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Cenozoic tectonic evolution of the Pamir–Tien Shan system: Evidence from thermochronology, provenance analysis, and tectonic geomorphology in the Tajik depression and its margins

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The onset of intra-continental plate convergence between India and Eurasia 50 Ma ago caused a complex spatial and temporal distribution of crustal deformation in western Central Asia: the development of the Himalayan thrust belt; the growth of the Pamir orocline; the reactivation of the Variscan Tien Shan orogen. The Tajik depression is an intracontinental basin situated at the northwestern margin of the Pamir; to the north it is bounded by the Tien Shan and to the south by the Hindu Kush. The basin contains sediments of up to 10 km thickness.

The pre-orogenic part of the sedimentary section, which accumulated from Late Jurassic through Paleogene time, includes fine-grained clastic, carbonate, and evaporitic sediments that were deposited under relatively quiescent conditions, close to sea level. During collision, the thin-skinned fold-and-thrust belt of the Tajik depression was completely detached from its basement along Jurassic evaporites. The pre-orogenic deposits are conformably overlain by a thick syn-orogenic clastic section of Miocene to Pliocene age. These Mio-Pliocene rocks are pervasive throughout the Tadjik depression and consist largely of red fluvial sandstone and conglomerate. These deposits show characteristics typical of foreland-basin systems and reflect the successive uplift and approach of major nappes from the southeast and northwest.

We performed detrital geo-thermochronology on rocks of Paleogene to Neogene age in the Tajik depression. We used LA-ICPMS U-Pb zircon and zircon and apatite fission-track dating to understand the provenance and the thermal evolution of the sediments. Length measurements in ion-irradiated and multiply edged apatite allow temperature-time modeling of the youngest history of the basin in reset sample and of the hinterland history in detrital grains. For the detrital apatite grains, the connection between the age groups from dating and the track lengths in different grains can also be made by the parameter Dpar. All U-Pb zircon and fission-track zircon ages are unrest and are suggestive of the Pamir as the main source area; for example, the crystalline basement of the Central Pamir was already exposed in the Oligocene. The apatite fission-track system was reset only locally testifying to a relatively weak thermal overprint; for example, at the Pamir thrust front we obtained ages as young as $\sim$4 Ma.

We also present a case study on deformation and exhumation of the Tajik depression and its hinterland by analyzing the Late Cenozoic tectonic activity in the Tajik depression and Hissar range of the southwestern Tien Shan with methods of remote-sensing based tectonic geomorphology, such as stream profile, basin asymmetry, and valley shape analysis. We investigated the geometry of the drainage network and how it has been modified during development of the northern Tajik depression and Hissar Range. The time evolution can be addressed by working out river incision and river capture. Integration with longer-time scale is done by hinterland fission-track thermochronology.