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Governing Forces in Fractured Reservoirs: A Data-Driven Sensitivity Analysis

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In recent years, research to understand recovery mechanisms in fractured porous media has become more common. Specifically, recovery in fractured rock is governed by three forces: viscous force, gravitational force, and capillary force. This study provides a review and numerical simulation to capture the effect of the combined forces that determines the oil recovery in fractured porous media. Also, we extend our discussion to include an upscaling method for field-scale applications.

We capture these governing forces through numerical simulation with a finite volume scheme and unstructured grid. The fractures are modeled with the Discrete Fracture Model (DFM) approach. We conducted a series of oil-water and oil-gas flow simulation scenarios by varying permeability contrast, viscosity contrast, density contrast, capillary contrast, injection rate, fracture opening (aperture), fracture orientation, and fracture network. Then, we developed a ternary diagram to classify several recovery mechanisms based on the percentage of working forces. Also, we developed a new upscaling method for field-scale application. We conducted a comprehensive literature review to compare our results with existing theories in the literature. For verification, we matched the published experimental data and assigned the results to existing technology, such as conventional water injection and injection in the weak water-wet reservoir, ... etc. Finally, this method will help our understanding of the dominant recovery mechanisms in fractured porous media.

From the simulation results, we observed that permeability contrast, viscosity contrast, and injection rate control the viscous force in the reservoir. Also, fracture aperture has a significant impact on viscous forces since it is related to permeability via the cubic law. The capillary contrast between fracture and matrix governs the water-oil interface position in fracture-matrix connection. When capillary forces dominate over viscous forces, it can slow down the water breakthrough and increase oil gain, which is known as imbibition. However, when gravitational forces increase, they will negatively impact capillary forces. As a result, oil recovery will be mainly driven by viscous forces. Also, since the ratio of competing forces varies at different positions in the reservoir, we introduced a new upscaling technique to assess the dominant recovery mechanism at certain areas of interest in a reservoir.

This work aims to improve the understanding of several possible recovery mechanisms scenarios in fractured porous media based on the fundamental forces acting in a reservoir. Also, we present an upscaling technique of these mechanisms for field-scale application.

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References

Time Block Preference

Time Block B (14:00-17:00 CET)

Participation

In person

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