ESC2016-616, 2016
35th General Assembly of the European Seismological Commission

Kinematics of present-day 3D surface displacement of the southwester Tien Shan with GPS and InSAR data: Implications for active tectonics and seismic hazards

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The Tian Shan is a tectonically active belt characterized by widespread faulting and intense seismicity. GPS measurements show that a total of 20 mm/yr north-south convergence across the western Tian Shan (74°-78°E) is distributed broadly in the interior of the Tian Shan and on its margins. But there are two competing explanations for how the strain buildup is accommodated by slip on either single fault on the edges or numerous faults throughout. Either the present-day convergence is partitioned essentially by numerous slowly-moving (at rates of a few mm/yr) faults with which small to moderate earthquakes were associated, or otherwise is localized primarily on the two flanks of the Tian Shan where the basal detachment faults emerge and large earthquakes occurred infrequently.

In order to understand which one is better to characterize the deformation pattern as illustrated by the existing GPS and historic earthquakes, we used GPS observations taken at about 80 campaign sites in 1994-2012 and 220 ENVISAT ASAR acquisitions (Track 420 and 148) in 2003-2009 to determine three-dimensional displacement field of convergence deformation in the Kashgar depression, southwestern Tian Shan and construct a dislocation model for strain accumulation along the basal detachment fault.

GPS measurements show that the Kashgar depression moves northerly relative to Siberia and a total of 5-7 mm/yr crustal shortening is distrubibted over a 200 km distance from the northwestern Tarim Basin to the southwest Tian Shan. GPS velocities south of the Kashgar Anticline show that the Tarim Basin moves at rates of 16-17mm/yr relative to Siberia. The GPS sites between the Kashgar anticline and the Maidan fault, which separates the Kashgar degresson from the southwest Tian Shan, slow down in rates by 2-3mm/yr and are reduced further to 10-11 mm/yr in the southwest Tian Shan. Our results show that almost all InSAR vertical velocities are between $^{-1}$.5 and 3.5 mm/yr in the Kashgar depression and southwest Tian Shan. I

Slip behavior on the detachment fault under the Kashgar Depression and its downdip extension beneath the southern flank of the Tian Shan governs the deformation pattern and seismicity of major earthquakes there. In the interseismic period, the detachment fault and its ramp faults under the Kashgar Depression are locked, instead its downdip extension under the Tian Shan is creeping at a rate comparable to the shortening rate across the Kashgar depression. Large earthquakes such as the 1902 Artux earthquake released eventually all accumulated stresses thank to the locking of the detachment fault and transferred elastic strain southward along individual ramp faults onto the Keketamu and Artux anticlines. We suggest that the large earthquakes nucleate somewhere around the maximum uplift rate and the maximum gradient in horizontal velocity determined by InSAR and GPS geodesy.

Foundation item: National Natural Science Foundation of China 41374030,41474016,41474051 [U+FF0C] 41474097