High-Resolution Sequence Stratigraphy and Seismic Attributes Analysis of the Leonardian Bone Spring Formation, Northern Delaware Basin

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Abstract

The Bone Spring Formation in the Delaware Basin portion of Texas and New Mexico's Permian Basin province has earned the distinction of having the most proved oil reserves and highest oil production of any US tight oil play. Consequently, in order to optimize the development of its prolific stacked pay zones, analysis of the varying reservoir quality of the Bone Spring reservoirs is warranted. In this study, high-resolution sequence stratigraphy is investigated by integrating more than 220 square miles of 3-D seismic with 140 wells in the Bone Spring Formation, northern Delaware Basin. The investigation reveals the entire Bone Spring group which averages roughly 3,500 feet thick can be subdivided into eight alternating carbonate, clastic sand, and shale members deposited in slope and basin settings. The operational members include the Avalon shale, first, second, and third bone spring sandstones, and carbonate-rich intervals above them. This third-order cyclic reciprocal sedimentation results from the interplay between allocyclic sedimentologic processes, the result of sea-level changes where carbonates were deposited in transgressive and highstand systems tracks and clastics in regressive and lowstand systems tracks. Fourth-order cycles on the other hand, barely resolvable by seismic, are greatly influenced by autocyclic processes. To image the plane geometry and reveal substantial changes in deposition and reservoir quality, multiple seismic attributes are analyzed. Seismic geometric attributes, seismic inversion, and spectral decomposition are concentrated on the

second Bone Spring sandstone with a 200 ft average thickness. This member can be further separated into three units by high-resolution sequence stratigraphic correlation performed on the petrophysical logs. Upper and lower units (the thickness of each is about 60 ft and 70 ft) have a complex deep-water mass transport style of deposition. Within these units, unconventional reservoir potential varies greatly both vertically and laterally over relatively short distances. The middle unit is a carbonate-rich interval with reduced reservoir quality, which reveals incision and erosion of the carbonate shelf moved more carbonate content into the basin. The detailed study of upper and lower sandstone units has far-reaching implications not only for horizontal well drilling in the immediate study area, but also for reservoir pattern recognition within the Bone Spring Formation across the Delaware Basin.