MIS22-01 Room:213 Time:April 29 14:15-14:30

Formation evaluation and production interval determination at the 1st offshore methane hydrate production test site

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In order to evaluate productivity of gas from marine methane hydrate (MH) by the depressurization method, on March 2013, the first offshore production test form MH concentrated zone (MHCZ) was conducted by the Research Consortium for Methane Hydrate Resource Development in Japan (MH21) at the AT1 site located in the north-western slope of Daini-Atsumi Knoll in the eastern Nankai Trough, Japan.

Before the production test, during the pre-drilling campaign conduced in 2012, extensive geophysical logging and pressure coring using Hybrid Pressure Coring System were conducted at monitoring well (AT1-MC) and coring well (AT1-C), in order to obtain fundamental information about reservoir properties of MH bearing formation for reservoir characterization, and also to decide on the production interval.

The MHCZ confirmed by the geophysical logging at AT1-MC has a thin-turbidite assemblage (from several tens of centimeters to a few meters) with 60 m of gross thickness; it is composed of lobe/sheet type sequences in the upper part, and relatively thick channel sand sequences in the lower part. The MHCZ at AT1-MC is thicker than those found in wells drilled in 2004 (β1, 45 m), which were located about 150 m northeast of MT1-MC. This fact indicates that the predictions provided by a seismic interpretation and an inversion analysis were reasonable. Moreover, we confirmed that the silt-dominant formation just above the MHCZ was more than 20 m thick ; this was expected to be a seal formation. The well-to-well correlation between two monitoring wells (AT1-MC and MT1) in a 40 m distance shows fairly good lateral continuity of these sand layers (upper part of MHCZ), indicating an ideal reservoir for the production test.

In the upper part of the MHCZ, hydrate pore saturation (Sh) estimated from resistivity log showed distinct difference in value between sand and mud layers, compared to Sh from Nuclear Magnetic Resonance (NMR) log. Resistivity log has higher vertical resolution than NMR log, so it is favorable for these kinds of thin bed evaluation. In this part, 50 to 80% of Sh was observed in sandy layer. On the other hand, lower part of the MHCZ, Sh estimated from both resistivity and NMR log showed higher background value and relatively smoother curve than upper part. In this part, 50 to 80% of Sh was observed in sandy layer as well.

On the basis of the above observations, a production interval was planed. When we consider an effective depressurization, the existence of sealing layers is critical both above and below the interval. We expect that thin silty layers within the lower part of MHCZ will serve as a sealing layer that will prevent water coning from water-bearing layers. Therefore, we stopped drilling the production well at about 20 m above BSR, and decided to produce from approximately 40 m from the top of the MHCZ.

Our future (ongoing) work is to integrate reservoir characterizations based on well logs and pressure core data for the history matching of production test results.

This study is a part of the program of the Research Consortium for Methane Hydrate Resources in Japan (MH21 Research Consortium).

Keywords: methane hydrate, offshore production test, formation evaluation, production interval, eastern Nankai Trough, Daini-Atsumi Knoll

MIS22-02 Room:213 Time:April 29 14:30-14:45

P-wave velocity features of Methane Hydrate-Bearing turbidity sediments sampled by Pressure Core Tool

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Turbidity sediments around the production test site at Daini-Atsumi knoll were deposited under channels and lobes of a submarine fan environment. It implies that sediments contain property difference caused by depositional environment, fundamentally. In addition, MH crystals among sediment grains overprint their original physical properties. Thus, difficulties in MH reservoir arise in clarifying the properties of MH-bearing sediments and normal sediments from logging data. To analyze their physical properties, core samples of MH-bearing sediments were taken at the first offshore production test site using a wireline tool called the hybrid pressure coring system (Hybrid PCS), which prevents dissociation of MH in the sampled cores.

