

An Integrated Geostatistical and Seismic Facies Analysis Approach to Detect the Carboniferous Unayzah Stratigraphic Traps of Central Saudi Arabia

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ABSTRACT

The aeolian Unayzah A reservoir in central Saudi Arabia occurs in both structural and stratigraphic traps. Structural traps are relatively easier to identify using seismic mapping techniques. Stratigraphic traps, on the other hand, are becoming an important game changer in exploration as the risk of identifying them is high, but the reward could potentially be huge. The Carboniferous Unayzah reservoirs consist of a complex succession of continental clastics that were deposited following the Hercynian Orogeny and Gondwana glaciation. The upper Unayzah Group, containing most of the hydrocarbons, consists of the Wudayhi Member which comprises fine-grained sandstones and siltstones deposited in aeolian dunes, lacustrine deltas, swamps, and ephemeral lakes. Above the Wudayhi lies the Tinat Member comprising sandstones and siltstones deposited in playa lakes and dunes. A geostatistical approach was employed to characterize the trapping mechanism, and correlate it with exploration success. A total of 50 plus wells were used in the study area based on post-drilling analysis reports and well summaries, including source, reservoir, seal, charge and trap elements. A seismic facies analysis verification scheme was used to ascertain the geostatistical approach. This seismic facies model employed identifying facies based on well logs, core data and seismic information. The identified facies are further improved by incorporating seismic event continuity into the waveform classification. The most critical component for stratigraphic trapping is the presence of a lateral up-dip playa seal facies with low porosity and permeability. The lateral distribution of lithology is controlled by sedimentary facies. Therefore, recognizing facies and corresponding lithologies is key to characterizing the stratigraphic traps. The two sedimentary systems generally distributed in the study area are the aeolian system to the west, and the fluvial flood reworked aeolian system in the east. The western area, dominated by aeolian dunes (sandstone reservoir) and playa (siltstone seal), has further potential as confirmed by hydrocarbons discovered in the drilled wells. The fluvial-dominated eastern area appears less promising owing to an absence of effective seals. Favorable areas for stratigraphic traps are mapped to reduce the exploration risk and highlight potential areas for further exploration.