Designing a Pilot-Scale Experiment for the Production of Natural Gas Hydrates and Sequestration of CO_2 in Class 1 Hydrate Accumulations

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Problem Statement

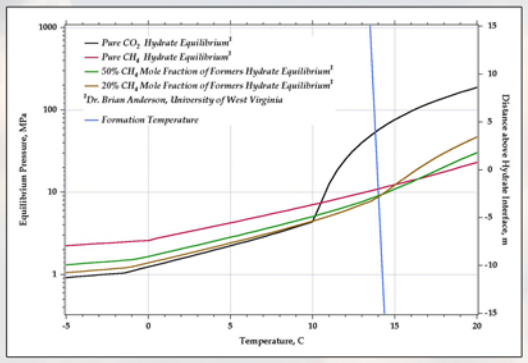
Investigate the feasibility of sequestering CO_2 and producing CH_4 in natural gas hydrate accumulations at the scale of pilot experiments.

- Laboratory experiments conducted at the University of Bergen and ConocoPhillips Reservoir Engineering laboratory indicate that CO_2 could be successfully exchanged with CH_4 in small gas hydrate bearing Bentheim sandstone cores.
- Transport of the guest molecules was principally via diffusion in the laboratory experiments.
- This study used numerical simulation to investigate whether the exchange technology could be applied on the pilot scale for a Class 1 hydrate accumulation.

Background

- Conventional production technologies for geologic accumulations of natural gas hydrate include depressurization, thermal stimulation, and inhibitor injection.
- Global assessments of natural gas resources have shown that gas hydrate resources exceed those of conventional resources, which is indicative of the potential for clathrate hydrate sequestration of CO_2.
- Production of natural gas hydrates using the CO_2 exchange technology conceptually represents a neutral carbon energy source; where, one molecule of CO_2 is sequestered for each produced molecule of CH_4.

- The CO_2-CH_4 exchange technology is founded on the favorable thermodynamics of CO_2 hydrates over CH_4 hydrates, but this also leads to technical challenges associated with producing secondary hydrates and clogging of the reservoir.

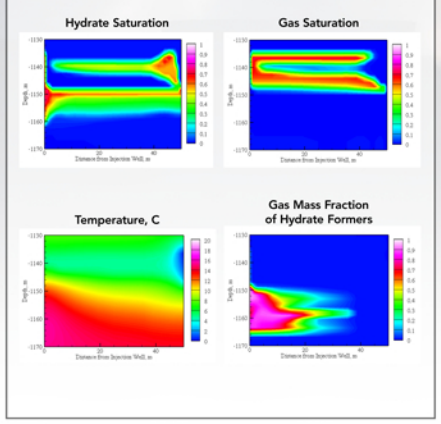


Method(s) Used

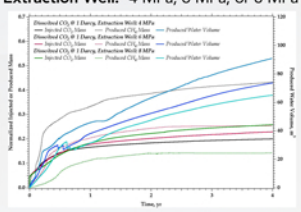
STOMP-HYD was used to simulate the injection of CO_2 into a sandstone formation, confined above and below by shale, having a hydrate-bearing layer overlying a mobile gas layer (i.e., Class 1 Hydrate Accumulation).

Results

Hydrologic Domain: 1 Darcy, 0.7 Initial Hydrate Saturation
Injection Well: 10% Microemulsion @ 15 MPa, 30C
Extraction Well: 4 MPa
Time: 4 years



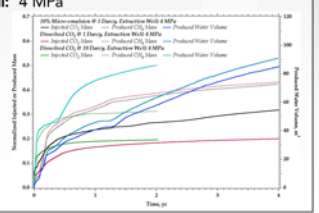
Hydrologic Domain: 1 Darcy, 0.7 Initial Hydrate Saturation
Injection Well: Dissolved CO_2 @ 15 MPa, 30C
Extraction Well: 4 MPa, 6 MPa, or 8 MPa



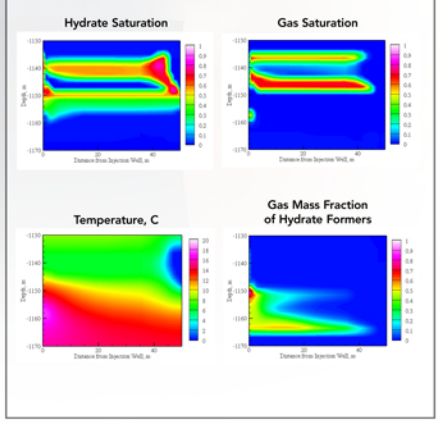
Sequestered CO_2, Produced CH_4, and Produced Water as a function of Extraction Well Pressures

Hydrologic Domain: 1 Darcy, 0.7 Initial Hydrate Saturation
Injection Well: 10% Microemulsion @ 15 MPa, 30 C
Extraction Well: 4 MPa
Time: 4 years

Sequestered CO_2, Produced CH_4, and Produced Water as a function of Conductivity and CO_2



Hydrologic Domain: 10 Darcy, 0.7 Initial Hydrate Saturation
Injection Well: Dissolved CO_2 @ 15 MPa, 30C
Extraction Well: 4 MPa
Time: 2 years



The sequestration/production scheme involved a five-spot well pattern with the central well serving as the injection well and the perimeter wells as the extraction wells, using a 50-m well spacing. Injection wells were screened across the sandstone and the extraction wells were screened across only the hydrate-bearing interval. To investigate the response of the formation a series of simulations were conducted that varied injectant temperatures from 15 to 60° C, and three forms of injected CO_2:

1) saturated aqueous solution,
2) micro-emulsion, and
3) pure CO_2.

Formation properties represented those of a permafrost accumulation, following the descriptions of [1]Moridis (2007).

Reference

[1] Moridis, GJ, MB Kowalsky, K Pruess. 2007. "Depressurization-Induced Gas Production from Class 1 Hydrate Deposits," SPE Reservoir Evaluation and Engineering, 10(5):458-481.

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