Nondestructive, high-pressure analyses were conducted in both the 2012 summer drilling campaign and the 2013 winter collaboration study. To handle Hybrid PCS cores during the pressure coring campaign in the summer of 2012, a pressure core analysis and transfer system (PCATS) was installed on the research vessel Chikyu (Yamamoto et al., 2012). The measurements can be taken at the in situ water pressure at depth without causing any core destruction or MH dissociation. In January 2013, GT, USGS, AIST, and JOGMEC researchers conducted a collaborative study. In this study, the pressure core characterization tools (PCCTs) developed by GT also measured P-wave velocity of MH-bearing sediments.

In the PCATS analysis, the results showed a difference of more than 1,200 m/s in P-wave velocities between the MH-bearing sandy and muddy layers. This difference in P-wave velocities was confirmed by PCCTs measurements. Also, P-wave velocity of a turbidite interval tend to decrease upward as same as grading of a turbidite. The result implies that MH concentration is related with pore size of sediments.

Acknowledgement

Authors would like to express thanks to Geotek at 2012 pressure core operation/analysis. Authors are grateful to USGS and Georgia Tech members who struggled with PCCTs operation/experiments in AIST Hokkaido. This research is conducted as a part of MH21 research and the authors would like to express their sincere appreciation to MH21 and the Ministry of Economy, Trade and Industry for disclosure permission for this research.

Keywords: Gas hydrate, P-wave velosity, Turbidite, Pore-filling type, Grain size distribution

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MIS22-03 Room:213 Time:April 29 14:45-15:00

Reservoir Characterization and geological modeling for methane hydrate-bearing sediments around the 1st Offshore Product

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The eastern Nankai trough is considered as an attractive potential resource of methane hydrates (MHs) and the first offshore production test was performed around the Atsumi-oki in 2013. The objective of this study is to conduct MHs reservoir characterization of methane hydrate (MH)-bearing turbidite sediments around the test site.

The depositional environment of MH-bearing sediments around the production test site is a deep submarine-fan turbidite system (e.g., Takano et al., 2009). To evaluate MH dissociation and gas production performance, we require precise geological models that describe facies variations of turbidite sediments and their corresponding petrophysical properties. In this study, we performed MHs reservoir characterization integrated from well log, core and 3D seismic data, and the 3D geological models were constructed based on geostatistical approach.

In accordance with the geological modeling workflow, (1) layering and gridding along the geological horizon and facies variations (framework modeling) and (2) defining internal properties (property modeling) were performed for the reservoir. Property modeling includes calculation of the distribution of facies and petrophysical properties such as hydrate saturation, porosity, and permeability, which are required as input to the reservoir flow simulation for predicting gas production performance.

This study is a part of the program of the Research Consortium for Methane Hydrate Resource in Japan (MH21 Research Consortium).

MIS22-04 Room:213 Time:April 29 15:00-15:15

Source of iodine and methane in gas hydrate layers in the Kumano Basin, Nankai Trough

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Because iodine has a strong biophilc behavior in marine system, pore waters in methane hydrate layers are often enriched in iodine as well as methane. The presence of long-lived radioisotope of iodine in nature therefore provides the potential age of source formations for methane. We have determined iodine isotopic ratios of pore waters collected frequently form sandy methane hydrate zone between 200 and 400 m below the seafloor in the Kumano Basin, Nankai Trough to examine the loci of source formations and processes to deliver and accumulate methane in the present methane hydrate stability.

Concentrations of iodine dissolved in pore waters peak at the top of sandy gas hydrate layers at 200 mbsf, where the iodine isotopic ratios also show the lowest/oldest values. Methane and iodine could have been derived from the landward old sediments through the sandy aquifers to the present methane hydrate zone. Transport of methane from old organic-rich sediments to the hydrate stability preferentially accumulates methane hydrates in thick sandy layers in the Kumano Basin.

Keywords: Methane hydrate, Iodine isotope, Pore water

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Trials of the methane hydrate observations in the local governments

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Nine prefectures of 1 local government prefecture of the Sea of Japan side established "Association of Ocean Energy Exploitation of Resources Promotion Sea of Japan" (the following, Association of Sea of Japan) in September, 2012. They support methane hydrate exploitation of resources of the government and aim at the local activation and job creation. Niigata and Hyogo that were members of the association of Sea of Japan carried out a prefecture original methane hydrate investigation. They appeal to the government for development promotion of the government by showing the result. On the other hand, Wakayama located on the Pacific side wants to appeal to the government for the reexamination of the development sea area by showing that outer layer type methane hydrate exists to the sea area that is nearer the landside than the sea area that the government develops. The Independent Institute carried out collaborative investigation each with Niigata, Hyogo and Wakayama in 2013. I show the results of research.

