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Strategies for Gas Production From Hydrate Accumulations Under Various Geological and Reservoir Conditions

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The objective of this study is the analysis and development of appropriate strategies for gas production from a wide range of natural hydrate accumulations. These strategies involve the three main hydrate dissociation mechanisms (depressurization, thermal stimulation, inhibitor effects) either individually or in combination. Selection of the appropriate strategy is strongly influenced by the geological setting and the conditions prevailing in the hydrate accumulation. The TOUGH2 general-purpose simulator with the EOSHYDR2 module was used for the analysis. EOSHYDR2 models the non-isothermal gas release, phase behavior and flow in binary hydrate-bearing porous and fractured media (involving methane and another hydrate-forming gas) by solving the coupled equations of mass and heat balance, and can describe any combination of mechanisms of hydrate dissociation.

In terms of production strategy and behavior, hydrate accumulations are divided into three main classes. In Class 1 the permeable formation includes two zones: the hydrate interval and an underlying two-phase fluid zone with free (mobile) gas. In this class, the bottom of the hydrate stability zone occurs above the bottom of the permeable formation. Class 2 features a hydrate-bearing interval overlying a mobile water zone (e.g., an aquifer). Class 3 is characterized by the absence of a hydrate-free zone, and the permeable formation is thus composed of a single zone, the hydrate interval. In Classes 2 and 3, the entire hydrate interval may be well within the hydrate stability zone (i.e., the bottom of the hydrate interval does not necessarily indicate hydrate equilibrium).

We study gas production from several accumulations that span the spectrum of realistic representations within and across the three hydrate classes. The numerical simulations indicate that, in general, the appeal of depressurization decreases from Class 1 to Class 3, while that of thermal stimulation increases. Thus, simple depressurization appears to enjoy an advantage over other production strategies in Class 1 hydrate deposits. The most promising production strategy in Class 2 hydrates involves combinations of depressurization and thermal stimulation, and is clearly enhanced by multi-well production-injection systems, e.g., a five-spot configuration. Because of the very low permeability of hydrate-bearing sediments, the effectiveness of depressurization in Class 3 hydrates is limited, and thermal stimulation through single well systems seems to be the strategy of choice in such deposits (and especially so in high hydrate saturation regimes). These observations should only be viewed as general principles because the significant variability within each class, the case sensitivity and the insufficient body of prior experience on hydrates do not allow the outright dismissal of any production strategy in any class. The sensitivity of production to important parameters and conditions is investigated, and the limitations of the various production strategies are discussed.