



NRC Publications Archive Archives des publications du CNRC

New insights on gas hydrate formation in sand through magnetic resonance imaging

Bagherzadeh, S. Alizera; Englezos, Peter; Moudrakovski, Igor L.; Ripmeester, John A.

This publication could be one of several versions: author's original, accepted manuscript or the publisher's version. /
La version de cette publication peut être l'une des suivantes : la version prépublication de l'auteur, la version acceptée du manuscrit ou la version de l'éditeur.

Publisher's version / Version de l'éditeur:

Proceedings of the 7th International Conference on Gas Hydrates (ICGH 2011), 2011-07

NRC Publications Record / Notice d'Archives des publications de CNRC:

<https://nrc-publications.canada.ca/eng/view/object/?id=59d5d14b-3441-49f7-859e-60504664f46e>
<https://publications-cnrc.canada.ca/fra/voir/objet/?id=59d5d14b-3441-49f7-859e-60504664f46e>

Access and use of this website and the material on it are subject to the Terms and Conditions set forth at

<https://nrc-publications.canada.ca/eng/copyright>

READ THESE TERMS AND CONDITIONS CAREFULLY BEFORE USING THIS WEBSITE.

L'accès à ce site Web et l'utilisation de son contenu sont assujettis aux conditions présentées dans le site

<https://publications-cnrc.canada.ca/fra/droits>

LISEZ CES CONDITIONS ATTENTIVEMENT AVANT D'UTILISER CE SITE WEB.

Questions? Contact the NRC Publications Archive team at

PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca. If you wish to email the authors directly, please see the first page of the publication for their contact information.

Vous avez des questions? Nous pouvons vous aider. Pour communiquer directement avec un auteur, consultez la première page de la revue dans laquelle son article a été publié afin de trouver ses coordonnées. Si vous n'arrivez pas à les repérer, communiquez avec nous à PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca.



NEW INSIGHTS ON GAS HYDRATE FORMATION IN SAND THROUGH MAGNETIC RESONANCE IMAGING

S. Alireza Bagherzadeh, Peter Englezos*
Department of Chemical and Biological Engineering
University of British Columbia
Vancouver, BC, V6T 1Z3
CANADA

Igor L. Moudrakovski, John A. Ripmeester
Steacie Institute for Molecular Sciences
National Research Council
Ottawa, ON, K1A 0R6
CANADA

ABSTRACT

Methane hydrate was formed in an unconsolidated bed of silica sand and the process was monitored with magnetic resonance imaging. The sand particle size and the water content were varied and their effect on hydrate nucleation and growth was observed. It was found that hydrate formation in porous media does not proceed in a uniform manner and nucleation of hydrate crystals occurs at different times and different positions inside the bed, a phenomenon which is referred to as multiple nucleation in space and time. Furthermore, hydrate formation was found to be faster in a bed with lower water content and smaller particle size.

Keywords: hydrate formation, magnetic resonance imaging, kinetic, nucleation, porous media

NOMENCLATURE

I	Intensity of the MRI image [a.u.]
I_0	Intensity at time 0 [a.u.]
n	Number of moles of gas [mol]
n_f	Number of moles of gas consumed at the end of experiment [mol]
t	Time [min]
PSR	Particle Size Range (diameter in μm)
W.C.	Water Content (mL)
χ	Percentage of conversion of water to hydrate(%)

INTRODUCTION

Hydrates or clathrates are crystalline storehouses of natural gas which are composed of cage-like structures of hydrogen-bonded water molecules known as the host lattice. Generally, any molecule

with an appropriate size can be accommodated inside the cages under favorable thermodynamic conditions, usually high pressure and near freezing temperature. These molecules are called the guest species and examples of that include CH_4 , C_2H_6 , C_3H_8 , CO_2 , N_2 , H_2 , THF, etc [1-8].

The discovery of this interesting substance goes back to 1811 when Sir Humphry Davy observed a hydrate of chlorine in his lab [9]. In 1934, Hammerschmidt reported the plugging of oil and gas pipelines by hydrate and this formed the basis of the hydrate inhibition industry [10]. Later, in the 1960's, Russian scientists found hydrates in nature [11]. A more complete list of early international contributions on hydrate science can be found in [12].

* Corresponding author; Phone: +1 604 822 6184, Fax: +1 604 822 6003, E-mail: englezos@interchange.ubc.ca