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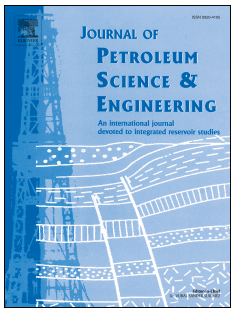

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Surrogate Models for Production Performance from Heterogeneous Shales

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Abstract

Heterogeneity in geologic parameters such as permeability, porosity and formation compressibility is observed in all reservoirs including the ultra-low permeability reservoirs such as shales. Computing requirements for reservoir simulation of these reservoirs are extensive because of the complexity in geologic model. Surrogate models have been used successfully in conventional reservoirs and homogeneous low-permeability reservoirs. In this study, robust surrogate models are developed to evaluate production performance from heterogeneous low-permeability reservoirs. A workflow is presented to create surrogate models from any or all of the properties which affect production. Methods of representing various degrees of heterogeneities in permeability are considered in this paper. The surrogate models are mathematical functions for important outcomes – recoveries, gas oil ratios (GOR) with respect to the heterogeneous property as input. Representing productions at particular time for different permeability distributions requires a unique function. Logarithmic equation for oil recovery and power law equation for cumulative GOR are found to be the most appropriate functions. The developed surrogate models are then utilized to forecast production for any input distribution of permeability using Monte Carlo simulations. Outputs in the form of probability density functions (PDF) of oil recovery and cumulative GOR are generated after statistical analysis. The probabilistic output is then interpreted as deterministic time series by considering mean values along with their uncertainty bands of standard deviations and 5-95% probability ranges. These

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