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Sediment storage and stability along the western Tibetan plateau margin

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The Indus is one of the major rivers draining the western Tibetan plateau. Many studies have stressed rapid incision and uplift along the river's course through the western Himalayan syntaxis, whereas process rates in the upper reaches near the western Tibetan plateau margin have yet to be quantified. Moreover, little is known about the volumetric amount of sediment that is stored along the low-gradient plateau margin, let alone the potential rates at which this sediment may be released by glacial and fluvial processes. We start filling this knowledge gap by offering a first-order regional quantification of intramontane sediment storage.

We compare different geospatial algorithms for objectively delineating sediment storage contained in large valley fills from digital topographic data, and estimate the stored total sediment using a probabilistic volume-area scaling approach. Before applying this scaling to real topography, we conducted a geometrical scaling for different shape factors to quantitatively constrain prediction errors associated with bedrock geometry. Finally, we applied the volume-area scaling to using 90-m SRTM sample data representing different valley types and lithologies in the Ladakh and Zanskar Ranges drained by the upper Indus River.

Our estimates show that >40 km^3 of sediment are stored in the 15,000 km2 Zanskar catchment, which is mostly an arid bedrock landscape with mean elevations of ∼3500 m. Storage potential on hillslopes is limited such that most material is perched along deeply incised reaches (∼80%) or infilling low-gradient headwaters (∼20%), where the otherwise steep and rugged drainage network of the Zanskar grades into the gently sloping low-relief topography that characterizes the Tibetan Plateau. Sediment storage covers between 3 and 8 % of the total catchment areas of dissected basins. This is consistent with storage estimates from other mountain belts with grossly differing climatic and lithological conditions. However, the fraction of sediment storage may be as high as 25% in low-relief high-elevation basins on the plateau.

Depending on published estimates of regional rates of denudation and exhumation, we infer average sediment residence times of ∼25 to >260 kyr in this region along the western Tibetan Plateau margin. This estimate is consistent with the preservation and landform ages of some of the oldest glacigenic deposits in the Himalaya-Tibet orogen, and points to the importance of sediment flux and storage in preserving bedrock topography, while providing spatially distributed reservoirs for highly episodic sediment transport events.