Operation Report

of

Sakhalin Slope Gas Hydrate Project 2012,

R/V Akademik M. A. Lavrentyev Cruise 59

August 7 - 30, 2012

Vladivostok – Korsakov - Sakhalin Slope – Korsakov - Vladivostok

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1. INTRODUCTION

Y. K. Jin, H. Shoji, A. Obzhirov, B. Baranov

1.1. Framework of the SSGH Project

The Sakhalin Slope Gas Hydrate Project (SSGH Project) 2007–2015 is an international collaborative effort among scientists from Russia, Korea and Japan to investigate on natural gas hydrates accumulated on a continental slope offshore Sakhalin Island. Main objectives of this project include:

(1) To characterize gas hydrates and gas hydrate-bearing sediments in the Sakhalin Slope,
(2) To understand gas migration and gas hydrate formation mechanisms at methane seep areas,
(3) To trace methane migration from gas hydrate system to atmosphere through water column and its impact to global warming
(4) To understand process of gas hydrate destabilization and its influence on slope failure as one of geological hazards and
(5) To establish a monitoring network for a long-term gas hydrate stability variation.

Participating Institutes:

Kitami Institute of Technology (KIT), Japan
Korea Polar Research Institute (KOPRI), Korea
V. I. Il'ichev Pacific Oceanological Institute FEB RAS (POI), Russia
P. P. Shirshov Institute of Oceanology RAS, Russia

Members of the Steering Committee of the SSGH Project:

Hitoshi Shoji,
Environmental and Energy Resources Research Center,
Kitami Institute of Technology, Japan

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V. I. Il'ichev Pacific Oceanological Institute, FEB RAS, Russia

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The steering committee members agreed to discuss and determine (1) tasks for participating institutes on both field and laboratory investigations, (2) field operation plans including details of survey techniques, study site selections, schedules, participants and cost-shared budgeting, (3) publication procedures including data sharing, personnel exchanges and co-authorships and (4) new research plans including new subjects and participants for the sake of our mutual scientific interests and merits.

1.2. Goals of the SSGH-12 Project

We have obtained a lot of remarkable results in the northern Sakhalin continental slope from the CHAOS (Carbon-Hydrate Accumulation in the Okhotsk Sea) Project (2003, 2005, 2006); lots of gas flares in the water column, many gas fluid seepage structures on the seafloor, gas hydrate samples including massive gas hydrate chunk (about 35 cm thick) near the seafloor, and gas hydrate-related structures in gas hydrate-bearing sediments. These results encourage us to continue and expand our research activities in the Sakhalin continental margin.

As the CHAOS project with such fruitful results ended in 2006, the SSGH Project was launched as a new project in 2007. The first two-years' cruises (SSGH-07 and 08) in 2007 and 2008 were totally devoted to areal mapping of the seafloor and water column structures related to gas/fluid seeping phenomena in the gas hydrate area on the northeastern continental slope off Sakhalin Island, Okhotsk Sea. Further study is continued by ocean sediment coring to understand the formation mechanism of gas hydrate in terms of gas, water and sediment characteristics and biogeochemical processes taking place near sea bottom environment. Since 2011, study areas of the project have been expanded to the central (Study Area 2) and southern slope (Study Area 3) of Sakhalin Island to investigate regional gas hydrate-related phenomena along the Sakhalin slope. In the SSGH-12 expedition, Study Area 3 was visited again and the Tatarsky strait area (Study Area 4) to the southwest of the island was newly surveyed to search gas hydrate occurrence (Fig. 1.1).

Research goals of the SSGH-12 expedition carried out in new study areas (Areas 3 and 4) included:

1. Core sampling for gas, pore water, gas hydrate and sediment characteristics at gas/fluid seepages.
2. Detailed mapping of bathymetry around gas/fluid seep areas.
3. Detection of gas chimney near seafloor.
4. Detection of gas flare in the water column emitted from gas/fluid seepages.
5. CTD and water sampling for water column condition and chemistry

1.3. Field Operation of SSGH-12 Project

Field operation of SSGH-12 project was conducted using R/V Akademic M.A. Lavrentyev (Fig. 1.2). This cruise was carried out from August 7 to 30, 2012. R/V Lavrentyev sailed with the following ship route; Vladivostok (August 7)-Korsakov (August 10)-the study area (August 10-25)-Korsakov (August 26-28)-Vladivostok (August 30).

A total of 28 scientists took part in the cruise including Japanese (Kitami Institute of Technology), Korean (Korea Polar Research Institute) and Russian (V. I. Il'ichev Pacific Oceanological Institute FEB RAS and P. P. Shirshov Institute of Oceanology RAS) participants (Appendix 5.2). POI is the organizing institution of the SSGH 2012 cruise.

During this expedition, two study areas (Study Area 3 and Study Area 4) were separately investigated (Fig. 1.1). Study Area 3 is the southern slope of Sakhalin Island to the south of the Terpeniya Ridge. Little detection of gas flares has reported in this area, but new nine gas flares found in the 2011 cruise gave us motivation to research gas hydrate/gas seepage phenomena in this cruise. Study Area 4 has been considered as a very promising area to detect gas flares and gas hydrates because previous sparker seismic data showed that many gas chimney structures are densely developed and the BSR are widely distributed in the area.

During the expedition, about 100 gas flare images were registered by hydroacoustic survey. Among them, 62 gas flare sites are newly detected ones. Sediment coring for gas/fluid/gas hydrate analysis at 26 sites and CTD casting and water sampling at 21 sites were conducted. Two gas hydrate samples were first retrieved in each of the Study Areas 3 and 4-1.

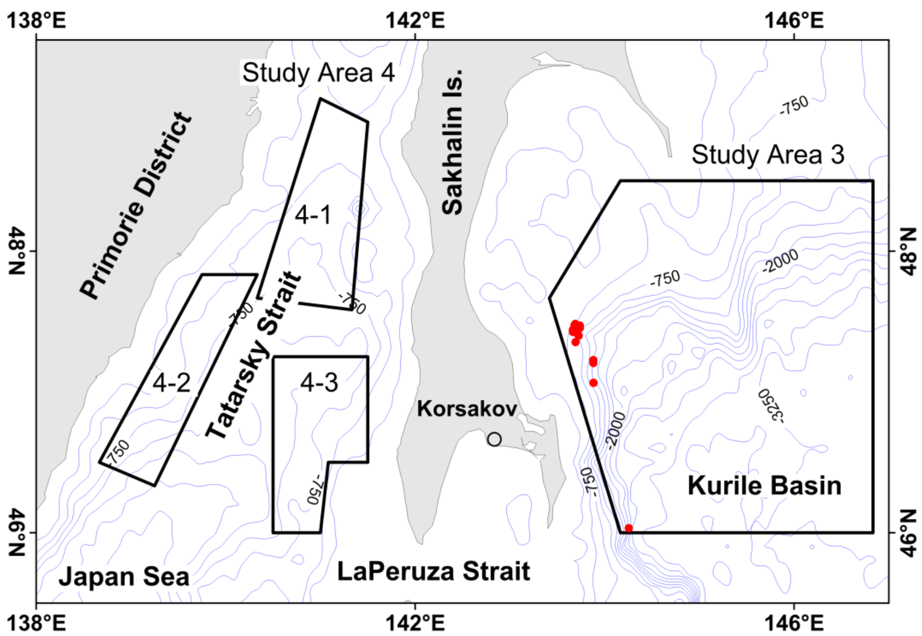

Fig. 1.1. Study areas of SSGH-12 expedition. Red dots are gas flares detected in the previous expedition

Fig. 1.2. R/V Akademik M.A. Lavrentyev

1.4. Survey Permissions and Supports

Russian Side

R/V Akademik M. A. Lavrentyev Cruise 59 (7 – 30 August, 2012) was organized in accord to the following official documents in Russian side:

1. Permission from Russia Federal Agency for Science and Innovations on July, 06 2012, No 79 to provide expedition in the Kuril basin slope of the Okhotsk Sea and Tatarsky Strait slope of the Japan/East Sea (Fig. 1.3) according to expedition Program and Agreement from May 10, 2012 of SSGH Project 2012 from 7 to 30 August, 2012.
2. Program expedition R/V Akademik M. A. Lavrentyev Cruise 59 (7 – 30 August, 2012) from POI FEB RAS is confirmed by Presidium of FEB RAS of 04 July, 2012.
3. Orders to provide expedition R/V Akademik M. A. Lavrentyev Cruise 59 (7 – 30 August, 2012) from POI (09 July 2012, No.34-e) and from Presidium FEB RAS (27 July 2012, No.16121-61H).
4. Agreement about joint scientific researches and to cover expenditures to carry out expedition in the Okhotsk Sea (21 days) using R/V 'Akademik M.A. Lavrentyev', to study submarine gas hydrates at the Okhotsk and Japan/East Sea among POI FEB RAS, KOPRI and KIT (Signatures: May 10, 2012).

Korean Side

This field investigation is supported by the followings in Korean side:

1. Korea Polar Research Institute grant PN12020

Japanese Side

This field investigation is supported by the followings in Japanese side:

1. Kitami Institute of Technology
2. The Japan Society for the Promotion of Science KAKENHI 232540083. The Japan Society for the Promotion of Science KAKENHI 22540485

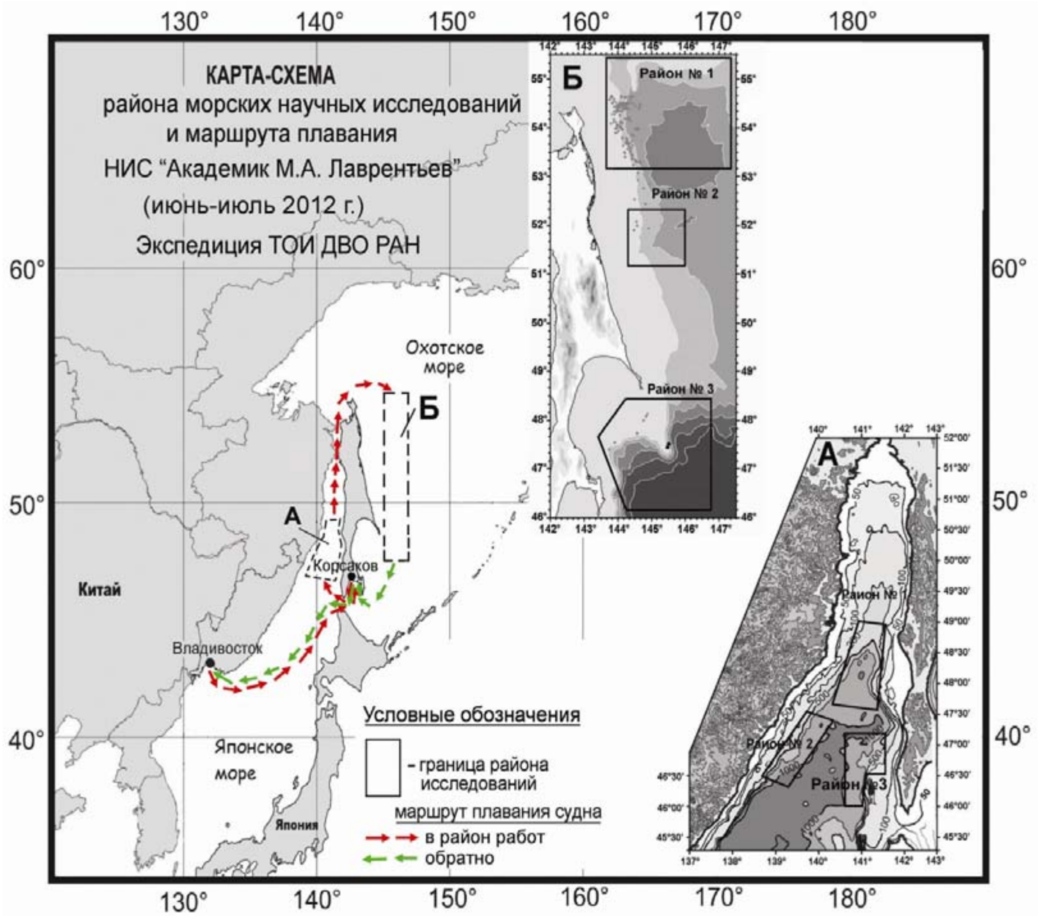

Fig. 1.3. Proposed survey areas and routes for SSGH-12 expedition in the permission.

2. TECTONIC AND GEOLOGICAL SETTING

B. Baranov, Y.K. Jin, H. Shoji, A. Obzhirov

The Study Areas 3 and 4 (4-1 - 4-3) of 59 cruise RV "Akademik M.A. Lavrentyev" cover the most southern part of Eastern Sakhalin slope and the Tatarsky Strait, correspondently (Fig. 2.1).

2.1. Southern part of the Eastern Sakhalin slope

Morphology. Study Area 3 locates the Eastern Sakhalin slope facing the Kurile Basin. Sea bottom lays practically horizontal and has very smooth relief on the shelf and in abyssal part of the basin. The steepest slope angles and most complicated morphology are typical for basin slope. The inclination angles in the upper part of the slope have ranges of 5-10° and in the lower part 1-2°. The slope has distinct shelf break located at depths 140-190 meters. Canyons, landslides and deep-water terraces are wide-spread morphological elements of the slope (Gnibidenko et al., 1995).

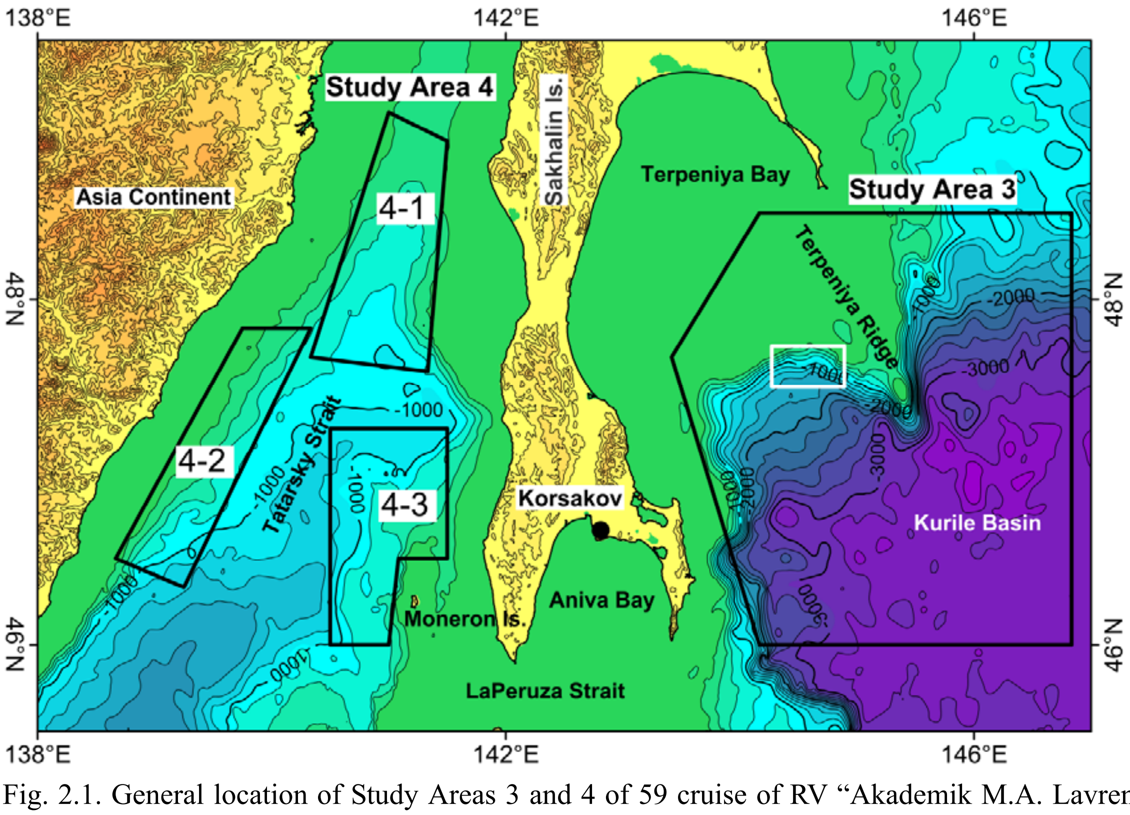

Fig. 2.1. General location of Study Areas 3 and 4 of 59 cruise of RV "Akademik M.A. Lavrentyev". White box shows areas of bathymetric investigations during 50 and 56 Cruises of RV "Akademik M.A. Lavrentyev". Contour interval is 200 m. SRTM data were used for map construction (http://srtm.usgs.gov/index.php.)

