PROVENANCE OF SANDY SEDIMENTS AND THEIR POSSIBILITY OF HOSTING GAS HYDRATE IN THE EASTERN MARGIN OF JAPAN SEA

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ABSTRACT
The MD179 as well as the UT09 and KY09-05 cruises were undertaken in the eastern margin of Japan Sea in 2009 and 2010 aiming at recovery of deep seated gas and gas hydrate, methane induced carbonate, and deep sediments older than 300 ka in order to develop geologic model of gas hydrate accumulation and evaluate the possible environmental impact of gas hydrate for the last glacial-interglacial cycles.

Sediment samples below the seafloor were obtained in the Umitaka Spur, the Joetsu Channel, and thin sandy layers are intercalated with thick muddy sediments, which are often strongly bioturbated with burrows and pellets. Those sandy sediments consist of fine- to medium-grained sand grains, and are sometimes tuffaceous. The results of pore-size distribution measurements and thin-section observations indicate that porosities of muddy sediments are around 50 % but those of arenites range from 42 to 52 %, of which mean pore sizes and permeabilities are larger than those of siltstones and mudstones. While the presence of gas hydrate in intergranular pores is not confirmed, the soupy occurrence in recovered sandy sediments may strongly indicate the presence of gas hydrate filling the intergranular pore system of arenite sands.

So as to know the time of deposition and sedimentary environment of coarse-grained sediments, thermoluminescence (TL) dating of constituent quartz grains and grain-size distributions are analyzed.

The geological modeling of the gas hydrate formation and evolution system is concerned for energy resource potential in the Japan Sea as well as the Nankai Trough areas. Permeable intergranular pore systems of arenite sand, fractures, faults as well as gas chimneys may have played an important role as conduits for gas migration, and sandy sediments hosting gas hydrate in their intergranular pore system may likely occur.

This study was performed as a part of the MH21 Research Consortium on methane hydrate in Japan.

Keywords: gas hydrates, sand, porosity, permeability, thermoluminescence, TL

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**INTRODUCTION**

A number of extensive methane plumes and active methane seeps associated with gas hydrate mounds exposed on the seafloor may indicate the presences of methane fluxes and gas hydrates in shallow sediment layers of the Umitaka Spur and Joetsu Knoll of the Joetsu Basin 30 km off Joetsu City in Japan Sea. The seismic data obtained have shown fault-related gas chimney structures below the spur and knoll as well as BSRs. The depths of BSRs are estimated around 115 mbsf (Matsumoto et al., 2009).

The research objectives of this paper are focused on the subjects as follows;
1. Provenances and sedimentary environments of coarse-grained sediments
2. Pore properties and grain-size distributions of coarse-grained sediments
3. Provenance and transportation history of sediment grains by measuring TL (thermoluminescence)

They may clarify pore properties, mechanisms and paths of methane flow in porous sandy sediments and occurrences of gas hydrate in host sediments (Uchida et al., 2010).

**SEDIMENT SAMPLES**

**Onboard Sampling**

Coarse-grained sediments were subsampled onboard by plastic bins. They had been kept and wrapped by aluminum foil carefully onboard, which were dried in the oven in low temperature around 50 degree C, so as to prevent deformations and maintain pore systems due to unconsolidated sediments. Pore-size analyses (Figure 1, 2), thin-section observations and TL measurements have been undertaken at the lab in Akita University. Grain-size analyses were conducted by the laser diffraction spectrometry method.

**Sandy Sediment Samples**

A small amount of sandy sediment layer generally were observed as intercalations in thick muddy sediment layers, which were usually thin layers or lamina and sometimes up to 5 cm thick (Figure 1 ). They are more or less tuffaceous. Sediment layers are often strongly bioturbated with many trace fossils (Figure 2) and sometimes thinly laminated (Figure 3). Occurrences of flowed sandy layer and soupy sand were observed on three occasions, which may indicated the presence of pore space hydrate (Uchida et al., 2009) filling the intergranular pore system of sediments in the subsurface condition.

![Figure 1 A sandy layer slightly deformed in muddy formation](image1)

![Figure 2 Strongly bioturbated sediment layer](image2)

![Figure 3 Thinly laminated sediment layer](image3)
**Petrophysical Measurements**

Sediment samples were obtained for various measurements and observations as follows;

1. Pore-size distributions, porosities and permeabilities of coarse-grained and muddy sediment samples by the mercury porosimetry.
2. Microscopic observations for sediment samples by blue-colored resin impregnated thin sections.
3. TL (thermal luminescence) measurements of quartz and feldspar constituent grains for investigating the time of depositions and their provenances.

3. Grain-size distributions of coarse-grained sediment samples.

**RESULTS OF ANALYSES**

Pore-size distribution measurements and thin-section observations of fine- to very fine-grained arenite sands were undertaken. Porosities of arenites are around 50 % (Figure 4), of which mean pore sizes and permeabilities are larger than those of siltstones and mudstones (Figures 5, 6). Presence of hydrate in intergranular pores of arenite sands is unknown.

According to Figures 7 and 8, most of sandy sediments are fine- to very fine-grained sands, which show relatively well-sorted (Figure 9). It should be noted that the results of grain size distribution measured by the laser diffraction spectrometry are sometimes different from those measured by the sieving analyses.
A concentration of gas-hydrate requires the pore space within the host sediments to be large enough to allow the gas hydrate to form, similar to the controls on the occurrence of conventional oil and gas accumulations. The distribution of porous and coarser grained host sandy sediment is one of the most important factors controlling the occurrence of gas hydrates, as well as pressure-temperature conditions.

Figure 7 Cumulative grain size distribution curves of sediments.

Figure 8 Depth changes of mean grain size of sediments.

Figure 9 Depth changes of sorting of sediments.

Provenance and transportation history of coarse-grained sediments will be estimated by measuring TL of sand grains. The petrophysical properties may clarify the mechanisms and paths of methane flow in porous sediments and occurrences of gas hydrate in host sediments.

CONCLUSIONS

1. Small amounts of sandy sediment are retrieved as thin intercalations in Pleistocene silty layers. These coarser sediments might have been transported approximately around 3 to 30 ka, where supplying sediments may not be abundant due to sea level fluctuation during Pleistocene ice age.
2. Pore-space hydrates are observed to occur primarily in fine- to medium-grained sands filling the intergranular pore systems of arenite sands, and have been recognized in the Mallik as well as in the Nankai Trough areas, which are considered to be common even in the subsurface sandy sediments at the eastern margin of Japan Sea.
3. Concentration of gas hydrate may need primary intergranular pores large enough to occur within a host sediment that may be arenite sand without matrix grains deposited in such as channels.
4. This appears to be a similar mode for conventional oil and gas accumulations. It is suggested that the distribution of a porous and coarser-grained host sandy sediments is one of the most important factors to control the occurrence of gas hydrates, as well as physicochemical conditions.
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REFERENCES
