Natural Fracture Patterns Exposed on Bedding Planes: Using Observations in Outcrops to Infer Subsurface Trends

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Summary

Natural fracture patterns were characterized for three well exposed bedding planes of the Lower Triassic Sulfur Mountain Formation (outcrop equivalent to the subsurface Montney Formation) that outcrops along the roadcut at Hood Creek in Kananaskis Country, Alberta. Fracture analysis was conducted on field photos processed in FracPaQ (a MATLAB™ toolbox) for 2 m by 3 m rectangular sampling windows on each bed plane. The studied beds occur 2.08 m apart in vertical stratigraphy and are exposed along a 27 m lateral section of the outcrop. Although the three beds consist of siltstone to very fine-grained sandstone and have experience the same tectonic stresses, the fracture networks differ notably in fracture length, orientation, density, and intensity. Bed F has a total of 96 fracture traces, with trace lengths ranging from 0.02-1.73 m (average length 0.31 m) and Bed G has a total of 926 fracture traces, with trace lengths ranging from 0.01-1.66 m (average length 0.15 m), whereas Bed I has a total of 1981 fracture traces, with trace lengths ranging from 0.01-1.11 m (average length 0.09m). All beds had a relatively narrow dispersion envelope for dominant fracture orientations, with a strong East-West preferred orientation. Bed F exhibits orthogonal fractures, Bed G exhibits conjugate fractures, whereas Bed I has a unimodal fracture orientation. Fracture density and intensity increased between Bed F, Bed G and Bed I, with Bed F having the lowest average density (84.66 / meter^2) and intensity (4.99 m/m^2), Bed G having high average fracture density (644.24 / meter^2) and intensity (22.56 m/m^2), and Bed I having the highest fracture density (1145.73/ meter^2) and intensity (31.09 m/m^2). Although the kinetics and timing of fracture generation at Hood Creek is unknown, it is hypothesized that subtle lithological and geomechanical variability within the outcrop and a complex burial history compartmentalized the stress acting on each bed causing the layers to preferentially fracture under different stress conditions.

Observations from the fractured bedding planes can be used as an analogue for fracture networks that might be present within the subsurface. Although the beds studied are < 25 cm thick, the concepts and visualizations can be upscaled to subsurface reservoirs. Fracture density and intensity maps show that there is lateral variability along each of the exposed bedding planes. If a vertically cored well was taken from these beds, the number of fractures that were intersected by the well would vary depending on the location, which could then impact fracture modeling conducted for the subsurface play. Additionally, by using scanlines across each bed as a proxy for horizontal wells, observations are made for varying the placements and orientations of the scanline. This study shows depending on the placement and orientation of a horizontal well compared to the orientation of the fracture network, different fracture sets are intersected by the well and, therefore, might become critically stressed leading to induced

seismicity. Fracture networks can also influence vertical and lateral connectivity within reservoirs, contribute or hinder permeability and flow of formation fluids, and ultimately impact long- and short-term hydrocarbon production trends. Therefore, using observations from fracture systems within outcrops provides vital information on visualizing and quantifying fracture networks that are difficult to impossible to determine in the subsurface.

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