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The characteristics of fines migration and clogging of sediments recovered from the gas hydrate deposits from the Ulleng Basin, East sea, Korea

Caractéristiques de la migration des particules fines et du colmatage des sédiments récupérés à partir des gisements d'hydrate de gaz du bassin de l'Ulleng, mer de l'Est, Corée

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ABSTRACT: The gas hydrates is an ice-like crystalline compound mostly composed of water and natural gas. Gas hydrates are widespread, occurring in both permafrost sediments and deep marine sediments on the world's continental margins. The large amounts of gas hydrate reserves suggest the potential of gas hydrates as an energy resource if economically viable production methods were developed.

The fines migration is one of the major issues for managing safe and efficient gas production from unconsolidated gas hydrate deposits. The migrating fines can alter geotechnical properties such as permeability and strength. Formation damage caused by fines migration and clogging reduce the permeability significantly and thus the productivity. Two-dimensional micro model test has been adopted to characterize fine migration and clogging. The varied test conditions include pore throat width, pore-water chemistry and single and multiphase flow. The tested sediments are natural fines extracted from the gas hydrate deposits in the Ulleung Basin, East sea, Korea.

The test results show that the characteristics of permeability changes induced from fine migration can vary depending on the pore size distribution host sediments, the characteristics of fines, multiphase flow, and pore-fluid chemistry. Multiphase flow can accelerate the pore throat clogging by concentration and localizing fines at the gas-liquid interfaces. Pore fluid chemistry alters the capacity of certain fines to cluster and thus cluster size relative to the pore-throat width. The interactions can be also assessed with electrical sensitivity of fines.

RÉSUMÉ: Les hydrates de gaz sont un composé cristallin, semblable à de la glace, composé principalement d'eau et de gaz naturel. Les hydrates de gaz sont très répandus, tant dans les sédiments de pergélisol que dans les sédiments marins profonds situés sur les marges continentales du monde. Les grandes quantités d'hydrates de gaz suggèrent le potentiel des hydrates de gaz en tant que source d'énergie si des méthodes de production économiquement viables étaient développées.
La migration des particules fines est l'un des problèmes majeurs pour la gestion d'une production de gaz sûre et efficace à partir de gisements d'hydrate de gaz non consolidés. Les particules fines en migration peuvent modifier les propriétés géotechniques telles que la perméabilité et la résistance. Les dommages à la formation causés par la migration et le colmatage des particules réduisent considérablement la perméabilité et donc la productivité. Le test micro-modèle bidimensionnel a été adopté pour caractériser la migration fine et le colmatage. Les conditions de test variées incluent la largeur du seuil des pores, la chimie des eaux des pores et un écoulement monophasé et multiphasé. Les sédiments testés sont des particules fines naturelles extraites des gisements d'hydrate de gaz dans le bassin d'Ulleung, en mer de l'Est, en Corée.
Les résultats des tests montrent que les modifications de la perméabilité induites par la migration des particules fines peuvent varier en fonction de la répartition de la taille des pores des sédiments hôtes, des caractéristiques des particules fines, de l'écoulement multiphasé et de la chimie des fluides interstitiels. L'écoulement multiphasé peut accélérer le colmatage du seuil de pore en concentrant et en localisant les particules fines aux interfaces gaz-liquide. La chimie des liquides interstitiels modifie la capacité de certaines particules fines à se regrouper et donc la taille de ce regroupement par rapport à la largeur du seuil de pore. Les interactions peuvent également être évaluées avec la sensibilité électrique des particules fines.

Keywords: hydrate, production, fine migration, clogging

1 INTRODUCTION

The gas hydrates is an ice-like crystalline compound mostly composed of water and natural gas. Gas hydrates are widespread, occurring in both permafrost sediments and deep marine sediments on the world's continental margins. The large amounts of gas hydrate reserves suggest the potential of gas hydrates as an energy resource if economically viable production methods were developed.

