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Developing a shale heterogeneity index to predict fracture response in the Mancos Shale

Aubry DeReuil (1), Lauren Birgenheier (1), and John McLennan (2)

(1) Department of Geology and Geophysics, University of Utah, Salt Lake City, UT, United States (aubry.dereuil@utah.edu),
(2) Department of Chemical Engineering, University of Utah, Salt Lake City, UT, United States (jmclennan@egi.edu)

The interplay between sedimentary heterogeneity and fracture propagation in mudstone is crucial to assess the potential of low permeability rocks as unconventional reservoirs. Previous experimental research has demonstrated a relationship between heterogeneity and fracture of brittle rocks, as discontinuities in a rock mass influence micromechanical processes such as microcracking and strain localization, which evolve into macroscopic fractures. Though numerous studies have observed heterogeneity influencing fracture development, fundamental understanding of the entire fracture process and the physical controls on this process is still lacking. This is partly due to difficulties in quantifying heterogeneity in fine-grained rocks. Our study tests the hypothesis that there is a correlation between sedimentary heterogeneity and the manner in which mudstone is fractured. An extensive range of heterogeneity related to complex sedimentology is represented by various samples from cored intervals of the Mancos Shale. Samples were categorized via facies analysis consisting of: visual core description, XRF and XRD analysis, SEM and thin section microscopy, and reservoir quality analysis that tested porosity, permeability, water saturation, and TOC. Systematic indirect tensile testing on a broad variety of facies has been performed, and uniaxial and triaxial compression testing is underway. A novel tool based on analytically derived and statistically proven relationships between sedimentary geologic and geomechanical heterogeneity is the ultimate result, referred to as the shale heterogeneity index. Preliminary conclusions from development of the shale heterogeneity index reveal that samples with compositionally distinct bedding withstand loading at higher stress values, while texturally and compositionally homogeneous, bedded samples fail at lower stress values. The highest tensile strength results from cemented Ca-enriched samples, medial to high strength samples have approximately equivalent proportions of Al-Ca-Si compositions, while Al-rich samples have consistently low strength. Moisture preserved samples fail on average at approximately 5 MPa lower than dry samples of similar facies. Additionally, moisture preserved samples fail in a step-like pattern when tested perpendicular to bedding. Tensile fractures are halted at heterogeneities and propagate parallel to bedding planes before developing a through-going failure plane, as opposed to the discrete, continuous fractures that crosscut dry samples. This result suggests that sedimentary heterogeneity plays a greater role in fracture propagation in moisture preserved samples, which are more indicative of in-situ reservoir conditions. Stress-strain curves will be further analyzed, including estimation of an energy released term based on post-failure response, and an estimation of volume of cracking measure on the physical fracture surface.