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Study of Formation Mechanisms of Gas Hydrate

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Gas hydrates, which had been found in subsurface geological environments of deep-sea sediments and permafrost regions, are solid crystalline compounds of gas molecules and water. The estimated energy resources of hydrates are at least twice of that of the conventional fossil fuel in the world. Gas hydrates have a great opportunity to become a dominating future energy. In the past years, many laboratory experiments had been conducted to study chemical and thermodynamic characteristics of gas hydrates in order to investigate the formation and dissociation mechanisms of hydrates. However, it is difficult to observe the formation and dissociation of hydrates in a porous media from a physical experiment directly. The purpose of this study was to model the dynamic formation mechanisms of gas hydrate in porous media by reservoir simulation.
Two models were designed for this study: 1) a closed-system static model with separated gas and water zones; this model was a hydrate equilibrium model to investigate the behavior of the formation of hydrates near the initial gas-water contact; and 2) an open-system dynamic model with a continuous bottom-up gas flow; this model simulated the behavior of gas migration and studied the formation of hydrates from flowed gas and static formation water in porous media.
A phase behavior module was developed in this study for reservoir simulator to model the pressure-volume-temperature (PVT) behavior of hydrates. The thermodynamic equilibriums and chemical reactions were coupled with the phase behavior module to have functions modelling the formation and dissociation of hydrates from/to water and gas. The simulation models used in this study were validated from the code-comparison project proposed by the NETL.
According to the modelling results of the closed-system static model, we found that predominated location for the formation of hydrates was below the gas-water contact (or at the top of water zone). The maximum hydrate saturation observed was located just below the gas-water contact.
The open-system dynamic model showed that the hydrates were basically uniformly distributed in a homogeneous porous media at a constant gas migration rate. However, if the gas migration rate was extremely low, the hydrates will tend to concentrate at the bottom of water zone (i.e. at the first contact of the water and the flowed gas) and finally blocked the vertical flow of gas. The models we designed can be scaled up to a field scale, and the research findings from this study can be contributed to the dispersion analysis of an in-situ hydrate reservoir.