The study of Okhotsk sea sediment based Echo sounder system

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Abstract. This article describes one investigation of Okhotsk Sea sediment in the northwest Pacific margin, the study based the use of the advanced tool called Echo sounder system,made a large scale acoustic sweep to the east slope of Sakhalin Island.Through the acquisition of the echo signal, the multi-channel digital capturing and imaging post-processing system achieved and visualizd the seabed gas flares (GF)、cold seep and the seabed. After the discovery of GF, depending on GPS real-time tracking and positioning system, using gravity sampler and other sampling tool, in various waters successfully collected core samples of sediment, and the samples were analyzed in time, evaluated the amount of methane emission and depositing in the area and other kinds of data, provided useful information to analyze the causes of the region's gas hydrate depositing and mining methods.By the conclusion of the investigation experience, it will make positive effection in sediment investigating methods of our country.

1. Introduction

In this China-Russian inspection process of Okhotsk Sea, through the application of deep seabed survey equipment Echo sweep underwater acoustic detection system, many GF and cold seeps eruption points[1,2] of the Okhotsk Sea nearby SaHalin island have been found, such as Figure 1. Red dot marked on the chart as the GF and cold spring eruption point.Through sonar and GPS positioning, using gravity apply sampling and other sampling equipment, the seabed sediment cores have been successfully sampled, This article discusses the constitution of sediment exploration and acquisition system using, discuss statistical analysis of sediment core samples, and ultimately draw a number of conclusions.

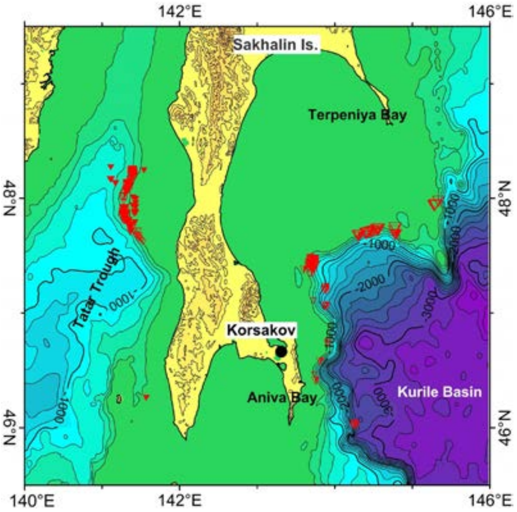

Fig. 1 GF of Okhotsk seas and cold seeps eruption points

Currently, ocean sediment recognition technology include different techniques of high resolution multi-channel seismic reflection technology, submarine heat detection technology, seabed imaging technology, drilling technology are commom ways to search the sediment under the seabed. The high-resolution multi-channel seismic reflection way is good at its continuous, high measuring efficiency, high resolution, digital recording and other technical advantages, has become the first choice of deep-sea exploration of sediment.

The purpose of this study is to figure out the distribution of sediment at Sakhalin slope, understand sediment quantity of different terrain. Multi-channel seismic reflection equipment --Echo underwater acoustic detection system, can be deposited layer in a cross-sectional scanning the seabed in a short time, find GF and cold seeps[3,4], effectively figure out the location and condition of useful sediment at the entire region, provide reliable information support to next step of core sampling.

2. Method of The Study

2.1 Echo Sounder System Structure.

The main goal of hydroacoustic survey was the search and investigation of underwater gas seepage acoustic manifestations. For this purpose, collection of information about acoustic back scattering level was carried out simultaneously using frequencies of 12 kHz, 20 kHz and 135 kHz in the water column and from the seabed;The data obtained can be used also for:evaluation of the gas seepages intensity;accurate determination of the depth, estimation of the reflection coefficient and other seabed characteristics.

The hydroacoustic observations were carried out using a hydroacoustic complex created on the bases of the upgraded ship'secho sounders Sargan-EM and ELAC,sonars Sargan-GM,see Fig.2, and multichannel digital registration of sonar echoes on four independent channels with frequencies of 12kHz, 20 kHz and 135kHz. At a time with acoustic measurements, accurate vessel's coordinates are estimated with the help of global positioning system (GPS). Block-scheme of the complex is represented on the Fig.3, its basicparameters are listed in the Table 1.

