CERE
Center for Energy Resources Engineering

CERE - SEMINAR

Thursday 21 September 2023
09:15 to 10:00 a.m.
Building 229, Room 003
(Breakfast is served from 9:00, please bring your own coffee/tea)
Online from link in calendar invitation

"Multiscale investigation on CH_4 hydrate production and CO_2 hydrate storage at marine subsurface"

By

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Abstract

Gas hydrates are crystallized compounds consisting of cage-like structures formed by water molecules and gas molecules such as methane (CH_4) and carbon dioxide (CO_2) [1]. Abundant CH_4 hydrates as prospective energy resources are distributed in natural hydrate-bearing sediments [2]. To recover CH_4 gas for energy utilization, it is needed to dissociate solid CH_4 hydrates into gas and water. Depressurization as the most economically feasible exploitation method has been implemented in several field tests [3, 4]. However, it is still a bottleneck to maintain long-term efficient production of CH_4 hydrates. Essential properties of hydrate-bearing sediments, e.g. pore surface wettability and gas/water/hydrate saturations/occurrences [5, 6], are the controlling factors deciding CH_4 hydrate formation/dissociation and thus need well understood.

In first microscale study, microfluidic chips (10 μL) were employed to investigate CH_4 hydrate dynamics. This work focused on: (1) confirm whether CH_4 gas hydrates form through agitation; (2) how CH_4 hydrates and gas/water vary dynamically; and (3) conclude effects of gas saturation/distribution and hydrophilicity/hydrophobicity on CH_4 hydrate dynamics. Outcomes of this work would help to understand fluid properties and solid surfaces affecting hydrate formation/dissociation in micropores, providing pore-scale insights on CH_4 hydrate dynamics in different fluid saturation and wettability. Micro-characteristics of CO_2 hydrate dynamics were also studied to confirm the feasibility of CO_2 hydrate storage in pores simulating marine subsurface.

CH_4-CO_2 hydrate swapping is a potential way for carbon-neutral CH_4 hydrate exploitation [7]. The swapping mechanism is that the enthalpy of CO_2 hydrate formation can compensate that of CH_4 hydrate dissociation [8]. However, this method is inefficient when it is employed solely due to limited mass transfer. Combination of CH_4-CO_2 swapping with depressurization could efficiencies by additionally dissociating hydrates and enhancing mass transfer [9, 10].

In second macroscale study, a steel reactor (142 ml) with in-situ Raman and a larger reactor (980 ml) with marine loose sands were both employed to investigate a new combination method: coupled amino acid injection and slow depressurization with hydrate swapping exploitation. Amino acids are

environmental-friendly promotors without generating foam and used to kenetically faciliate hydrate formation [11]. Multistep depressurization after CH_4-CO_2 hydrate swapping has been proved capable to combat the trade-off of CH_4 recovery and CO_2 storage [12-14] in our recent works. This work targeted to verify: (1) whether CH_4-rich gas production and CO_2-rich hydrate storage can be enhanced by amino acid injection and depressurization; (2) mechanisms of amino acid injection and slow depressurization affected CH_4/CO_2 hydrate formation/dissociation; (3) effects of amino acid types, solution concentrations, injection pressures and depressuization modes on exploitation performances. The results would guide optimizing CH_4 gas recovery and CO_2 hydrate storage by this new combination method of amino acid injection coupled with controlled depressurization on CH_4/CO_2 mixed hydrates.

References:

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