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Enhancing Pre-Stack Seismic Inversion Using Neural Networks for Clastic Reservoir Characterization – Simian Field, Offshore Nile Delta, Egypt

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ABSTRACT

In hydrocarbon exploration, seismic guided estimation of reservoir properties away from well calibration is a common problem that geophysicists, geologists and reservoir engineers face. This problem arises due to the low resolution of seismic data (typically 10's meters and non-unique) relative to petrophysical data (typically 10's centimeter resolution and well calibrated to real rocks and fluids) as well as a lack of suitable models linking the two dataset. The characterization of reservoirs is a challenge to geoscientists who need to understand vertical and horizontal property distribution over the whole hydrocarbon field and supporting aquifer. The objective of this paper is to develop a framework under which we can improve the clastic reservoir characterization by using the pre-stack inversion and the neural-network analysis. The aim is to go beyond the limitations of full-stack seismic data and reduce the uncertainty as much as possible. The pre-stack inversion is a very powerful method to delineate the reservoirs and has been successfully used in the reservoir characterization but also has its limitations regarding the requirement of a reliable set of wavelets, suitably wire-line logged wells and sufficiently dense initial model. Therefore, the need arises for using another complementary method that can overcome the pre-stack inversion limitations. Artificial Neural Networks have the ability to recognize complex, non-linear relationships between seismic attributes and petrophysical data. The proposed workflow applied to the Simian gas field, one of the offshore Nile Delta's Pliocene gas fields. The available dataset includes; seismic partial angle stacks, well log data, and interpreted horizons. The workflow includes two main stages; pre-stack inversion stage and the neural network analysis. In the first stage, we applied the pre-stack inversion to produce elastic volumes (P- and S-impedances, and density) along with the derived facies volume. Then, we used the full-stack seismic as an internal attributes generator, and the inverted volumes as external attributes to train the artificial neural network to predict the water saturation and porosity. Hence, the integration of the two methods provides an intelligent solution for the clastic reservoirs' characterization. As the pre-stack inversion provides reliable impedance volumes and the neural-network analysis goes beyond the inversion limitations and characterizes the clastic reservoirs effectively.