during the Late Quaternary. Therefore, we can estimate that the Kunlun fault likely began the left-lateral strike-slip faulting at 5 ± 0.5 Ma based on total 55 km displacement and a long-term average strike-slip rate 10 ± 1.5 mm/yr. Therefore, this study provides an acceptable timing constraint on initiation of left-lateral strike-slip faulting of the Kunlun fault zone.

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