The fines migration is one of the major issues for managing safe and efficient gas production from unconsolidated gas hydrate deposits (Konno et al. 2014). The migrating fines can alter geotechnical properties such as permeability and strength. Formation damage caused by fines migration and clogging reduce the permeability significantly and thus the productivity (Han et al. 2018). Two-dimensional micro model test has been adopted to characterize fine migration and clogging. The varied test conditions include pore throat width, pore-water chemistry and single and multiphase flow. The tested sediments are natural fines extracted from the gas hydrate deposits in the Ulleung Basin, East Sea, Korea.

2 EXPERIMENTAL SET UPS

2.1 Micromodel setups

The micromodel system using multiphase fluid flow is in Figure 1. A microscope (Olympus IX51-LWD 4X/0.1) is placed above the micromodel, to visually monitor fines migration during experiments. A syringe pump is connected to inlet port to inject fluids and fines. The pressure at the outlet port is regulated with back pressure regulator and porous filter is

equipped in the outlet port to prevent fines migrating into the back pressure regulator.

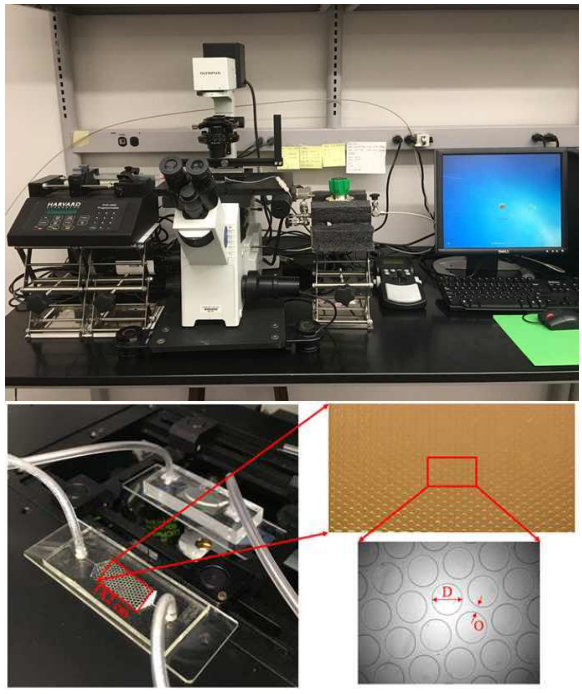

Figure 1. Micromodel experimental setups

The micromodel has the dimension of 2cm x 1cm. The diameter, D, of the circle in the micromodel stands for the diameter of sediment particles, and the pore size, O, of the micromodel stands for the pore size in sediments. The pore sizes used in this study are 20, 40, 60, and 100 μm.

2.2 Materials

Fines used in the micromodel experiments have been extracted from the gas hydrate-bearing interlayered sandy deposits in the Ulleung Basin, East Sea, Korea (Figure 2). The fine contents in the fluids in this study are 0.1, 0.2, 0.5, 1 ,2, 5, and 10% by weight. The fluids used in this study are deionized water, brine, and CO_2 gas.

Figure 2. Fines from the gas hydrate deposits Ulleung Basin, East Sea, Korea

2.3 Experimental Procedures

Clogging experiments have been performed in single and multiphase flow regimes. In single phase flow regime, clogging trends according to fine concentrations, pore sizes, salinity were studied. In multiphase flow regime, the effects of multiphase on the fine migration and clogging have been studied.

In single phase flow experiments, after assembling micromodel system, brine or deionized water with various fine contents are injected and the trends of fine migrations and clogging are monitored.

In multiphase flow experiments, after assembling micromodel system, brine or deionized water with various fine contents. After the injection of brine or deionized water, certain amount of CO2 gas is injected. After the system is equilibrated with the injected CO2, multiphase flow with various fine contents are initiated in the micromodel and the fine migration trends are monitored.

