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Non-equilibrium modeling of hydrate dynamics in porous media

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Abstract

Natural gas hydrates represents a substantial possible energy source for the future. Unlike conventional hydrocarbon resources hydrates are widely spread globally in offshore deposits and permafrost regions. Hydrates in porous media are unable to establish thermodynamics equilibrium. The reason for this is that local temperature and pressure are given locally by geothermal gradients and hydrostatics (or fluid mechanics in flowing systems). Gibbs phase rule can never be fulfilled for hydrates in a porous media because there are too many phases compared to the 2 degrees of freedom already fixed by nature since also adsorbed layers (mineral surfaces, hydrate surfaces) have impact for the hydrate phase transitions in the pores and have to be accounted for. Practically this implies that reservoir simulators for modeling of hydrate production needs to consider competing processes of hydrate formation and dissociation under the constraints of mass- and heat transport. We therefore propose to use a reactive transport simulator as basis for our hydrate model. Every phase transition that involves hydrate is treated as a "pseudo reaction" with corresponding thermodynamics and kinetics. For this purpose we also developed consistent absolute thermodynamics for all phase involved so as to enable free energy minimization. Kinetic models are developed based on a phase field theory with implicit hydrodynamics and heat transport. Simulation results are extracted and systemized into simplified models suitable for reservoir simulators. The approach is illustrated and discussed for pressure reduction and injection of carbon dioxide as two production methods of methane hydrate.

Biography

Bjørn Kvamme completed his PhD in molecular physics and the Norwegian University of Science and Technology in 1984. He was a professor at Telemark University College from 1987 to 1998 and then moved to University of Bergen for 2 years at Chemistry department and professor at department of Physics and Technology from 2000. He is presently running a research group of 12 PhD students, one post.doc and an additional professor. Thermodynamic and kinetic modeling are keywords for research that stretched from quantum mechanics up to reservoir scale natural or industrial processes. He has so far published more than 200 review papers.