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Evolution and characterization of fracture patterns: Insights from multi-scale analysis of foreland Buxa carbonates in Arunachal Lesser Himalayan fold-thrust belt

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Fractures, at different scales, are an integral component of shallow crustal deformation associated with progressive evolution of a fold-thrust belt (FTB). We characterize the fracture evolution from the Buxa dolomite of the Lesser Himalayan sequence of the frontal segment of the Main Boundary thrust (MBT) sheet in the eastern Arunachal Himalayan FTB, where they form the most dominant structure. The MBT forms a fault-bend fold along 17°, 335. Based on fracture analysis carried out at outcrop and microscopic scales, we classify fractures with respect to their angular relationship to bedding, as low-angle, oblique and high-angle fractures with fracture-bedding angles between 0°-30°, 30°-70° and 70°-90° respectively. We infer the temporal evolution of fracture sets using cross-cutting, offset and abutting relationships. The low-angle fractures are observed to be formed first, followed by oblique and high-angle fractures. Stereoplot analysis reveals that early formed, low-angle fractures are pre-folding structures while the most dominant late stage, high-angle fractures form synchronous to folding. Microscopic analysis shows that majority of the high-angle fractures are extensional in nature and acted as the most preferred pathway for fluid migration. Therefore, we focus on studying the spatial arrangement of these high-angle fractures at different scales of observation to understand fluid flow through them during progressive deformation.

Spacing data gathered from scan-lines laid across thin-sections (microscopic scale) and outcrops at distances of ∼470 m, ∼415 m and ∼410 m from the MBT zone, as constrained from regional cross-section, reveal that fracture intensity is higher in the microscopic scale. However, Coefficient of Variation, *Cv*, of spacing values is similar in both the scales of observation at two locations. This observation is further bolstered by the fact that cumulative plots of fracture spacing values collected from outcrops and under the microscope are best described by power-laws that indicate scale-independence. At another location (∼415 m from MBT zone) however, the fractures appear clustered at the outcrop scale but random at microscopic scale. It is suspected that this might be an artefact of problems associated with collection of data from the outcrop because of poor quality of exposure.

Integrating structural and statistical analyses, we infer that the high-angle fractures formed during the large-scale fault-bend folding of the MBT sheet. Propagation and linkage of these fractures resulted in patterns which are best described by power-laws and have similar clustering attributes across different scales of observations.