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Reservoir scale simulation of hydrate dynamics

Bjørn Kvamme (1), Mohammad Taghi Vafaei (2), Ashok Chejara (3), and Khaled Jemai (4)

(1) University of Bergen, Bergen, Norway (bjorn.kvamme@ift.uib.no), (2) University of Bergen, Bergen, Norway (mohammadtaghi.Vafaei@ift.uib.no), (3) University of Bergen, Bergen, Norway(Ashok.Chejara@ift.uib.no), (4) University of Bergen, Bergen, Norway (Khaled.Jemai@ift.uib.no)

Gas hydrates in reservoirs are generally not in chemical equilibrium and there may be several competing hydrate phase transitions like for instance hydrate dissociation due to pressure or temperature changes, hydrate reformation, hydrate dissociation due to contact with undersaturated fluids and mineral surfaces. The limited numbers of reservoir simulators, which have incorporated hydrate, are normally simplified by considering only pressure and temperature and oversimplified kinetic description. Reservoir scale simulation of hydrate dynamics are important investigations, which enable engineers to predict the production potential of a gas hydrate reservoir and propose efficient production scenarios. Hydrate phase transitions are generally fast compared to mineral dissolution and precipitation, which stresses the need for implicit analysis of the geo mechanical impact of the different coupled processes involved in hydrate dissociation and formation. This is critical in order to prevent formation damages, which can result in collapses or leakages. Several research groups have been recently working on this subject but there seems to be significant differences in their approaches and results. In addition, the few reservoir simulation codes for hydrate production, which consider geo mechanics, do this through explicit couplings to geo mechanical software packages. In this work a reactive transport reservoir simulator, namely Retraso CodeBright has been modified to account for hydrate kinetic reactions in the reservoir. For this purpose, hydrate has been added as a pseudo-mineral component and advanced kinetic models of hydrate reactions generated through phase field theory simulations have been simplified and implemented in this reservoir simulator. It can be extended to account for as many hydrate phase transitions as likely and consider kinetic rates of different competing reactions. The primary step was to study the effect of hydrate growth or dissociation with a certain kinetic rate on the mechanical properties of the reservoir. The simulator has been validated through available references comparing performance of different hydrate simulators. In the next step, effects of hydrate formation and dissociation on the reservoir characteristics are studied through porosity and permeability changes. Details of the simulator, and numerical algorithms, are discussed extensively and some relevant examples are shown.