Oil & Natural Gas Technology

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Quarterly Progress Report
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Comparative Assessment of Advanced Gas Hydrate Production Methods

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Gas Hydrates Assessment
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Quarterly Report – Q4 (FY2008)

Executive Summary

This project will compare and contrast, through numerical simulation, conventional and innovative approaches to producing methane from gas hydrate-bearing geologic reservoirs. Initially, the project will investigate the production of gas hydrates from idealized reservoir configurations. If the initial investigation shows promise for the innovative approaches, additional simulation studies will be conducted using actual gas hydrate reservoir data from the Alaska North Slope (ANS) region.

Results of Work During Reporting Period

Phase I

Task 1: Project Management

A project review was held in Morgantown on August 25, 2008. Due to a misunderstanding on presentation dates, the modeling task leader missed the review but did represent the project during a separate review on August 26.

At the request of the NETL COR, a revised Cooperative Agreement was prepared and submitted for review and approval.

Task 2: Technology Status Assessment

This task was completed in the third quarter of this year with the submission of the summary report.

Task 3: Reservoir Simulation

The revised Cooperative Agreement includes a series of investigations that will employ STOMP-HYD to numerically simulate the production of natural gas hydrate accumulations. The objectives of this series of investigations will be to determine injection scenarios that are suited for an accumulation class. The principal focus will be the design of a pilot-scale field experiment. The production parameters that can be controlled include:

- injectant form
  - dissolved CO_2
  - CO_2 micro-emulsion
  - pure CO_2
- injectant and extraction well pressure
- injectant temperature

    - constant temperature
    - variable temperature
- injection and extraction well screen intervals
- formation permeability (i.e., hydraulic fracturing)

Performance metrics for the simulations will include production rates, production effectiveness, CO_2 sequestration, and energy consumption.

This series of investigations was initiated this quarter by considering production of Class 1 natural gas hydrate accumulations (i.e., a hydrate-bearing layer above a mobile gas layer within a confined permeable formation). For pilot-scale experimental purposes, the spacing between the injection and extraction well is 50 m. As the Class 1 accumulation involves two distinct layers within the permeable zone, several well screen intervals are being considered. The production parameters include:

- injectant form
    - dissolved CO_2
    - 25% volumetric micro-emulsion
    - 50% volumetric micro-emulsion
    - pure CO_2
- well pressure
    - 15 MPa injection pressure
    - 4, 6, 8 MPa extraction pressure
- injectant temperature
    - 15, 30, 45, 60°C
    - 60°C decaying to 30°C
- screened intervals
    - hydrate and full injection-well screening
    - hydrate extraction-well screening
- formation permeability
    - 1, 10, 100 x intrinsic permeability of formation

Results from a portion of the simulations involving Class 1 Hydrate Accumulations are being published[1] at the upcoming GHGT-9 conference, being held in Washington, D.C.

Whereas the numerical simulation of hydrate production using the more conventional technologies of depressurization and thermal stimulation is intricate with a large number of possible phase transformations, the simulation of the CO_2 injection technologies is further complicated by the inclusion of an additional component, the occurrence of mixed hydrates, and the possibility for liquid-CO_2 phase. These types of simulations commonly suffer from convergence problems that either requires relatively small time steps or restarting a stalled execution. The most promising scenarios for producing Class 1 natural gas hydrate accumulations appear to be those that produce a hydrate-free zone around the injection and extraction wells, but force flow through the hydrate zone. Maintaining reduced pressures around the extraction well creates a hydrate free zone through conventional depressurization. Forcing

[1] White, M.D. and B.P. McGrail. 2008. "Designing a pilot-scale experiment for the production of natural gas hydrates and sequestration of CO_2 in Class 1 hydrate accumulations," In Proceedings of 9th International Greenhouse Gas Control Technologies Conference, November 16-20, 2008, Washington, D.C.

flow through the hydrate-bearing zone requires that the extraction well only be screened within the hydrate-bearing zone. Free hydrate zones around the injection wells are created by injecting into the hydrate-bearing zone at elevated temperatures or by injecting into the lower hydrate-free zone.

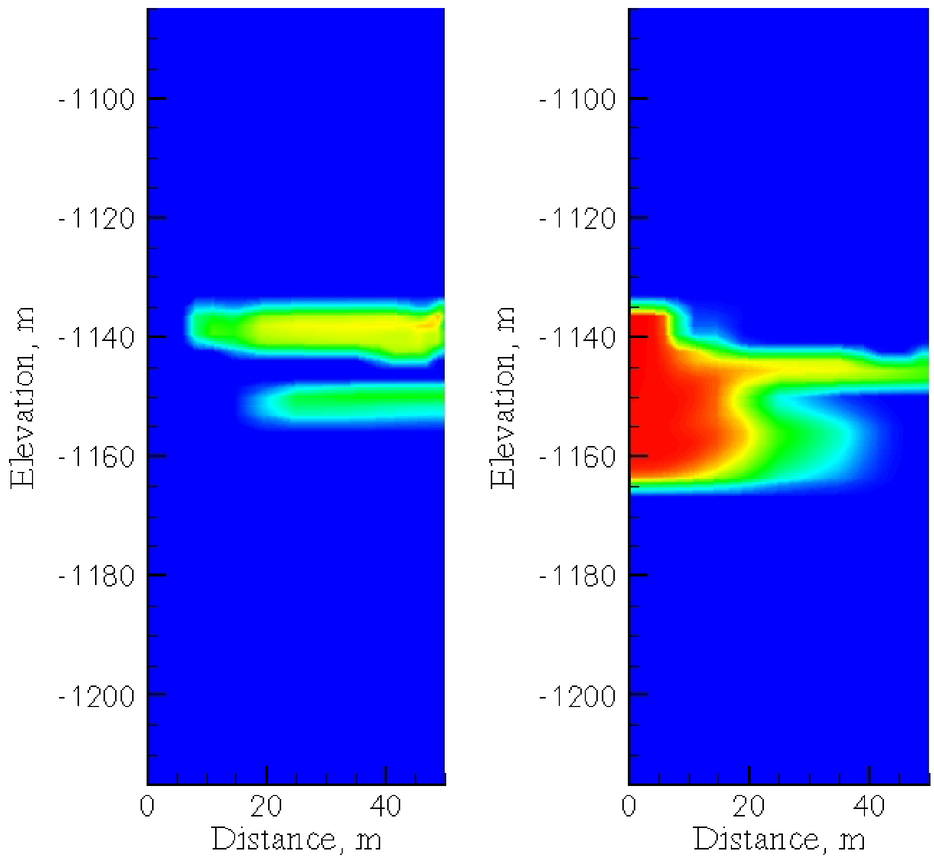

Figure 1. Hydrate saturation (left) and aqueous mass fraction of CO_2 (right) after producing a Class 1 Hydrate Accumulation using a dissolved CO_2 injectant stream at 60 C. Lower hydrate interval is secondary hydrate that is nearly pure CO_2 hydrate and upper hydrate interval is mixed CH_4-CO_2 hydrate at saturations below the initial hydrate saturation of 0.7.

Significant Issues and Corrective Action

None.

Publications and Presentations

White, M.D. and B.P. McGrail. 2008. "Designing a pilot-scale experiment for the production of natural gas hydrates and sequestration of CO_2 in Class 1 hydrate accumulations," To be presented at the 9th International Greenhouse Gas Control Technologies Conference, November 16-20, 2008, Washington, D.C.

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