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Combined CO₂ storage in hydrate with simultaneous release of CH₄ and limitations of adding N₂ to the CO₂**Bjørn Kvamme**

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Huge resources of energy in the form of natural gas hydrates are widely distributed worldwide in permafrost sediments as well as in on shore sediments. A novel technology for combined production of these resources and safe long-term storage of carbon dioxide is based on the injection of carbon dioxide into in situ methane hydrate-filled sediments. This will lead to an exchange of the in situ methane hydrate over to carbon dioxide- dominated hydrate and a simultaneous release of methane gas. Recent theoretical and experimental results indicate that the conversion from natural gas hydrate to carbon dioxide hydrate and mixed carbon dioxide/methane hydrate follows two primary mechanisms. Direct solid state transformation is possible, but very slow. The dominating mechanism involves formation of a new hydrate from injected carbon dioxide and associated dissociation of the in situ natural gas hydrate by the released heat. Nitrogen is frequently added in order to increase gas permeability and to reduce blocking due to new hydrate formation, and will as such also reduce the relative impact of the fast mechanism on the conversion rates. In addition to carbon dioxide, other sour gases, such as hydrogen sulfide, may follow the carbon dioxide from the sour gas removal process. Hydrogen sulfide is a very aggressive hydrate former. It is abundant in various amounts in thermogenic hydrocarbon systems. In this work, we investigate the sensitivity of possible additions of hydrogen sulfide in carbon dioxide/nitrogen mixtures, and how the ability to form new hydrate changes with the additions of hydrogen sulfide. This analysis is applied to four case studies: (1) Bjørnøya gas hydrate basin, (2) the Nankai field in Japan, (3) the Hikurangi Margin in New Zealand, and (4) a gas hydrate basin in South-West Taiwan. The hydrate saturations found in these fields vary over a range from 25–80%. Pressures range from 4–22.6 MPa and temperatures from 275.15–292.77 K. For all these ranges of conditions, even 1% H₂S will substantially increase the ability to form new hydrate from an injected CO₂/N₂ mixture containing H₂S. Except for the most shallow of the reservoirs (Bjørnøya) 1% H₂S results in formation of a new hydrate for all concentrations of CO₂ in N₂ above 1%. Implementation of results from this work into a reservoir simulator is a natural follow-up which can shed light on the macroscopic consequences in term of possible local blocking of the flow due to content of H₂S. The mass transport, mass balances, and energy balances in a reservoir simulator are also needed for a more detailed evaluation on how the content of H₂S and CO₂ changes over time and location in the reservoir due to various processes in addition to hydrate formation. H₂S and CO₂ dissolves significantly in pore water, and also adsorbs well on various sediment minerals.

Biography

Bjørn Kvamme obtained his MSc in Chemical Engineering (1981) and PhD in Chemical Engineering (1984) from the Norwegian University of Technology and Natural Sciences. After a short period with SINTEF and two years at Bergen University College, he was appointed as full Professor in 1987 and started education of MSc and PhD in Process Technology in Telemark. He is appointed as a Professor in Gas Processing at the Department of Physics, University of Bergen in March 2000. He is the author/co-author of 422 publications during last 25 years, of which 148 are in good international scientific journals. He has 2270 citations as per May 1, 2017, and has presented numerous papers at international conferences.

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