

EGU21-10405

<https://doi.org/10.5194/egusphere-egu21-10405>

EGU General Assembly 2021

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Uplift and growth of the northwest Pamir

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The Pamir forms the northwestern tail of the Tibetan plateau and is a first-order tectonic feature of the Cenozoic Indo-Eurasian collision. The nature of the topographic uplift and orogenic growth of the entire northwestern margin of the Pamir is poorly constrained; however, this history can provide important constraints that are required to test geodynamic models of the tectonic evolution of the Pamir. Here we focus on the uplift history of the western and northwestern unglaciated margin of the Northern Pamir, the Darvaz and the Peter-the-First Ranges. These three ranges were formed by three major fault systems: the Main Pamir Thrust (MPT), the Darvaz and the Vakhsh fault zones (DFZ, VFZ). To assess the impact of tectonic uplift on the geomorphic evolution, we analyzed geomorphic characteristics of the topography, the longitudinal river profiles and the relief. To better constrain the regional crustal cooling history and uplift, we obtained thermochronologic cooling ages from the three regions.

We present 19 new zircon (U-Th-Sm)/He (ZHe) ages, 7 apatite fission track (AFT) ages, and 4 apatite (U-Th-Sm)/He (AHe) ages, ranging between >200 and 4 Ma, 14 and 4 Ma, and 15 and 3 Ma, respectively. The three units are characterized by unique Neogene cooling pathways, suggesting that they exhumed independently.

We discovered extensive low-relief landscapes with Neogene sedimentary cover uplifted ~2 km in elevation above the present-day regional base level. Our analysis indicates that the Panj and Vakhsh rivers form the regional base levels for the river network draining the entire northern and western margin of the Pamir. In the hanging wall of DFZ, the Paleozoic bedrock is characterized by significant relief (>1 km), the Neogene cover onlaps directly onto this Paleozoic bedrock. The tributary rivers crossing these landscapes are characterized by gentle, concave upstream longitudinal profiles at high elevation. These are interrupted by major knickpoint zones and steep downstream segments draining towards the deeply incised Panj and Vakhsh rivers. This indicates that the Darvaz Fault hanging wall had been uplifted and eroded prior to deposition of upper Neogene sediments, suggesting that the DFZ has a prolonged Neogene slip history. In contrast to the northeastern Pamir, here, the MPT-hanging-wall is characterized by reset late Oligocene-Early Miocene ZHe cooling ages ranging between 26 and 17 Ma. AFT and AHe-ages between 15 and 13

Ma suggest that exhumation suddenly terminated during the middle Miocene. In contrast, Jurassic sandstones exposed near the DFZ yield mostly un-reset Triassic-Jurassic ZHe ages (~250-170 Ma), a reset AFT age of ~5 Ma and a 2.5 Ma AHe age. Within the Peter-the-1st-Range, we obtained fully reset ~ 5 Ma ZHe ages, and ~4 Ma AFT ages. The rapid cooling trends since at least ~5 Ma suggest that deformation and a significant portion of crustal shortening propagated into the Tadjik foreland basin, causing enhanced uplift and erosion of the hanging wall of the VFZ and related faults. This deformation triggered ~2 km uplift of the entire northwest Pamir, recorded in uplifted paleo-landscapes and dissected tributaries of the Panj and Vakhsh rivers.