Seismic Data Conditioning for Identification of Sand Dunes in the Early Jurassic Nugget Formation in the Moxa Arch*

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Abstract

The Moxa Arch has been an important geologic structure for hydrocarbon exploration since the mid-1940s in the Green River Basin. It is also recognized by the US Department of Energy as one of two carbon sequestration sites within Wyoming. The Early Jurassic Nugget Formation within the Moxa Arch is a possible reservoir for carbon sequestration, however past drilling may have compromised it as such. The Nugget Formation is an eolian sandstone that was deposited as part of the Early Jurassic sand sea that covered Arizona, Utah, and southwestern Wyoming. Seismic attribute analysis shows the presence of northwest-southeast trending linear geologic features believed to be eolian dunes and inter-dunal deposits. Previous works, using outcrop study, on the Nugget Formation have measured a northeast-southwest general paleo-wind direction during the time of deposition.

The petrophysical analysis of three surrounding wells also shows that the eolian sands have high porosity resulting in low impedance, while the inter-dunal deposits, composed of halite and anhydrite, are impermeable barriers and have high impedance. Furthermore, the structure-oriented filtering (SOF), when applied on the prestack data during seismic processing, improves the overall data quality and increases the resolution of the discontinuities seen in the coherence based attributes. After SOF, the time slices look sharper with preserved discontinuities and suppressed acquisition footprints. Analysis of co-rendered coherence and curvature clearly displays the extent and nature of the eolian dunes within the 3D volume. The seismic attribute analysis on the lineaments and the Ant Track workflow on the curvature attribute shows that the average paleo-wind direction was around N-225 degrees E which supports the previous outcrop studies.
1. Abstract

The Moxa Arch is a major geologic feature representing a paleo-eolian basin in southwestern Wyoming. The early Jurassic Nugget Sandstone, which underlies the Moxa Arch, is a possible reservoir for carbon sequestration, however, exploration for oil and gas has been limited in the area. The Nugget Sandstone is characterized by eolian sand dunes and interdunal deposits. Previous works using outcrop study, seismic attributes and well-log analysis indicated that the well C is more representative of a sand dunal environment compared to the well A. The presence of NW-SW trending eolian dune lineaments in the seismic data, which is coincident with the research through the Scholarship and giving us an opportunity to work with the seismic survey and the well logs. The seismic data was acquired using 3D land streamer acquisition methodology. The well analysis was performed using Schlumberger’s Petrophysics and Geophysical software packages. The results from the well analysis suggests that the overall lithology of the Nugget Sandstone may be uniform (i.e. sandstone); however, there is a significant amount of internal heterogeneity with bump facies, generated using Ant Track workflow (Silva et al., 2005) on corendered slice of the seismic data. The eolian dune lineaments begin to appear 24 ms below Nugget (fig. c). The eolian dune lineaments become prominent around 44 ms below Nugget (fig. d). The eolian dune lineaments are more prominent in the acoustic impedance (Zpimp) and reflectivity (Refl) tracks. The lithology is predominantly sandstone, there is a significant amount of internal heterogeneity in the well to seismic tie, confirms that the lineaments seen in the seismic data are within the Nugget Sandstone.

3. Seismic and Well data

4. Petrophysical Analysis and Lithological Heterogeneity

5. Seismic Attribute Analysis

6. Seismic Facies Analysis

7. Paleowind Direction

8. Modern-day Analog

9. Conclusions

The Nugget Sandstone is an interbedded deposits of eolian sand and interdunal deposits. High-resolution structural 3D seismic data were acquired in the Moxa Arch area over the Nugget Sandstone. The petrophysical analysis indicated that the Nugget Sandstone is a uniform sandstone (sandstone:impedance) and shows some internal heterogeneity. Large-scale and small-scale eolian deposits (sand dunes) are observed in the Nugget Sandstone. The cross beddings of the eolian sandstone indicate wind direction here is from NW to SE (Fig. 5). The wind direction shows the presence of NW-SW trending eolian dunes and interdunal deposits. Previous works, using outcrop study, seismic attributes and well-log analysis indicated that the well C is more representative of a sand dunal environment compared to the well A. The presence of NW-SW trending eolian dune lineaments in the seismic data, which is coincident with the research through the Scholarship and giving us an opportunity to work with the seismic survey and the well logs. The seismic data was acquired using 3D land streamer acquisition methodology. The well analysis was performed using Schlumberger’s Petrophysics and Geophysical software packages. The results from the well analysis suggests that the overall lithology of the Nugget Sandstone may be uniform (i.e. sandstone); however, there is a significant amount of internal heterogeneity with bump facies, generated using Ant Track workflow (Silva et al., 2005) on corendered slice of the seismic data. The eolian dune lineaments begin to appear 24 ms below Nugget (fig. c). The eolian dune lineaments become prominent around 44 ms below Nugget (fig. d). The eolian dune lineaments are more prominent in the acoustic impedance (Zpimp) and reflectivity (Refl) tracks. The lithology is predominantly sandstone, there is a significant amount of internal heterogeneity in the well to seismic tie, confirms that the lineaments seen in the seismic data are within the Nugget Sandstone.

References

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