Integration of Deterministic Seismic Inversion with Machine Learning for Reservoir Characterization

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Abstract

Seismic inversion plays a key role in reservoir characterization. The inversion allows interpreters to transfer data from interface properties to layers and physical properties. Various deterministic approaches are available for interpreters to achieve this objective, including model-based, trace-based, recursive approaches, etc. Machine learning methods are increasingly adopted in reservoir characterization workflows to identify nonlinear and complicated relationships between various parameters, helping to predict one parameter from another or combine one with others.

In this study, we employ pre-stack model-based inversion to invert seismic data for P-wave and S-wave impedances. We extract numerous seismic attributes from the seismic data and use them to train a Feedforward Neural Network to predict the computed impedances at well locations. We compare the impedance models from deterministic inversion with those produced by the ANN. The resulting models are validated using wells that were not included in the inversion or ANN training. The ANN demonstrates good capability to reproduce results close to the inversion results. Having close impedances from the inversion and ANN enhances our confidence in the impedance models.

Next, the P-wave and S-wave impedance models are used for a detailed characterization of the fluvial-deltaic reservoir in the study area. Various quantities are derived, including Poisson ratio, Bulk modulus, Shear modulus, Lambda-Rho, and Mu-Rho. All models are combined using another ANN that has been trained to classify the area of interest into reservoir and non-reservoir facies. The trained ANN allows us to delineate potential reservoir facies and identify some new zones that are not drilled.

In conclusion, the ANN emerges as a key player in reservoir characterization. The above study's methodology can be applied to other fields. As the proposed workflow is data-driven, better results can be achieved than those in the present study.