Our former bathymetric investigations were located in upper slope of the Terpeniya Ridge (see Fig. 1). Terpeniya Ridge is underwater continuation of Terpeniya Peninsula and represents a block with steep eastern slope and gentler western slope. Two domains could be distinguished in the eastern slope, namely steep slope in depth interval 250-1500 m and flat terrace located deeper than 1500 m. Several canyons cut the steep slope and the largest one of them starts deeper than 200 m and continues up to contour of 1650 m. Other smaller canyons begin from contour line of 700 m. All canyons strike in NS direction and have very steep slopes that indicate on their fault origin (Operation Report, 2012).

Structure. Study Area 3 covers three structural domains, namely broad shelf of the Terpeniya Bay, slope of the Kurile Basin and southwestern Kurile Basin. Terpeniya Trough locates in shelf area. This trough together with Aniva Trough corresponds to South-Sakhalin sedimentary Basin. Structure of the Terpeniya Trough represents complex of anticlines and synclines originated on basement consisting of Mesozoic terrains which are metamorphic and oceanic blocks. Thickness of Cenozoic sedimentary cover varies from 2 to 8 km (Kharakhinov, 2010).

Kurile Basin slope represents the region of transition from continental crust of the Sakhalin shelf to the oceanic crust of the Kurile Basin. Our former seismic investigations show that soft sediments are almost absent in the upper part of seismic sections on the eastern slope of the Terpeniya Ridge. Absents of sediments is possibly conditioned by active erosion of the eastern slope accompanied by outcropping of more ancient sedimentary rocks; the latter plays role of the acoustic basement on the seismic profile (Operation Report, 2012). Basing on dredging data (Tsoi, Shastina, 2000; Terekhov et al., 2008) it was established that the lower part of the sedimentary section of the Terpeniya Ridge eastern slope is composed by mudstones containing complexes of Paleocene - Early Eocene and Early Oligocene radiolarians. Overlying tuff-diatomite layer is composed by strata of Late Oligocene –Early Miocene, and of Early Miocene - Middle Miocene age. Cenozoic sediments overlap with unconformity Maastrichtian – Danian volcanic-clastic and volcanic-sedimentary rocks of the basement (Terekhov et al., 2010).

Two seismofacies were distinguished in the western slope of the Terpeniya Ridge, namely well-stratified facies and reflector pure facies. The well-stratified facies locates on the slope and canyon heads and its cross-section is visible up to 200 msec. In the lower canyons the amount of reflector starts to decrease and well-stratified facies transforms to reflector poor facies. Reflector-poor facies spreads over the terrace and probably represents the mass wasting material (Operation Report, 2012).

The thick sedimentary cover masks the rugged basement morphology of the Kurile Basin, so that it is largely an abyssal plain outlined by the 3000-3300 m isobath. The basement is located at a depth of up to 8 km below sea level and corresponds to the seismic layer with a velocity of 4.8-5.2 km/s (Bikkenina et al., 1987; Gnibidenko et al., 1995). Seismic refraction studies show that the crust of the southwestern Kurile Basin begins with a thick (up to 5 km) sedimentary blanket with a compressional wave velocity of 1.7-4.3 km/s. This is underlain by a 4.8-5.2 km/s layer with a thickness of 2.0-2.8 km, presumably representing the upper consolidated, volcanogenic-sedimentary section of the oceanic crust (layers 1 and 2). The underlying 4-5 km thick, high-velocity layer (6.4-7.2 km/s) corresponds to oceanic layer 3. The Moho discontinuity occurs at 11-13 km below the sea level (Popov and Anosov, 1978; Bikkenina et al., 1987; Gnibidenko et al., 1995).

Faults. Three deep-seated faults cross the Study Area 3 (Fig. 2). They are continuations of the East Sakhalin fault which represents N-S- striking dextral strike-slip conjugated thrusts and reverse faults of north-western strike and normal faults of north-eastern strike. One fault runs in the central Terpeniya Bay and limits the Kurile Basin to the west and two faults limit the Terpeniya Ridge. The recent activities of these faults are probably reduced from east to west as it has seen from shallow earthquakes distribution (see Fig. 2.2).

Gas seepage. Expressions of gas seepage are observable within Study Area 3 in seismo-acoustic data. These data include gas flares (hydroacoustic anomalies in the water column) and gas chimneys in sediment cover. Many gas flares were found on shelf and slope break inside Study Area 3, but only three of them were observed deeper than 300 m (see Fig. 2.2). One of the flares corresponds to gas chimney detected on seismic profile (Operation Report, 2012).

2.2. Tatarsky Strait

Morphology. Tatarsky Strait strikes in N-S direction with distance of 700 km separating the Sakhalin Island from the Asia continent. Tatarsky Strait connects to the Amur estuary via Nevel'skoy Strait to the north and become open to the Japan Basin to the south. In the bottom relief Tatarsky Strait corresponds to through striking in south-west – north-east direction. Its depth is 1800 m on 46°N and it decreases up to 200 m north of 48°30' N (Fig. 2.2).

Western side of the trough is linear and very steep near 46°N that indicates its fault origin. Eastern slope morphology is more complex. Its northern part consists of north-eastern and north-western-striking segments which joints under right angle. North-western-striking segments has very steep slope and probably connected with fault. Southern part consists of two steps separating by scarps by high of 300 m. Some scarps are very steep and epicenter of most strong earthquake (M=7.3) occurred on the Sakhalin Island is located on such a scarp to the north from Moneron Island (see Fig. 2.2). Axial part of the trough consists of several segments which change their strike from N-W to W-E directions.

Structure. Western (continental) coast and shelf of the Tatarsky Trough consists of weakly deformed volcanic rocks of Tertiary and Cretaceous ages which has basaltic and intermediate

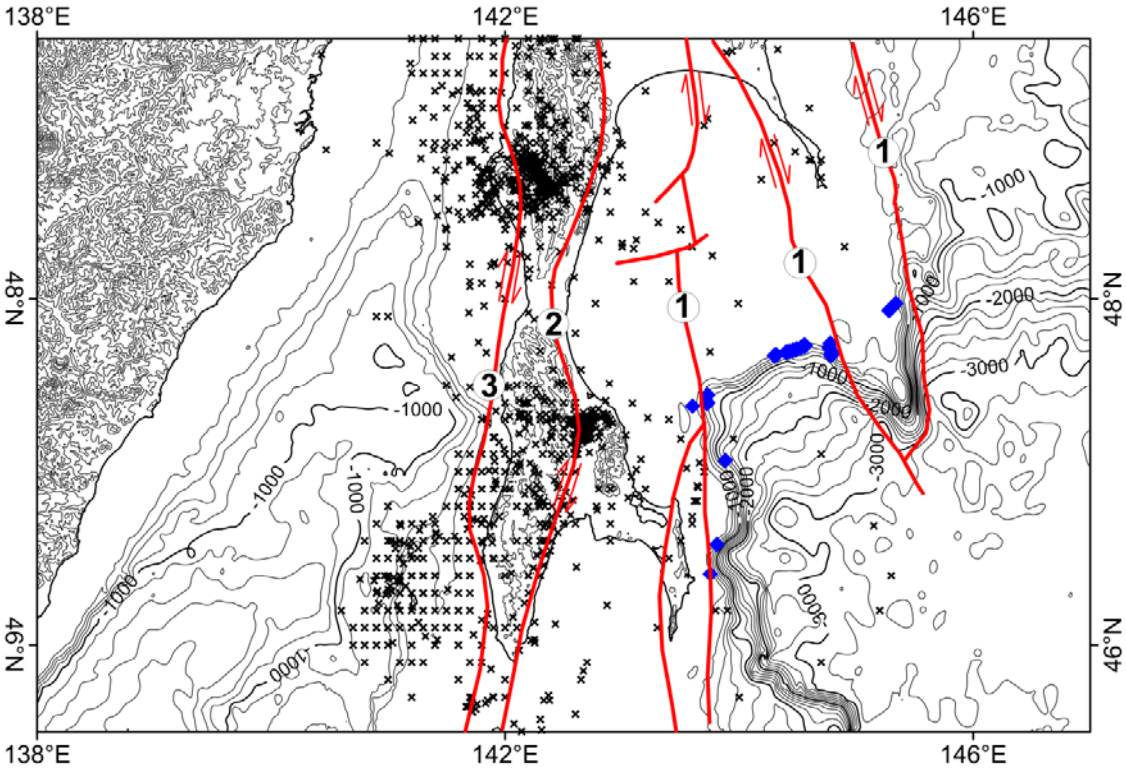

Fig. 2.2. Fault systems of the study areas according to Karakhinov, 2010. 1 – continuations of the East Sakhalin faults, 2 – Central Sakhalin fault, 3 – West Sakhalin fault. Crosses indicate shallow earthquakes, blue diamonds mark gas flares.

composition and correspond to Sikhote-Alin volcanic belt (Fig. 2.3). Eastern coast and shelf belong to West-Sakhalin foredeep where Tertiary and Upper Cretaceous volcanic rocks of the Hokkaido-Sakhalin accretional system are outcropped.

Two main sedimentary basins can be distinguished in the central Tatarsky Trough: Northern and Southern Basins. Southern and North Sakhalin Basins are the new originated rift structures of Cenozoic age. These basins were superimposed on Cretaceous-Paleogene structures of the Eastern Asian continental margin and represent graben system striking in north-eastern direction.

Volcanic activity areas of Late Miocene – Pliocene age could be connected with graben formations. The thickness of sediments equals 6 km in Northern Tatarsky Basin and up to 8 km in the Southern Tatarsky Basin. Tatarsky Trough is characterized by high heat flow with maximal value up to 171 mW/m^2.

Faults. The west coast of the Sakhalin Island is bounded by the West Sakhalin fault that represents dextral strike-slip. Strong seismic activity indicates that this fault is very active (see Fig. 2.2). In its some segments reverse faults could occur due to the fault bend.

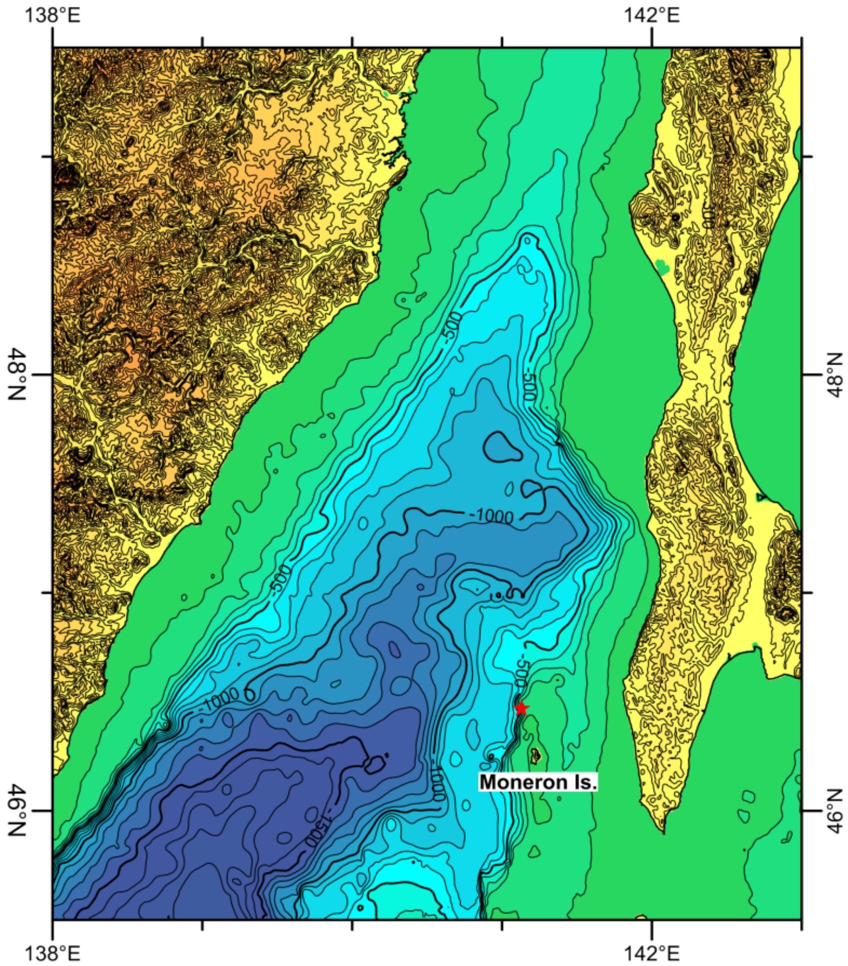

Fig. 2.3. Bathymetric map of the Tatarsky Strait. Red star marks epicenter of the Moneron earthquake. Contour interval is 100 m. SRTM data were used for map construction (http://srtm.usgs.gov/index.php.)

The trough is characterized by complex pattern of normal faults (see Fig. 2.4). They strike parallel to the Asia continent and Sakhalin Island along the western and eastern sides of the trough. The normal faults have north-western or north-eastern direction in the central part of the Tatarsky Trough.

Gas seepage. Up to now gas flares were not observed in Study Area 4. Five seismic cross-sections which were obtained during 53 Cruise of RV "Akademik M.A. Lavrentyev" show structures similar with gas chimneys in the Study Area 4-1. Probably the same gas chimneys would have been shown at subvertical geological bodies in Fig. 2.4 which indicate on fluids activity (Karakhinov, 2010).

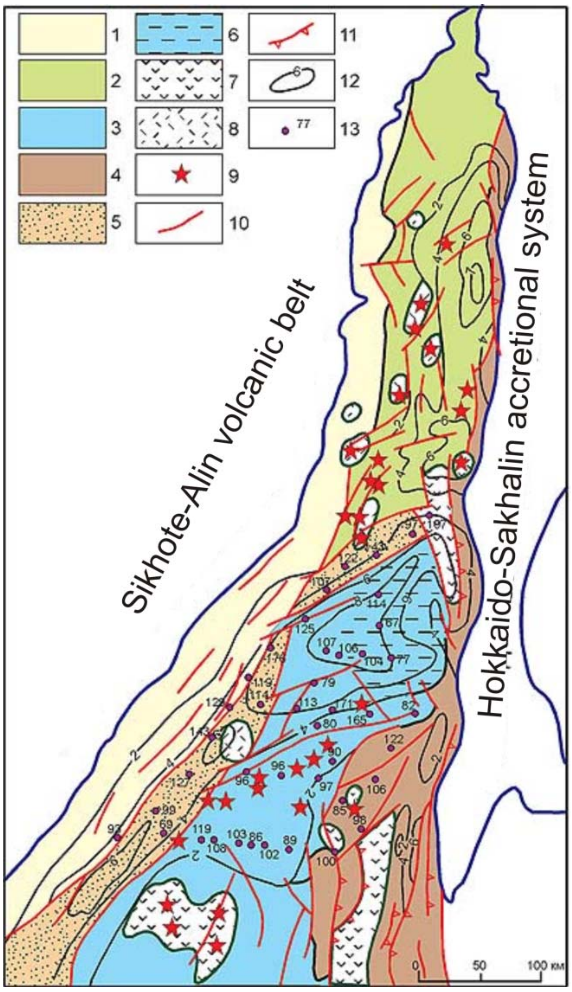

Fig. 2.4. Structural map of the Tatarsky Trough according to Kharakhinov, 2010. 1-3 – main structural elements: 1 – western Sikhote-Alin block, 2 – Northern Tatarsky graben with thinned continental crust, 3 – Southern Tatarsky basin with suboceanic crust; 4 – blocks of the Hokkaido-Sakhalin accretional system; 5 – rift grabens with thinned continental crust; 6 – the most thinned suboceanic crust; 7 – Oligocene-Eocene volcanic structures; 8 – areas of Late Miocene – Pliocene volcanic activity; 9 – subvertical geological bodies – indicators of fluids activity, 10 – normal faults, 11 – reverse faults and thrusts, 12 – thickness of Cenozoic sediments in km, 13 – heat flow in mW/m^2

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3. GEOPHYSICAL SURVEYS

Three methods were used for geophysical surveys: bathymetric, seismic and hydroacoustic ones.

3.1. Bathymetric Survey

B. Baranov, A. Koptev

Bathymetric investigations conducted during the 59 Lavrentyev cruise (SSGH-12 expedition) were concentrated on two main targets: 1) mapping of the sites in the Study Areas 3 and 4 (see Fig. 2.1) with aim to obtain data about specific bottom features connected with the seepage. 2) mapping of the major morphological features of the eastern Sakhalin slope and Tatarsky Trough for updating of the existing bathymetric map. In addition to the bathymetric surveys it was necessary to choose the location for sediments sampling on sites (pre-sampling survey). The bathymetric survey was carried out along the tracks combined in the orthogonal or irregular networks for investigation of the seepage sites. Bathymetry survey was also performed continuously during whole working time on sampling stations and on the approaches to them.

