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Fluid-Fault rock interaction during progressive deformation in Pelling-Munsiari thrust fault zone: A preliminary study from Darjeeling-Sikkim Himalayan fold thrust belt

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In a fold thrust belt,the dominant thrust fault rocks generally record strong overprinting of dislocation-controlled deformation mechanisms by frictional mechanisms during progressive deformation. Fluids play an integral role during evolution of such fault zones by opening channels by fracturing or by sealing existing fractures by forming veins, or by a combination of both.

In the Sikkim Himalayan fold thrust belt (FTB), the Pelling-Munsiari thrust (PT) is one of the dominant thrusts that is the roof thrust of the Lesser Himalayan Duplex. Growth of the duplex has folded the overlying PT sheet, exposing it at various structural positions. We focus this study along the hinterlandmost (Mangan) and forelandmost (Suntaleykhola) exposures of the PT zone. We attempt to develop a temporal sequence of fracture growth by studying offsets recorded along fractures of different orientations, and also quantifing the variation in fracture population from hinterland to foreland. Additionally, we probe the role of fluids during the different stages of progressive deformation by studying fractures versus filled in fractures (veins). We examine the sources and temperature of the fluids as a function of the structural position of the exposed PT zones.

The PT fault rocks are dominantly quartz-mica mylonite. At the hinterlandmost exposure, three dominant fracture orientations are recorded at $\sim$0°–30° ($\sim$46%),$\sim$30°-70° ($\sim$37%), and$\sim$70°-90° ($\sim$17%) with respect to the mylonitic foliation. Low-angle fractures are offset by the younger, high-angle fractures. Vein population study reveals that the early-formed fractures are filled in by fluids while the later ones are independent of it.The same fault zone records a higher fracture population in the forelandmost exposure with orientations of$\sim$0°-30° ($\sim$16%), $\sim$30°-70° ($\sim$47%) and $\sim$70°-90° ($\sim$37%) with respect to the mylonitic foliation. In this outcrop, fluids are present in both low-angle and high-angle fractures.

Based on recrystallized quartz grain-size analysis from differently oriented veins, the Mangan PT zone records similar distribution of temperatures ($\sim$555°C-548°C±50°C) for foliation-parallel and high angle veins. However, in the foreland-most PT exposure, the temperature of these veins ranges from 515°C±50°C(low angle veins) to 415°C ±50°C(high angle veins). Preliminary results from isotopic analysis indicate that the veins in the hinterlandmost PT zone record δ18O (10.7‰ ±0.03-11.04‰ ±0.03) that is similar to the host rock δ18O value (7.6‰ ±0.04). In the forelandmost PT zone, δ18O values range from 8.07‰ ±0.04 in foliation-parallel vein to 9.61‰ ±0.09 in high-angle veins. The 1.54‰ decrease in δ18O value possibly corresponds to 100°C increase in temperature from low-angle to high-angle vein. These δ18O values of the veins are similar to the host rock δ18O value suggesting that the fluids circulating through these fault zones are dominantly intraformational fluids.