

Low-T detrital thermochronology dates mid-Miocene initiation of extension in the Thakkhola-Mustang graben (central Nepal) and provides evidence for orogen-scale transition from channel flow to underthrusting

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Several competing models have been proposed to explain the connection between contractional structures, dominating the southern margins of the Himalayan-Tibetan orogen system, and extension, typical of the Tibetan plateau. Cenozoic E-W extension is documented in the Tibetan Plateau through strike-slip faults and grabens, while N-S extension has been widely documented along the South Tibetan detachment zone (STDZ), near the Tibet-to-Himalaya boundary. However, several arc-parallel extensional features extend as far south as the STDZ and the High Himalaya, and it is growingly recognized that extension along these features initiated in the mid-Miocene. Several authors identify the strain partitioning model as the most accurate in describing several features present at the Himalaya-Tibet transition, predicting concomitant strike-slip deformation and OP extension along the arc, even near its center where convergence obliquity = 0. If they are kinetically linked, they will share a common onset.

We test this concept by looking at the long-term exhumation history of the Thakkhola-Mustang graben, the most central of the grabens, where we obtained detrital apatite fission track and (U-Th-Sm)/He thermochronology from modern river sand. We interpret the thermochronological dataset using a 2D numerical model of the thermal evolution of the crust around a normal fault, using an optimization method that minimizes the misfit between observed and predicted age distributions. The obtained history of extension in the Thakkhola-Mustang graben is consistent with other, independent stratigraphic constraints. From the relationship between the two different thermochronometers, we identify two distinct exhumation events, an earlier event which terminated by 20 Ma and a younger event which initiated between 13 and 11 Ma and accelerated after 10 Ma. We link the first event to regional exhumation related to motion along the STDZ, while the younger event marks the initiation of E-W extension in the Thakkhola-Mustang graben. Onset of extension is constrained by an increase in age density in the apatite (U-Th-Sm)/He thermochronometer distribution and is confirmed by the results of the thermo-kinematic modeling.

The timing of extension initiation in this region is contemporaneous with motion on other orogen parallel structures in other parts of the Himalayas, suggesting that the cessation of extrusion along the STDZ and onset of orogen-parallel extension correspond to a transition from an extrusion-dominated mode driven by the weight of the Tibetan Plateau to an underthrusting-dominated mode driven by subduction of the Indian plate.