Modeling Rock Cores Using MATLAB

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Introduction

The study of CO_2 sequestration and storage in rocks has significant applications in the fight against climate change.

The goal of the present study is to create a visual model of core-scale rocks, which reside at an intermediate stage between pore and reservoir scale.

This study also seeks to simulate certain experiments that are conducted in the lab (single and multi-phase flow), so that a deeper understanding of the physical experiment can be achieved in observing the model.

Method

Code was manufactured to create cylindrical and rectangular models with various rock properties, such as permeability, porosity, and lamination geometry, to represent real rocks that are used in lab experiments.

MATLAB Reservoir Simulation Toolbox (MRST), a free downloadable addition to the traditional MATLAB platform, was used to create all models and simulations in this study.

Modules in MRST were used to produce simulations of one and two-phase flow that were applied to the models and helped produce graphs related to how each rock stores carbon.

Results

Figure 1: Real Rock Core

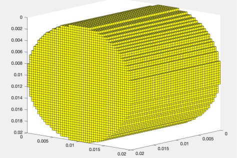

Figure 2: Cylindrical Model of Rock Core

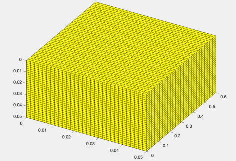

Figure 3: Rectangular Model of Rock Core

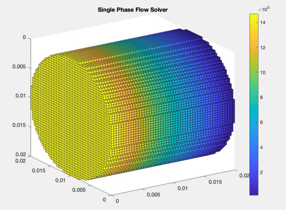

Figure 4: Pressure Gradient from Single-Phase Flow Solver

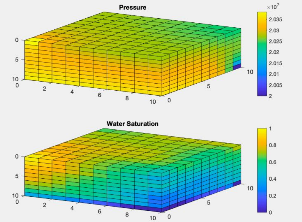

Figure 5: Pressure and Water Saturations from Two-Phase Flow Solver

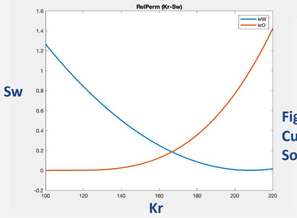

Figure 6: Relative Permeability Curve from Two-Phase Flow Solver

Explanation and Analysis

The single-phase flow solver (Figure 4) consists of boundary conditions with pressures that shift at either end of the model, while the two-phase model (Figure 5) focuses on a water and non-wetting solution as they move through the model with one another. The two-phase solver also produces density comparisons and relative permeability curves (Figure 6).

The models and simulations were able to be constructed accurately using MRST. Their purpose in providing a visual aid to the carbon storage and other mechanisms that were occurring within the rock cores was successful.

Conclusions

Core-scale modeling is a small but integral piece of the carbon storage puzzle. This study evidences that core-scale models act as a conduit to go from pore to reservoir scale. They allow for a deeper understanding of the carbon storage mechanisms in rock cores and provide insight to the small physical processes that impact core-related experiments in the lab.

Recommendations for future studies include extending the code to automatically calculate effective permeability values and the ability to map laminations to the model directly from a photo of a rock core.

Works Cited

1. K.A. Lie, An introduction to reservoir simulation using MATLAB, https://www.cambridge.org/9781108492430
2. R.T, Two Phase AD Simulator, https://github.com/raymondt8/fas_mrst/blob/master/twoPhaseAD.m