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Please fill in your abstract title.	High-definition Analysis and Evaluation of Gas Displacement EOR Processes in Fractured Shale Oil Formations

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Abstract

Objectives

The main objective of this study is to analyze and describe quantitatively the effectiveness of several alternative strategies of gas-displacement EOR processes in increasing production from multi-fractured shale oil reservoirs. The study evaluates the efficacy of (a) three different gases (CH_4, CO_2 and N_2) as displacement agents, (b) continuous gas injections vs. "huff-and-puff" processes, and (c) the effects of bottomhole management, in addition to describing the effects of various natural or induced fracture regimes.

Methods, Procedures, Process

In this numerical simulation study, we use the TOUGH+Millstone simulator with the OilGasBrine option that describes the coupled flow, thermal and geomechanical processes associated with the flow of fluids in shale reservoirs. We focus on the analysis of the 3D minimum repeatable element (stencil/domain) that can describe a hydraulically-fractured shale reservoir under production. This stencil is discretized using a very fine (to a mm-scale) grid. We compare the solutions to a reference case that involves simple depressurization-induced production (no gas drive), and we monitor continuously the rate and composition of the production stream, as well as the spatial distributions of pressure, temperature, phase saturations and relative permeabilities. Note that the geomechanical results and effects associated with this study are reported elsewhere.

Results, Observations, Conclusions

The results of the study indicate that CO2 appears to be the most effective gas displacement agent, leading to a substantial production increase because of significant reductions in the viscosity and the irreducible saturation (associated with the decrease in the interfacial tension) of oil. The effectiveness of CH4 is lower, and that of the N2 is the lowest because of its minor impact on viscosity. Continuous injection appears to have a slight overall advantage over the huff-and-puff process, but their relative performance is a function of the time frame of production and of the displacement gas. In continuous injection, a continuous linear decline of the bottomhole pressure provides the best production performance. In all cases, early arrival of the displacement gas at the hydraulic fracture may pose a problem if it bypasses a significant portion of the matrix volume.

Novel/Additive Information

Novel components of this study are the simultaneous consideration of all processes (including flow, thermal, geomechanical, physical-chemical) associated with the gas-drive EOR operation and production of fluids from shale oil reservoirs using high-resolution 3D grids, capturing in detail phenomena that are attenuated in coarser grids. Additionally, the study describes the system behavior for several displacement gases and production scenarios (continuous displacement, huff-and-puff, bottomhole pressure management), thus providing important quantitative information for the design and management of EOR processes in shale oil reservoirs.