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Fast-Track and Robust Reservoir Modeling Using Probabilistic Neural Network

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ABSTRACT

In highly heterogeneous basins with complex subsurface geology, as the Nile Delta basin, the accurate prediction of reservoir characteristics is a must. The reservoir characterization is a continuous process that begins with the field discovery and ends with the last phases of production and abandonment. Reservoir static modeling is the final step in the reservoir characterization process and consists of building an upscaled geologic model to be an input to the fluid simulations. The geostatistical reservoir-modeling (stochastic modeling) methods are widely used instead of the traditional deterministic modeling methods to consider the spatial statistics and uncertainties. However, the modeling workflows are slow, requiring months from initial model concept to flow simulation or other outputs; Moreover, the early stages errors become cumulative and are difficult to retrospectively change. The neural network inversion gained popularity over the last decades for its ability to establish non-linear relationships between the petrophysical logs and seismic data. It has been used to predict various reservoir properties with a reasonable amount of accuracy. Its main limitation resides at seismic resolution, and to overcome this problem a resolution-enhancing workflow has been adopted. This case study is from a Pliocene turbidite field in the offshore Nile Delta to illustrate the proposed modeling workflow. As a beginning, the resolution enhancement of seismic data is accomplished using derivative attributes and structural smoothing. Then, after proper well-log data conditioning, the training and cross-validation of Probabilistic Neural Network (PNN) are performed to produce shale volume (Vsh), porosity (φ), and water saturation (Sw) 3D volumes. The permeability (k) is calculated from por-perm relationship inside the reservoir. The results are then sampled in 3D grids and tested using dynamic simulation method to assimilate production history. After the initial history match process, PNN parameters are adjusted to improve the match. The final model represents the best match to original field measurements and production data which is then used in drilling decisions and production planning. The proposed neural network workflow reduces the reservoir modeling construction time by 80-90%, mitigates the cumulative error problems, and decreases the statistical uncertainty as it depends purely on seismic data to distribute the reservoir properties.