

Measurement of methane hydrate sediment permeability using several chemical solutions as inhibitors

Hideki Minagawa⁽¹⁾, Yusunori Nishikawa⁽¹⁾, Ikuko Ikeda⁽¹⁾, Yasuhide Sakamoto⁽²⁾, Takeshi Komai⁽²⁾, and Hideo Narita⁽¹⁾

Methane Hydrate Research Laboratory, National Institute of Advanced Industrial Science and Technology (AIST)

(1) 2-17-2-1, Tsukisamu-Higashi, Sapporo, 062-8517, Japan

(2) 16-1, Onogawa, Tukuba, Ibaraki 305-8569, Japan

ABSTRACT

The water permeability of methane hydrate (MH) sediments in distilled water increased somewhat with elapsed time under stable pressure and temperature conditions due to MH dissociation by the distilled water. The apparent water permeability increased with fluctuation under MH dissociation pressure and temperature conditions as a result of resistance against water flow caused by methane gas due to dissociation of the MH. The apparent water permeability gradually increased to absolute permeability, without gas and MH, after dissociation of MH in the sediment due to residual gas caused by the MH dissociation. Permeability measurements of MH sediments for methanol, surfactant (sodium dodecyl sulfate, SDS), and antifoaming agent solutions were examined under MH stable conditions and dissociation pressure and temperature conditions to increase the water permeability of MH sediment. Permeability increased under stable MH pressure and temperature conditions after the flow liquid was changed from distilled water to methanol and antifoaming solutions. However, permeability of the surfactant decreased after a change in the flow liquid from distilled water to surfactant solution. The permeability subsequently increased slowly with elapsed time. The permeability measured for each solution varied with the MH dissociation pressure and temperature conditions. Permeability of the methanol solution gradually increased with dissociation of the methane hydrate, but it took a long time to achieve absolute permeability because of residual gas due to methane hydrate dissociation. Permeability in the surfactant solution increased with fluctuation because gas bubbles formed in the pores. The permeability finally increased to less than 10% of absolute permeability. The permeability increased with dissociation of the methane hydrate when an antifoaming agent solution flowed in the sediment. Furthermore, the apparent permeability increased to absolute permeability when gas bubbles generated by methane hydrate dissociation dispersed and/or dissolved into the solution.

KEY WORDS: permeability, methane hydrate, sediment, solutions, inhibitor.

INTRODUCTION

The Methane hydrate deposited in sea floor sediments and permafrost is a potential unconventional methane resource. In-situ dissociation of natural gas hydrate is necessary to commercially recover natural gas

from natural gas hydrate sediment. Exploitation of methane hydrate and production methods of methane gas from methane hydrate, such as de-pressurization, thermal stimulation, and inhibitor injection, have been proposed. Gas permeability and water permeability in methane hydrate sediments are important factors in any method to estimate the production efficiency of methane gas. It is possible that gas due to dissociation of methane hydrate remains in the pores in the sediment, particularly in the thermal stimulation and inhibitor injection methods, and that the gas prevents the flow of water or inhibitors into the sediment. Reformation of methane hydrate by methane gas due to dissociated methane hydrate may also occur in the low-temperature region in sediment. Reformation of methane hydrate may decrease the permeability and cause difficulty in injecting water or inhibitors. This phenomenon was observed in our previous laboratory experiment, i.e. the apparent water permeability of MH sediment fluctuated under MH dissociation pressure and temperature conditions because of methane gas created by the MH dissociation. Moreover, it took a long time for the apparent permeability to increase to absolute permeability (water permeability of the sediment without gas or MH) because of residual gas due to MH dissociation in the sediment.

Low-concentration chemical solutions were examined for use in permeability measurements to suppress the residual gas in the pores due to methane hydrate dissociation; there are economical and practical considerations associated with chemical solution injection, recovery, and contamination.

This study describes water permeability of artificial methane hydrate (MH) sediments for several diluted chemical solutions, including methanol, surfactant, and an antifoaming agent, at concentrations from 1.0wt.% to 0.1wt.%.

EXPERIMENTAL

Figure 1 schematically illustrates the apparatus for measuring water permeability. The experimental apparatus consisted of a temperature-controlled core holder, water and gas inlet-outlet lines with pressure gauges, and a data-recording system. The core holder is combined with a hydrostatic tri-axial pressurized system. The sample of sediment is set in a cylindrical rubber sleeve and pressurized from both axial and radial directions with a maximum pressure of 20MPa. The temperature of the core holder is controlled from -10 to 50 degrees C by circulating