Sweet Spots Identification over a Basin-Center Gas Play Utilizing Deterministic Seismic Inversion

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SUMMARY

Both pre- and post-stack deterministic inversion of 3D seismic data were applied to map sweet spots within a Permo-Carboniferous clastic unit that has been identified as a potential basin-centered gas play in Saudi Arabia. The resulting acoustic and shear impedances were utilized to locate potential drilling locations. More than 30 wells within the area of interest covered by the 3D seismic data were used for this inversion.

A rock physics feasibility study including fluid substitution modeling and cross-plot analysis was carried out using eight wells; prior to conducting the seismic inversion. A mud invasion correction was performed to correct the log readings for the mud invasion zones to calibrate to in-situ reservoir conditions. Shear logs were predicted using different model transforms and fluid substitution was performed with model fluids ranging from brine to gas. This modeling was carried out using Gassmann’s equation over all eight wells. Modeling results showed more than 90% correlation between acoustic impedance and total porosity. Modeling also illustrated that $\lambda_\rho$ was the most sensitive elastic moduli when substituting gas for brine. Results revealed that $\mu_\rho$ was highly sensitive to porosity variation, but not to the pore fluid type. Sweet spots of porous hydrocarbon-bearing clastic reservoirs can therefore be identified as having low acoustic impedance, $\lambda_\rho$, and $\mu_\rho$. Based on the modeling from the eight wells, a transform was generated to relate porosity to $\mu_\rho$, and another was generated to compute water saturation from $\lambda_\rho$.

Inverted acoustic impedance was used to map the porosity sweet spots. In addition to mapping of the impedance, seismic sections of $\lambda_\rho$ and $\mu_\rho$ were generated and showed an excellent correlation with porosity and water saturation logs from the wells. The transforms generated from the rock physics analysis were also used to create porosity and water saturation volumes from the $\mu_\rho$ and $\lambda_\rho$ estimates, respectively.