3.1.1. Equipments

Bathymetric investigations were conducted using ship-mounted deep-water echosounder ELAC LAZ-72 E-V. Its technical characteristics are:

Operating frequency	12 kHz
Nominal power in impulse	2 kWt to 200 Wt
Beam polar pattern	10º x 10º
Duration of impulse	0.3, 1 or 3 ms
Range of measurements	0 - 15000 m
Depth of underwater sound projector	4.5 m
Standard accuracy	± 1%

Reflected echo signal after nomination and filtering is transformed by digitizer ELAC STG-721 and is passed to the user in accordance with protocol RS232 without time reference. Navigation reference was fulfilled using 12-channel navigator receiver GARMIN GPSMap 420s with support of WAAS technology. Estimated accuracy of positioning (HDOP) did not exceed 2-5 m during whole cruise. Every second the receiver produces data consisting of coordinates and time both on the display and into the outer channel in accordance with protocol RS-232.

Data from satellite navigator receiver and echo sounder are synchronized and registered by specially designed program, operating on usual personal computer. As a result each measurement of depth is uniquely tied to time and receives exact geographic coordinates. Re-calculation of coordinates to the form, convenient for further processing, is performed simultaneously. Complete bathymetric information is available immediately after each echosounder line. Sound velocity was accepted as 1500 m/s during registration. Corrections for salinity and pressure were not applied. Cycling of measurements was determined by depth range and then was adjusted as 2-6 seconds.

3.1.2. Data

As it was noted above the bathymetric surveys were devoted to detailed mapping of the seepage sites and investigations of the major morphological features of the eastern Sakhalin slope and the Tatarsky Trough for updating of the existing bathymetric maps. In addition to the bathymetric surveys it was necessary to choose the location for sediments sampling on sites (pre-sampling survey). The bathymetric lines, which were run during this cruise, are shown in Fig. 3.1. The total length of the bathymetric tracks was equal to 1845 nm in the areas under investigation. Most detailed bathymetric survey was carried out on Study Areas 3 and 4-1. The data obtained were processed using Grapher 7 software with aim to delete incorrect depth measurements. Software Surfer 9 was applied for constructing of bathymetric maps.

3.1.3. Results

General morphology. The density of bathymetric survey gave us opportunity to construct general bathymetric maps only for Study Areas 3 and 4-1 (Fig. 3.1). Study Area 3 was confined to the western slope of the Kurile Basin. Kurile part of the Sakhalin slope facing the Kurile Basin is the deepest one (>3000 m). Sea bottom lays practically horizontal and has very placid relief on the shelf and in abyssal part of the basin. Data on relief on Study Area 3 were obtained within narrow band between slope break and 1500-meter contour line. As it was revealed earlier (Operation Report, 2012) EW-striking area of the slope within this polygon is the steepest (5-10º) and cut by canyons. Below 1500 m the slope is gentler.

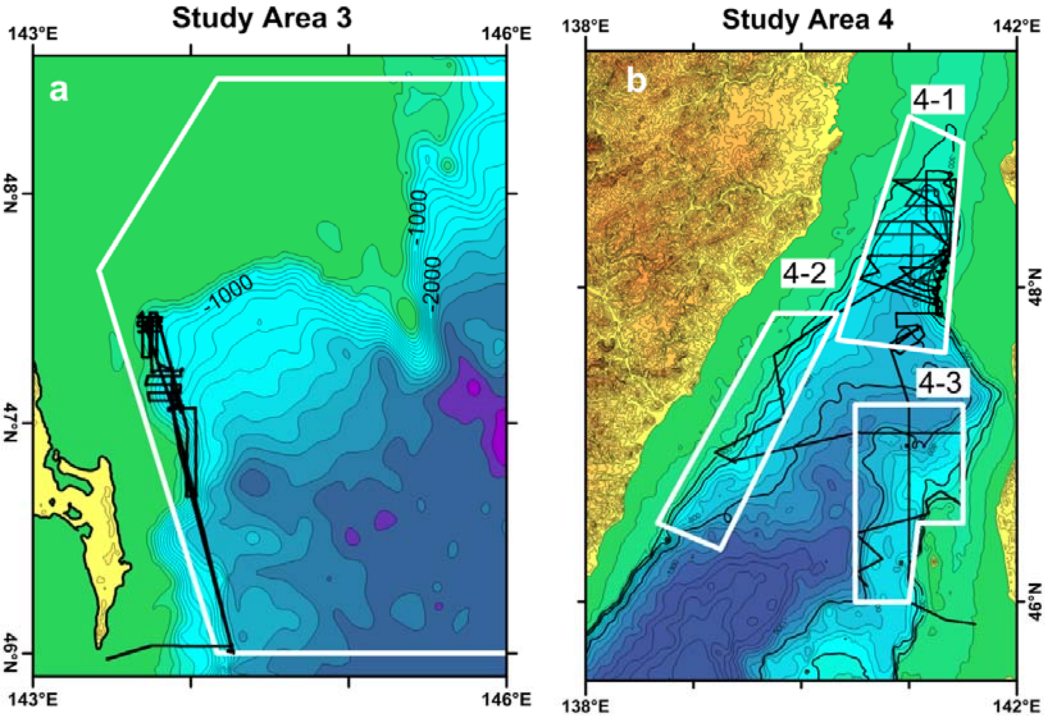


Fig. 3.1. Location of the bathymetric survey lines in Study area 3 (a) and Study area 4 (b). Bathymetry based on SRTM data. See Fig. 1 in Tectonics Chapter for general location.

Similar morphology was revealed also for NS-striking area of the slope investigated in present cruise (Fig. 3.2a). In the north of this area two large canyons with general EW-strike are located. Width of the canyons is 10 km and depth reaches 800 m. Heads of the canyons are located at depths of 200-500 m and below 1500 m they disappear. Further to the south the slope is cut by several other canyons having smaller dimensions. Comparison of newly obtained map with the map constructed on base of SRTM data (Fig. 3.2b) leads to conclusion that only two major canyons are seen on the SRTM map for this slope area.

Study Area 4-1where the bathymetry survey was carried out in most detail embraced northern end of the Tatarsky Trough, its eastern flank, axial part and western flank (Fig. 3.3a). Western flank of the trough within the study area is rectilinear. Its eastern flank in the north has northeastern strike and in the very south the strike begins to change for northwestern one. Depths in the axial part of the trough increase in direction from north to south from 500 to 1075 m. Bottom morphologies in the western and eastern sides of the trough axis are essentially different (Fig. 3.4). In the east the trough bottom gently transits into its slope and in the west this transition is realized via series of asymmetric swells. The swells strike parallel to the slope and have heights of 25-30 m. Seismic data justified that swells origination is conditioned by washing-in or sliding of sediments (see Seismic Survey chapter). The map constructed on base of SRTM data (Fig. 3.3b) in present scale correlates well with our map excluding the trough bottom where washing-in swells are practically undistinguished on SRTM map.

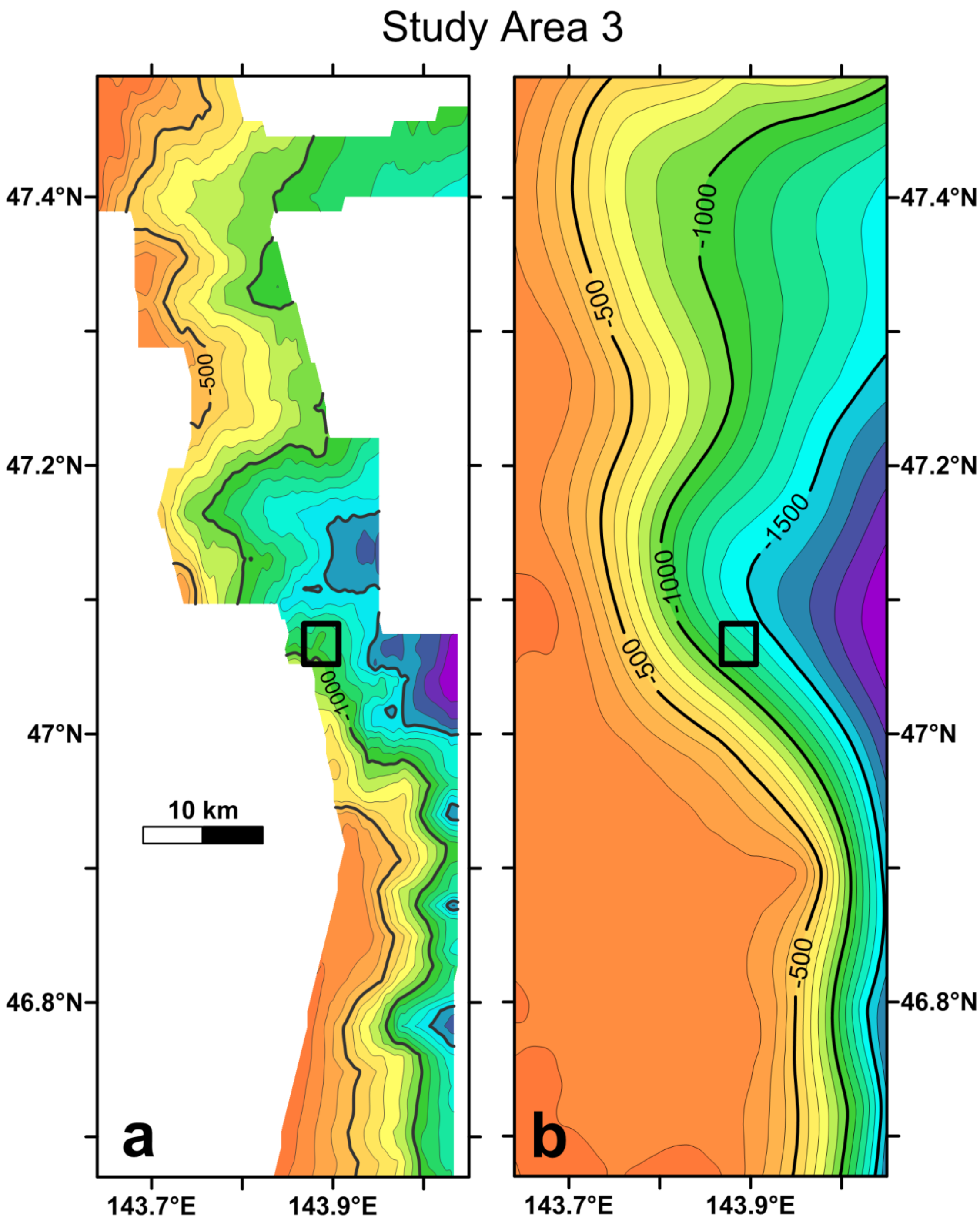


Fig. 3.2. Bathymetric maps of the upper western slope of the Kurile Basin (Study Area 3) based on data obtained during this cruise (a) and SRTM data (b). Contour interval is 100 m. Boxes mark area of detailed investigations shown in Fig. 3.5.

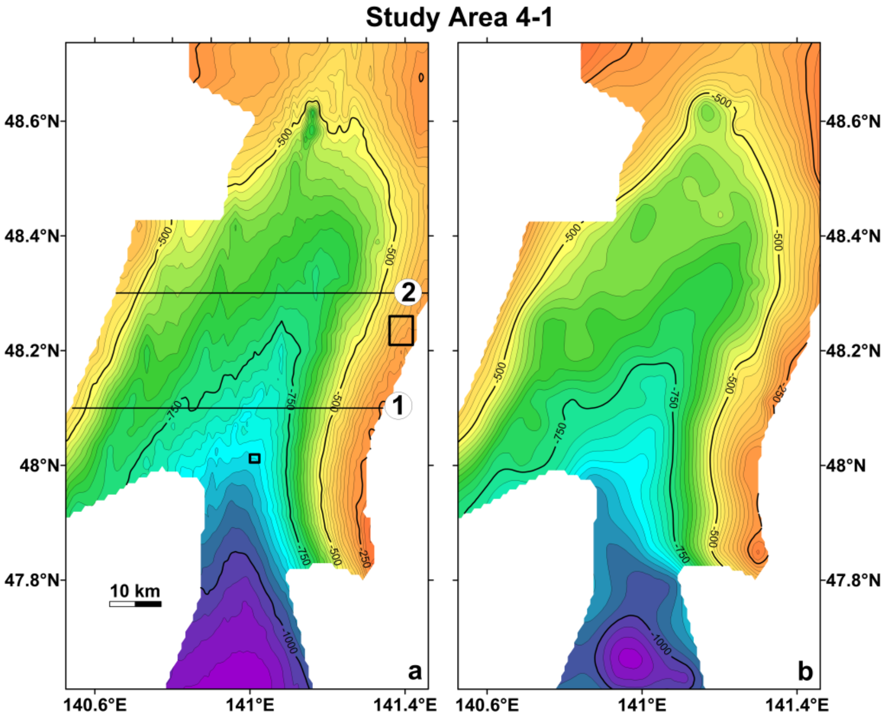


Fig. 3.3. Bathymetric maps of the Tatarsky Trough (Study Area 4-1) based on data obtained during this cruise (a) and on SRTM data (b). Contour interval is 25 m. Boxes mark areas of detailed investigations shown in Fig. 6. Numbered thick lines indicate location of the bathymetric profiles shown in Fig. 3.4.

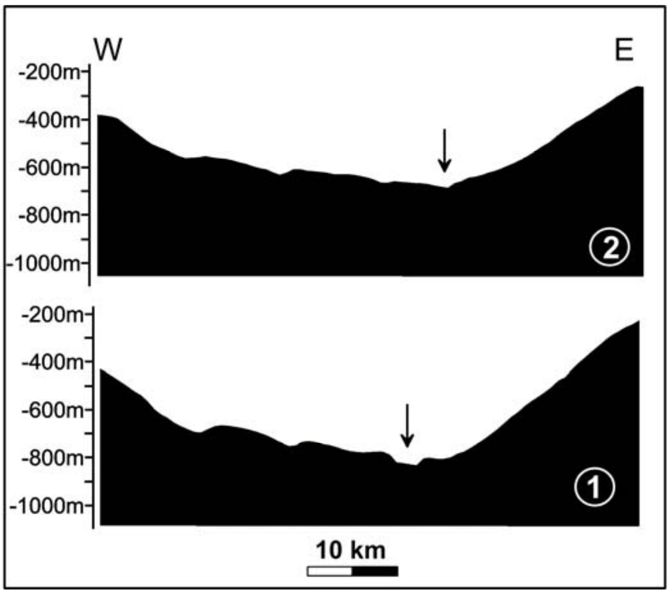


Fig. 3.4. Bathymetric profiles crossing the Tatarsky Trough. Arrows show the trough axis. See locations in Fig. 3.3a.

Detailed bathymetry. Three detailed bathymetric maps were prepared for the sampling sites located inside the Study Areas 3 and 4-1 (Figs. 3.2 and 3.3a). Area of detailed investigations on Study Area 3 was located on southern slope of EW-striking canyon and embraced depth interval from 1260 to 960 m. Central part of the area is occupied by a spur of southern canyon's wall, represented by a small rise (Fig. 3.5). The rise strikes in NW direction and its length is over 2 km. Its top is flat and is outlined by 1100 m contour line. Northwestern flank of the rise is steeper than its southeastern slope. Both slopes are cut by small canyons. One of them (located on northwestern slope) may be interpreted as a small landslide based on its morphology (Fig. 3.5).

