Geophysical Research Abstracts
Vol. 13, EGU2011-9992, 2011
EGU General Assembly 2011

Miocene gneiss domes and syn-orogenic extension in the Pamir

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Outcrops of medium- to high-grade metamorphic rocks are sparse on the Tibetan plateau but underlie >30% of the Pamir. These rocks occur in several gneiss domes throughout the Pamir; the largest are the 300 $\times$ 100 km composite Shaxdara and Alichur domes in southern Tajikistan and northern Afghanistan. Previously regarded as exposures of Archean-Proterozoic basement, the domes mostly comprise Paleozoic and Mesozoic metasedimentary rocks, which experienced Barrovian metamorphism with local migmatization; voluminous magmatism occurred during the Cretaceous and Cenozoic.

We studied the exhumation of these domes using U-Th-Pb, Rb-Sr, 40Ar-39Ar, apatite fission-track, and (U-Th)/He geo-thermochronology in conjunction with structural and petrological observations. Exhumation from mid-crustal depths occurred mainly during the Miocene. The kinematics of exhumation is best scrutinized in the Shaxdara dome, where syn-orogenic extension fits a rolling-hinge model, originally put forward to describe extension in the Basin and Range province. In the Pamir, extensional doming is the mid-upper crustal expression of major shortening concentrated within the central Pamir (reactivating the Rushan-Pshart-Bangong suture zone) and within the Hindu Kush and Karakoram blocks.

A major top-to-S normal shear zone along its southern boundary, the South Pamir detachment, accommodates exhumation of the Shaxdara dome. To the east, vergence of exhumation switches to top-to-N along the less prominent Yashikul detachment zone rimming the Alichur dome in the north; in the southeastern Pamir plateau further diminished extension occurred within the Mesozoic cover sediments. The Central Pamir domes (Yazgulom, Gudara, Muzkol−Sarez) show similar Miocene cooling ages and north-south extension. Tectonic denudation ceased in the early Pliocene. Apatite (U-Th)/He ages from the Shaxdara may indicate a renewed episode of rapid cooling starting in the late Pliocene or Pleistocene, likely related to incision of the Pjansch river. The pronounced difference in relief between the Shaxdara dome and the eastern Pamir plateau argues against a purely climatic cause for Pleistocene river incision.

We attribute doming and extension to overall transpressional thickening with long-wavelength–low-amplitude buckling of the entire crust. Concurrent to subsequent mid-upper crustal extension compensates for excess thickening. The tectonics of the southern and central Pamir may be driven by shallow underthrusting of the western edge of the cold and rigid Indian lithosphere, which has detached from the Hindu Kush slab to the west, beneath the hot and thick Pamir crust. In contrast, in the northern Pamir (including the Kurgovat dome) Cenozoic extension is limited to the upper crust. Syn-orogenic extension and gneiss dome formation of the amount documented in the Pamir is unparalleled in the Tibet orogen and provides insights into mid-crustal processes largely concealed in Tibet; it offers new possibilities for understanding collisional orogeny.