Reservoir Characterization of Complex Proglacial Ribbon Channels Through Integration of Seismic Attribute, Spectral Decomposition and Subsurface Geological Datasets: The Upper Ordovician Sarah Formation in Northern Arabia

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ABSTRACT

The complexity of Upper Ordovician proglacial channel systems, and subsequently developed reservoirs, have received considerable attention in recent years, particularly the petroliferous accumulations in North Africa and Jordan. The age equivalent synglacial sediments of the Sarah Formation in Northern Arabia also yield extensive hydrocarbon reserves. The Sarah Formation in the subsurface of the Nafud Basin is characterized by intense heterogeneity, rapid facies variations and complex erosional events. Sand accumulations are linear within narrow elongate ribbon channels incised into the preglacial stratigraphy, with porosity developed in sweet spots dictated by variations in grain size. Recent efforts in using advanced geophysical methods applied to a moderate quality 3D seismic volume resulted in a significant increase in geological understanding, which has directly translated into drilling success. Collaboration between seismic processers and interpreters has achieved tangible success in improving the imaging of channels utilizing techniques such as spectral decomposition, horizontal curvature, and direct mapping of the top and base of the reservoir. Blended RGB (red, blue and green) spectral decomposition has proven particularly useful with discrete Fourier transform (DFT), continuous wavelet transform and S-Transform algorithms at the 15, 20 and 25 Hz frequencies. Increased channel detection along with previously unseen channel morphology, cross cutting and splaying/bifurcating relationships has significantly enhanced the geological model. This was initially through simple channel classification (primary feeder “trunk” channels, secondary feeder channels and tertiary splays) and porosity mapping to understand the relationship between channel morphology/behavior, grain size distribution and ultimately porosity distribution. This mapped network of channels was then overlain on basin structure maps to understand the regional controls on channel distribution and behavior. The workflow and case study presented in this contribution highlights the profound benefit from adopting a multidisciplinary approach to the exploration of complex reservoirs, when detection, distribution and prediction of pay zones are beyond any single technique. The use of advanced seismic processing and interpretation has not only enhanced our understanding of the geological processes at numerous scales of investigation, it has also had a positive impact on reducing exploration risk.