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Fracture Characterization and Modeling Various Oil-Recovery Mechanisms for a Highly Fractured Giant Light-Oil Carbonate Reservoir

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Abstract

Proper fracture characterization and a good understanding of the fracture-matrix system are critical to properly predict oil recovery from naturally fractured reservoirs. In this work, we use an integrated analysis of image logs, production logs, and production history to help constrain matrix and fracture properties. This is done by extracting a sector from the history-matched full field model of a naturally fractured giant light oil carbonate reservoir and explicitly studying matrix fracture flows.

Even with constraints provided by the above analysis, there is still significant uncertainty regarding matrix permeability in our reservoir. We built simple mechanistic models to study the impact of this uncertainty on various oil recovery mechanisms such as miscible gas injection and primary depletion. We also quantified the impact of capillarity, diffusion and gravity on recovery mechanisms.

Introduction

In recent years discrete fracture models (DFM) have become popular to model large-scale flow charcteristics in naturally fractured reservoirs [1]. Discrete fracture models have the adavantage of representing the fracture features and the matrix explicitly thus eliminating the need for simplifying assumptions commonly used in dual porosity and equivivalent upscaled single medium models. The accuracy of these models is however dependent on proper characterization of the fracture features. Also, single medium and dual porosity models still play an important role as discrete fracture models are computationally intensive and simpler models can often be run quickly to understand certain recovery mechanisms better. Thus proper modeling of naturally fractured reservoirs would involve several steps as noted below: 1). Characterize the fractures with available field information such as rates, PLT logs, image logs and pressure transient information 2). Generate a reference solution using any of the discrete fracture models available. 3). Create effective properties through mechanistic modeling and comparison with the generated reference models for the corresponding dual porosity and single porosity models. There are several studies in the literature that address the step 1 by attempting to characterize the fracture network by integrating seismic, continuity cube interpretations and well data into discrete fracture network models [1-3]. However there are very few studies in the literature that make use of dynamic data such as PLT logs and production information to characterize the fractures. Recently Sullivan et al., [4] have made use of PLT log information to better characterize the permeability distributons of a giant light oil carbonate reservoir. In this work we extend the use of PLT information to better characterize fractures by analyzing this information at a discrete fracture scale. The second step of generating a reference models is an active area of research and there are several authors [1,5-8] have put forward several techniques such as control volume finite element methods [5,6], and multiscale methods [7,9] to generate reference solutions. Hui et al., [1] have recently used a finite difference control volume method to generate refererence solution for a realistic sector of a giant large carbonate reservoir. Typically such models would rely on proper inputs of realistic fracture attributes for accurate field scale predictions. As for the third step in the modeling of fractured reservoirs there are several studies which examine the various recovery mechanisms at a grid block scale and have developed expressions to integrate these mechanisms into dual-porosity model by means of transfer functions. Several authors such as Tealdi et al., [10], Kang et al., [11], Kossack et al., [12,13] and also discuss methods to upscale these fracture matrix systems to single porosity models for different recovery scenarios such as natural depletion and miscible gas injection. Wit et al., [14] have studied the simulation of the gravity drainage process for a huge field with long vertical fracture features and have come up with pseudo relative permeabilities for each gridblock in a huge stack of grid blocks. In this work we have constructed simple mechanistic models of the fracture – matrix system and studied the different recovery mechanisms such as miscible gas injection and primary depletion. We have studied the impact of the fracture parameters such as the fracture spacing, matrix parameters, such as the permeability on the overall recovery of these processes.