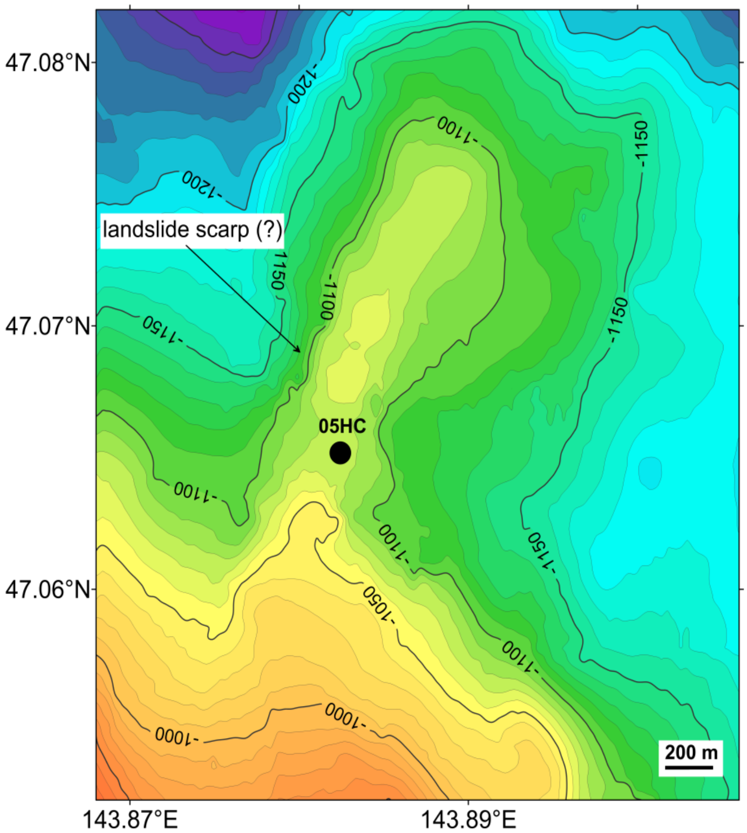


Fig. 3.5. Detailed bathymetric map of the station 05HC (filled circle). Contour interval is 10 m. See location in Fig. 3.2

Two areas on Study Area 4-1 were studied in detail; they are located in the base of northeastern slope of the Tatarsky Trough and in the upper part of this slope (Fig. 3.3a). The first of them was chosen for investigation because a structure of gas chimney type was found here on seismic profile running in LV53 Cruise of RV "Akademik M.A. Lavrentyev". Relief of this area has rather simple morphology; a slope with height of about 10 m divides the area into southwestern and northeastern parts (Fig. 3.6a). Southwestern part is occupied by a plane with rounded depressions and uplifts with depth variations of 4-8 meters. In northeastern part of the slope small rise with height of about 8 meters is located; it is stretched parallel to the slope in northwestern direction. Rise top has rounded sharp and corresponds to the structure of gas chimney type recorded on seismic profile. Gas flares were not observed in this area.

The second area is located in the upper part of Tatarsky Trough's northeastern slope in depth interval 400-275 m (Fig. 3.3a). This area attracted interest mainly because numerous gas flares were found here (Fig. 3.6b). The slope strikes in northeastern direction; angle of its inclination is 2º. The most remarkable feature of slope morphology is occurrence of two grooves striking in nearly NS direction at an acute angle to the slope's strike. The first of them begins from 300 m contour line and is traced at distance over 2 km up to 350 m contour line. Width of the groove is 250 m and depth is 15-20 m. The second groove located to the east from the first one was mapped only partially, but probably has the same dimensions. Several rounded depressions were also mapped on the slope; their maximum size reaches 250 m and depth is about 10 m. These depressions apparently represent pockmarks. The pockmarks are inactive, because gas seeps above them were not observed.

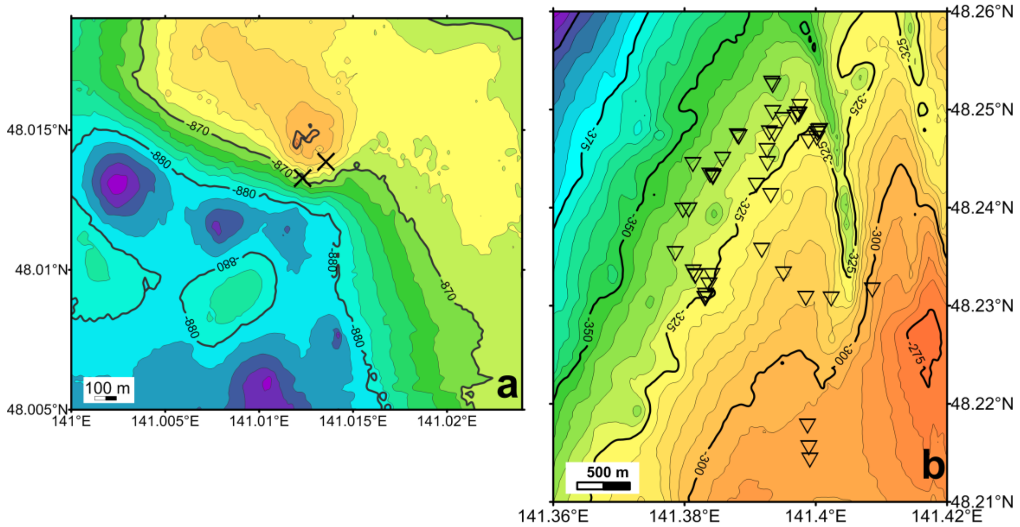


Fig. 3.6. Detailed bathymetric maps of the stations 21HC and 23HC showing by crosses (a) and of the area with abundance of the gas flares indicating by triangles (b). Contour intervals are 2 m and 5 m, correspondently. See location in Fig. 3.3a.

The grooves are observed on majority of bathymetry profiles recorded in depth interval 400-300 m; thus they may be regarded as characteristic morphologic feature of upper part of trough's eastern slope. Their origination is apparently conditioned by rupture of upper sedimentary cover due to sliding of deposits.

Results of bathymetry survey are the following.

1. Morphology of southern part of Sakhalin Eastern slope adjacent to the Kurile Basin was updated. In this area numerous canyons of nearly EW-strike were found including the canyons which are absent on SRTM map, though the last presently is regarded as the best digital map of this region.

2. In western part of the Tatar Trough relief forms associated with wash-in deposits were found. These relief forms are absent or poorly manifested on SRTM map.

3. It was supposed that sliding of deposits presently occurs even on such gentle slopes as the eastern slope of the Tatarsky Trough.

References

Operation Report of Sakhalin Slope Gas Hydrate Project 2011, R/V Akademik M.A.Lavrentiev Cruise 56, New Energy Resources Research Center, Kitami Institute of Technology, Kitami, H. Shoji, Y.K. Jin, A.Obzhirov and B. Baranov, 2012, 140 p.

3.2. Seismic surveys

V. Prokudin, E. Sukhoveev, D. Rukavishnikova

3.2.1. Equipments

Seismic investigations were conducted using GeoPulse Sub-bottom Profiler system (Figs. 3.7 and 3.8). Its technical characteristics are:

Output frequency	3.5 kHz
Nominal power in impulse	up to 10 kWt
Pulse Cycles	4 cycles of the frequency selected
Band pass filter	3 – 7 kHz
Depth of transducer tow	4 m
Distance “antenna GPS – reception point”	5 m
Registration program	GeoPro2 (Mac OS X)

The profiling runs with speed of 5.5-6.2 knots. Excitation interval was 1.3-4.6 sec, thereby shot interval was equal about 4-13 m. Sample rate was 80 μs.

Seismic surveys were carried out during the cruise LV-59 for: 1) detection of the gas chimneys, and 2) identification of the most upper sediment structure. Maximal penetration was 100 msec and resolution up to 2 msec. A total of 67 profiles were obtained during the cruise; these profiles were stored as 104 files with SEGY format. Table 1 contains profile coordinates and number of files. Study areas were located on the 4 distinct sites in the Terpeniya Ridge (Study Area 3) and Tatarsky Strait (Study Area 4). Location of seismic profiles shown in Figs. 3.9-3.12. A total length of 1669 L-km sub-bottom profile (SBP) data was acquired during the cruise.

3.2.2. Results

Morphology. Structure of sediments upper part in the Tatarsky Strait has been forming mainly as a result of unconsolidated deposits sliding from the slopes. It is known that this process in underwater conditions may occur at slope inclined larger than 10°. Typical inclination angles in the study areas are about 2-30 for Primorye slope and 1-20 for Sakhalin slope. So sliding processes and associated deformation of sedimentary cover are most widely spread in the western part of the Tatarsky Strait (Figs. 3.13 and 3.14). In Sakhalin slope sliding processes are observed mainly in shelf edge area (profiles LV59_32-40) and rarely in its lower part (profiles LV59_18). In the north of polygon 4-1 washing-out deposits occur in the zone of Primorye Current influence; it is accompanied by origination of erosion channels with depth up to 200 m (Fig. 3.15). Turbidites flows formed by this process (Posamentier and Walker, 2006) transport sedimentary materials down along the slope shown in profiles of LV59_31, LV59_26, LV59_25), and then the materials deposit in this area within levee channels, on the slope and near its foot (mass transport deposits).

Acoustic anomalies. Data obtained earlier on the North-Eastern Sakhalin Slope permitted us to recover correlation between gas flares and local acoustic anomalies of channel-like shape (gas chimneys). Small number of such structures was also obtained on study area 3 (Fig. 3.16). However gas chimneys were not found on study areas in the Tatarsky Strait. Structures morphologically similar to gas chimneys were recognized in the study area 3 from a number of profiles, and they are associated with diapirs. Majority of recorded gas flares are represented as acoustic anomalies of “bright spot” type. Such anomalies associated with shallow-water gas-bearing sediments have been described by Kim et al. (2008). On study area 4-1 we observed strong reflection area located near shelf edge (Fig. 3.17); numerous gas flares are associated with it. Similar anomalous area was recorded also on polygon 4-3 (Fig. 3.18), but gas flares were not found here. Possibly this is because of 15-meter sedimentary layer above the gas-bearing stratum.

References

Posamentier H.W., Walker R.G. Deep-Water Turbidites and Submarine Fans Facies Models Revisited. SEMP Special Publication No. 84, 2006. SEPM (Society for Sedimentary Geology), ISBM 1-56576-121-9, p.1-122.

Kim D.C., Lee G.S., Lee G.H., Park S.C. Sediment echo types and acoustic characteristics of gas-related acoustic anomalies in Jinhae Bay, southern Korea // Geosciences Journal, 2008. Vol. 12, No.1. P. 47-61.

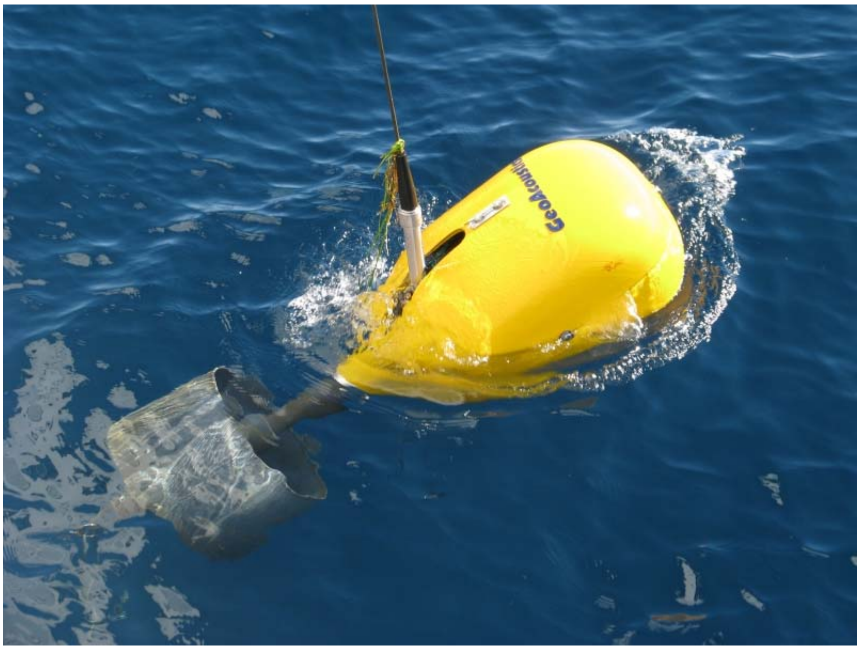


Fig. 3.7. Transducer tow of GeoPulse Sub-bottom Profiler system.

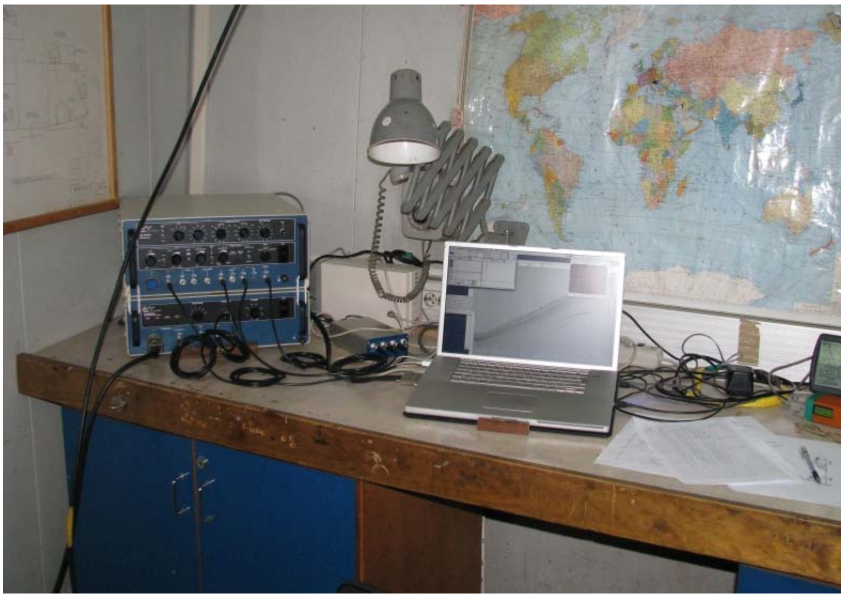


Fig. 3.8. Registration complex of GeoPulse Sub-bottom Profiler system consisting of control box (generator, amplifier and filter) and Macintosh PC control.

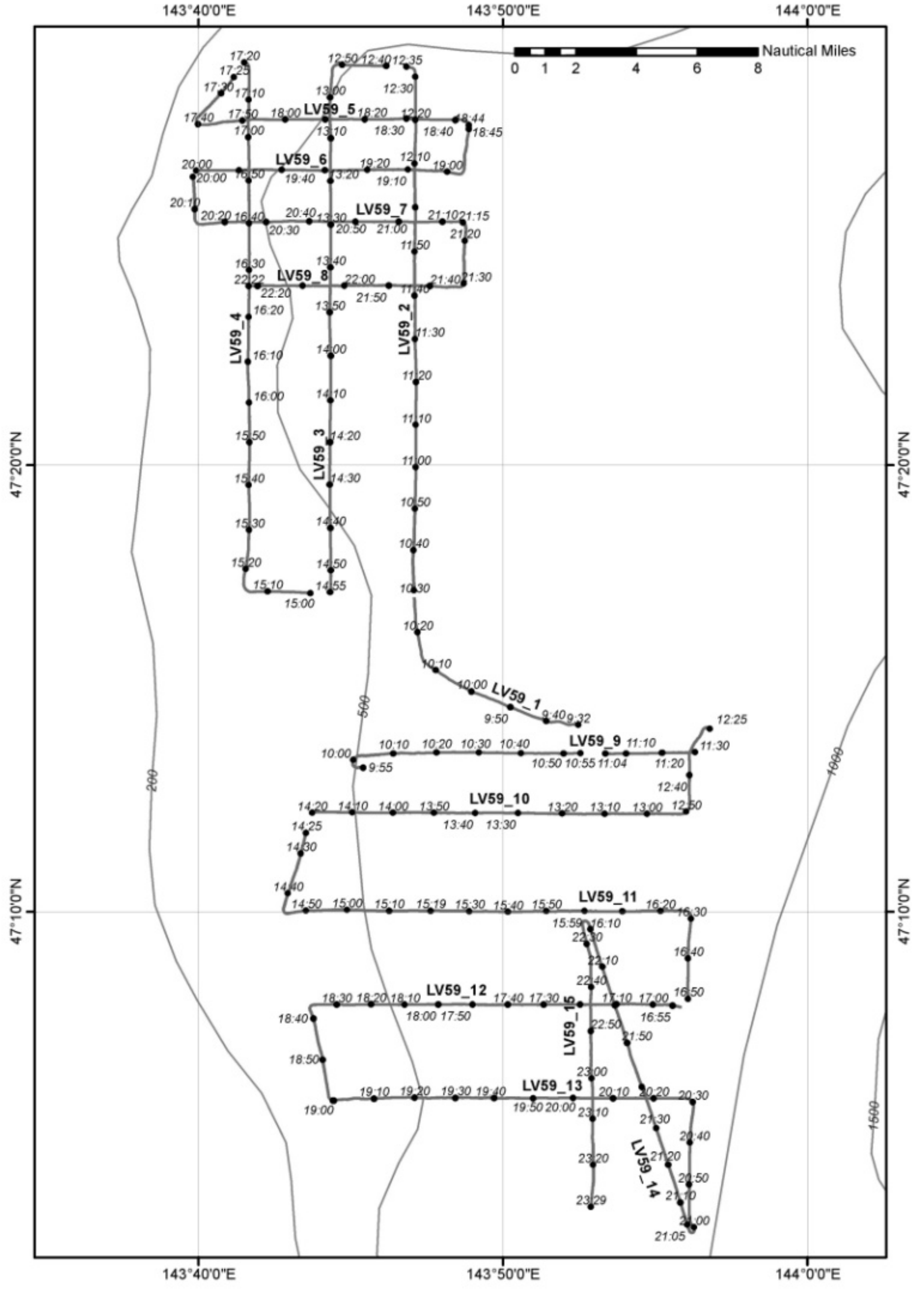


Fig. 3.9. Location of seismic profiles LV59_1 – LV59_15, Study Area 3. Numbers indicate time.