3 RESULTS

3.1 Single phase flow regime

The clogging has occurred regardless of pore sizes and fine contents. The Figure 3 shows the clogging with 100 μm pore size and 0.1% fine contents, which are the biggest pore size and the lowest fine contents.

The salinity affects the clogging trends depending on the mineralogy of the fines. Salinity tends to lower the potential of clogging by dispersing the clay minerals. Thus, in marine sediments, the salinity can help prevent clogging

the pores during fines migration. The dilution of salinity due to hydrate dissociation during gas hydrate production can exacerbate the clogging. Such a trend has been observed in some sediments, but has not been observed in other sediments. The differences in the results can be explained with the presence and absence of clay minerals in fines. In the Ulleung Basin, most of fines are from biogenic origins and are composed of OPAL-A, which is a type of amorphous silica.

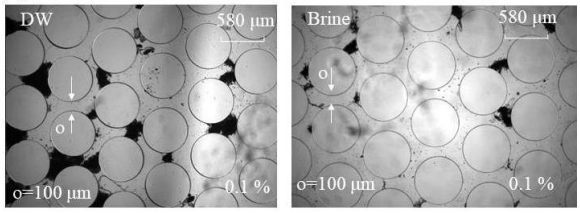

Figure 3. Experimental results in single phase regime, DW: deionized water

3.2 Multiphase flow regime

More intense clogging has occurred in multiphase flow regime. The Figure 4 shows the comparison of clogging between the results from single phase flow and multiphase flow. This implies during the dissociation of gas hydrate and the production of gas from gas hydrate deposits, more clogging can occur and damage the permeability of the deposits.

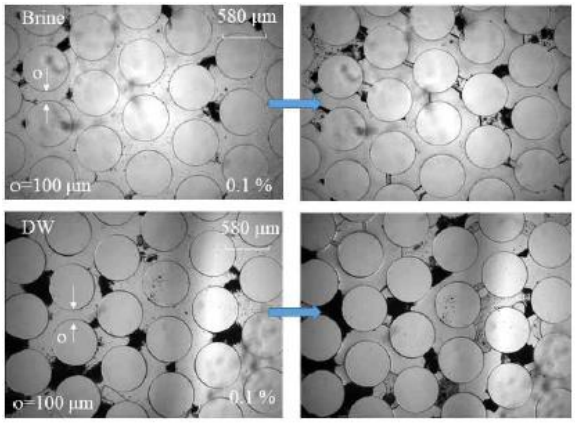

Figure 4. Experimental results in multiphase flow regime. The left side is the single phase flow and the right side is the multiphase flow. DW: deionized water

4 CONCLUIONS

The test results show that the characteristics of clogging induced from fine migration can vary depending on the pore size distribution host sediments, the characteristics of fines, multiphase flow, and pore-fluid chemistry. Multiphase flow can accelerate the pore throat clogging by concentration and localizing fines at the gas-liquid interfaces. Pore fluid chemistry alters the capacity of certain fines to cluster and thus cluster size relative to the pore-throat width. The interactions can be also assessed with electrical sensitivity of fines.

The clogging of pores by fine migration can damage the permeability of gas hydrate deposits during gas production from gas hydrate deposits. The measure for preventing pore clogging should be developed for efficient gas production in the presence of fines in the reservoirs.

5 ACKNOWLEDGEMENTS

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6 REFERENCES

Han, J., Kwon, T., Lee, J.Y., Kneafsey, T.J. 2018. Depressurization-induced fines migration in sediments containing methane hydrate: X-ray computed tomography imaging experiments, *Journal of Geophysical Research: Soild Earth* **123**, 2539–2558.

Konno, Y., Fujii, T., Sato, A., Akamine, K., Naiki, M., Masuda, Y., Yamamoto, K., Nagao, J. 2014. Key Findings of the World’s First Offshore Methane Hydrate Production Test off the Coast of Japan: Toward Future Commercial Production. *Energy Fuels,* **31 (3)**, 2607–2616.