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Mountain rivers may need centuries to adjust to earthquake-triggered sediment pulses, Pokhara, Nepal

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Mountain rivers respond to strong earthquakes by not only adjusting to changes in local base level, but also by rapidly aggrading to accommodate excess sediment delivered by co- and post-seismic landslides. A growing number of detailed sediment budgets suggests that it takes rivers several years to decades to recover from such seismic disturbances, depending on how recovery is defined. We test this notion and study how rivers adjusted to catastrophic sedimentation triggered by at least three medieval earthquakes in the central Nepal Himalaya. In the vicinity of Pokhara, the nation's second largest city, rapid aggradation formed a large fan covering 150 km^2 of mountainous terrain over a length of some 70 km. The fan prograded into several tributary valleys, rapidly infilling their lower reaches with several tens of meters of sediment from a major point source tens of kilometers away. A robust radiocarbon chronology of these valley fills provides an ideal framework for gauging average rates of fluvial incision and adjustment. We use high-resolution digital elevation data, geodetic field surveys, aerial photos documenting historic channel changes, and several re-exhumed tree trunks in growth position to define dated geomorphic marker surfaces. We compare various methods of computing the volumes lost from these surfaces to arrive at net sediment yields averaged over decades to centuries. We find that contemporary rates of river incision into the medieval earthquake debris are between 160 and 220 mm yr^{-1}, with corresponding sediment yields of 10^3 to 10^5 t km^{-2} yr^{-1}, several hundred years after the last traceable seismic disturbance. These rates greatly exceed the density-adjusted background rates of catchment-wide denudation inferred from concentrations of cosmogenic ^{10}Be in river sands sampled in different tributaries. The lithological composition of active channel-bed load differs largely from local bedrock and confirms that rivers are still busy with excavating medieval valley fills. Pronounced knickpoints and epigenetic gorges at tributary junctions add to the picture of a drawn-out fluvial response, while the re-exhumed tree trunks indicate that some distal portions of the earthquake-derived sediment wedge have been incised to near their base. Our results challenge the notion that mountain rivers recover within years or even decades following earthquake disturbance. We caution against generalizing the spectrum of fluvial response in this context, as the valley fills around Pokhara document the possibility of a more protracted fluvial response that may have been ongoing for as long as 900 years despite the high and aggressive erosion that characterizes Himalayan rivers. Beyond the scientific community, our results may motivate some rethinking of post-seismic hazard appraisals and infrastructural planning during the rehabilitation phase in earthquake-struck regions.