**Back structures (back-faults and back-folds) from collisional orogen: field findings from Lesser Himalaya, Sikkim, India**

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**Abstract:** Back structures (back folds and back shears) with hinterland-ward vergence have been reported from several collisional orogens. Recognition of back structures is important in tectonics, resource, and earthquake studies. Back structures have so far been reported in meso-scale from Greater Himalayan Crystallines (Mukherjee, 2013) and Lesser Himalaya (Bose & Mukherjee, 2015) from Bhagirathi river section, western Himalaya, India. Our fieldwork in the Paleoproterozoic phyllites, quartzites of Daling Group (Lesser Himalaya, Sikkim, India) revealed brittle back shears of both top-to-N/NE (up) back-reverse and top-to-N/NE (down) back-normal faults at three zones ($BSZ_A$, $BSZ_B$, $BSZ_C$). No secondary brittle shear zones, neither $R_1$ nor $R_2$, were found associated with these zones. The $BSZ_A$ is extremely well developed ~ 3 km N to Damthang, where the Daling Group quartzites contain brittle back shear Y-planes with up to 5 cm thick fault gouge. Here the back shear Y-planes clearly cut the fore-shear Y-planes indicating the back shear postdated the top-to-S/SW fore-shears. Geochronologic dating of fault gouge can constrain the absolute timing of back deformation. The fault gouge within the Y-planes of back shear sometimes contains faint P-planes of same back shear sense. The Y-planes are at places sub-horizontal and dip moderately elsewhere. The $BSZ_B$ near Singtam shows back shears in the form of brittle P-planes bound by Y-planes, and a single meter-scale overturned-isoclinal-synformal back fold with ~ ENE dipping limbs and axial plane. At places, ductile shear

indicators S- planes bound by C-planes were found parallel to P- and Y-planes, respectively. Thus back thrusting that initiated in the ductile regime probably continued in the same sense in the brittle regime. The $BSZ_C$ is well exposed from W of the village Kyongsa (near Geyzing) up to a nearby 'Farm Science Centre'. Top-to-NE (up) back shears were observed in this location in terms of Y- and P-planes in schistose rocks, quartz sigmoids and few back folded quartz veins. Whether $BSZ_A$, $BSZ_B$ and $BSZ_C$ constitute a single back-thrust zone remains indeterminate. Other than $BSZ_A$, $BSZ_B$ and $BSZ_C$, back shears are present in the Lesser Himalaya in Sikkim but are less ubiqutous. Only at two locations between Ravangla and Tarek, back shears were observed in cm-scale sheared quartz veins. This work along with the previous reports of back shear (Mukherjee, 2013; Bose & Mukherjee, 2015) indicates plausibly such structures are more common in the Himalaya. Presence of back structures probably connotes a critical taper mechanism of deformation.

**Keywords: 1.** Back-fault, **2.** Himalayan tectonics, **3.** Lesser Himalaya, **4.** back shear, **5.** brittle shear, **6.**critical taper

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