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Compaction Behavior of Toyoura Sand during Methane Hydrate Dissociation

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ABSTRACT

In the recent activities of off-shore drillings conducted in Tokai-oki and Kumano-nada off the coast of Japan, MH21 research consortium of Japan confirmed methane hydrate in sandy and/or mud-sand alternation layers. Dissociation of methane hydrate existing in pore of marine sediments in deep water may result in strata deformation surrounding possible production wells in the future. A specially designed pressure vessel was used to clarify compaction behavior of methane hydrate bearing sediment during the dissociation of methane hydrate. In the study, methane hydrate was formed artificially in Toyoura sand which was densely compacted in the vessel, and compaction behavior on hydrate dissociation was monitored along with the measurements of vertical displacement, temperature and pore pressure. It was found that the displacement of Toyoura sand during hydrate dissociation approached finally to that of plain Toyoura sand. The experimental results imply that the final deformation is mainly caused by the depressurizing performance for methane hydrate dissociation.

KEY WORDS: methane hydrate; hydrate dissociation; compaction behavior; Toyoura sand

INTRODUCTION

Drilling survey for methane hydrate in the region of Kumano-nada to Tokai-oki has brought a prospective evidence of hydrate reservoir under the deep seafloor off the coast of Japan. MH21 research consortium of Japan has been developing a production simulator or a hydrate reservoir simulator from the beginning of the MH21 project. Our research group is providing a consolidation calculation module for the production simulator. Meanwhile, there is not much information on compaction behavior of sand reservoir during dissociation of methane hydrate. It is still difficult to have better understanding of real phenomena during dissociation of methane hydrate in production. Especially, mutual relationships among pore pressure, temperature and deformation in hydrate bearing sediment. Experimental achievement has not been made so far over strata deformation with regard to hydrate dissociation in sediment strata. The development of such calculation module needs field verification sooner or later to evaluate simulation results. In the mean time, a simple and small scale verification test is needed to improve and modify the calculation module. A small model of hydrate reservoir has been designed to perform hydrate dissociation. Synthetic methane hydrate is formed in the reservoir model of Toyoura sand to ascertain compaction behavior of the small reservoir while methane hydrate is dissociated. Since production of methane hydrate is expected by depressurizing method, a small scale verification test is designed to apply depressurization method to hydrate dissociation. Depressurizing pore pressure raises effective stress resulting in strength increase under tri-axial confinement. On the other hand, decrease in hydrate saturation lessens shear strength. The dependence of shear strength on hydrate saturation has been confirmed experimentally employing Toyoura sand containing laboratory formed methane hydrate (Masui et al. 2005). The purpose of the study is to ascertain the compaction behavior of Toyoura sand containing synthetic methane hydrate while hydrate dissociation is performed by depressurization method. Dissociation test has been carried out on a small scale using a specially designed pressure vessel to measure pore pressure and temperature in the reservoir model. In this paper compaction behavior during hydrate dissociation can be represented by relationships among vertical displacement of reservoir sand, pore pressure and temperature.

EXPERIMENTAL PROCEDURE

Preparation of Reservoir Model

Toyoura sand is packed into the water-filled pressure vessel to prepare a reservoir model of sand (150mm in diameter, 100mm thick) to form methane hydrate. The pressure vessel is designed specially to measure pore pressure and temperature simultaneously as shown in Fig.1. In the pressure vessel, guide tubes and thermo sensors have been installed symmetrically in the reservoir model and the arrangement of measuring point can be illustrated in Fig.1. Water content of reservoir sand can be prepared by discharging water to adjust water volume prior to hydrate formation. Methane gas is percolated into reservoir sand to gain pressure at 8MPa to form methane hydrate for about 48hours keeping temperature at 278K. Cell pressure can be controlled to increase up to 9MPa together with pore pressure maintaining the pressure difference