Fig. 2 Echo sounder Sargan-EM and sonar Sargn-HM

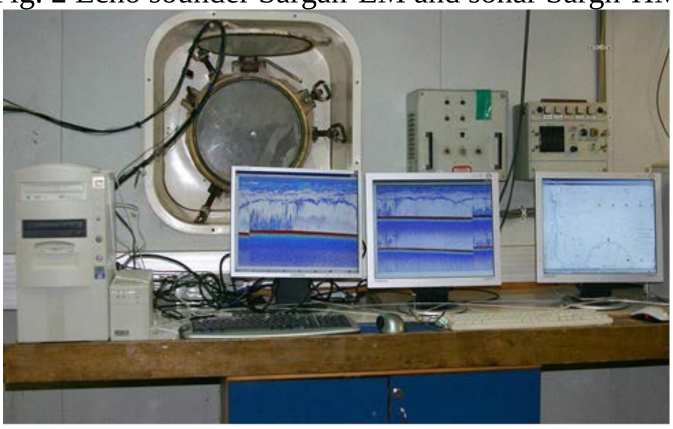

Fig. 3 The multi-channel digital capturing and imaging post-processing system

Table 1 The main parameters of acoustic equipments

Device	ELAC	Sargan-EM	Sargan-HM	
Operating frequency,kHz	12	19.7	19.7	135
Beamwidth,grad	12	10	14	4
Output power, W	2000	6000	2500	2000
Impulse length, ms	0.8; 3; 10	0.5; 1; 3; 10	1; 3;10; 30	0.3; 1; 3;

Record of acoustic back-scattering signals was made in two basic modes—full speed mode and low speed mode ,see Figure 4.

In full speed mode, the background observations were conducted continuously within all studied area on a full speed of a vessel (9-12 knots), thus the echo sounders Sargan-EM and ELAC(two channels of frequency -12 and 20 kHz, sounding executed in a vertical derection) were used.

In low speed mode, The acoustic survey was conducted in given areas on a mean speed of a vessel (3-6 knots). The echo sounders Sargan-EM and ELAC of frequency 12 and 20 kHz(two rays in a vertical direction) and s sonar Sargan-GM of frequency 20 kHz or 135 kHz(two rays, an angle of 30ºfrom a vertical direction in a side from a vessel movement) were used. Application of such regime has allowed to increase approximately three times viewed square during search of submarine gas sources and to estimate the position of these sources relative to the vessel.

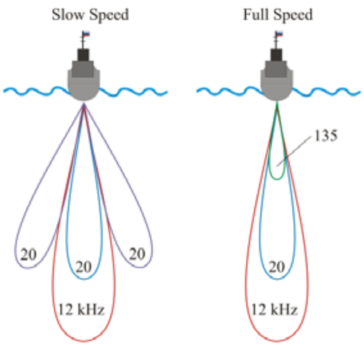

Fig. 4 Two basic regimes of acoustic back-scattering signals

2.2 Sediment Sampling.

One type of corer was prepared for sediment sampling: hydro-corer (HC) by diameter of 138 mm. Their length was 575 cm. To rapidly extract sediment column from the corer, special flexible plastic 2-sectional liners were used with diameter of 125 mm.

After rising of a hydrocorer on the deck, liners with sediment were moved in the laboratory, and sediment was cut up on two parts for subsequent operational processing. Time interval from rise corer on the deck up to cutting of sediment in laboratory amounted 10 minutes,see Figure 5.Following sedimentological study of the sediment cores was realized with the use of standard scheme including description of structure, texture, color, density, inclusions (concretions, shells, dropstone) [5,6], as well as gas-hydrates and character of contacts between layers. Smear slides were made for continued investigation under microscope with the aim of preliminary determination of sediment components.

Fig. 5 Sampling the gas sediment

During 56-th cruise of R/V"Akademik M.A. Lavrentyev" sediment coring was carried out within two areas:southern part of area NO1 and western part of area NO3(Terpeniya Bay). 18 sediment cores and 3 grabs(one of them has brought nothing) were taken totally[7,8]. Two cores have recovered gas hydrater; 9 cores contained carbonate concretions of different size, shape and density; two cores have brought specific authigenic mineral called glendonite("gennoyshi") and two cores were estimated as background. Recovered sediments have mainly Holocene-Late Pleistocene age.

3. Sediment Data Analysis

See Table 2, it is located at latitude: 53 ° 22.865', Longitude: 144 ° 24.957' at station numbers for a group core data of lv56-05HC component analysis, and the analysis shows that combustible ingredients in the core is more than 99% of methane, also containsmall amounts of CO2 and other hydrocarbons, as Fig.6 ,the methane content in different depths.