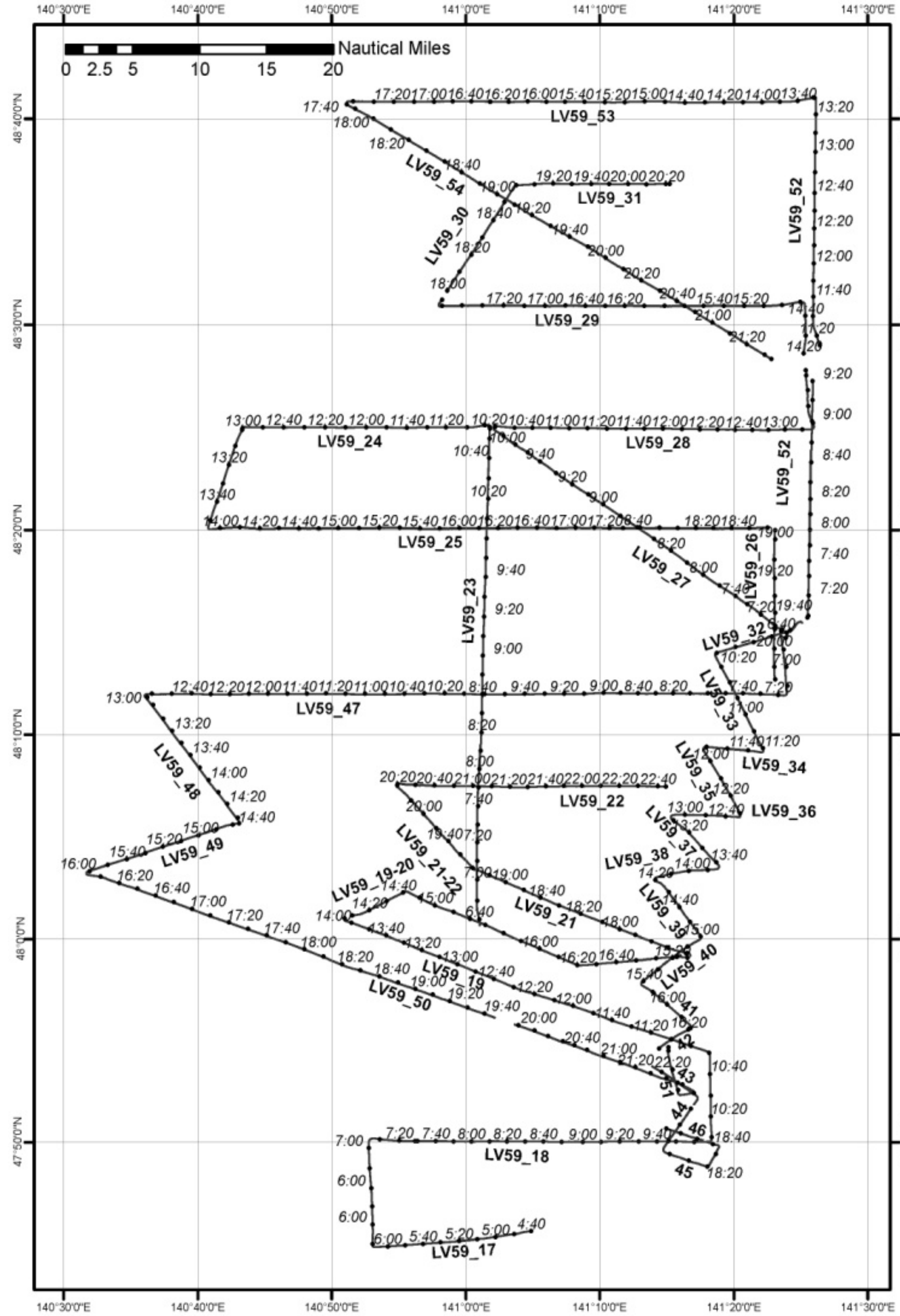


Fig. 3.10. Location of seismic profiles in Study Area 4-1. Numbers indicate time.

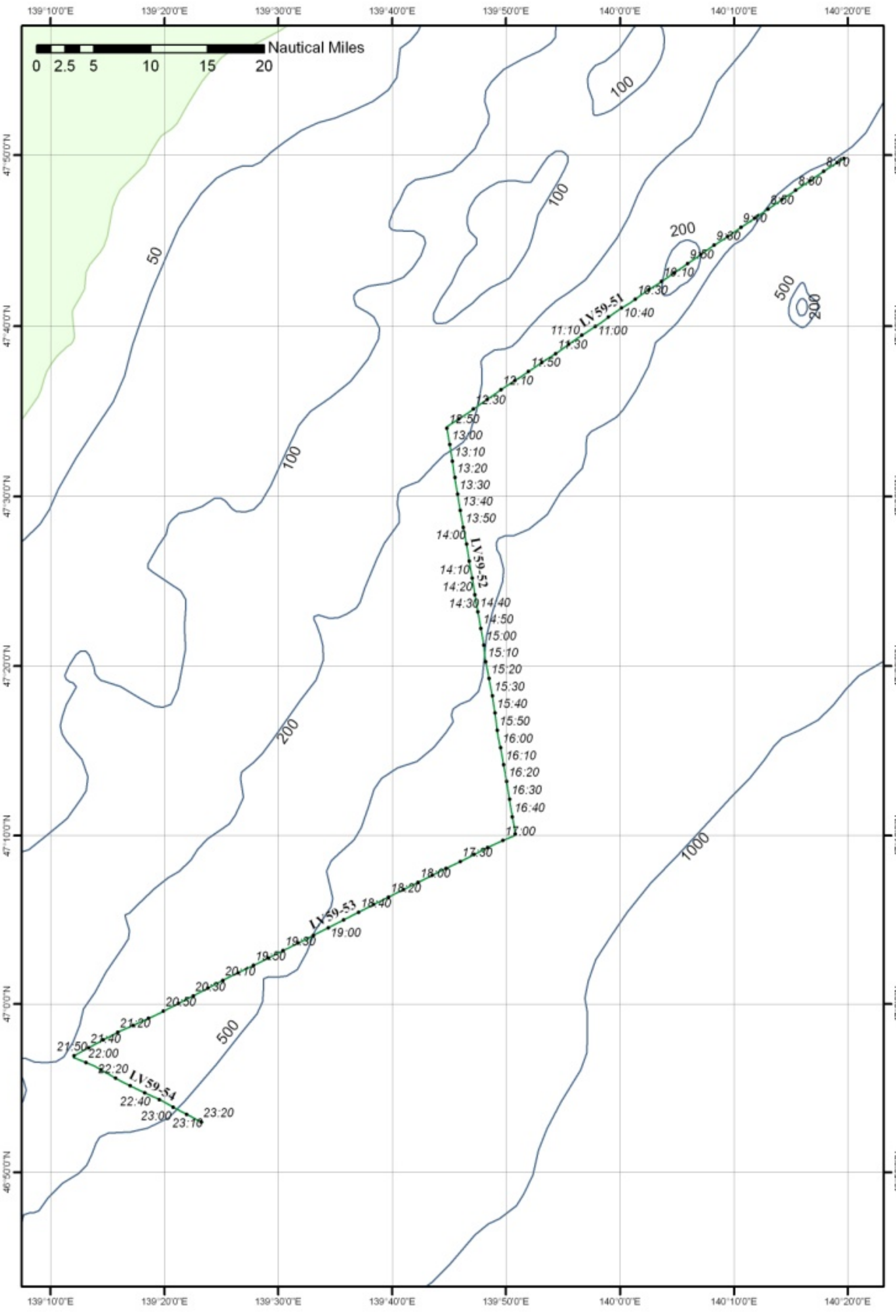


Fig. 3.11. Location of seismic profiles in Study Area 4-2. Numbers indicate time.

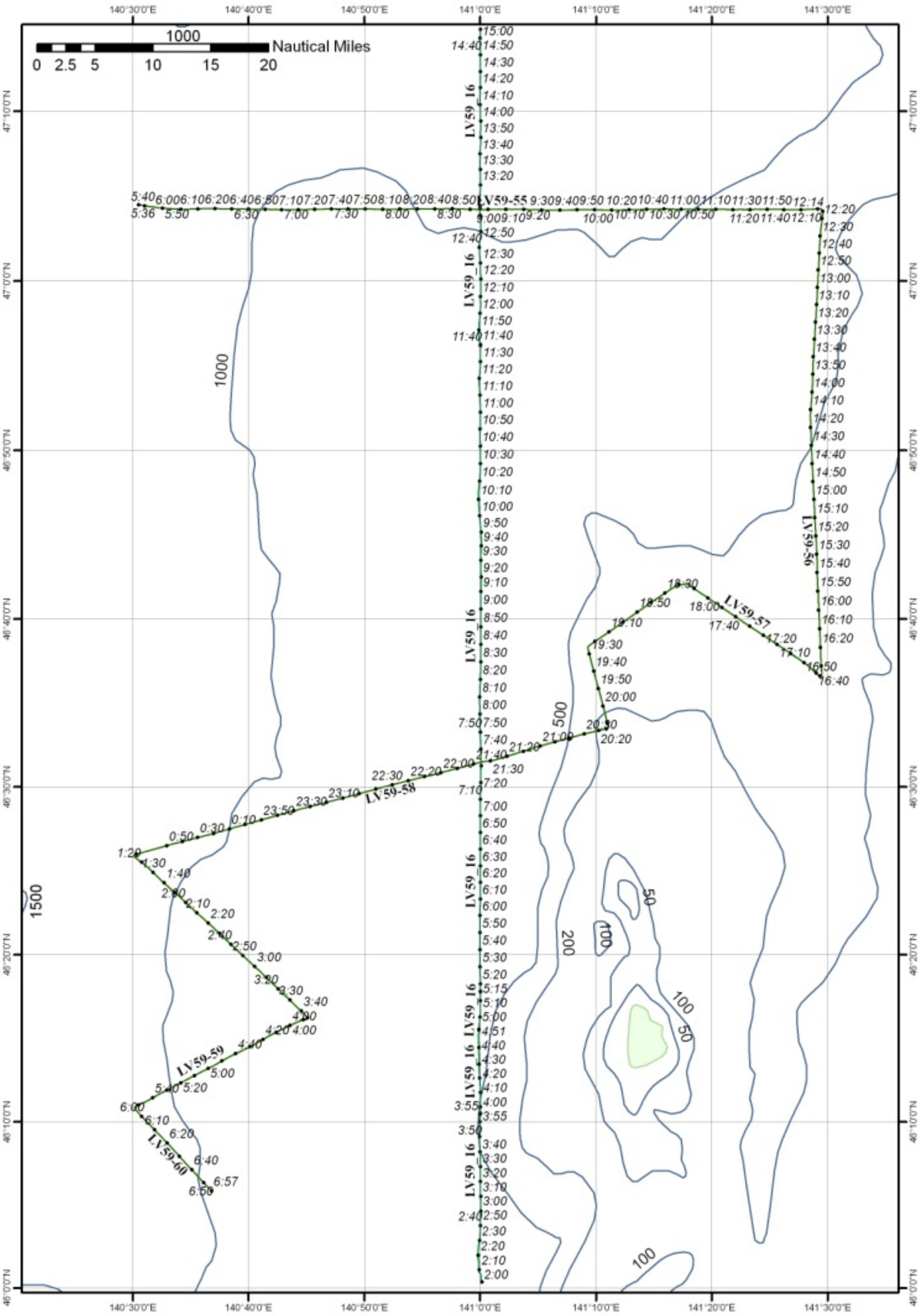


Fig. 3.12. Location of seismic profiles in Study Area 4-3. Numbers indicate time.

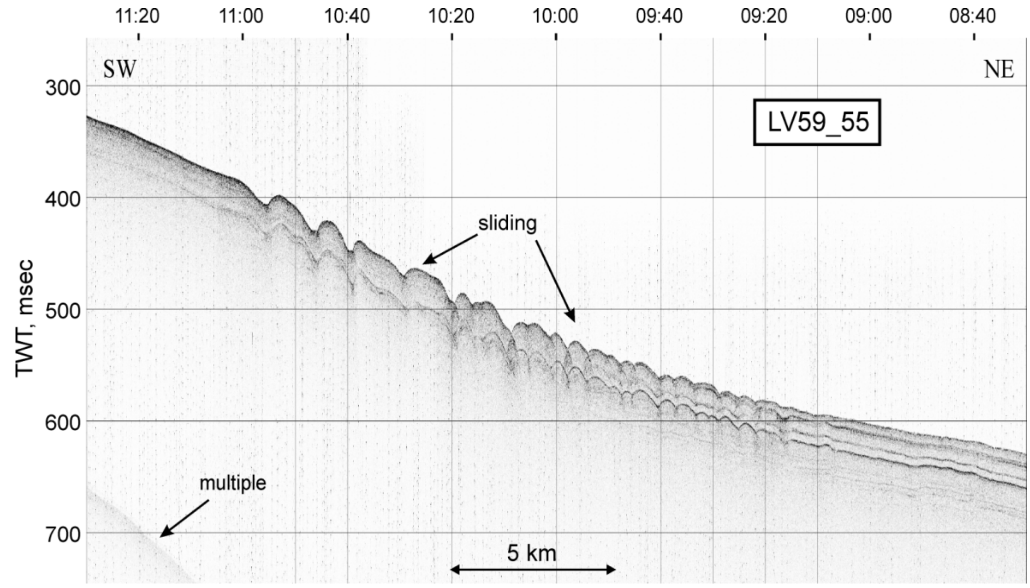


Fig. 3.13. Deformation of the upper sedimentary cover connected with a sliding process. See profile location in Fig. 3.10.

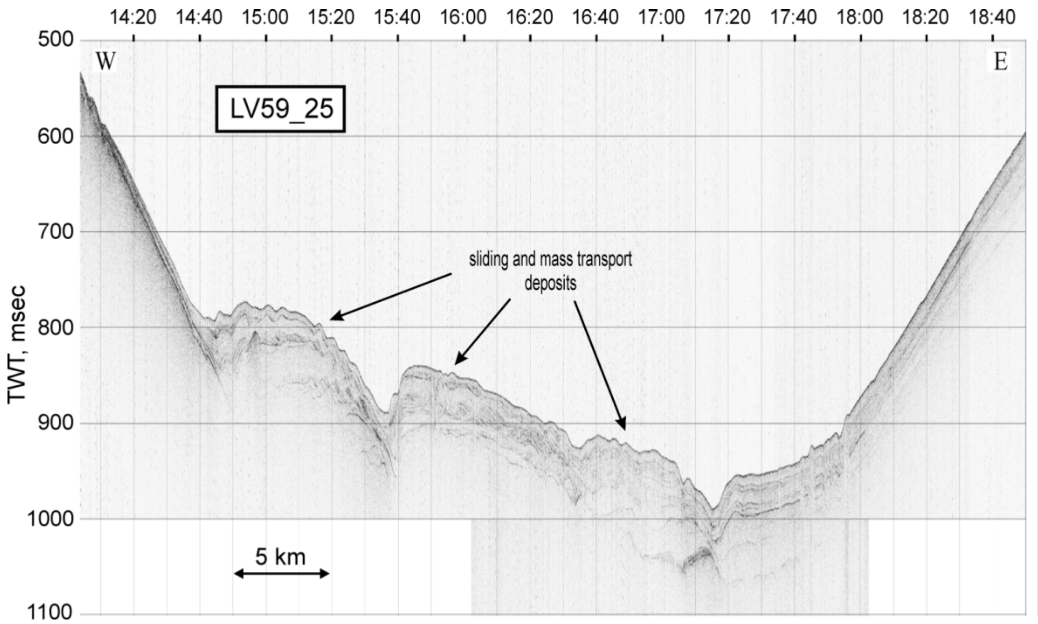


Fig. 3.14. Sesimic profile LV59_25 showing the process of sliding and mass transport deposit. See profile location in Fig. 3.10.

