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Field Scale Simulation for the Effect of Relative Permeability on Dissociation and Gas Production Behavior during Depressurization Process of Methane Hydrate in Marine Sediments

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ABSTRACT

Methane hydrate (MH) is one of the potential resources of natural gas. We have developed a numerical model for MH dissociation process in porous media to analyze the physical phenomena in a MH reservoir and predict gas production behavior during MH dissociation. Absolute permeability and relative permeability with MH formation were formulated with our experimental results and introduced into the simulator. Then, MH reservoir model in the adjacent Sea of Japan was constructed on the basis of the results of the preliminary drilling 2003 in Nankai trough area. Using this simulator, some field scale simulation run for depressurization process was carried out to discuss the effect of absolute permeability, relative permeability and MH saturation on MH dissociation and gas production behavior.

KEY WORDS: Gas hydrate; Methane; Marine sediment; Absolute permeability; Relative permeability; Depressurization; Dissociation; Simulation.

INTRODUCTION

Methane hydrate is ice-like solid substance in which water molecule structure contains embedded methane molecules under low-temperature and high-pressure conditions (Sloan, 1998). When 1 m^3 of MH is decomposed, about 150m^3 of methane gas is produced. MH is one of the potential resources of natural gas in the near future, because the large amount of reservoir exists in marine sediments or in permafrost regions worldwide (Makogon, 1988; Okuda, 1993; Sato et. al, 2001a, 2001b). Some extraction methods of MH from the reservoir in marine sediments have been proposed, such as depressurization, thermal stimulation and inhibitor injection (Makogon, 1981). These are all based on the in-situ dissociation process of MH that is transformed into methane gas and water. Only methane gas can be produced from the reservoirs in marine sediments. To evaluate the productivity of methane gas from the reservoirs, it is necessary to develop the production simulator and carry out parameter study by using the simulator. Fig.1 illustrates the outline of research for MH extraction from marine sediments. Especially, it is very important to estimate the properties and the permeability of MH reservoir in such situations as dissociation and consolidation.

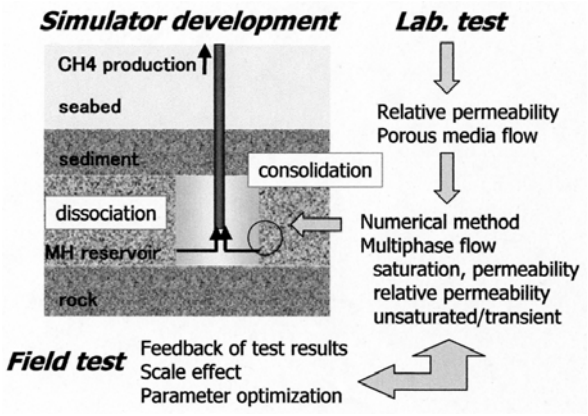

Fig.1 Concept of gas hydrates extraction from marine sediments and development of production simulator.

In addition, the results for the preliminary drilling in Nankai trough carried out in 2003 indicated that 1) MH reservoirs existing in the adjacent sea of Japan were not always uniform, 2) the reservoirs had some heterogeneous structures and were characterized by permeability anisotropy due to alternation of strata consisting of sand and mud layers.

In this study, we have developed a numerical model for MH dissociation process in porous media to analysis the physical phenomena in a MH reservoir and predict gas production behavior during MH dissociation. Absolute permeability and relative permeability with MH formation were formulated with our experimental results and introduced into the simulator. Then, MH reservoir model of the adjacent Sea of Japan was constructed on the basis of the results of the preliminary drilling. Using this simulator, some filed scale simulation run for depressurization as one of in-site MH dissociation process was carried out. Absolute permeability, relative permeability and MH saturation were changed as the