In the joint investigation with Niigata, plural plumes were observed in Mogami trough east slope (from depth of the water 200m 600m) .

In the joint investigation with Hyogo, I carried out observation of a methane plume and the structure and the seafloor topography under the sea bottom in Oki east sea area. Furthermore, I performed a piston core ring and gathered five samples and confirmed plural traces of the methane hydrate.

In the joint investigation with Wakayama, plural plumes were observed in Shionomisaki canyon (from depth of the water 1,700m 2,200m). There is hardly the report of the plume on the Pacific side so far. Therefore I want to continue observing it in future.

Keywords: methane hydrate, methane plume, quantitative echo shounder, piston core

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MIS22-06 Room:213 Time:April 29 15:30-15:45

Quantify methane seeping flux from Ashizuri knoll, Nankai Trough

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The Ashizuri Knoll is located on the southern margin of Tosa Basin (ca. 1000 m depth) in the western Pacific Ocean. The top of the knoll is 534 m depth.The BSR have been detected around the knoll. Beside, seepage methane bubbles were found at top of the knoll. Extensive geochemical surveys on the water column around Ashizuri Knoll were done in September, 2013.The primary purpose of the study was to quantify the seeping flux of methane from the knoll by measuring the spatial distribution of methane around the knoll. Besides, we akso tried to clarify the origin of methane by determining both δ13C and δD values.

Enrichment of thermogenic methane up to 145 nmol/L was detected just above the top of knoll. Besides, the methane enriched plume spread northeastward of the knoll at the water depth of 450- 660 m. The calculated methane flux was almost the same with that of off Joetsu hydrate area.

MIS22-07 Room:213 Time:April 29 15:45-16:00

Characteristics of natural gas hydrates retrieved off the southeastern and southwestern Sakhalin Island

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Gas hydrate samples were retrieved at the southeastern and southwestern Sakhalin Island in the cruises of LV59 and LV62 (R/V Akademik M. A. Lavrentyev). Sakhalin Slope Gas Hydrate (SSGH) project started in 2007, and we retrieved sediment cores including gas hydrates off northeastern Sakhalin Island in 2009-2011. In the recent cruises (2012-2013), we sampled sediment cores at the Terpeniya Ridge and the Tatarsky Trough (SE and SW Sakhalin Island, respectively). We found a lot of gas plumes ascend from the sea bottom and the dissolved methane in sediment pore water was rich. Gas hydrate crystals were recovered from both areas and stored into liquid nitrogen tank. Their dissociation heat and hydration number were measured by a calorimeter and Raman spectrometer, respectively. Dissociation heat of gas hydrates was almost the same as that of pure methane hydrate. Raman spectra showed that the hydrate crystals of both Terpeniya Ridge and Tatar Trough belonged to the structure I, and the hydration number was estimated about 6.0. Molecules of hydrogen sulfide were detected in both large and small cages of the structure I. Therefore, the hydrate crystal is similar to that obtained from NE Sakhalin Island in our previous cruises.

We obtained hydrate-bound gas and dissolved gas in pore water on board and measured their molecular and stable isotope compositions. Empirical classification of the methane stable isotopes; δ^{13}C and δD indicated that the gases obtained at the Terpeniya Ridge are microbial origin via carbonate reduction, whereas some cores at the Tatarsky Trough showed typical thermogenic origin. We retrieved three sediment cores with gas hydrate at the Tatarsky Trough, and their δ^{13}C of hydrate-bound methane were -47.5 ‰, -44.2 ‰, and -68.8 ‰, respectively. Therefore, gas hydrates encaged both microbial and thermogenic gases yield at the Tatarsky Trough. Ethane-rich (up to 1% of the total guest gas) hydrates were found at the Terpeniya Ridge and the Tatarsky Trough, and encaged ethane was also detected in their Raman spectra. Ethane δ^{13}C of the all gas samples suggested their thermogenic origin.