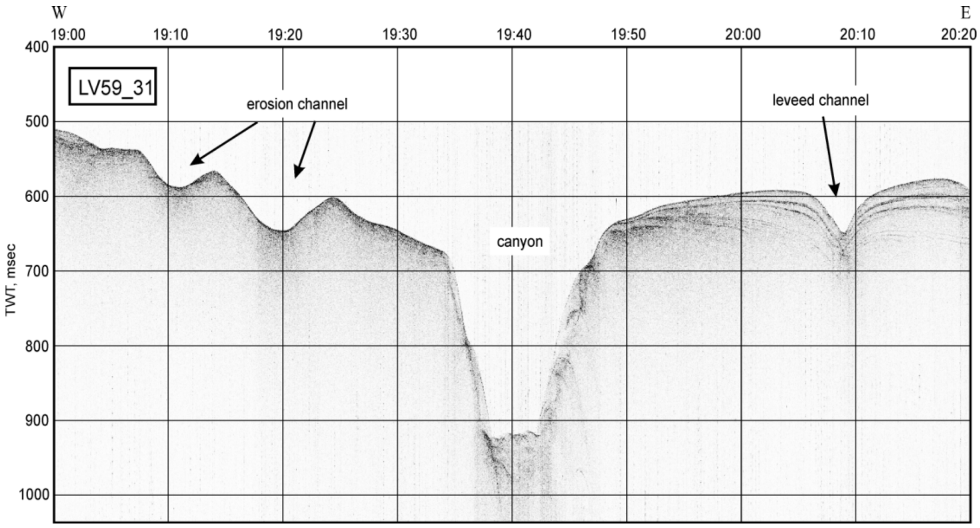


Fig. 3.15. Strong currents control erosion, transportation and sedimentation of the sediments in the northern Study Area 4-1. See profile location in Fig. 3.10.

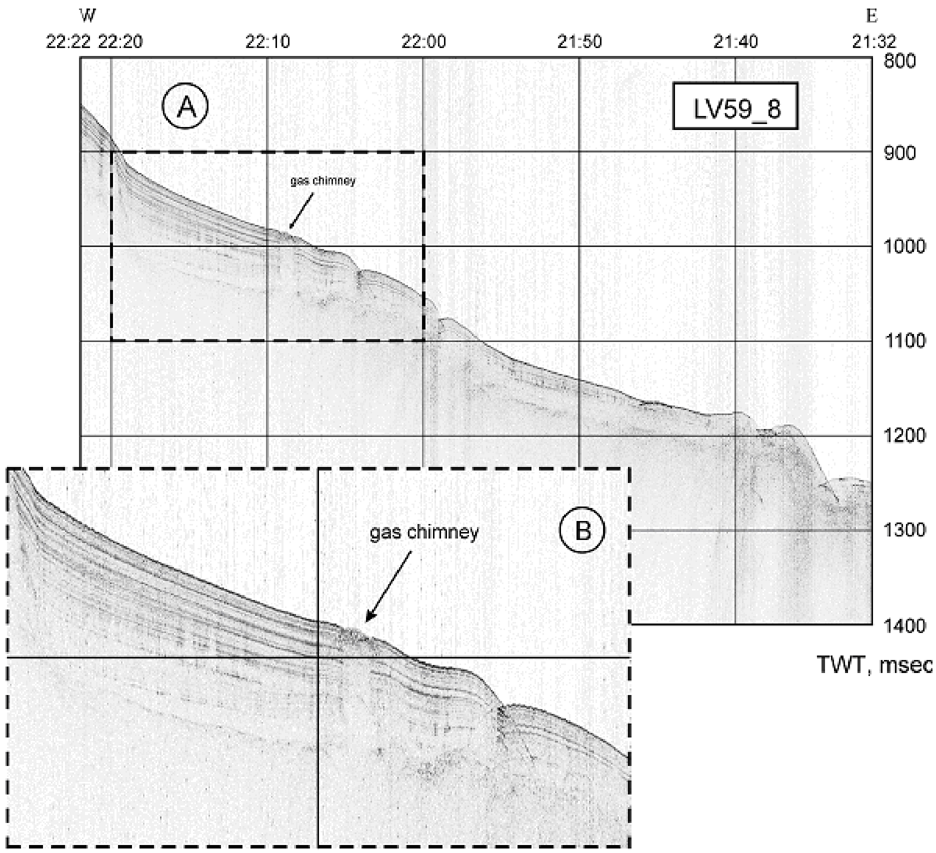


Fig. 3.16. Structure of the upper sedimentary layer on southern Sakhalin slope, seismic profile LV59_8 (A) and part of profile LV59_8 showing gas chimney (B). See profile location in Fig. 3.9.

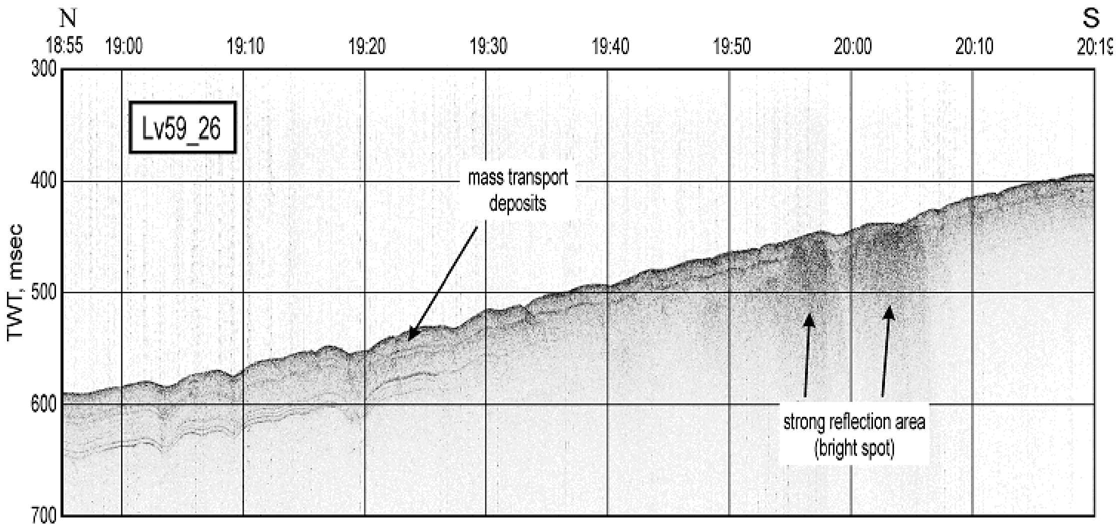


Fig. 3.17. Example of strong reflector area connected to gas expulsion. Many gas flares were detected inside this area. Left side of the profile shows weakly deformed sediment. It is suggested that deformation has occurred due to creep process. See profile location in Fig. 3.10.

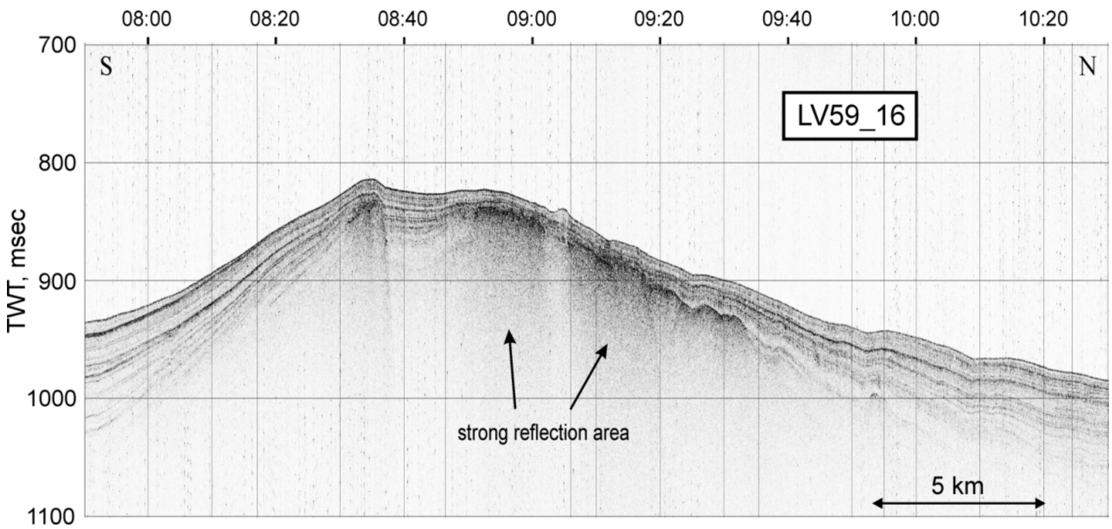


Fig. 3.18. Example of strong reflector area that is probably connected with gas-bearing stratum in the Study Area 4-1. See profile location in Fig. 3.12.

Table 3.1. Seismic profile coordinates and number of files.

Date: (2012, August)	**Profile, №**	**File name**	**Time (GMT)**		**Length (km)**	**Start**		**End**	
			Start	**End**		**Latitude, N**	**Longitude, E**	**Latitude, N**	**Longitude, E**
12	LV59_1	*LV59-1*	09:32	10:29	9.7	47°14,187	143°52,485	47°17,097	143°47,087
12	LV59_2	*LV59-2*	10:30	12:35	21.8	47°17,201	143°47,083	47°28,898	143°46,813
12	LV59_2-3	*LV59-3*	12:40	12:51	2.0	47°28,909	143°46,172	47°28,933	143°44,579
12	LV59_3	*LV59-3*	12:51	14:55	21.8	47°28,933	143°44,579	47°17,158	143°44,317
12	LV59_3-4	*LV59-4*	15:00	15:15	2.6	47°17,135	143°43,683	47°17,201	143°41,588
12	LV59_4	*LV59-4*	15:15	17:20	21.8	47°17,201	143°41,588	47°28,980	143°41,499
12	LV59_4-5	*LV59-5*	17:25	17:40	2.4	47°28,657	143°41,159	47°27,603	143°39,988
12	LV59_5	*LV59-5*	17:40	18:44	11.1	47°27,603	143°39,988	47°27,586	143°48,881
12	LV59_5-6	*LV59-6*	18:45	18:57	1.9	47°27,501	143°48,890	47°26,493	143°48,547
12	LV59_6	*LV59-6*	18:57	20:00	10.8	47°26,493	143°48,547	47°26,572	143°39,932
12	LV59_6-7	*LV59-7*	20:00	20:14	2.0	47°26,428	143°39,816	47°25,378	143°40,008
12	LV59_7	*LV59-7*	20:14	21:15	10.8	47°25,378	143°40,008	47°25,431	143°48,630
12	LV59_7-8	*LV59-8*	21:15	21:30	2.5	47°25,415	143°48,687	47°24,057	143°48,722
12	LV59_8	*LV59-8*	21:30	22:22	8.9	47°24,057	143°48,722	47°23,998	143°41,655
13	LV59_9	*LV59-9*	09:55	10:54	9.0	47°13,226	143°45,408	47°13,551	143°52,552
13	LV59_9 (ending)	*LV59-9_2*	11:04	11:30	3.7	47°13,546	143°53,364	47°13,572	143°56,342
13	LV59_9-10	*LV59-10*	12:25	12:50	3.6	47°14,102	143°56,794	47°12,239	143°56,016
13	LV59_10	*LV59-10*	12:50	14:20	15.5	47°12,239	143°56,016	47°12,218	143°43,742
13	LV59_10-11	*LV59-11*	14:25	14:45	3.4	47°11,768	143°43,533	47°09,980	143°42,843
13	LV59_11	*LV59-11*	14:45	16:29	16.8	47°09,980	143°42,843	47°09,908	143°56,182
13	LV59_11-12	*LV59-11*	16:29	16:50	3.4	47°09,908	143°56,182	47°08,051	143°56,084

13	LV59_12	*LV59-12*	16:53	18:37	15.4	47°07,861	143°55,869	47°07,847	143°43,659
13	LV59_12-13	*LV59-12*	18:37	19:00	4.0	47°07,847	143°43,659	47°05,770	143°44,421
13	LV59_13	*LV59-13*	19:00	20:30	14.9	47°05,771	143°44,440	47°05,732	143°56,244
13	LV59_13-14	*LV59-13*	20:30	21:02	5.4	47°05,732	143°56,244	47°02,800	143°56,219
13	LV59_14	*LV59-14*	21:02	22:23	13.7	47°02,798	143°56,212	47°09,800	143°52,692
13	LV59_15	*LV59-14*	22:23	23:29	11.9	47°09,800	143°52,692	47°03,377	143°52,896
15	LV59_16 (beginning)	*LV59-15*	02:01	03:55	18.7	46°00,356	141°00,144	46°10,425	141°00,005
15	LV59_16 (continuation)	*LV59-15_2*	03:56	04:50	9.3	46°10,482	141°00,009	46°15,483	140°59,892
15	LV59_16 (continuation)	*LV59-15_3*	04:51	05:15	4.1	46°15,521	140°59,896	46°17,753	141°00,028
15	LV59_16 (continuation)	*LV59-15_4*	05:15	07:50	28.6	46°17,795	141°00,027	46°33,256	141°00,017
15	LV59_16 (continuation)	*LV59-15_5*	07:50	11:40	42.5	46°33,260	141°00,017	46°56,204	141°00,015
15	LV59_16 (continuation)	*LV59-15_6*	11:41	13:06	15.2	46°56,251	141°00,011	47°04,438	140°59,976
15	LV59_16 (ending)	*LV59-15_7*	13:07	14:57	19.2	47°04,463	140°59,980	47°14,819	141°00,010
16	LV59_17	*LV59-16*	04:40	06:08	14.7	47°45,590	141°04,854	47°44,824	140°53,135
16	LV59_17-18	*LV59-16*	06:08	07:05	9.9	47°44,824	140°53,135	47°50,148	140°52,893
16	LV59_18 (beginning)	*LV59-16*	07:05	07:28	4.1	47°50,148	140°52,893	47°50,047	140°56,182
16	LV59_18 (ending)	*LV59-17*	07:29	10:10	27.5	47°50,047	140°56,195	47°50,220	141°18,346
16	LV59_18-19	*LV59-18*	10:10	10:50	7.7	47°50,230	141°18,345	47°54,375	141°18,146
16	LV59_19	*LV59-18*	10:50	14:05	35.9	47°54,375	141°18,146	48°01,005	140°50,932
16	LV59_19-20	*LV59-19*	14:08	14:40	5.5	48°01,118	140°51,222	48°02,258	140°55,310
16	LV59_20	*LV59-19*	14:40	16:20	17.4	48°02,258	140°55,310	47°58,701	141°08,324
16	LV59_20-21	*LV59-19*	16:20	17:17	10.5	47°58,701	141°08,324	47°59,148	141°16,739

16	LV59_21	*LV59-20*	17:17	19:20	21.6	47°59,152	141°16,741	48°03,472	141°00,505
16	LV59_21-22	*LV59-20*	19:20	20:21	10.3	48°03,472	141°00,505	48°07,574	140°54,888
16	LV59_22	*LV59-21*	20:21	22:45	24.8	48°07,577	140°54,891	48°07,454	141°14,932
17	LV59_23	*LV59-22*	06:36	10:56	45.2	48°00,654	141°01,019	48°25,036	141°01,760
17	LV59_24	*LV59-23*	10:56	13:01	22.7	48°25,040	141°01,757	48°24,889	140°43,272
17	LV59_24-25	*LV59-24*	13:01	14:05	8.9	48°24,884	140°43,270	48°20,119	140°42,393
17	LV59_25	*LV59-24*	14:05	18:54	50.0	48°20,119	140°42,393	48°20,081	141°23,009
17	LV59_26	*LV59-25*	18:55	20:19	13.3	48°19,982	141°23,074	48°12,695	141°23,052
18	LV59_27	*LV59-26*	06:57	10:20	32.8	48°14,749	141°23,852	48°25,031	141°02,154
18	LV59_28	*LV59-27*	10:20	13:17	29.2	48°25,034	141°02,160	48°24,989	141°25,949
18	LV59_28-29	*LV59-27*	13:17	13:54	5.2	48°24,989	141°25,949	48°27,785	141°25,367
18	LV59_28-29 (ending)	*LV59-28*	14:20	14:47	4.6	48°28,591	141°25,195	48°31,077	141°25,213
18	LV59_29	*LV59-28*	14:47	17:55	33.1	48°31,077	141°25,213	48°31,222	140°58,200
18	LV59_30	*LV59-29*	17:55	19:00	12.3	48°31,222	140°58,200	48°36,780	141°03,740
18	LV59_31	*LV59-29*	19:00	20:23	14.0	48°36,780	141°03,740	48°36,849	141°15,200
19	LV59_32	*LV59-30*	09:30	10:21	8.5	48°15,443	141°25,102	48°13,931	141°18,594
19	LV59_33	*LV59-31*	10:21	11:24	9.8	48°13,931	141°18,594	48°09,152	141°21,981
19	LV59_34	*LV59-32*	11:24	11:52	5.3	48°09,152	141°21,981	48°09,303	141°17,714
19	LV59_35	*LV59-33*	11:52	12:31	7.0	48°09,303	141°17,714	48°06,041	141°20,496
19	LV59_36	*LV59-34*	12:31	13:07	6.4	48°06,041	141°20,496	48°05,943	141°15,304
19	LV59_37	*LV59-35*	13:07	13:16	1.3	48°05,943	141°15,304	48°05,518	141°16,080
19	LV59_37 (ending)	*LV59-35_2*	13:16	13:45	4.8	48°05,424	141°16,286	48°03,419	141°18,695
19	LV59_38	*LV59-36*	13:45	14:21	5.7	48°03,419	141°18,695	48°02,835	141°14,191
19	LV59_39	*LV59-37*	14:21	15:01	6.7	48°02,835	141°14,191	48°00,002	141°17,503
19	LV59_40	*LV59-38*	15:01	15:42	6.8	48°00,002	141°17,503	47°57,793	141°13,081

