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Effect of kinematics of orogenic wedge on kinematic evolutionary paths and deformation profiles of major shear zones: An example from the eastern Himalaya

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We examine how the deformation profile and kinematic evolutionary paths of two major shear zones with prolonged deformation history and large translations differ with varying structural positions along its transport direction in an orogenic wedge. We conduct this analysis on multiple exposures of the internal thrusts from the Sikkim Himalayan fold thrust belt, the Pelling-Munsiari thrust (PT), the roof thrust of the Lesser Himalayan duplex (LHD), and the overlying Main Central thrust (MCT). These two thrusts are regionally folded due to growth of the LHD and are exposed at different structural positions. The hinterlandmost exposures of the MCT and PT zones lie in the trailing parts of the duplex, while the foreland-most exposures of the same studied shear zones lie in the leading part of the duplex, and thus have recorded a greater connectivity with the duplex. The thicknesses of the shear zones progressively decrease toward the leading edge indicating variation in deformation conditions. Thickness-displacement plot reveals strain-softening from all the five studied MCT and the PT mylonite zones. However, the strain-softening mechanisms varied along its transport direction with the hinterland exposures recording dominantly dislocation-creep, while dissolution-creep and reaction-softening are dominant in the forelandmost exposures. Based on overburden estimation, the loss of overburden on the MCT and the PT zones is more in the leading edge (~26km and ~15km, respectively) than in the trailing edge (~10km and ~17km, respectively), during progressive deformation. Based on recalibrated recrystallized quartz grain thermometer (Law, 2014), the estimated deformation temperatures in the trailing edge are higher (~450-650°C) than in the leading edge (350-550°C) of the shear zones. This variation in the deformation conditions is also reflected in the shallow-crustal deformation structures with higher fracture intensity and lower spacing in the leading edge exposures of the shear zones as compared to the trailing edge exposures.

The proportion of mylonitic domains and micaceous minerals within the exposed shear zones increase and grain-size of the constituent minerals decreases progressively along the transport direction. This is also consistent with progressive increase in mean R_s-values toward leading edge exposures of the same shear zones. Additionally, the α-value (stretch ratio) gradually increases toward the foreland-most exposures along with increasing angular shear strain. Vorticity estimates from multiple incremental strain markers indicate that the MCT and PT zones generally record a decelerating strain path. Therefore, the results from this study are counterintuitive to the general

observation of a direct relationship between higher Rs-value and higher pure-shear component. We explain this observation in the context of the larger kinematics of the orogen, where the leading edge exposures have passed through the duplex structure, recording the greatest connectivity and most complete deformation history, resulting in the weakest shear zone that is also reflected in the deformation profiles and strain attributes. This study demonstrates that the same shear zone records varying deformation profile, strain and kinematic evolutionary paths due to varying deformation conditions and varying connectivity to the underlying footwall structures during progressive deformation of an orogenic wedge.