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Machine Learning-assisted Vuggy Carbonate Reservoir Characterization: Application to Mature Oil Fields

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ABSTRACT

Reservoir characterization of carbonate formations is challenging due to heterogeneities and diagenesis. Vugs in carbonate formations hold the potential for fluid storage, and enhanced oil recovery from mature fields. In general, vugs can be identified from core samples and high-resolution image logs, which are limited and expensive. The goal of this work is to develop novel methods to detect vugular porosity in wells without core samples and image logs. The Cambrian Copper Ridge Formation in the Appalachian basin is selected for this study. This carbonate formation produces hydrocarbon from remnant fields. First, vugs are identified from a limited number of wells with relevant core samples and image logs. Next, an ensemble of various machine learning algorithms, such as Support Vector Machine, Artificial Neural Network, and Random Forest etc., are used to train the model using conventional well log suites, such as gamma ray, bulk density, neutron porosity, and photo-electric index. Model performance is assessed by using 5-fold cross-validation method. The results show that Support Vector Machine is the best performer for vug prediction among all other machine learning algorithms. Higher proportion of model-predicted vugs correlated to hydrocarbon production data. Furthermore, a new well was drilled inside the study area with whole core collection. The predicted vugs correlated to presence of actual vugs and distribution of oil in the core. Such techniques can be useful for local and regional-scale reservoir characterization of other carbonate formations.