Seismic Behavior Along a Fault Segment in an Active Continental Collision Zone: New Paleoseismic and Structural Data of the Pamir Frontal Thrust in the Alai Valley, Kyrgyzstan, Central Asia.

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The Pamir Frontal Thrust (PFT) constitutes the northernmost boundary of the Pamir mountain range at the NW edge of the India-Eurasia collision zone. Due to the ongoing collision this active system propagates into and overthrusts the Quaternary deposits of the Alai Valley, an intermontane basin separating the Pamir from the Tien Shan in the north. Geodetic data across the Central Pamir document a shortening rate of 25 mm/yr, with a dramatic decrease of ~10 mm over a short distance across the northernmost Trans-Alai range (250 km aperture); this suggests that almost half of the shortening in the greater Pamir – Tien Shan collision zone is absorbed along the PFT.

Consequently, the frontal thrusts must accommodate a significant amount of slip and may be capable of generating ≥M7 earthquakes in this part of the orogen. In contrast to similar tectonic settings along the Himalayan megathrust, the present-day seismicity in the Pamir apparently does not reflect the long-term deformation history. Despite few studies in the late 20\textsuperscript{th} century, and an extensive data base of recent earthquakes, the relationships between seismicity and the geometry of the thrust zone are not well understood. In this context our study aims to improve the understanding of the earthquake geology of the PFT by asking two principal questions: (1) How much of the PFT is activated during an earthquake rupture? (2) Does the paleoseismic slip history agree with the geodetically-derived shortening rate?

Here, we present our results of five analyzed paleoseismic trenches that reveal the youngest manifestation of thrusting along the central segment of the PFT. We combined field-based observations with a TanDEM-X data, UAV-based DEMs, and dGPS profiling for an offset analysis along the fault scarp. The interpretation of the trench stratigraphy and event horizons in the context of these tectonic landforms was combined with radiocarbon and luminescence dating to develop an earthquake chronology.

We find robust evidence for at least three surface-rupturing events during the past 6 kyr. At least
one event can be recognized in all five trenches separated by ~10 km, indicating a full-length activation of the central fault segment during rupture. Ages obtained from uplifted fluvial terraces coupled with the total cumulative fault offset indicate a Holocene slip rate of up to 3.5 mm/yr. Based on dip-slip motion offsets per event we estimated an average earthquake paleo-magnitude ranging between M6.5-7.0.

Despite the regional extent of the central PFT, and a rather high displacement gradient across it, our results suggest a seismic behavior characterized by strong surface-rupturing earthquakes, short surface ruptures, and low slip rates. Earthquakes along this structure do not cover the total geodetic shortening, which suggests that a strongly segmented PFT system may be linked with active seismogenic deformation in the alluvial-fan covered piedmont regions to the north. However, the preservation potential for fault scarps in the piedmont may be low in this highly dynamic environment due to climate-driven fluvial and glacial processes in the high sectors of the Pamir.