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Natural gas hydrate occurrence and detection in the Sea of Okhotsk

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Gas hydrate in the Sea of Okhotsk

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Key words : Natural gas hydrate, the Sea of Okhotsk, CHAOS project, gas migration, gas seepage

Abstract : The Sea of Okhotsk is the unique area providing the highest methane production rate of the northern hemisphere. The area of focused fluid venting offshore the NE Sakhalin continental slope was investigated during the CHAOS (Hydro-Carbon Hydrate Accumulations in the Okhotsk Sea) expeditions onboard of RV "Akademik Lavrentyev" in 2003, 2005 and 2006. The International Research Project CHAOS (Russia-Korea-Japan) aimed at the study of gas hydrate formation processes associated with the fluid venting in the Sea of Okhotsk. Several new gas hydrate accumulations were discovered during the cruise. Hydrate-associated structures have been named as KOPRI, VNIIOkeangeologia, POI and KIT (the names of cruise participant institutes). Some of hydrate-bearing cores contain big amount of gas hydrates: massive gas hydrate layers (up to 35 cm thick) were recovered. The shallowest submarine gas hydrate accumulations in the world (at the depth less then 400 m) were discovered during the cruise.

1. INTRODUCTION

The continental margin of the northeastern Sakhalin Island, the Sea of Okhotsk, is a well known gas hydrate occurrence area, where manyactive gas and fluid venting sites at the seafloor and gas flares in the water column have been detected (Fig. 1) [1,2,3,4,5]

In the framework of the CHAOS(hydro-Carbon Hydrate Accumulations in the Okhotsk Sea) international research project, multidisciplinary field expeditions were carry out in 2003 (R/V Lavrentyev cruises 31 and 32) and 2005 (R/V Lavrentyev cruise 36).

The main research targets of CHAOS project are as followings;

- To study formation, distribution, and characteristics of the gas hydrate accumulation fields in the Sea of Okhotsk.
- To investigate the gas transport mechanism and migration pathways through sub-surface, water column to atmosphere.
- To investigate the microbiology and geochemistry associated with gas hydrate formation and dissociation.
- To study geological and tectonic controls on gas hydrate stability condition and slope stability.

2. METHOD AND DATA

In the frameworkof the 2003 CHAOS (hydro-Carbon Hydrate Accumulations in the Okhotsk Sea) Project, high-resolution seismic and hydro-acoustic surveys were carried out simultaneously on the same survey tracks (Fig. 1).

A total 83 km of high-resolution seismic data were collected to examine detailed subsurface features associated with gas/fluid emanations in gas hydrate-bearing sediments. The data were obtained using a sparker system "SONIC-4" made in Russia.

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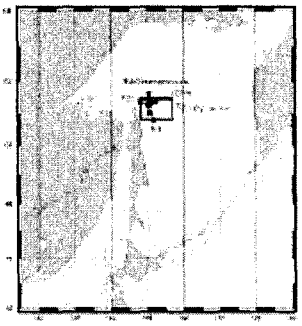

Fig. 1 Location of the study area

A sparker source was operated at the frequency of 200-1200 Hz and the energy of 500-2000J. Single channel streamer was used as a receiver. The system provides a resolution of 2-5 m for sediment strata and a bottom penetration of 50-300 m. To detect and investigate acoustic indications of gas emission sources into water column, the level of acoustic backscattering was collected using mainly 12 kHz hydroacoustic system "ELAC".

3. RESULTS

Major findings of the 2003 and 2005 CHAOS expeditions are as following;

1) Seafloor expressions: Side-scan sonar mosaicshows many seafloor expressions like pockmarks in the NE Sakhalin slope (Fig. 2). They are well associated with gas venting sites. The diameters of some pockmarks are up to 500 m. These giant pockmarks are almost circular.

2) Gas flares in the water column: During hydroacoustic survey in the CHAOS cruises, a lot of flares emitted from the seafloor were newly compiled. Some flares rise up to about 800 m meters from the seafloor to the sea surface (Fig. 3). Methane concentration in the water column dramatically increased near the bottom of the flare sites by several tens thousand times as much as background value.

3) Gas hydrate occurrences: Several gas hydrate accumulations were newly discovered during the cruise. Hydrate-associated structures have been named as KOPRI, VNIIOkeangeologia, POI and KIT (the names of cruise participant institutes). Some of hydrate-bearing cores contain big amount of gas hydrates. Remarkable pure gas hydrate layer up to 35 cm thick was recovered at the KOPRI structure (Fig. 4). Gas hydrates sampled at 390 m in the water depth in the Gisella structure is likely to be the shallowest one among reported ones so far.

Fig. 2. Side-Scan Mosaic of the study area showing many seafloor expressions

4) Gas chimney structures in the gas hydrate-bearing sediments: High-resolution sparker profiles show many near-vertical structures (hereafter chimneys)through the gas-hydrate bearing sediments, which seem to rise from the BSRs and occasionally reach to the seafloor. On the seismic profiles, we classifychimneys into two groups showing different seismic characteristics; (1) narrow (100~200 m in width) and confined white-colored wipeout (little or no coherently reflected seismic energy) chimneys, (2) wide (more than 500 m) and diffuse dark-colored (enhanced reflection) chimneys. It seems that no wipeout chimneys reach the seafloor, whereas enhanced reflection (ER) chimneys mostly reach up to the seafloor and are associated with the distinct bathymetric expressions like pockmarks.

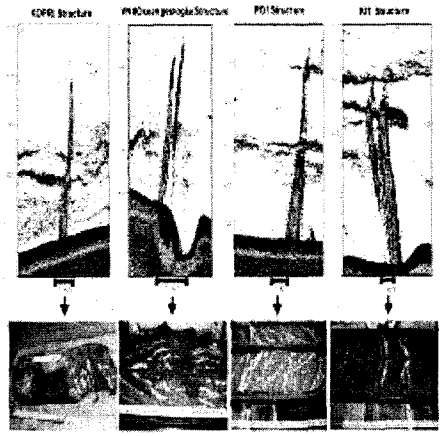

Fig. 3. Gas flares and gas hydrate occurred at the seepage structures

5) Marine landslide structure, double BSR, Mud volcano around the Lavrentyev Fault: South of

Fig. 4. Natural gas hydrate recoverd at the KOPRI structure.

gas seepage areas, multibeam bathymetric map and high-resolution sparker profiles reveala large scale fault system (here called 'Lavrentyev Fault'). A remarkable feature on the map and the profiles is landslide-like bathymetry along the fault. Occurrence of double BSR has been reported in Nankai Trough, Japan. In the Lavrentyev Fault, sparker profiles show similar reflectors to double BSR. More geophysical data including multichannel seismic data are needed to confirm the reflectorsas double BSR. Mud volcano was found on sparker profiles at the deepest area in the Lavrentyev Fault area. Some gas flares occurred on the mud volcano.

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