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Study of the Single Phase and Two Phase Flow Properties of the Berea Sand and Oil Sand; A Network Model Study

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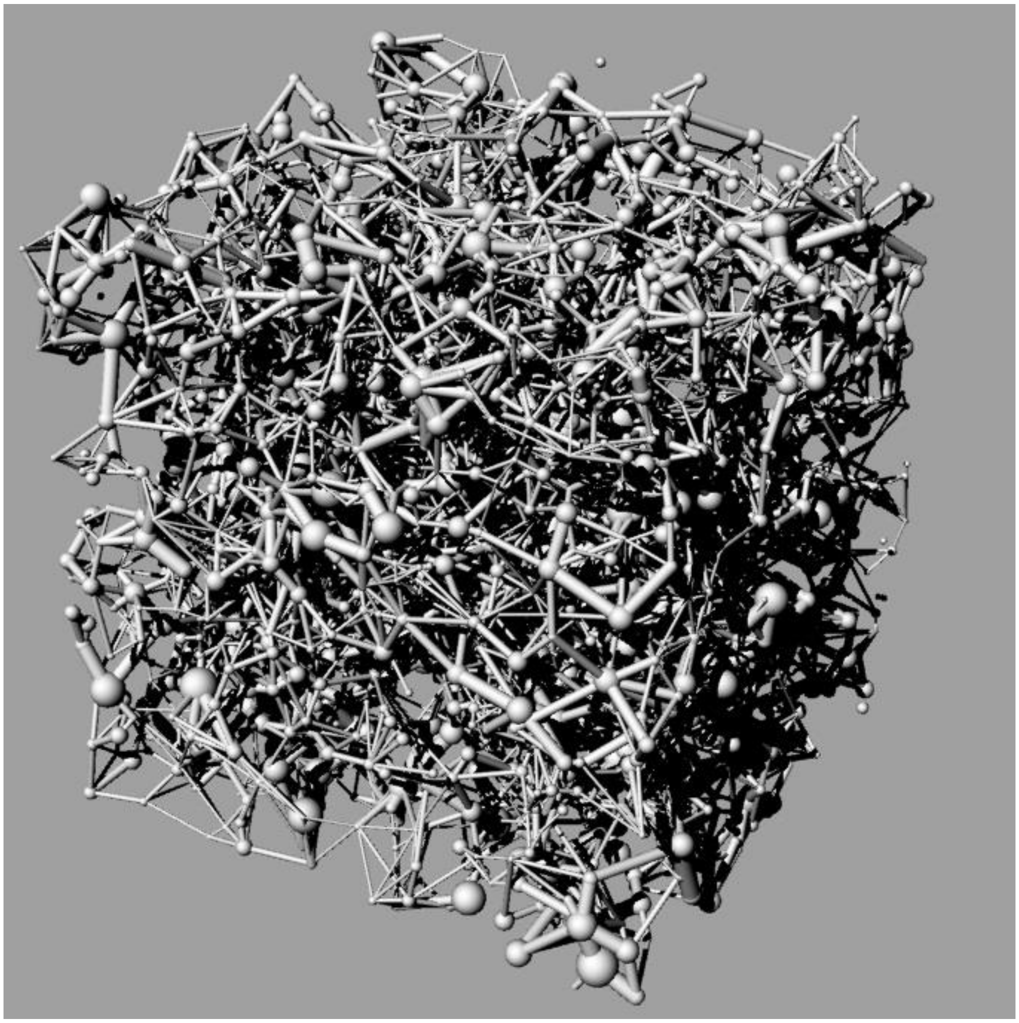
Introduction

Porosity, permeability, and formation factor are among the most important rock properties since they can be used for evaluation of hydrocarbon recovery. Pore size distribution and throat size distribution have direct effect on porosity and a major effect on the permeability and formation factor of the medium. By being able to replicate the properties of the porous media, it can be possible to model and predict single phase and two phase flow properties. The goal of this work is to find the right pore body structure and distribution along with the corresponding throat size distribution in order to match the topology of said porous media and then use it for predicting multiphase flow properties. Full pore scale modeling (digital core analysis) is computationally expensive and time consuming. Laboratory measurements are considerably more expensive and considerably more time consuming than digital core analysis. The approach taken in this study is to represent pore space using 3D network models, and to tune these network models to be able to predict flow behaviour in tight rocks.

Theory and/or Method

A 3D random network model is constructed using realistic pore size, throat size, and throat length distributions obtained from the literature as a representation of the Berea sandstone and Oil sands. The porous space is represented by pore bodies of different shapes and sizes which are connected to each other by pore throats of varying length and diameter. Pore bodies are randomly distributed in space and their connectivity varies based on the connectivity number distribution which is used in order to generate the network. Pore size distribution, throat radius size distribution, throat length distribution, and connectivity number is tuned in order to match the single phase flow properties. The obtained networks are fed to the network modelling software in order to predict two phase flow properties.



The network modelling software solves the fundamental equations of two-phase immiscible flow incorporating the effect of wettability and interfacial tension. Pore level displacement mechanisms such as piston-like displacement, pore body filling, and snap-off are incorporated. The model can handle both a continuous film of the wetting phase and discontinuous wetting on the walls of the network elements. At strong wetting conditions this guarantees low wetting-phase saturation after forced drainage. Wetting phase trapping occurs only because of non-wetting-phase bypassing during forced drainage. On the other hand, non-wetting phase trapping is as a result of both bypassing of the wetting phase, and snap-off. It is demonstrated how changing the pore size distribution, pore connections and pore throats/lengths, it can be possible to model capillary pressure, relative permeability, and resistivity index curves in tight porous media.

Conclusions

The results show that the single phase flow properties calculated by the network model match the experimental data available in the literature. This indicates that the network is a good representaion of the porous medium. In addition, predicted two phase flow properties are in good agreement with physical expectations and show the effect of wettability and interfacial tension.

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