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Long-lived cross-strike structures and lateral segmentation of the Main Himalayan thrust, west Nepal

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Large earthquakes, such as the M7.8, 2015-Gorka-Nepal earthquake, provide constraints on the present-day geometry of the basal detachment of the Himalayan orogen, the Main Himalayan thrust. Several studies suggest that cross-strike structures dissect the Main Himalayan thrust and may control the rupture length and seismicity distribution along the Himalayan orogen. The influence of these cross-strike structures on deeper, ductile regions of the Himalaya during older episodes of orogenesis is more cryptic, but can be evaluated with detailed tectonometamorphic characterization of the Himalayan metamorphic core. New phase equilibria modelling, monazite U-Th/Pb petrochronology and white mica $^{40}Ar/^{39}Ar$ geochronology data from the Himalayan metamorphic core reveal significant along-strike variations in pressure–temperature–time–deformation paths between rocks exposed in the Karnali and Jajarkot klippen, west Nepal foreland. In the Karnali klippe, pressure and temperature conditions peaked at $>$0.7–1.0 GPa and $>$650–700 ˚C between 35 and 30 Ma, followed by cooling, decompression and melt crystallization starting at 30 Ma. Karnali klippe rocks cooled below $\sim$450 ˚C progressively from the south flank (20–17 Ma) to the north flank (17–14 Ma). In the Jajarkot klippe, pressure and temperature conditions peaked at 0.75–1.2 GPa and 550–600 ˚C at 25 Ma, followed by cooling below $\sim$450 ˚C and decompression at 25–20 Ma. The klippen record contrasting metamorphic pressures between 35 and 25 Ma; Jajarkot klippe rocks were progressively buried to increasing depths while Karnali klippe rocks were translated over a frontal ramp to shallow crustal levels. Because the two klippen are at similar along-strike positions, these data imply that a vertical or east-dipping lateral ramp in the Main Himalayan thrust separated the Karnali klippe from the Jajarkot klippe during the Oligocene. The location of this putative Main Himalayan thrust lateral ramp coincides with other, younger cross-strike structures and lateral variations such as the middle Miocene to Holocene Lunggar rift in the Asian crust, the West Dang transfer zone in the late Miocene to Holocene foreland fold-thrust belt, and a significant eastward decrease in present-day seismic activity. These features coincide with the inherited, crustal-scale Lucknow basement fault and a zone of slab tear in the underplating Indian lithosphere, which point to the protracted influence of inherited structures on the evolution of the orogen. Our new results demonstrate that (1) the Himalayan metamorphic core did not evolve homogeneously along-strike of the orogen, (2) a lateral ramp dissected the Main Himalayan thrust in west Nepal during the Oligocene, and (3) segmentation of the Himalayan orogen likely occurred along long-lived basement cross-strike structures rooted in the Indian lithosphere.