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Holocene along-arc extension in the Himalayas: the Yadong Cross Structure

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The Himalayan Arc accommodates $\sim$ 2 cm/yr of shortening from the India-Eurasia collision, mostly along the Main Himalayan Thust. Perpendicularly to the main structures, regional cross structures formed by en échelon grabens and half-grabens mark Quaternary extension from central Tibet to the Himalayas. The Yadong-Gulu Rift system is the most striking one with a total length of $\sim$ 500 km. Its southernmost segment -the $\sim$100-km-long Yadong half-graben- entrenches through the Himalayas and forms a 500-to-1500-m-deep asymmetric basin. The average basin surface elevation of $\sim$ 4500 m contrasts with high reliefs of the Jomolhari range that reach 7326 m. They are separated by the N15-trending Yadong normal fault (also called Jomolhari Fault System, JFS) that forms spectacular triangular facets and affects glacial landforms.
Though observed as early as the 1980s, offset moraines were never studied in detail in terms of measured displacement or age determination. Recent efforts from paleoclimate studies yielded a high-resolution framework to identify the various stages of Holocene glacial advances and associated moraine formation. These landforms display specific geomorphometric features recognized regionally (ELA, rugosity, crest freshness) that allow correlating across the various glacial valleys within the Yadong Rift and across similar settings in western Bhutan and eastern Nepal. This serves as a robust basis to place the moraine sequence within the Holocene paleoclimatic record and propose formation ages.
By combining satellite images from Sentinel-2 (10 m, visible and NIR), Pléiades (0.5 m, visible) and a Pléiades-derived tri-stereo photogrammetric DEM (1 m), we map the fault trace and affected landforms in details and measure co-seismic and cumulative vertical offsets. Paleoclimatic age constraints yield age-vs-displacement measurements along the whole 100-km-long JFS and define a chronology of Holocene deformation events. Within the limits of our observations, we conclude that the last surface-rupturing earthquake likely occurred between 3 and 8 ka BP and produced an average surface displacement of $\sim$2 m. According to scaling relationships, the associated earthquake would have reached Mw 7.2. In addition, cumulative deformation suggests an average vertical slip rate of $\sim$1 mm/yr for the Holocene.