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Impact of Compositional and Textural Heterogeneity on Mechanical Behavior of Mancos Shale

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The performance of subsurface geologic formations is a function of the hydro, mechanical, and chemical properties of formations with compositional and textural heterogeneity across a range of scales. In particular, mechanical properties (elastic properties, fracture toughness, anisotropy, etc.) are controlled by a variety of geologic variables, including mineralogy, cements, and organic content, and the spatial distribution of these characteristics. In this work an integrated approach of multiscale imaging, mineralogy distribution, nano-indentation, machine learning, sedimentation features, and numerical simulations is employed to investigate the impact of the micro-lithofacial heterogeneities on mechanical properties for Cretaceous Mancos Shale.

Nano-indentation results are mapped into detailed mineralogical distribution based on MAPS (Modular Automated Processing System) technique and high resolution backscattered electron images to relate measured Young's moduli to depositional characteristics of micro-lithofacies. Numerical simulation results of nano-indentation are used to interpret the impact of spatial heterogeneity of composition, texture phases, and interfaces of phases on mechanical responses. A range of Young's moduli from nano-indentation is generally larger by a factor of 1 to 4 compared to axisymmetric compression results. This difference shows the important effect of pores, microcracks, and bedding boundaries on bulk elastic response as in axisymmetric compression results. Together these data sets show the influence of cement distribution on mechanical response. Variations in micro-lithofacies are the most critical factor in determining the mechanical response of this important Mancos constituent, and are likely responsible for its success in hydrofracture-based recovery operations as compared to other Mancos lithofacies types. In addition, well-bore breakout testing results as a function of bedding plane and loading angles will be discussed to highlight the importance of compositional and textural distribution on mechanical deformation processes over time.

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