Pore-Level Bénard-Marangoni Convection in Microgravity

P. Mohammadmoradi[1], A. Kantzas[1]

[1]University of Calgary, Calgary, AB, Canada

Abstract

Pore-level displacement of heavy-oil during thermal operations such as SAGD and CSS is a multi-scale phenomenon due to the complex nature of depletion mechanisms. As the gravity drainage is the main depletion mechanism within the intergranular pore space, the surface tension-related phenomena are dominant within microstructures and intragranular pore spaces. In a micro-scale pore-throat system, the effect of Marangoni flow is amplified because of extremely reduced buoyancy-driven flows; microgravity. Due to the low Bond number, the fluid-fluid and solid-fluid interface development is controlled by the geometry and wettability of the medium and is not greatly affected by gravity and viscose forces. In this work the COMSOL Multiphysics® software platform is used to simulate oil mobilization in a single-pore geometry as a result of Bénard-Marangoni convection mechanism and the reduction of the bypassed oil saturation due to the thermally induced interfacial tension gradient fluxes is monitored. The displacement scenarios are designed and conducted in a wide range of temperature and wettability conditions. According to the results, during the heating process the fluids configuration is dictated by the capillary pressure and deformed by the capillary pressure gradient across the interface.

Reference

1. F.J. Argüelles-Vivas, T. Babadagli, Gas (air)–heavy oil displacement in capillary media at high temperatures: A CFD approach to model microfluidics experiments, Chemical Engineering Science, Volume 140, 2 February 2016, Pages 299-308, ISSN 0009-2509.

2. M. Khosravi, A. Bahramian, M. Emadi, B. Rostami, E. Roayaie, Effect of Marangoni flow on recovery of bypassed oil during CO2 injection, Journal of Petroleum Science and Engineering, Volume 114, February 2014, Pages 91-98, ISSN 0920-4105.

3. M. Hennenberg, M. ZiadSaghir, A. Rednikov, J.C. Legros, Porous media and Benard–marangoni problem, Transp. Porous Media, 27 (1997), pp. 327–355.

4. A.C. Lam, R.S. Schechter, W.H. Wade, Mobilization of residual oil under equilibrium and non-equilibrium conditions, Soc. Pet. Eng. J., 23 (5) (1983), pp. 781–790.