Table 2 The analysis data of the cores

Length position of core (cm)	**CH4 (mkl/l)**	**C2H4 (nl/l)**	**C2H6 (nl/l)**	**C3H6 (nl/l)**	**C3H8 (nl/l)**	**CO2 (ml/l)**
10	3	0.00001	0.00000	0.00000	0.00000	8.61
30	16	0.00001	0.00001	0.00001	0.00001	4.86
50	11	0.00001	0.00001	0.00001	0.00001	4.56
70	96	0.00002	0.00002	0.00002	0.00002	5.20
90	88	0.00002	0.00002	0.00002	0.00002	3.45
110	189	0.00002	0.00002	0.00002	0.00002	4.82
130	290	0.00001	0.00001	0.00001	0.00001	7.28
150	396	0.00001	0.00001	0.00001	0.00001	9.37
170	586	0.00002	0.00002	0.00002	0.00002	10.09
190	1251	0.00000	0.00001	0.00001	0.00001	13.75
210	15350	0.00000	0.00018	0.00000	0.00025	15.71
230	64434	0.00000	0.00021	0.00000	0.00037	18.26
250	96921	0.00000	0.00021	0.00000	0.00049	17.77
270	110270	0.00000	0.00018	0.00000	0.00054	12.53
290	134702	0.00000	0.00016	0.00000	0.00055	18.38
310	130801	0.00000	0.00017	0.00000	0.00053	18.97
330	124287	0.00000	0.00017	0.00000	0.00059	17.87
350	166198	0.00000	0.00017	0.00000	0.00065	21.21

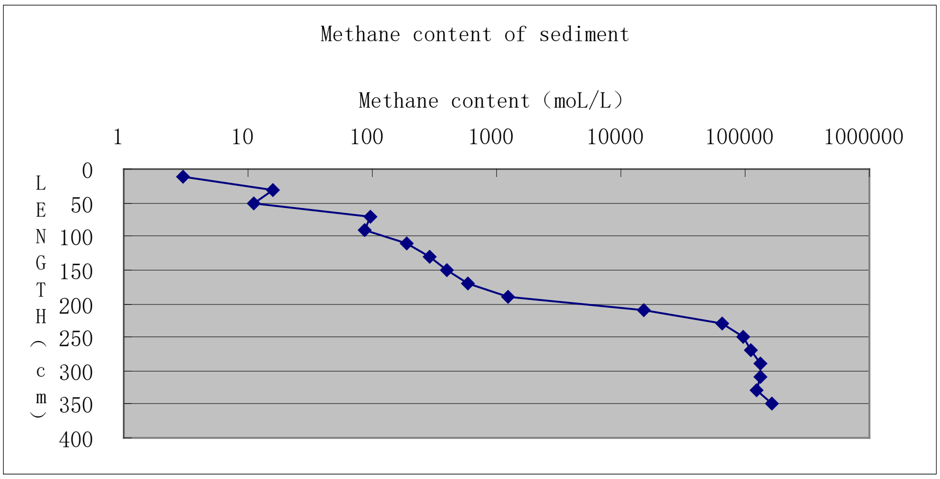

Fig. 6 The distribution curve of the methane content in sediment

Through anaylizing,the methane content distribution curve is seen with increasing depth of the sediment core, will increase exponentially in the sediment. At a depth of 250cm ~ 300cm, methane content close to the maximum and saturation.

4. Conclusion

Sedimentary section of studied areas has been described in detail in reports of previout cruises. As investigations were carried out on the same part of the Sakhalin slope, as earlier, any new features of a sedimentary section were not revealed. This testifies that sediment composition within all NE Sakhalin slope is constant. All described earlier lithological slices characteristic for this region, were recovered: clay-diatomaceous, clay homogeneous, clay with the traces of sediment heave due to gas expansion and clay gas-saturated with pseudobrecciated texture.

3.1 Sedimentary section within area NO1 has all evidences of methane emanations influence on sediment composition. The presence of methane-derived carbonate concretions, fragments of chemoautotrophic mollusk fauna (for example, Calyptogena), gas-saturated sediments with specific pseudobrecciated texture, layers and lenses of gas hydrates testify about it.

3.2 Glendonite crystals discovered at some stations, testify about existence of unusual conditions during some periods of sediment formation(both sediment enrichment by organic matter and low temperature of near-bottom waters).

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