Keywords: gas hydrate, stable isotope, Sea of Okhotsk, Raman spectroscopic analysis, Calorimetry

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MIS22-08 Room:213 Time:April 29 16:15-16:30

First attempt to drill down hydrate mound and gas chimney by BGS Rockdrill 2

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A series of shallow piston coring (PC) has identified dense accumulation of massive gas hydrates in the upper part of hydrate mounds and gas chimneys in Japan Sea since 2004, however, because of limited penetration of PC, distribution and resource potential of gas hydrate below ~10 mbsf have not been clearly answered as yet. On the other hand, 3D seismic profiles have revealed significant pull-up structure, a characteristic velocity pseudo-structure, in gas chimneys, suggesting an accumulation of significant amount, probably 20 to 30 vol.%, of gas hydrates in gas chimneys. In the summer 2013, Meiji University and British Geological Survey deployed BGS benthic drilling machine, Rockdrill 2, on hydrate mounds in Joetsu basin, Japan Sea, and successfully drilled through inhomogeneous, gas hydrate- and carbonate-bearing hard sediments and occasional soft and gassy sediments down to 32 mbsf. Core recovery was unfortunately low throughout the coring due to extensive dissociation of gas hydrate and gas expansion during and after coring. However, we could recover massive gas hydrate samples, 5 to 12 cm long, from a number of horizons down to 32 mbsf. Several 2 to 7 m thick zones of gas hydrate accumulation have been inferred from integrated profiles of drill logs, video-monitor observation, and discontinuous sediment core record. Shallow drilling of Rockdrill 2 is likely to have proved a dense distribution of gas hydrates in deeper part of hydrate mounds and gas chimneys.

Keywords: gas hydrate, Japan Sea, hydrate mound, gas chimney, Rockdrill 2

MIS22-09 Room:213 Time:April 29 16:30-16:45

Formation of shallow gas hydrates and geochemistry of gas and pore water from UT13 cruise in the Japan Sea

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Active gas venting and distribution of massive gas hydrates are largely observed on the summits of the Umitaka Spur and Joetsu Knoll in the eastern margin of the Japan Sea, where the fault system associated with strong anticline structure constrains the accumulation of gas and following gas hydrate formation. The UT13 cruise has conducted to collect shallow sediments from the Oki Trough, north eastern of Noto Peninsula, and offshore Akita-Yamagata areas, where gas chimney structure and strong backscatter indicate migration of gas-charged fluid and potential formation of gas hydrates near the seafloor. Geochemistry of pore water, dissolved gas, and hydrate-dissociated gas reflect the geochemical environments associated with the delivery of gas and fluid and formation/dissociation of gas hydrates in the shallow sediments.

Flake-like and nodular gas hydrates were observed at 1-6 mbsf in the Oki Trough and offshore Akita-Yamagata, respectively. Concentrations of methane dissolved in pore water are high, comparable to those in the Umitaka Spur and Joetsu Knoll area, and the SMI depths are accordingly shallow at ~2.7 mbsf in the entire research area, indicating high potential of gas hydrate accumulation in the shallow sediments. Concentrations of chloride are sporadically low in all areas due to gas hydrate dissociation during core recovery, accumulations of small gas hydrates with saturations up to 20% were observed, reflecting ubiquitous formation of gas hydrates in the research area. Concentrations of calcium and magnesium show fine increase and decrease in response to sulfate changes at deeper than SMI, reflecting the change of the methane flux mainly, the formation/dissociation of gas hydrates may have changed seafloor topography and geochemical properties of pore water and gas in the shallow sediments.

Contrary to the Umitaka Spur and Joetsu Knoll area where thermogenic gas dominates in the shallow gas hydrates, chemical and isotopic compositions of gas indicate that the majority of gas is of biogenic origin with minor contribution from thermogenic ethane and hydrogen sulfide, the latter may result in expanding gas hydrate stability and forming gas hydrates near the seafloor.

