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THREE-DIMENSIONAL UNSTABLE DISPLACEMENT OF MISCIBLE VISCOUS FLUIDS FROM POROUS MEDIA

Abstract

Microgravity investigations serve as a tool, which could help to study flows in porous media being much better understood in microgravity studies eliminating the masking effects of gravity. The problem is relevant to a hydrocarbon recovery, which is performed by the flow of gas under a pressure differential displacing the high viscosity fluid. Entrapment of high viscosity fluid by the low viscosity fluid flow lowers down the quality of a hydrocarbon recovery leaving the most of viscous fluid entrapped thus decreasing the production rate. The developed models and obtained results are applicable to description of liquid non-aqueous phase contaminants underground migration, their entrapment in the zones of inhomogenity, and forecasting the results of remediatory activities in the vicinities of waste storages and contaminated sites. The goal of the present study was to perform linear and non-linear stability analysis of displacement and flushing of a highly viscous fluid by a less viscous one from porous medium. The Saffman-Taylor instability was investigated analytically. The results of previous investigations showed that for immiscible fluids accounting for surface tension allows to determine characteristic length scale of instability (width of viscous fingers). While for miscible fluids linear analysis obtaining analytical dependences of fingers width on values of governing parameters was proved to be impossible. The novelty of results presented in the paper is that taking into account small viscous terms and using Navier-Stokes system of equations instead of Darcy model allowed to obtain analytical solutions determining finger thickness for miscible fluids. Numerical investigations of the instability in displacement of viscous fluid by a less viscous one in a two-dimensional and three-dimensional geometry were carried out. The effect of the three-dimensional phenomena on development of instability was investigated. The authors wish to acknowledge the support by Russian Foundation for Basic Research (Grant 09-08-000265).