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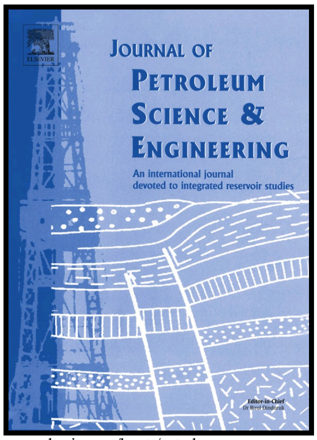

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Omar Al-Hinai, Rencheng Dong, Sanjay Srinivasan, Mary F. Wheeler

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A new equi-dimensional fracture model using polyhedral cells for microseismic data sets

Omar Al-Hinai[a,*], Rencheng Dong[a], Sanjay Srinivasan[b], Mary F. Wheeler[a]

[a] *Center for Subsurface Modeling, University of Texas at Austin, United States*
[b] *Department of Energy and Mineral Engineering, Pennsylvania State University, United States*

Abstract

We present a method for modeling flow in porous media in the presence of complex fracture networks. The approach utilizes the Mimetic Finite Difference (MFD) method. We employ a novel equi-dimensional approach for meshing fractures. By using polyhedral cells we avoid the common challenge in equi-dimensional fracture modeling of creating small cells at the intersection point. We also demonstrate how polyhedra can mesh complex fractures without introducing a large number of cells. We use polyhedra and the MFD method a second time for embedding fracture boundaries in the matrix domain using a "cut-cell" paradigm. The embedding approach has the advantage of being simple and localizes irregular cells to the area around the fractures. It also circumvents the need for conventional mesh generation, which can be challenging when applied to complex fracture geometries. We present numerical results confirming the validity of our approach for complex fracture networks and for different flow models. In our first example, we compare our method to the popular dual-porosity technique. Our second example compares our method with directly meshed fractures (single-porosity) for two-phase flow. The third example demonstrates two-phase flow for the case of intersecting ellipsoid fractures in three-dimensions, which are typical in microseismic analysis of fractures. Finally, we demonstrate our method on a two-dimensional fracture network produced from microseismic field data.

Keywords: Mimetic Finite Difference method, Discrete fracture model, Microseismic

1. Introduction

Fractures play a significant role in porous media fluid flows. As a result, there is an enormous body of literature devoted to flow modeling in fractured media. The most common approaches rely on homogenization or upscaling of the fracture network. The most notable example of upscaling is the dual-porosity/dual-permeability method (DPDP) (Arbogast et al., 1990; Warren and Root, 1963). In the DPDP model, fractures are represented as a continuous medium within a computational cell and communicate with the rock matrix through interaction terms and shape factors. The DPDP approach has been widely used in reservoir simulation, as it is fast and relatively simple to adopt. The main challenge of DPDP is in incorporating complex physical processes. Much like other upscaling approaches, it is often difficult to upscale non-linear effects such as gravity and capillary pressure.

In contrast, discrete fracture models (DFM) directly represent fracture networks in the computational mesh, accounting for fracture geometry and connectivity. By doing so, DFM can solve for complex physical processes without the need to upscale those effects. In the DFM setting, one typically has the option of either an equi-dimensional or a lower-dimensional representation of fractures. In the equi-dimensional case, fractures are represented directly in the computational mesh with the same dimensionality of the overall problem. Examples of this approach can be found in (Hægland et al., 2009; Ochs et al., 2002). Maintaining the dimensionality of the fracture domain has the advantage of

*Corresponding author
Email addresses: ohinai@gmail.com (Omar Al-Hinai), rencheng_dong@utexas.edu (Rencheng Dong), sanjays@psu.edu (Sanjay Srinivasan), mfw@ices.utexas.edu (Mary F. Wheeler)