19	LV59_41	*LV59-38*	15:42	16:18	6.1	47°57,793	141°13,081	47°55,601	141°16,761
19	LV59_42	*LV59-39*	16:18	16:38	3.5	47°55,601	141°16,761	47°54,605	141°14,403
19	LV59_43	*LV59-40*	16:53	17:19	4.4	47°53,744	141°13,845	47°52,453	141°16,840
19	LV59_44	*LV59-41*	17:21	17:27	1.1	47°52,336	141°17,087	47°51,851	141°17,029
19	LV59_44 (ending)	*LV59-42*	17:30	17:56	4.6	47°51,641	141°16,808	47°49,550	141°14,761
19	LV59_45	*LV59-42*	17:56	18:21	4.4	47°49,550	141°14,761	47°48,827	141°18,118
19	LV59_45-46	*LV59-42*	18:21	18:35	2.0	47°48,827	141°18,118	47°49,768	141°18,894
19	LV59_46	*LV59-42*	18:35	18:44	1.2	47°49,768	141°18,894	47°49,998	141°18,028
19	LV59_46 (ending)	*LV59-43*	18:46	19:09	3.6	47°50,072	141°17,745	47°50,650	141°14,971
20	LV59_27-47	*LV59-44*	06:38	07:15	6.0	48°15,158	141°23,598	48°11,955	141°23,967
20	LV59_47	*LV59-44*	07:15	12:55	59.0	48°11,955	141°23,967	48°11,840	140°36,173
20	LV59_48	*LV59-45*	12:55	14:35	14.2	48°11,833	140°36,178	48°05,669	140°43,062
20	LV59_49	*LV59-46*	14:35	16:01	14.6	48°05,668	140°43,058	48°03,283	140°31,786
20	LV59_50	*LV59-47*	16:01	19:47	40.0	48°03,280	140°31,780	47°56,120	141°02,271
20	LV59_50 (ending)	*LV59-47_2*	19:58	21:59	17.8	47°55,806	141°03,649	47°52,476	141°17,066
20	LV59_50-51	*LV59-47_2*	21:59	22:08	1.4	47°52,476	141°17,066	47°52,374	141°15,922
20	LV59_51	*LV59-47_2*	22:08	22:33	4.4	47°52,374	141°15,922	47°54,662	141°15,126
21	LV59_52	*LV59-48*	07:08	09:20	21.4	48°15,721	141°25,467	48°27,264	141°25,846
21	LV59_52 (ending)	*LV59-48_2*	11:15	13:29	22.2	48°29,018	141°26,379	48°41,011	141°26,011
21	LV59_53	*LV59-49*	13:29	17:34	42.7	48°41,012	141°26,017	48°40,730	140°51,081
21	LV59_54	*LV59-50*	17:35	21:35	34.6	48°40,697	140°51,112	48°40,730	141°22,815
23	LV59_55	*LV59-51*	07:55	12:50	52.4	47°49,805	140°19,692	47°33,989	139°44,801
23	LV59_56	*LV59-52*	12:50	16:51	45.0	47°33,948	139°44,812	47°10,001	139°50,742
23	LV59_57	*LV59-53*	16:51	21:50	54.6	47°09,998	139°50,738	46°56,894	139°12,004

23	LV59_58	*LV59-54*	21:50	23:23	16.4	46°56,890	139°12,001	46°52,960	139°23,591
24	LV59_59	*LV59-55*	05:36	12:13	74.5	47°04,503	140°30,483	47°04,216	141°29,529
24	LV59_60	*LV59-56*	12:15	16:36	50.9	47°04,108	141°29,589	46°36,594	141°29,371
24	LV59_61	*LV59-57*	16:36	18:18	18.2	46°36,594	141°29,365	46°42,032	141°17,464
24	LV59_62	*LV59-57*	18:18	19:25	12.4	46°42,032	141°17,464	46°38,367	141°09,323
24	LV59_63	*LV59-57*	19:25	20:13	9.2	46°38,367	141°09,323	46°33,517	141°11,008
24	LV59_64	*LV59-58*	20:14		53.8	46°33,462	141°10,894		
25				00:35				46°26,860	140°34,935
		LV59-58_2	00:35	00:59		46°26,851	140°34,889	46°26,244	140°31,640
		LV59-58_3	01:00	01:13		46°26,238	140°31,607	46°25,872	140°30,078
25	LV59_65	*LV59-58_4*	01:13	03:46	26.2	46°25,872	140°30,078	46°16,197	140°45,079
25	LV59_66	*LV59-59*	03:47	05:54	21.5	46°16,136	140°45,040	46°10,763	140°30,176
25	LV59_67	*LV59-60*	05:54	06:57	12.5	46°10,763	140°30,176	46°05,833	140°36,793

3.3. Hydroacoustic Investigation

A. S. Salomatin

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
- registration of the frontal zones, internal waves and other oceanological processes
- study of a spatial distribution of fish, zoo plankton, and acoustic evaluation of their biomass.

The hydroacoustic observations were carried out using a hydroacoustic complex created on the basis of the upgraded ship's echo sounders Sargan-EM and ELAC, sonar Sargan-GM (Fig. 3.19) and multichannel system of digital registration (Fig. 3.20). The hydroacoustic complex provided a possibility of simultaneous registration of sonar echoes on four independent channels with frequencies of 12 kHz, 20 kHz and 135 kHz. 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 in the Fig. 3.21, and its basic parameters are listed in the Table 3.2.

Fig. 3.19. Echo sounder Sargan-EM and sonars Sargan-GM

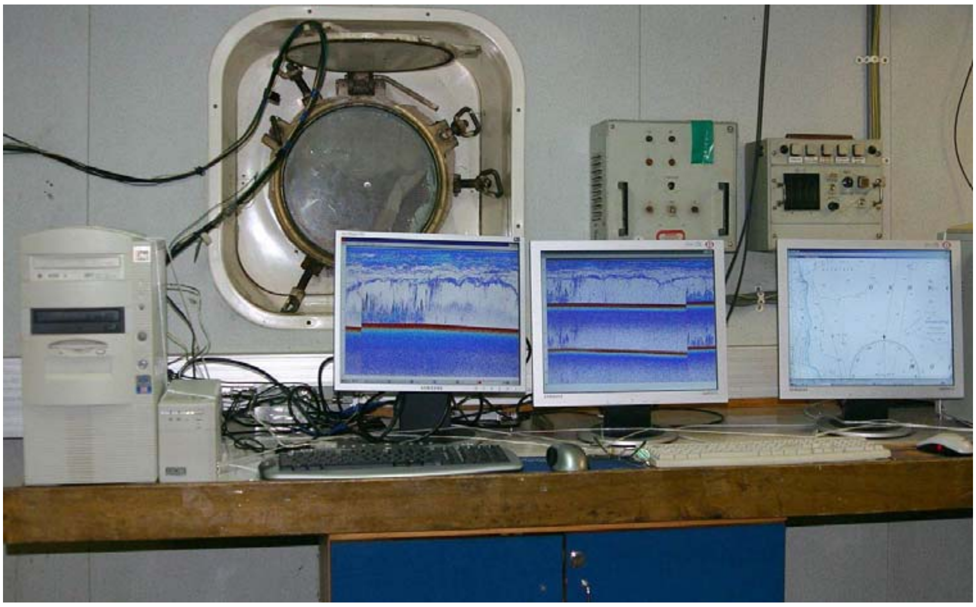


Fig. 3.20 Multichannel digital registration system

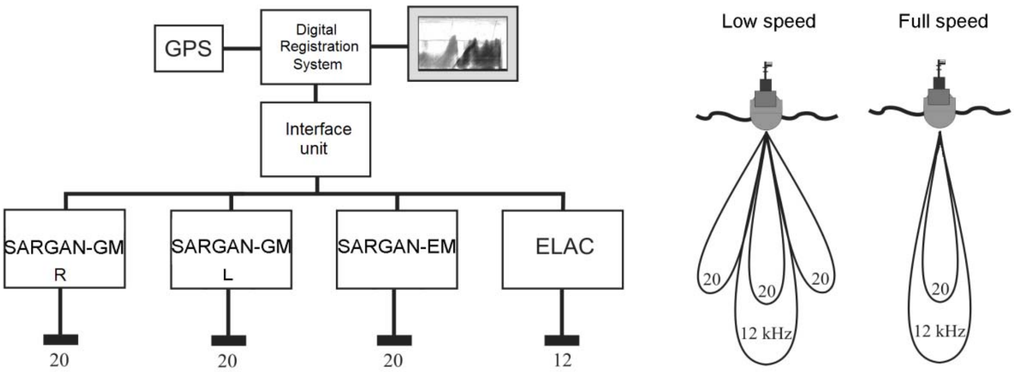


Fig. 3.21. The hydroacoustic complex block-diagram.

Table 3.2. Main parameters of acoustic equipment

Device	ELAC	Sargan-EM	Sargan-GM	
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

Multichannel system of digital registration is designed for the collection, initial handling, accumulation and visualization of the hydroacoustic information from four channels simultaneously and it includes:

- the analog block
- two sound cards Creative Labs
- personal computer (Pentium-II and higher)
- operation system Win 32 type
- “Sonic” software for input, handling, storing and visualization of echo-signals.

Echo-signals are converted to digital form with the help of four 16-bit analog-to-digital converters of sound cards; their synchronous detection and low frequency filtration are carried out further. The parameters of echo-signal registration (range of registered depths, mean sound speed etc.) are set by the program (see Fig. 3.22) or with the help of initializing file.

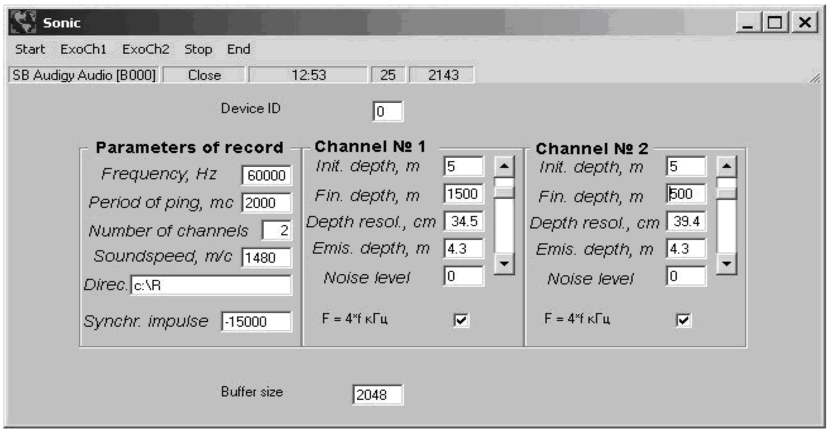


Fig. 3.22. An example of “Sonic” initial dialog

The digitized echo-signals are recorded as data files on a hard disk of the computer. The dynamic range of a system exceeds 90 dB. Record format of echo-signals is as following: first 8 bytes – date and time of echo sounder ping (type of variable – *date* of Visual Basic 6 system programming), further the values of echo-signals of given ping follow in the order of depth increase, with which they come. Each counting of echo-signal takes 2 bytes (type of variable - *integer*). Number of counting (*N)* is equal to ratio of registered depth range to depth resolution, and therefore the record of one ping takes $8+2N$ bytes. The name of a data file is determined by both a channel number of a sound card and time of the first echo-signal in this file (in hours and minutes). For example, if the first echo-signal was sent by June 1, 2010 at 2 hours 25 minutes, the data file is recorded with name of *0225.1dt or 0225.2dt*, depending on channel numbers in a folder *Data\1Jun10* or *Data1\1Jun10* depending on numbers of a sound card. Additionally, configuration file *0225.1cf* or *0225.2cf* is recorded in the same folders as initializing file (INI-file) that contains the necessary information about parameters of echo-signal registration (see Table 3.3).

Table 3.3. An example of configuration's file

[Common]	[Echosounder]
date=6/6/2010	Freq = 19700
time=2:07:36	Working frequency
name Vessel – Academic M.A. Lavrentyev	hAnnt = 4.3
region = Okhotsk Sea	[SoundCard]
nCh = 1	Device ID = 0
soundSpeed = 1480	Freq = 60000
Sound speed in water, m/sec	uMax = 1
Period=2000	[ParReg]
Period of ping, m/c	hBegin = 5
nF=1200	hEnd = 1500
Number of pings in the file	h = 29.6
Dir=e:\Lavr50\20-R	N = 5051
dateEnd=2:07:36	[Ver]
	Ver = 1.0.0.1

The visualization of echo signals in real time is carried out using two standard colour monitors. Each channel is represented on the two multi-coloured echograms with independent range of depths and with independent colour palette. The software provides synchronous detection, filtration, registration and visualization of an echo signal in the required range of depths.

The digital registration system has two synchronization modes - internal and external. In a mode of internal synchronization all acoustic devices are managed by the digital registration system. This mode is preferential, because it allows us to use variable frequencies of ping. At an external synchronization mode one of echo sounders act as the master and it manages other devices and digital registration system. The external synchronization mode is enforced in the case where one of echo sounders does not support external trigger. In this cruise the mode of external synchronization was used.

Preliminary results

Hydroacoustic survey was spent as on the move a vessel, and in drift. Total time of acoustic survey amounted to 412 hours. Total length of acoustic survey amounted to 2500 miles. About 100 registrations of 64 gas flares (GFs) were carried out; about 62 of them were found for the first time. Fig. 3.23 shows spatial distribution the registered GFs. New 17 GFs were registered in the Sea of Okhotsk; 16 GFs at eastern slope of Sakhalin Island and at the first time one at west slope of Kuril basin at the depth 2200 meters. In this area, GF F1 was revealed by repeated observation with some intervals that it changed length and intensity of echo signal with time. Its maximum height is ~2100 meters and intensity of echo signal is increased by two orders. Even, the intensity change, meaning pulsation of GF, occurred just in a few minutes on August 14 (Fig. 3.24).

The presence of such fluctuations makes it possible to evaluate rising speed of bubbles. The rising speed of bubbles at a depth of 1000 - 1500 meters was high, more than 30 cm/sec.

For the first time 45 GFs were registered in Tatarsky Strait at the western slope of the Sakhalin Island. GFs occurred at different depths from 150 up to 2200 meters, but most of them locate in Tatarsky Strait at depths of 300-330 meters (Fig. 3.25).

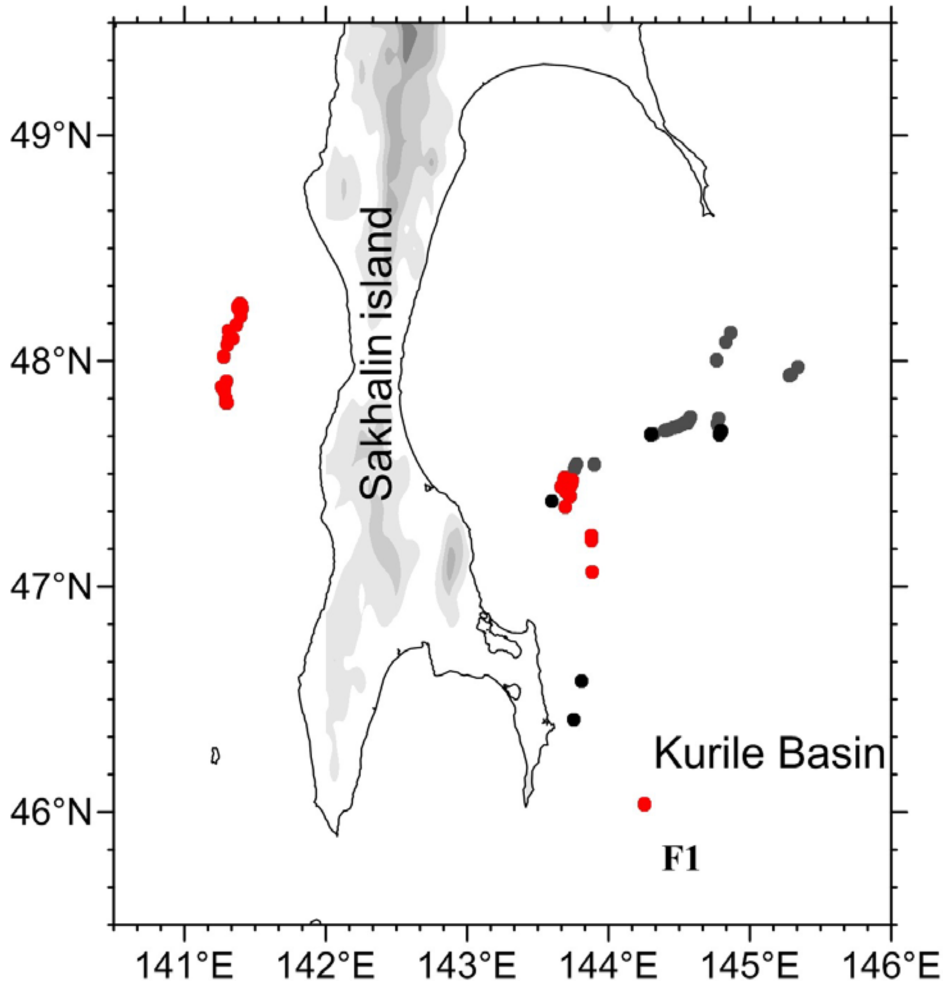


Fig. 3.23. The scheme of GF registered in the southern part of the Sea of Okhotsk and in the Tatarsky Strait, cruise 59- red circles.

