Rate of slip from multiple quaternary dating methods and paleoseismic investigations along the Talas-Fergana Fault: tectonic implications for the Western Tien Shan Range

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Abstract

This work provides new paleoseismic results, based on field investigations and high-resolution satellite images along the Talas-Fergana Fault (TFF), which is the largest right-lateral strike-slip fault system of the Tien-Shan Range (Central Asia). This fault is running for 400 km-long and may therefore produces one of the largest intracontinental earthquakes in this region. However, no large instrumental or historical earthquakes are reported for this major fault and for this reason this fault system is not always considered as potential sources for large seismic events. Moreover, we know that the absence of large earthquakes (M> 7.5) in the instrumental or historical records does not truly represent the full spatial extent of the deformation and that active faults in the Tien-Shan Range rupture in occasional large earthquakes with recurrence times of several thousand years.

Despite a general mapping of this fault and few offset estimates, the kinematics and the role of this strike-slip fault system is still poorly understood. Our study presents original results with the first detailed fault surface mapping of the TFF produced with high-resolution satellite images (Worldview, Pléiades, SPOT 6/7). We propose that the TFF is segmented into nine geometric segments based on variations in strike direction and these morphological and geometric observations have strong implications for the seismogenic potential of the fault system.

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Another important point is that the slip rate and chronology of past earthquakes along the TFF remained unknown and are still debated. To determine the first geological slip rate of _˜4.6 mm/yr, an alluvial fan surface on the Kyldau Valley (41.140◦N, 73.937◦E) was surveyed using a Real Time Kinematic (RTK) GPS allowing construction of a 1-m resolution Digital Elevation Model (DEM). This study is highly original in that it accurately dates a late-Quaternary morphological surface through an exhaustive, detailed, and direct comparison between all available dating methods (three Terrestrial Cosmogenic Nuclides, luminescence and radiocarbon) on a single depth profile. Moreover, to discuss occurrences of past earthquakes on the Kyldau segment, a paleoseimic trench was excavated across a pond formed within this alluvial surface.

Together, all these original results, allow us to discuss the fault segmentation, potential magnitudes for the TFF, earthquake geology and the role of this major structure in the Tien-Shan Range. In this paper, we propose two possible roles that the right-lateral TFF may play in accommodating shortening in the Tien-Shan Range related to Indo-Eurasian collision. The first is that the TFF acts as a transform fault and its motion is simply taken up by thrusting at each end terminations, the second is in relation with counterclockwise rotations around a vertical axis to accommodate the regional deformation. The second hypothesis with counterclockwise rotation across the TFF system around a vertical axis reconcile geodetic (2 mm/yr) and geologic rates (4.6 mm/yr). This allows us to produce a speculative model with possible fault rotation processes distributed along _˜2500 km reactivating major strike-slip fault systems of the Tien-Shan Range.