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Statistical and Machine Learning Methods for Spatial Prediction of Microporosity in Carbonate Reservoirs

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ABSTRACT

Micropores can significantly impact reservoir quality and production potential in carbonate reservoirs. Yet, subsurface derived porosity estimates cannot differentiate micropores from the effective porosity which is contributing to reservoir flow. Microporous reservoirs are pervasive throughout the Arabian platform and studies have shown that not only are the micropores oil-bearing but they can contribute to secondary oil recovery through a time-dependent spontaneous imbibition process. Advances in enhanced oil recovery techniques are making production from poorly swept microporous intervals a possibility. Success of any EOR strategy is dependent on accurate spatial prediction of microporosity and hence reservoir quality. Here, we present two methods for micropore prediction in the subsurface: multivariate polynomial regression and artificial neural network models. Data for this case study comes from a Jurassic, bimodal carbonate reservoir. Key depositional lithofacies include micritic mudstones, bivalve-coated grain pack/grainstones, Cladocoropsis pack/grainstones, stromatoporoid coralgal pack/grainstones, and skeletal-oolitic grainstones. An idealized reservoir model was constructed to visualize lithofacies and reservoir properties. Microporosity was quantified by confocal and light microscopy coupled with core plug and laboratory measurements. These data were then used to train and validate mathematical models for microporosity prediction. Descriptors, including measured porosity, texture, lithology and lithofacies were evaluated as input variables to the models. These were chosen as they can easily be attained from core data and/or estimated through petrophysical analysis. The models were then compared to identify the most appropriate and accurate prediction method. The more accurate model was then applied to the subsurface data in the reservoir model for microporosity prediction and visualization. Several key uncertainties exist in using machine learning models for subsurface micropore prediction and further research is needed to identify the descriptors that best relate available subsurface data to microporosity. Although the example outlined here is an idealized case, the methods and implications for microporosity distribution and prediction can be extended to any subsurface carbonate reservoir where microporosity plays a significant role in reservoir performance.