Total Organic Carbon Content Prediction From Well Logs via Artificial Neural Network Models

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Abstract

Total organic carbon (TOC) content is a fundamental parameter for source rock evaluation, a criterion for potential shale reservoir and an essential input in basin modeling analysis. A continuous TOC distribution is required for adequate source rock evaluation, which cannot be provided practically by lab measurement of samples. This work constructs two Artificial Neural Network (ANN) models for deriving continuous TOC distributions from well logs for two of the most important source rock successions in the region: Jurassic carbonate and Silurian clastic source rocks. A total of 1447 carbonate and 1085 clastic source rock samples from 49 wells, covering an area of 200 km × 350 km, were collected for TOC measurements. The data quality was strictly controlled by removing samples contaminated by oil-based mud, and by depth matching the samples to the logs. The five most commonly run logs (gamma, density, sonic, neutron and resistivity) are used for the maximum applicability of the models. All the five logs are used together as inputs to maximally capture relationship between TOC and logs. Two models have been constructed, trained and tested for the two source-rock successions respectively. The two models were applied to the 49 sampled wells. Comparison between the modelled results and the measured TOC shows that the models perform very satisfactorily. The lab-based TOC results are commonly sample-biased and they only capture the TOC values for the sampled depths. Source-rock layers are very heterogeneous in nature, which is very difficult to capture by analysis of selected samples. This innovative method predicted the heterogeneities better as it provides the continuous TOC distribution. The clastic source-rock model has also been successfully blind tested on two wells 900 km away from the wells used in modelling. The modeled

results also show that the carbonate source-rock model cannot be applied to clastic source rock, and vice versa. This, in principle, is true because logs are responses of full rock composition, in which TOC is only a small component. In conclusion, the ANN models provides continuous TOC distributions and it can capture source-rock heterogeneities. In addition, the models are specific to source-rock types. This method can help industry to save considerable cost and time, particularly when detailed and continuous source-rock assessment is needed to better understand conventional and unconventional petroleum systems.

Keywords: Total organic carbon content, source rock analysis, basin modeling, prediction, well logs, artificial neural network models

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