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Geomorphic legacy of medieval Himalayan earthquakes in the Pokhara Valley

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The Himalayas and their foreland belong to the world's most earthquake-prone regions. With millions of people at risk from severe ground shaking and associated damages, reliable data on the spatial and temporal occurrence of past major earthquakes is urgently needed to inform seismic risk analysis. Beyond the instrumental record such information has been largely based on historical accounts and trench studies. Written records provide evidence for damages and fatalities, yet are difficult to interpret when derived from the far-field. Trench studies, in turn, offer information on rupture histories, lengths and displacements along faults but involve high chronological uncertainties and fail to record earthquakes that do not rupture the surface. Thus, additional and independent information is required for developing reliable earthquake histories.

Here, we present exceptionally well-dated evidence of catastrophic valley infill in the Pokhara Valley, Nepal. Bayesian calibration of radiocarbon dates from peat beds, plant macrofossils, and humic silts in fine-grained tributary sediments yields a robust age distribution that matches the timing of nearby M>8 earthquakes in ∼1100, 1255, and 1344 AD. The upstream dip of tributary valley fills and X-ray fluorescence spectrometry of their provenance rule out local sediment sources. Instead, geomorphic and sedimentary evidence is consistent with catastrophic fluvial aggradation and debris flows that had plugged several tributaries with tens of meters of calcareous sediment from the Annapurna Massif >60 km away.

The landscape-changing consequences of past large Himalayan earthquakes have so far been elusive. Catastrophic aggradation in the wake of two historically documented medieval earthquakes and one inferred from trench studies underscores that Himalayan valley fills should be considered as potential archives of past earthquakes. Such valley fills are pervasive in the Lesser Himalaya though high erosion rates reduce preservation potential. Further studies may wish to seek such remnants of prehistoric earthquakes using extensive sedimentological work as well as numerical age control.