The Hidden Past of the Alai Valley: Understanding the Seismic History and Behavior of the Central Pamir Frontal Thrust System through Paleoseismology.

M. Patyniak¹, A. Landgraf², J R. Arrowsmith³, A. Dzhumabaeva⁴, A. M. Williams³, K. E. Abdarakhatov⁵, M. R. Strecker¹

¹University of Potsdam, Germany, ²NAGRA, Wettengen, Switzerland, ³Arizona State University, USA, ⁴National Academy of Science of Kyrgyzstan, Kyrgyz Republic

1 Introduction

The northernmost deformation front of the Pamir mountains, the Pamir frontal thrust system (PTS), is characterized by an array of deformed Quaternary landforms. Yet, the relationship between seismicity and surface rupture as well as the geometry of the thrust zone and differences between geodetic and geologic rates of contraction are not well understood.

To better characterize the seismicogenetic history of the PTS we investigated its youngest manifestation, the northward propagated Pamir Frontal Thrust (PFT). Based on tectonic geomorphology and paleoseismology, we want to understand its fault behavior in the context of present-day to millennial-scale deformation rates.

Here we present our observations from three trenches across the central segment of the PFT.

2 Research Questions

- How much of the PFT is activated during an earthquake rupture?
- Are there discrete seismotectonic segments that reflect limit ground rupturing earthquakes?
- Does the paleoseismic slip history agree with the geologically-derived shortening?

3 Geological Background

The Pamir Thrust System (PTS)

- Part of a complex tectonic structure involving southward underthrusting of the Eurasian lithosphere and slab-break-off; the PTS is located at the up-dip projection of the subducting Eurasian slab.
- Separates the northward-advancing Pamir from the seismically active Tien Shan basement-uplift province in the north and accommodates most of the shortening in this collision zone.
- Seismically active area is capable of producing large-magnitude earthquakes of M>7 or greater.

The Pamir Frontal Thrust (PFT)

- Northernmost fault of the PTS
- Northward propagation of the Main Pamir Thrust (MPT)
- Can be divided into the eastern, central and western segments, linked by northward striking dextral transfer zones
- Late Quaternary slip rate: ~0.3-6 mm/yr
- 4 earthquakes with 6.5-7M in the past 40 years

4 Results from the Achky-Suu Excavations

Evidence for multiple paleoearthquakes including at least two surface-rupturing paleoearthquakes:

- scarps heights of 5-10 m
- an alternation between hanging-wall collapse scarps and?
- multiple fault zones in two trenches: trench T1 = 2 main fault zones and at least 2 single rupture strands in between; trench T2 = 1 main fault zone and 1 single rupture strand out of the fault zone
- Stratigraphic interpretation of identified event horizons and applied geochronology

Acknowledgments

This poster was prepared for the 2018 ASCE Annual Meeting, 13-15 September 2018, Palm Springs, CA, USA.

References

Acknowledgments

The PFT is seisimically active with a complex history of several faulting events and co-seismic folding.

Historic earthquakes produced dip-slip events with limited vertical offsets, corresponding to magnitude ~M6 - 7 events. However, the complexity of the setting suggests that greater-magnitude events cannot be ruled out.

New Holocene slip rates decrease uncertainty over prior reported values, however underestimate geologically derived shortening rates by a factor of 2.3

CONCLUSIONS

Figure 3. Polymorphisms at the Achky-Suu site, with the highest peaks between M=6 and 7.0. The estimates are based on individual average displacements 0.4-1 m following Blais and Weldon (2006) and Wells and Coppersmith (1994).

Figure 5. Trench logs of three excavations along the central segment of the PFT. From top, left: west wall and reflected east wall of trench 1 (T1); north wall of trench 2 (T2) (Achky-Suu Site, this study); west wall of Komansu trench +15m further east on the central PFT segment from Arrowsmith et al. (1999) (unpublished). All trenches show planar deposits overlying over finer clastic, pyroclastic, and others. T1 and T2 indicate evidence for at least one earthquake that ruptured across both trench sites (1 km spread). Assuming extended fault length rupture we suggest similar event chronology as at the Komansu trench.

Figure 6. Overview photographs of the trenching sites.

Figure 2. Earthquake distribution in the Alai Valley with simplified structures of the PFT and MPT. Significant earthquakes in the past 100 years are labeled with year and magnitude.