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Multiscale Pore Network Modeling of Hierarchical Media with Applications to Improved Oil and Gas Recovery

For complex geological materials such as carbonates and tight sandstones having pores at several scales, the conventional relationships are not adequate to quantify transport properties. Therefore, it becomes important to study these complex rocks at the pore scale and apply relevant physics for transport properties. However, with the current state of imaging technology it is not possible to obtain realistic images of the rock having pores at several orders of magnitude in a single image. Therefore, it becomes necessary to generate artificial images having micropores, macropores and solids that span several length scales. Since, in these artificially generated three phase images we can have control over the size and spatial distribution of pores, we can attempt to mimic several real rock types. Once realistic artificial images are generated, although strenuous, a pore network can be extracted such that the transport properties are calculated, interplay between micro- and macro-porosity can be studied, which may lead to reservoir characterization that is much faster and at a lower cost.

In this work, first we have attempted to generate two phase and three phase multiscale images artificial images and then devised a method of network extraction on these three phase images in a single step and thus created a multiscale pore network model using OpenPNM. Also, a three-phase segmentation of real sandstone image was prepared where the developed algorithm can be tested.

In these multiscale artificial images, we have a cubic grid in the micropores region modeled as continua, with effective properties. The macropores are then stitched together with the continua scale, thus creating a hybrid hierarchical pore network that possess information at several scales. The multiscale pore network algorithm prepared in this work is fast and robust and has been tested on several 2D and 3D images. Porosity, permeability and formation factor has been calculated on the generated images and the resulting pore networks.

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