Exploring for Tight Oil in the Pennsylvanian Cleveland Sandstone on the Nemaha Ridge Using High Resolution 3-D Seismic and Stratigraphic Analysis: A New Play in an Old Area*

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Search and Discovery Article #40757 (2011)
Posted June 30, 2011

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* Adapted from poster presentation at AAPG Annual Convention and Exhibition, Houston, Texas, USA, April 10-13, 2011

Abstract

Although an active development target in the panhandles of Texas and Oklahoma, the Upper Pennsylvanian Cleveland Sandstone along the Nemaha Ridge of north-central Oklahoma and south-central Kansas has traditionally been viewed as a shallow (2,500’-3,000’), tight oil “teaser” or tertiary objective on the way down to other more economic objectives since the 1920’s. Much of the areal extent of the Cleveland is too thin and tight to be produced economically. However, by integrating high-resolution 3D seismic and detailed sequence stratigraphic analysis, thicker, productive Cleveland reservoir fairways can be identified and drilled economically on the Nemaha Ridge.

Cleveland depositional systems in the Nemaha Ridge area include river-dominated deltas and incised valleys, each with distinctive log and seismic characteristics. Deltaic reservoir successions occur in the upper two thirds of the Cleveland interval and are usually the best reservoirs. The deltaic reservoir units are composed of very fine to fine-grained sanding upward successions exhibiting dip-elongate behavior and rapid changes along strike. Cleveland valleys in the study area are blocky to fining-upward, lower medium to very fine grained units that occur in the lower part of the Cleveland succession.

Optimal drilling locations are best identified by fine-scale correlations and seismic mapping, linked to subtle syn-sedimentary tectonics. High-resolution 3D seismic (up to 1.4 million traces per square mile) has proven a key tool in differentiating and predicting optimal reservoir trends in this new play concept on the Nemaha Ridge.
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ABSTRACT

Tight sands in the Upper Pennsylvanian Cleveland Fm. are an active development target in the panhandles of Texas and Oklahoma, however, since drilling started in the 1920's along the Nemaha Ridge of north central Oklahoma and south central Kansas the Cleveland has traditionally been viewed as a shallow (2,500'-3,000'), thin, tight-oil "teaser" or tertiary objective on the way down to other more economic objectives. By integrating high-resolution 3D seismic and detailed sequence stratigraphic analysis, thicker, productive Cleveland reservoir pay can be identified and drilled economically on the Nemaha Ridge.

Cleveland depositional systems in the Nemaha Ridge area include river-dominated deltaands and incised valleys, each with distinctive log and seismic characteristics. Deltaic reservoir successions occur in the upper two thirds of the Cleveland interval and are usually the best reservoirs. The deltaic reservoir units are composed of very fine to fine-grained sanding upward successions exhibiting dip-couple lobe behavior and rapid changes along strike. Cleveland valleys in the study area are blocky to fining-upward, lower medium to very fine grained units that occur in the lower part of the Cleveland succession.

Optimal drilling locations are best identified by fine-scale correlations and seismic mapping, linked to subtle syn-sedimentary tectonics. High-resolution 3D seismic (up to 1.4 million traces per square mile) and seis-facies analysis has proven a key tool in differentiating and predicting optimal reservoir trends in this new play concept on the Nemaha Ridge and sets up and opportunity for focused horizontal exploitation. This type of analysis is broadly applicable to a number of other similar plays in new development areas.

Geology: Laterally Discontinuous Valley Fill & River-Dominated Deltaic Sands

Structural Cross Section showing the stepping of Cleveland stratigraphy over the North Brannan structure. This section follows the same line of section as the seismic image above.

Seismic section showing the nature of the structure stepped by the Lower and Upper Cleveland sands on the north-plunge of the North Brannan structure. This section follows the same line of section as the well-log cross section below. Note the strong amplitude anomalies associated with thick, porous sand development and the lack of response to thin sand development.
Ongoing Work & Conclusions

Conclusions

- L. Cleveland= Valley Fill Sands & U. Cleveland= River-Dominated Deltaics
- High-res 3D seismic delineates thick, porous Cleveland Sd.
- Areas of high accommodation allow seismic resolution of U & L Cleveland
- This work proposes numerous development & developcat wells
- Horizontal wells to optimize recovery in sub-reservoirs
- This analysis sets up a new oil play in a very old drilling province!