Identification of Potential Lacustrine Stratigraphic Intervals in the Woodford Shale, Oklahoma, Using Multi-Attribute 3D Seismic Displays and a Supervised Neural Network

Emilio J. Torres[1], Roger M. Slatt[1], Kurt J. Marfurt[1], Lennon E. Infante[1], and Luis A. Castillo[1]

[1]University of Oklahoma

ABSTRACT

With the latest exploration and development of unconventional shales focused on predominantly marine deposits, the potential of hypersaline, highly restricted marine and lacustrine deposits has not been studied systematically. The primary goal for this study is to resolve whether there are seismic indicators for such rocks within a predominantly marine shale, targeting specifically within the Woodford Shale formation in Oklahoma U.S.A. Several of the North American resource shales have been characterized as marine sequences with the common characteristic of being deposited unconformably above a carbonate formation where paleo sea level fluctuations allowed the development of erosional topography that might lead to restricted hypersaline lacustrine settings.

The differences in hydrocarbon generation and cracking kinetics result in different thermal maturity windows for marine and saline lacustrine deposits, where lacustrine rocks require higher thermal maturity for oil generation and cracking. Therefore, where high thermal maturity for a rock of a marine depositional environment thermally cracks the oil, that same maturity yield, the oil might be preserved for a lacustrine deposit, thus providing previously unidentified exploration and prospectivity targets. A model based seismic post-stack acoustic impedance inversion and a supervised neural network analysis was performed to predict the Total Organic Carbon (TOC) variation along the Woodford shale in South-Central Oklahoma, U.S.A. The results are tied with the Woodford Shale regional context for the identification of geological variations that potentially allowed the deposition of lacustrine rock intervals. The seismic interpretation, inversion and neural network property extension confirms the hypothesis that the impedance anomalies seen in the Woodford shale window correspond to internal lateral and vertical TOC-bearing facies variation.

The Woodford shale is both thicker and more TOC-rich where the underlying Hunton Group (carbonates) is completely eroded and the topographic relief is high. Seismic analysis at and above the unconformity surface produced by the erosion of the Hunton Group, reveals pod-shaped intervals of high TOC that may have been deposited as a very restricted interval. For this reason, we hypothesize that the structural lows may have been isolated lakes represented by locally increased accommodation space and restricted Woodford shale organic rich deposits, therefore providing opportunities for more innovative unconventionals exploration targeting.