



Formation of the giant Shakhdara migmatitic gneiss dome, Pamir, India–Asia collision zone

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Cenozoic gneiss domes comprise one third of the surface exposure of the Pamir Mountains and provide a window into deep crustal processes of the India–Asia collision. The largest of these is the 350×90 km Shakhdara–Alichur composite dome of the southern Pamir, Tajikistan and Afghanistan. The Shakhdara and Alichur domes formed by footwall exhumation of two low-angle detachments: In the larger Shakhdara dome the top-to-S South Pamir shear zone (SPSZ) exhumed crust from 30–40 km depth; in the Alichur dome the top-to-N Alichur shear zone exhumed upper crustal rocks. The subdomes are separated by a low-strain horst. Non-coaxial shear in the Shakhdara dome is pervasive over the ~ 4 km thick SPSZ. The top of the shear zone is preserved at mountain peaks, the base is incised by the Panj gorge, which exposes the ‘core’ of the dome; total erosion is less than 4 km throughout most of the dome.

We use a comprehensive geo-thermochronologic dataset of titanite, monazite, and zircon U/Th–Pb, mica Rb–Sr and $^{40}\text{Ar}/^{39}\text{Ar}$, zircon and apatite fission track, and zircon (U–Th)/He ages to constrain the exhumation history of the southern Pamir domes. Doming started at ~ 21 Ma by crustal buckling and activation of a top-to-N normal shear zone (Gunt shear zone) along the northern rim of the Shakhdara dome, resulting in exhumation and cooling. The bulk of the exhumation was accomplished by northward extrusion of the SPSZ footwall, which was active from ~ 18 –15 Ma to ~ 2 Ma; exhumation rates were 1–3 mm/yr. Erosion rates during and after the end of doming were 0.3–0.5 mm/yr within the domes and 0.1–0.3 mm/yr in the horst and in the SE Pamir plateau; incision rates of the major drainages were up to 1.0 mm/yr.

Domining by footwall exhumation of the SPSZ resulted in up to 90 km N–S extension, coeval with ongoing N–S convergence between India and Asia. Extension opposes shortening along and above the reactivated Rushan–Pshart suture zone, a wide fold-thrust belt north of the Shakhdara–Alichur domes. This geometry defines a ‘vertical extrusion’ scenario, comprising basal top-to-N underthrusting and thickening and hanging gravitationally driven top-to-S normal shear.