A new approach to characterizing fracture networks: an analysis of natural fractures within the Stillwell anticline, west Texas

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Over the past twenty years, the number of fracture studies in the literature has grown exponentially, but there is still debate about how to best sample and characterize natural fracture networks. Few studies take into account either fracture aperture or observational bias in the characterization of fracture systems. In addition, most fracture research has been limited to either the microscopic or macroscopic scale. We investigated fracture systems at the transition between the micro- and macroscopic scale at the well-exposed, Stillwell anticline in West Texas. The excellent cross-sectional exposure of the asymmetric anticline provided us the opportunity to analyze fracture systems within the same limestone bed at different structural positions, including the forelimb, the forelimb hinge, the middle limb, the backlimb hinge, and the backlimb. At each locality, we measured each fracture’s orientation, fill, morphology, length, and aperture. Since observational bias can strongly affect outcrop data, we developed a new multi-step method to account for the unequal probability of encountering fractures based on each fracture’s orientation relative to the observation plane and the orientation of each fracture within the rectangular shape of observation area. Based on these relative orientations, we weighted each fracture, assigning an integer-based correction factor. Our results suggest that fracture intensity and aperture data are significantly different at each structural position and appear to follow a power law distribution. Furthermore, some fracture sets at each location appear to correlate with the macro-scale outcrop joint sets. Finally, since fracture variables such as orientation, fill, length, and morphology are unlikely to be independent, we used a multivariable analysis known as Bayesian Updating to quantitatively analyze and compare fracture characteristics from different structural positions. The new sampling-bias correction method presented here, when integrated with multivariate analysis, provides a model for practical, accurate, and comprehensive characterization of complex fractures systems.