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Postglacial denudation outpaced by long-term exhumation, Ladakh and Zanskar, India

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The Transhimalayan Ladakh Batholith, testimony to an ancient island arc system accreted to the Eurasian margin, and the Zanskar Range, formed by syn-orogenic Indus Molasse sedimentary rocks, flank the semi-arid upper Indus River valley for several hundred kilometers. The conspicuous transverse topographic and erosional asymmetry of the Ladakh Batholith has been debated with regard to several potential tectonic, climatic, and erosional drivers. Explanations have invoked tectonic block tilting; differential and aspect-controlled glacial erosion; and active thrusting accompanied by burial below Indus Molasse sediments fed from the south. We contribute to this discussion and present a comprehensive regional inventory of 21 basin-wide denudation rates from cosmogenic 10Be in river sands derived from tributaries debouching along ∼170 km of the upper Indus River. We find that denudation rates in the Indus Molasse are on average higher than those in the granodioritic Ladakh Batholith, spanning a range of between 0.01 and 0.1 mm/yr.

Overall, these rates are orders below those reported along the more humid Himalayan orogen, and point to low denudation rates along the western Tibetan Plateau margin. Averaging over the last 5-60 kyr, our data may be considered postglacial judging from the published regional glacial chronology. Moreover, we find that our late Quaternary denudation rates are lower than long-term exhumation rates constrained by thermochronological data. Thus, denudation rates along both sides of the Indus Valley must have been higher some time before 60 ka in order to produce the observed topography and cooling patterns.

We note that the highest erosional gradient between juxtaposed Molasse and Batholith catchments occurs in the most asymmetric section of the Ladakh Range. There, the Indus has a 60-km alluviated reach, which stands out among the otherwise narrow bedrock gorges the river has cut for most of its course between the ranges. We discuss this distinct, though localized, erosional gradient and the apparent postglacial decrease of denudation with respect to current theories of block tilting, efficacy of erosion during glaciations, local damming, and potential active thrusting at the foot of the Zanskar Range.