Mudstone Nanoindentation—
How Little Cuttings can Make a Big Difference

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EXTENDED ABSTRACT

Shale formations are mainly laminated sedimentary rocks composed of carbonates and silt-size quartz particles, some clay inclusions, organic matter, and fluids in pore space. Small pore throats and oriented clays provide a great seal capacity and add anisotropy to mechanical properties.

During hydraulic fracturing laminations inside the rock provide stress contrast and work as elastic energy barriers for tensile fracture growth both vertically and horizontally. At the same time, preexisting flaws and planes of weaknesses may be centers of shear failures and improve rock permeability inside stimulated rock volume.

Reliable measurement of static Young's modulus is a key factor of successful fracture design for shale formations (Smith et al., 2001). Low-cost unconventional operators consider coring program to be too expensive for formation evaluation for each individual well. It is common in the industry to use dynamic modulus which is derived from sonic logs from vertical pilot wells. In this case, only gamma ray log is available in the lateral part of the well. Static parameters are estimated from a two-step correlation process: from gamma ray log to sonic log and from sonic log to static properties. That is why operators have no reliable data for fracture design and optimization of individual stages and use 'geometric spacing' and one design for all stages. Recent progress in completion procedures was achieved mainly by 'trial-and-error' method. As a result, production logging showed that 21% of perforation clusters are not producing in Eagle Ford shale (Miller et al., 2011).

A significant amount of data should be used to apply robust hydraulic fracturing 3D models. For the first order of approximation, the width of a vertical hydraulic fracture in transversely isotropic (TI) medium depends on the horizontal Young's modulus and Poisson's ratio measured parallel and perpendicular to bedding planes (Chertov, 2013). Even this, simplified, approach requires triaxial testing of core plugs in two mutually perpendicular directions.

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