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Along strike variation of active fault arrays and their effect on landscape morphology of the northwestern Himalaya

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The location and magnitude of the active deformation of the Himalaya has been debated for decades, but several aspects remain unknown. For instance, the spatial distribution of the deformation and the shortening that ultimately sustains Himalayan topography and the activity of major fault zones are not well constrained neither for the present day and nor for Holocene and Quarternary timescales. Because of these weakly constrained factors, many previous studies have assumed that the structural setting and the fault geometry of the Himalaya is continuous along strike and similar to fault geometries of central Nepal. Thus, the sub-surface structural information from central Nepal have been projected along strike, but have not been verified at other locations.

In this study we use digital topographic analysis of the NW Himalaya. We obtained catchment-averaged, normalized steepness indexes of longitudinal river profiles with drainage basins ranging between 5 and 250km^2 and analyzed the relative change in their spatial distribution both along and across strike. More specific, we analyzed the relative changes of basins located in the footwall and in the hanging wall of major fault zones. Under the assumption that along strike changes in the normalized steepness index are primarily controlled by the activity of thrust segments, we revealed new insights in the tectonic deformation and uplift pattern.

Our results show three different segments along the northwest Himalaya, which are located, from east to west, in Garwhal, Chamba and Kashmir Himalaya. These have formed independent orogenic segments characterized by significant changes in their structural architecture and fault geometry. Moreover, their topographic changes indicate strong variations on fault displacement rates across first-order fault zones. With the help of along- and across-strike profiles, we were able to identify fault segments of pronounced fault activity across MFT, MBT, and the PT2 and identify the location of along strike changes which are interpreted as their segment boundaries.

In addition to the steepness indices we use the accumulation of elevation data as a proxy for the strain that has been accumulated over a specific distance. Thus, despite the changes in topography, structural setting, and kinematics along the NW Himalaya we observe that the topography of the orogen is in good agreement with recently measured convergence rates obtained from GPS campaigns. These data suggest reduced crustal shortening towards the northwest.

Deformation in the Central Himalaya has been explained either by in-sequence thrusting along the MFT that localize the entire Holocene shortening or a combination of this with out-of-sequence thrusting in the vicinity of the PT2. In contrast to these conceptual models, we propose that the segmented NW Himalaya is a product of the synchronous activity of different fault segments, accommodating the crustal shortening along three independently deforming organic segments. The lateral discontinuity of these segments is responsible for the accommodation of the variation in the deformation and the maintenance of the topography of the Himalaya in NW India.