Pore-scale visualization of hydrate phase transitions during CO2 Injection into CH4 hydrate saturated porous media

Pandey, Jyoti Shanker; Strand, Ørjan; von Solms, Nicolas; Ersland, Geir; Almenningen, Stian

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AUTHORS (FIRST NAME, LAST NAME): JYOTI PANDEY\textsuperscript{1}, Ørjan Strand\textsuperscript{2}, Nicolas von Solms\textsuperscript{1}, Geir Ersland\textsuperscript{2}, Stian Almenningen\textsuperscript{2}
INSTITUTIONS (ALL): 1. CHEMICAL ENGINEERING, Danmarks Tekniske Universitet, Lyngby, Denmark.
2. Physics Department, University of Bergen, Bergen, Norway.
3. Department of Chemical Engineering, Danmarks Tekniske Universitet, Lyngby, Denmark.
ABSTRACT BODY:
Abstract: In this work, we visualize pore-scale hydrate phase transitions during CO\textsubscript{2} injection into CH\textsubscript{4} hydrate-saturated porous media. A total of six visualization experiments were performed using a water-wet, high-pressure silicon wafer-based micromodel with a pore network resembling a cross-section of sandstone. Liquid CO\textsubscript{2} was injected at a constant volumetric rate of 0.2-0.5 mL/hour into the pores already saturated by CH\textsubscript{4} hydrates at P = 59-69 bar and T = 3.3-4.5°C. The initial saturation of CH\textsubscript{4} hydrates was high (S\textsubscript{H} = 0.81-0.99), while the rest of the pore space was saturated by liquid water and CH\textsubscript{4} gas. The results showed that the hydrate phase changes were influenced by the initial liquid distribution and the amount of CO\textsubscript{2} injected. A low CO\textsubscript{2} injection rate formed massive hydrates surrounded by CO\textsubscript{2}-rich fluid, while high CO\textsubscript{2} injection rates and ultimate injection volumes led to the formation of massive hydrates without residual fluid saturation. Later, stepwise depressurization was performed to visualize the dissociation and reformation patterns of the resulting hydrates. Multiple hydrate dissociations and reformations were observed between the stability pressure of pure CH\textsubscript{4} hydrates and pure CO\textsubscript{2} hydrates. Migration of pore water and mixing of fluids caused localized hydrate reforming at lower pressures. This is the first pore-scale visualization of CO\textsubscript{2} injection into CH\textsubscript{4} hydrate-saturated porous media and demonstrates the feasibility of combining CH\textsubscript{4}/CO\textsubscript{2} exchange with pressure reduction to produce CH\textsubscript{4} gas.

(No Image Selected)