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High-Resolution Three-Dimensional Water Saturation Prediction – A Case Study from Offshore Nile Delta

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ABSTRACT

Scarab field is part of the offshore Nile Delta that lies in West Delta Deep Marine (WDDM) concession, 50–100 km offshore in the deep water of the present-day Nile Delta. A series of successive exploration and appraisal encountered gas-bearing sands in slope canyon settings on the concession. The Scarab field is submarine delta slope canyon system, with complex turbiditic channel-levee reservoirs. The available data for this study are sorted into well-logs and seismic data. The available well-logs are P-wave velocity (Vp), S-wave velocity (Vs), and density (ρ) logs for seven wells. Other attributes as λρ were calculated from the original logs. The available seismic volumes are partial angle stacks of near (0°- 15°), mid (15°- 30°) and far (30°- 45°). In addition to full angle stack seismic volume. Prior the inversion, a negative of the second derivative and fourth order derivative attributes were made and compared in an attempt to increase the seismic resolution either for full-stack or for partial-angle stacks. Using the enhanced partial angle stacks of near, mid, and far with proper deterministic wavelets, a geostatistical inversion was conducted in an attempt to improve the inversion resolution and assess model uncertainty. The inversion provides multiple model realizations, each of which honors the seismic data, the well data, and the geostatistics. The mean of the realizations gives a highly resolved estimate of the acoustic impedance and shear impedance. Then, Vp/Vs volume was computed as well as the Lamé parameter volumes of lambda-rho (λρ) and mu-rho (μρ). Implementing probabilistic neural network, the inversion results were used to predict a water saturation 3D volume with the highest possible resolution. The resulted saturation volume was tested using blind well analysis and gave impressive results. The resulted volumes were used to better define the reservoir and optimize the new well location. By honoring existing well-log data, geostatistical inversion provides a way to increase the vertical resolution of acoustic and shear impedances above that available from seismic data. In addition, neural network provides a formulation that can efficiently establish a non-linear link between inversion results and water saturation. The proposed workflow delivered high-resolution water saturation volume that could be used to refine the construction of a reservoir model amenable to fluid-flow simulation and production history match.