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Is the Montney Formation a Geomechanical Hybrid Sandstone-Shale Reservoir?

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Summary

The Montney Formation in Alberta and British Columbia, a unique siltstone oil and gas reservoir, is one of the most productive reservoirs in Canada. Hydrocarbon production in the Montney Formation is achieved mainly through stimulated horizontal wells in which hydraulic fracturing increases the surface area of the formation to maximize production. Fracture system development, whether natural or stimulated, is largely determined by the mechanical properties of the rock, which are in turn a function of organic and mineralogical composition.

Framework mineralogy must be considered when targeting a zone for hydraulic fracturing in an unconventional reservoir. In this context is important to note that though clays and organic matter are not considered part of the framework mineralogy in a conventional setting, their concentration in unconventional reservoir might be high enough to be taken into account. In tight sandstones, for example the rock is composed of hard grains and generally responds well to stimulation. In shales on the other hand, higher clay and organic matter content result in more ductile behaviour, and hydraulic fracturing might not be affective. Targeting the more brittle horizons in shales is thus of high significance for successful operation. The Montney Formation is composed predominantly of silt-size hard grains and moderate amounts of organic matter, but also up to 30 wt.% clay minerals . Siltstone reservoirs are understudied, and the relationship between rock composition and rock properties of siltstones is not well constrained. It is thus not clear whether the Montney Formation is geomechanically more similar to sandstone or to shale, or rather it exhibits unique geomechanical behaviour on the mixing line between those two end members.

Our investigation compares the mechanical properties of the Montney Formation to rock composition in four wells along a dip transect from shallow to deep burial. Dynamic Young's Modulus (YM), Poisson's Ratio (PR) and brittleness are calculated from diapole sonic and density well-logs and are calibrated to static measurements where available. Relative hardness profiles of core samples are created using an Equotip Bambino 2 hardness tester and compared with rock composition measured by QEMSCAN (inorganic) and LECO-TOC (organic).

Dynamic YM calculations results are two times higher than the static YM data, whereas dynamic PR was calculations show similar values to the static test results. Brittleness calculated from well-logs average 400, much higher than typical shale values. Vertical profiles of YM and PR can be correlated to facies transition and compositional differences. A statistical analysis indicating that hardness in the Montney Formation is controlled by the organic matter content in some facies, whereas other facies show no statistical correlation to soft minerals or organic matter content. Our findings suggest that that the Montney Formation siltstone is a geomechanical hybrid reservoir encompassing some of the properties of both end members- sandstones and shales. It is thus crucial to recognize facies differences and to target facies with appropriate elastic characteristics within the reservoir in order to ensure successful stimulation.