OTC 19260

Ultrasonic Wave Velocities Associated with Formation and Dissociation of Methane Hydrate in Artificial Sandy Sediment

T. Ebinuma, K. Suzuki, J. Nagao, H. Oyama, and H. Narita, Metahne Hydrate Research Labortory,
National Institute of Advanced Industrial Science and Technology (AIST)

This paper was prepared for presentation at the 2008 Offshore Technology Conference held in Houston, Texas, U.S.A., 5–8 May 2008.

Abstract
To determine whether ultrasonic wave velocities are affected by the occurrence and amount of methane hydrate in the pore spaces of sediments, we measured ultrasonic velocities in artificial methane hydrate-bearing sandy sediments during the formation and dissociation processes of methane hydrate. An artificial core specimen was made based on the properties of a natural core recovered from a site in the Nankai Trough near Japan. A core holder was used that permitted the independent application of both confining and pore pressures to the artificial core using a rubber sleeve and two syringe pumps. Piezoelectric ceramic sensors were positioned at both end faces of the core and used to oscillate and detect the compressional and shear ultrasonic waves. The formation of methane hydrate, by pressurizing water in the pore spaces of the core sample using methane gas, was associated with an increase in both wave velocities. The increase in ultrasonic velocities was particularly marked at saturations of methane hydrate in the pore spaces above 30% and the maximum velocity of the compressional wave exceeded 3,000 m/s. While ultrasonic wave velocities decreased with the dissociation of methane hydrate due to depressurization or heating, they exhibit hysteresis during formation and dissociation. These findings indicate that the velocities depend on the occurrence of methane hydrate in pore spaces as well as the concentration.

Introduction
Methane hydrate has considerable potential for use as a new energy resource. Marine methane hydrate occurs in a variety forms several hundred meters below the sea floor. The form considered to be the most well suited to exploitation is that contained within the pore spaces of sandy sediments, as it has relatively larger gas permeability compared to other forms. Since shallow sandy sediments are not usually consolidated, the methane hydrate within pores acts to increase the mechanical strength of the sediments which, consequently, affects production methods. It is thought that methods employing ultrasonic wave velocities are effective for studying the occurrence of interstitial methane hydrate in sandy sediments, and also for undertaking resource assessments of methane hydrate. To determine whether ultrasonic wave velocities are affected by both the occurrence and the amount of interstitial methane hydrate, we measured ultrasonic wave velocities in artificial methane hydrate-bearing sandy sediments during the formation and dissociation of methane hydrate.

A resonant column method was developed to study the seismic velocities of methane gas hydrate-bearing sand[1,2]. Velocities of compressional and shear waves, as well as the dynamic modulus were investigated at methane hydrate saturations below 35%; saturation is defined as the volume ratio of methane hydrate to pore space. Although measurements were performed under dry conditions, the properties under water-saturated conditions were theoretically calculated. The compressional and shear wave velocities increased to 2500 m/s and 1500 m/s at methane hydrate saturation of 35%, respectively.

In the present study, ultrasonic wave velocities were measured under water-saturated conditions at methane hydrate saturations of less than 75%. The velocities were also measured at the dissociation of methane hydrate due to depressurization and heating.

Experimental methods
Figure 1(a) shows the structure of the core holder, which is a pressure vessel with a design pressure of 25 MPa used for the measurement of ultrasonic wave velocity. A core specimen was placed in the core holder and covered with a butadiene-acrylonitrile rubber sleeve for the application of confining pressure by water. An outer jacket for a brine circulation bath and a