Geomechanical Analysis of the Three Forks Formation and Implications for Hydrocarbon Recovery

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ABSTRACT

The Three Forks is a tight reservoir that normally requires hydraulic fracturing to make production economical. Therefore, understanding the variability of geomechanical properties within the formation is critical for designing optimal artificial fracture stimulation schemes. Soft, ductile rock is not suitable for hydraulic fracturing because of its resistance to the propagation of artificial fractures; consequently, it is important to identify the more brittle rock types. A better understanding of the stratigraphic and lateral distribution of the most brittle rock types in the formation should drastically increase the Three Forks recovery factor, which has been reported as 8.9% (plus or minus 5.32%). The objectives of this study are to (1) investigate controls on Three Forks geomechanics, (2) identify geomechanical facies within the formation, (3) relate geomechanical facies to petrophysical logs, and (4) make recommendations that would improve hydrocarbon recovery. Analysis methods include mechanical hardness tests using an Equotip Bambino device on cores distributed across the play area, identification of lithological facies to compare with geomechanical properties, and statistical comparison of Leeb hardness (HLD) results with digital log data. Results indicate that within the Three Forks Formation, hardness generally decreases with depth but varies greatly within short intervals. Abundance of dolomite generally corresponds to higher HLD values. Conversely, abundance of anhydrite generally corresponds with low HLD values. The relationship between HLD and well-log values varies with well location, depth, and lithological facies. Strongest relationships occur towards the top of the formation. The well log with the strongest positive correlation to hardness is the resistivity log. The well log with the strongest negative relationship is gamma ray. However, depending on the location, moderate correlations exist between HLD and neutron porosity, density porosity, sonic porosity, and photoelectric logs. A greater understanding of these relationships will ultimately lead to better well stimulation techniques and improved recovery factor.

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