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Integrated Reservoir Characterization and Facies Modelling for the Heterogeneous Carbonate Platform of the Shu'aiba Reservoir, Saudi Arabia

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ABSTRACT

The Shu'aiba Formation is one of the giant carbonate reservoirs in the Middle East and is well-known for its complex architectures and heterogeneous reservoir characteristics. This heterogeneity in part is due to the development of rudist buildups, clinoforming and progradational geometry, syn-depositional tectonics and diagenetic overprint. The main challenge of modeling this complex reservoir is to represent all these geological features and honor all small scale geological, structural and petrophysical properties, to minimize the uncertainty between wells for enhancing the simulation model. Integrated high-resolution core-based study is the key to better understand this reservoir and hence develop a more accurate geological model. Core data were integrated with wireline logs, to develop the stratigraphic framework. Biostratigraphy and stable isotope chemostratigraphy were used to constrain the age model and define platform-to-basin transition and prograding clinoform geometry within the chronostratigraphic framework. The integrated dataset, include fifty-five cored wells and hundreds of uncored wells that are calibrated to wireline logs.

The stratigraphic succession of the Shu'aiba consists of a large scale 2nd-order composite sequence built by four 3rd- order sequences and 10 high frequency sequences. It represents a complete depositional sequence of transgressive to highstand packages bounded at the base and top by major unconformities and followed by major progradational system that toplaps at the upper Shu'aiba unconformity. The platform was divided into north and south blocks by W-E deep-seated graben-like fault systems. Each block has distinctive stratigraphic and facies architectures each with its corresponding diagenetic history that influenced reservoir quality.

The reservoir is subdivided into 25 layers on the basis of the chronostratigraphic framework with 29 lithofacies representing all depositional settings and reservoir anatomy. Lithofacies analysis were integrated with wireline logs and pore-perm data to characterize the spatial distribution of dynamic flow units, barrier or baffle zones. Methods of neural network analysis were used to predict facies in uncored wells and the 3-D structural and facies models were constructed. This new updated model will significantly enhance our understanding of the internal reservoir geometries and will significantly help on enhancing the development program and optimizing hydrocarbon recovery.