The importance of generating a realistic structural framework for modeling facies architecture in a massive clinothem system: A case study from the Nanushuk Formation of the Alaska North Slope, USA.

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ABSTRACT

Reservoir models provide critical input for planning and executing capitally efficient development programs. Successful models can reliably forecast production performance through space and time, while faithfully representing geological concepts and facies distributions observed in seismic and well data. Although advancements in geostatistical tools have improved the ability to create data driven, geologically robust models, challenges remain in the representation of realistic geological features, thin layered, highly heterogeneous reservoirs, and their impact on forecasted performance.

Here, we present an integrated modeling workflow based on seismic interpretation, well log correlation, rock physics analysis, and Sequential Indicator Simulation to: (1) identify and model stratal geometries (clinothems) in the Nanushuk Formation (Albian-Cenomanian) of the North Slope of Alaska and (2) distribute shallow marine depositional environments and lithofacies within modeled clinoforms. The Nanushuk Play near the modern Colville Delta is an ideal interval within which to test our approach because its geometry, reservoir sedimentology, and flow performance are captured in 3D seismic data and multiple wells with wireline logs, core, and production tests.

To build the structural model and ensure a well constrained model grid, initial Nanushuk horizons were picked manually following our geological concept and guided by well correlations. Multiple horizons were automatically tracked within target intervals, then refined locally to reach an optimum solution within each clinoform. To create the most geologically realistic result and identify interesting depositional features throughout the Nanushuk interval, multiple seismic attributes were mapped and viewed through a series of stratal slices. Cross-plots from rock physics analysis indicate that most reservoir lithofacies plot along trends in P-impedance and Vp/Vs. Lithotype zones were generated from seismic inversion attributes and guided sand-shale trends from wells and the model-grid horizons. After, lithotype curves were extracted at well locations and correlated to lithofacies at seismic scale as a quality control check.

Facies associations, including lower shoreface (LSF), upper offshore (UOF), lower offshore (LOS), and inner shelf (ISLF) were distributed inside of the model in two steps. First, a truncated Gaussian with trend algorithm was applied for distributing facies associations within the limit of each identified clinoform. After, Sequential Indicator Simulation was used to distribute lithofacies including clean sandstone, heterolithic lithofacies 1 (medium to fine grained sandstone interbedded with silty mudstone), heterolithic lithofacies 2 (very fined grained sandstone interbedded by silty mudstone), and mudstone within the model. This facies distribution within the detailed structural (clinothem) framework was critical for realistically characterizing the heterogeneous Nanushuk reservoir and non-reservoir intervals, resulting in more accurate flow predictions.

This workflow could be easily replicated in other thinly laminated heterolithic reservoirs to preserve geological observations made in seismic and wells. The current-state of the Energy Industry reality urges for demands cost and time-efficient processes to enhance profitability. The presented reservoir modeling workflow supports this reality and enables the efficient creation of a geologically realistic model. In turn, this model improves production forecasting and can be used to make better informed field development decisions that improve reservoir recoverability.

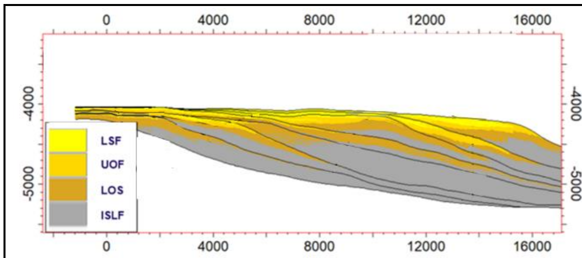

Figure 1. Geological Modeling of Progradation Sequences in Nanushuk Reservoir.