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Petrological Controls on Reservoir Performance in Unconventional Light Oil/Gas Plays: Three-Dimensional Insights from Bakken Formation, Southeastern Saskatchewan, Canada

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Abstract

Successful exploitation of hydrocarbons from shale and tight reservoirs has historically focussed on engineering and operations-based decisions such as extending the length of laterals, increasing the number of hydraulic fracture stages in wells, frack fluid optimization, increasing proppant tonnage and reducing well spacing. Reservoir simulation studies are equally being performed to prolong well life and improve well productivity (Clarkson et al., 2014; Kanfar and Clarkson, 2016). However, many unconventional oil and gas operators are yet to reasonably ascertain the underlying geological and petrophysical controls on fluid distribution, fracture occurrence and geometry, and rock geomechanical characteristics; all of which ultimately define the production behavior in shale and tight plays. This paucity of knowledge contributes to rapid well depletion and sub-optimal recovery which are problems faced by shale/tight oil and gas producers today.

This novel study utilizes a three-dimensional (3D) synthesis approach to demonstrate that an understanding of the pore to field scale geological and petrophysical characteristics of shale and tight reservoirs is fundamental to effectively defining field development and enhanced recovery strategies. A field undergoing secondary recovery in the Bakken Formation, Southeastern (SE) Saskatchewan, Canada, was selected as case study area. Utilizing seismic, well logs, core (laboratory analyzed), production and well test data, a 3D model was constructed. The modeling process involved a rigorous integration of seismic attribute mapping, gross depositional environment/sequence stratigraphic framework (Cronkwright et al., 2015), structural, petrophysical properties and fracture modeling to highlight internal reservoir properties and architechture that increase sweep efficiency and hence production performace in the Bakken Formation. Multiple scenario analyses were performed to investigate the implications of various petrogeological scenarios on a full field development strategy that optimizes the current enhanced recovery design. Base case model results were validated using field production performance, well connectivity analyses methods (defined by Mirzayez et al., 2015) and waterflood results.

This research underscores the important role of host rock attributes in influencing fluid interactions and fluid flow pathways in shale/tight plays. Consequentially, the reservoir response beyond the well bore region and sweep efficiency are controlled not just by induced fractures but also subtle facies changes that influence pore scale variations in matrix and fracture properties.

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