LITHOLOGICAL CONTROLS ON MECHANICAL ANISOTROPY IN SHALES TO PREDICT IN SITU STRESS MAGNITUDES AND POTENTIAL FOR SHEARING OF LAMINATIONS DURING FRACTURING

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ABSTRACT

Accurate and repeatable assessments of in situ stress magnitudes and orientation in unconventional reservoirs can be complicated by the heterogeneous, inelastic, and/or anisotropic mechanical properties of these rocks and their complex history of burial and diagenesis. The associated vertical and lateral variation in pore pressure and stress through the target zones and bounding intervals can further complicate this effort. For these reasons, some additional factors need to be considered beyond the typical workflow of determining closure stress from standard mini-frac data and using this data to calibrate log derived stress profiles. We present some case study examples from hydrocarbon-producing shales where a more rigorous analysis of the mechanical properties of the shale has allowed a more accurate and repeatable assessment of in situ stress and potential for lamination shearing. Horizontal fracture growth through shear activation of bedding-parallel fabric can be a preferred fracture propagation mechanism in these shales and this behavior can be diagnosed by this improved workflow. In one case study example, in the tight gas Montney siltstone of Western Canada, shear strength anisotropy is shown to be very significant, with bedding parallel shear cohesion less than 10% of the bulk rock cohesion. For such situations it can be shown that shear fracturing of laminations is likely. It has been demonstrated through pressure transient analysis of minifrac injection and flowback data that this can be diagnosed. Many fracturing related mechanisms are also stress dependent and their understanding requires assessment of all in situ stress magnitudes, not just minimum horizontal stress. An improved method of analyzing these stress magnitudes and fracturing mechanisms is described through anisotropy measurements in core samples and a micro-mechanical understanding of the rock fabric. In this way, a petrophysical relationship can be established between anisotropy parameters and rock properties.

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