Classification of Gas Hydrate Deposits and Corresponding Production Strategies

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RESEARCH OBJECTIVES

Gas hydrates are solid (ice) crystalline compounds, inside the lattices of which gas molecules can be encased. Vast amounts of hydrocarbons are thus trapped in hydrate deposits. 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.

APPROACH

The TOUGH2 general-purpose simulator with the EOSHYDR2 module was used for the analysis. EOSHYDR2 models the nonisothermal 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. This model can describe any combination of hydrate dissociation mechanisms—and can also account for up to four phases (gas phase, liquid phase, ice phase, and hydrate phase) and up to seven components (CH_4-hydrate, water, native methane, dissociated methane, native and dissociated components of a second hydrate-forming gas, salt, water-soluble inhibitors, and heat).

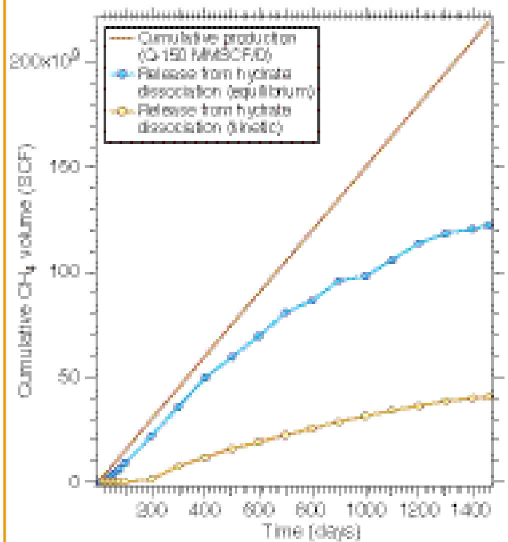

Figure 1. Cumulative release of CH_4 from hydrate dissociation during gas production from a Class 1 hydrate in the North Slope of Alaska

ACCOMPLISHMENTS

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).

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 for 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).

SIGNIFICANCE OF FINDINGS

This is the first-ever (a) classification of gas hydrate deposits and (b) development of general principles for gas production strategies based on the hydrate deposit classification.

RELATED PUBLICATIONS

Moridis, G.J., Numerical studies of gas production from methane hydrates. SPE Paper 75691, SPE Journal, 2003 (in press); Berkeley Lab Report LBNL-49765.

Moridis, G.J., Numerical simulation studies of thermally induced gas production from hydrate accumulations with no free gas zones at the Mallik Site, Mackenzie Delta, Canada. SPE Paper 77861, SPE 2002 Asia Pacific Oil and Gas Conference and Exhibition, Melbourne, Australia, October 8–10, 2002; Berkeley Lab Report LBNL-50256.

Moridis, G.J. and T. Collett, Strategies for gas production from hydrate accumulations under various geologic conditions. Berkeley Lab Report LBNL-52568, 2003.

ACKNOWLEDGMENTS

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