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Keywords: Shallow gas hydrates, pore water, dissolved gas, SMI

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Distribution of methanogenic and methanotrophic archaea in subseafloor sediment collected during UT12

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Methane hydrate is now one of the most popular energy sources in the world, and various amounts are presumed to be buried around Japan's continental margins. Methane contained in methane hydrate in the deep sea sediment is produced by microbial or thermogenic system. In the microbial system, methanogenic and methanotrophic archaea play an important role in this environment. However, the studies on characteristics and abilities of these microorganisms are still underway in the Sea of Okhotsk. Therefore, this study focuses on isolation of the methanogenic archaea and analysis of community construction and diversity of these microorganisms.

Sediment samples were collected from the subseafloor by the piston coring, during UT12 (Umitaka-maru Gas Hydrate Research Cruise 2012). Samples were collected from each core sample at appropriate intervals. The samples were stored at 4 ℃ for the microbiological cultivation experiment use, and at -80 ℃ for the microbiological diversity analysis use, respectively.

For the isolation, cultivation was carried out by enrichment culture using H_2/CO_2 medium. The cultivation temperatures were 15 ℃ and 30 ℃, respectively. We successfully isolated several methanogenic archaea from the samples of the surface of the subseafloor. The result of the 16S rRNA gene sequence analysis showed that some of the strains were identified as closely related strains of *Methanogenium marinum*. In a previous literature, *M. marinum* was isolated from the cold marine sediment from the Scan Bay, Alaska. We also conducted the experiment to measure the methane productivity of our isolates by the range of the cultivation temperature.

For the analysis of community structure and diversity of methanogens, DNA was extracted from each sediment sample, using the ISOIL kit following the manufacturer's protocol. The 16S rRNA gene of methanogenic archaea and the mcrA gene of methanogenic and methanotrophic archaea were amplified by PCR. The PCR product was purified by FastGene Gel/PCR Extraction Kit following the manufacturer's protocol. The purified products were analyzed by T-RFLP method and clone library method. The results of the T-RFLP analysis showed that the various fragments were observed. Clone library sequencing analysis of mcrA genes indicated that some of them were identified as related sequences to *Methanogenium*. Also, results from T-RFLP method were used for MDS (Multi-Dimensional Scaling) analysis.

This experiment was supported by grants-in-aid for scientific research <KAKENHI>(Ryo Matsumoto, Meiji University).

Keywords: shallow gas hydrate, methanogenic archaea, methanotrophic archaea

MIS22-11 Room:213 Time:April 29 17:00-17:15

Environmental variability of the Japan Sea clarified by

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Environmental variability of the Japan Sea was presumed using MD179 Cruse 3312 sediment core by inorganic and organic geochemical analysis. Analysis of this study went focusing on mainly thin-laminated dark layer (TL-1 to 3). TOC was about 0.8% in TL-2 and 3, on the other hand, the TL-1 layer showed nearly 2%. In the central part of TL-2 to the upper part, all the samples of a C/S ratio are 1 or less. This has suggested strong reduction environment at the upper part of TL-2 layer.

The Pristane/Phytane ratio (Pr/Ph ratio) traditionally used as an oxidation-reduction index is shown that most analysis data are $<$3.0 and it was the reductive environment. Pentamethylicosane (PMI) which is the membrane lipid origin of the anaerobic methanotrophic archaea (ANME), C18-isoprenoid ketone characteristically detected to a cold-seep carbonate and hop-22 (29) ene (diploptene) also the origin were not clear, characteristically found out at a methane seeping point, those depth distribution was plotted and considered. Distribution of the AMNE marker in the inside of TL layers is heterogeneous, and the possibility of the sudden methane eruptions during the TL-2 deposition was suggested.

This study was supported by MH21, Research Consortium for Methane Hydrate Resources in Japan.

Keywords: Japan Sea, biomarker, TL layer, sulfur isotope compositon, anoxic environment, C/S ratio