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DOCTORAL DISSERTATION DEFENSE ANNOUNCEMENT

AT THE CULLEN COLLEGE OF ENGINEERING

The Petroleum Engineering Department Presents

Anisotropic Fracture Toughness Characterization of Shale Formation from Drill Cuttings

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Location: RM 124, Technology Bridge

Committee Chair:

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Committee Members:

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Abstract

Shale is a sedimentary rock composed of clay minerals and silt-sized particles. Its pore throat sizes are as small as 10 nm in its matrix, which leads to ultralow permeability. It has become economically viable for hydrocarbon recovery because of hydraulic fracturing, in which the required energy is defined by fracture toughness. Shale is mechanically unstable and retrieving a suitable core size for common tests is costly and time-consuming. Thus, there is a need to develop new methods applicable to small pieces such as drill cuttings, which are often the only sources available in real-time conditions.

This study proposes two methods for the geomechanical characterization of shale at the core scale based on the interpretation of small-scale measurements. Both rely on nanoindentations. The proposed conceptual models have applications in characterizing formation heterogeneity in the petroleum industry. The first determines Young's moduli from cuttings, and the results are compared with those of the core plugs from the Wolfcamp Formation. The sensitivity of the results to sample preparation is also discussed.

The second method characterizes the fracture toughness of shale based on the conceptual model proposed in accordance with the effective medium theory. The proposed model sheds light on the complexities of the induced fracture patterns in shale that differ from those observed in homogeneous materials, such as fused silica and aluminum. The conceptual model is realistic for shale because it captures the sample heterogeneity. The second method is tested at a small scale using different tip geometries. The interpreted fracture toughness values from the cube-corner and Berkovich tips are close, with less than 18% difference, which provides a partial validation for the conceptual model.

The proposed model is also tested against independent data obtained from the cracked chevron notched Brazilian disc (CCNBD) test. The difference between predicted fracture toughness values from nanoindentation and the CCNBD test is less than 13%, and this good agreement validates the proposed model. The proposed model has applications in characterizing the mechanical properties of shale using small samples from unconventional resources.