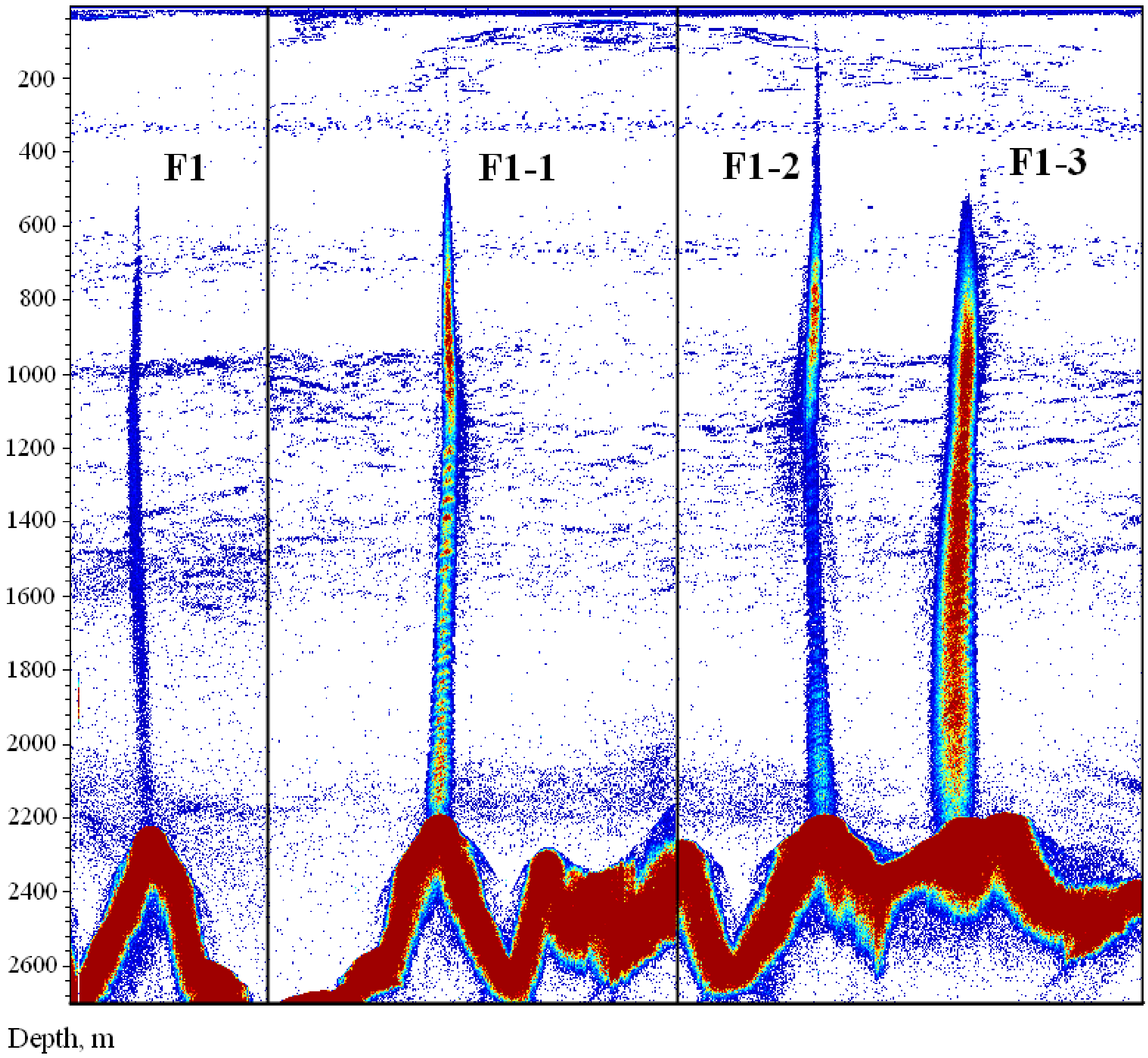


Fig. 3.24. The echogram obtained over four crossings the deepest GF F1

Bottom area with deep penetration in the sediments was frequently observed at 12 kHz. Example echogram obtained at full speed on one of these sites is shown in Fig. 3.26. Frontal zones, internal waves and other oceanological processes registered during the cruise. Table 3.4 gives the coordinates of GFs, course and speed of the vessel and depth of the seabed.

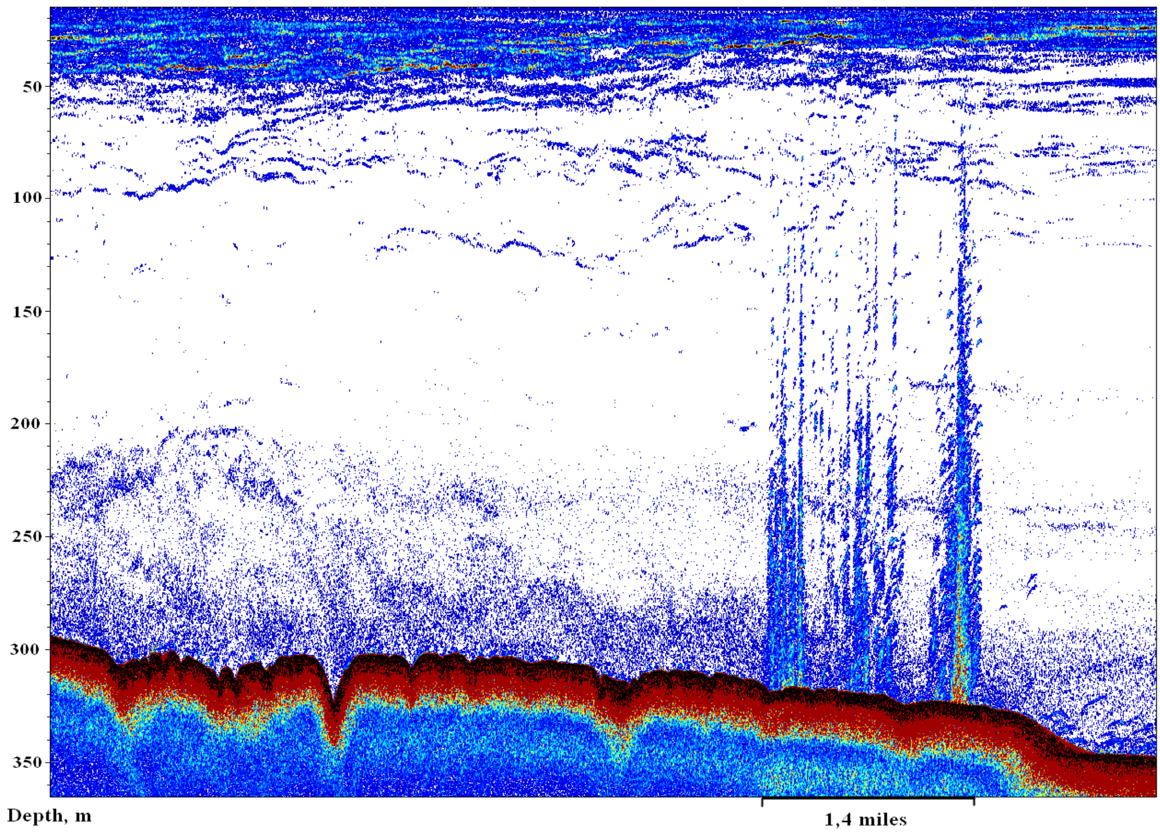


Fig. 3.25. Example echogram GF found in the Tatarsky Strait.

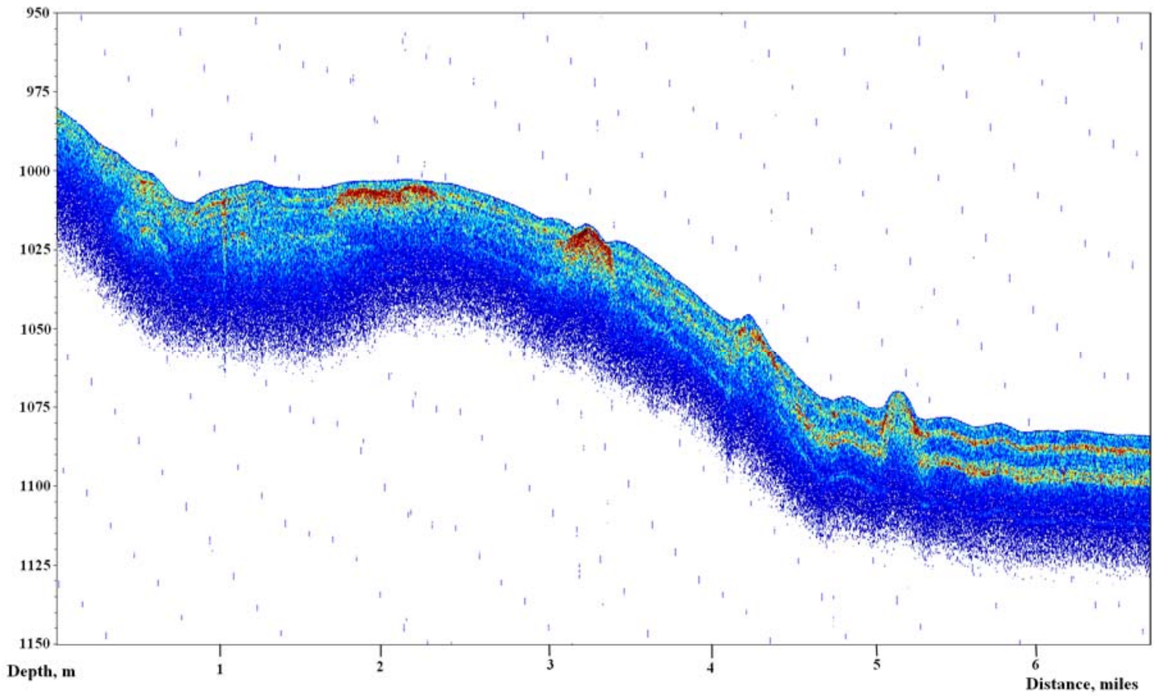


Fig. 3.26. Example echogram subbottom structure at a frequency of 12 kHz.

Table. 3.4. List of hydroacoustic “flare”-type anomalies

Name	Date	UTC Time	Latitude (N)	Longitude (E)	Speed, knt	Course	Depth, m
F1	10-Aug-12	21:07:13	46° 1.989'	144° 15.249'	10.5	348.8	2219
F2	11-Aug-12	02:59:37	47° 3.841'	143° 52.962'	6.8	352.8	1062.9
F3	11-Aug-12	05:12:49	47° 23.983'	143° 43.596'	6.3	89.1	735.1
F4	11-Aug-12	09:34:06	47° 27.107'	143° 44.336'	8.1	60.8	466.8
F5	11-Aug-12	11:49:32	47° 13.582'	143° 52.897'	7.3	168	900.5
F2-6	12-Aug-12	00:37:04	47° 3.858'	143° 52.970'	7.7	81.4	1054.4
F6	12-Aug-12	05:11:58	47° 12.263'	143° 52.858'	5	358.5	979.1
f7	12-Aug-12	12:58:33	47° 28.365'	143° 44.341'	6.2	185.7	427.8
F5-1	12-Aug-12	05:26:28	47° 13.550'	143° 52.865'	5.7	5	902.8
F8	12-Aug-12	13:08:37	47° 27.392'	143° 44.343'	3.9	176.5	444.3
F4-1	12-Aug-12	13:12:06	47° 27.133'	143° 44.348'	5.4	180.7	467
F9	12-Aug-12	15:57:44	47° 21.171'	143° 41.663'	5.2	359.3	243.6
F10	12-Aug-12	16:39:52	47° 25.376'	143° 41.654'	6.6	0.8	465.9
f11	12-Aug-12	16:48:33	47° 26.217'	143° 41.651'	5.2	359	429.8
f12	12-Aug-12	17:00:38	47° 27.363'	143° 41.640'	5.5	359.2	440.4
f13	12-Aug-12	17:20:56	47° 28.950'	143° 41.421'	4.9	235.4	148.6
F14	12-Aug-12	17:27:51	47° 28.453'	143° 40.943'	5.7	221	198.5
F15	12-Aug-12	19:32:42	47° 26.574'	143° 43.795'	5.9	273.3	555.3
F16	12-Aug-12	20:02:05	47° 26.436'	143° 39.819'	5	178.9	155.6
f17	12-Aug-12	20:25:36	47° 25.430'	143° 41.588'	6.1	92.2	453.7
F18	12-Aug-12	20:27:10	47° 25.426'	143° 41.822'	6	90.2	483.2
F19	13-Aug-12	05:11:22	47° 28.158'	143° 44.571'	3.3	347.5	436.9
F1-1	14-Aug-12	11:02:53	46° 2.046'	144° 15.161'	10.7	167.7	2188.5
F1-2	14-Aug-12	11:42:36	46° 1.997'	144° 15.173'	8.1	349.8	2192.3
F1-3	14-Aug-12	11:51:01	46° 1.963'	144° 15.392'	7.1	243.5	2196.1
sf20	16-Aug-12	10:04:04	47° 50.020'	141° 17.624'	6.8	89.7	267
sf21	16-Aug-12	10:52:47	47° 54.494'	141° 17.838'	5.4	287	199.3
SF22	17-Aug-12	20:04:19	48° 13.863'	141° 22.994'	5.9	180.7	321.7
F23	18-Aug-12	04:47:22	48° 14.695'	141° 23.149'	1.3	47.6	330.7
f24	18-Aug-12	04:54:59	48° 14.838'	141° 23.284'	4.1	117.7	331
SF22-2	18-Aug-12	05:58:02	48° 13.925'	141° 23.022'	1.2	141.3	322,1
SF25b	18-Aug-12	06:57:53	48° 14.802'	141° 23.933'	5.9	38.5	319.1
SF25e	18-Aug-12	07:00:48	48° 15.016'	141° 23.855'	4.4	313.7	323.9

F26	18-Aug-12	07:03:44	48° 15.145'	141° 23.607'	4.2	301.8	331.9
F27	18-Aug-12	23:31:49	48° 14.596'	141° 23.033'	8.9	30.2	331.4
F28	18-Aug-12	23:46:05	48° 14.865'	141° 24.026'	7.3	212.6	323.3
F24-1	19-Aug-12	00:07:39	48° 14.832'	141° 23.299'	4	187.4	329.8
F29	19-Aug-12	00:16:27	48° 14.592'	141° 23.061'	1.7	239.7	330.3
F64	19-Aug-12	00:28:16	48° 14.385'	141° 22.841'	1.7	214.6	332.8
F31	19-Aug-12	01:56:00	48° 14.952'	141° 23.811'	1.8	75.2	323.8
F30	19-Aug-12	01:35:24	48° 14.748'	141° 23.554'	1	200.6	326.3
F31-1	19-Aug-12	03:59:45	48° 14.823'	141° 24.011'	5.6	303.4	320.8
SF32	19-Aug-12	04:15:36	48° 14.846'	141° 23.622'	6.8	166.8	325.1
SF33	19-Aug-12	04:26:35	48° 14.535'	141° 23.457'	7.7	173.6	322.1
F24-2	19-Aug-12	04:31:47	48° 14.829'	141° 23.296'	6.3	342.1	331.4
F29-1	19-Aug-12	04:40:42	48° 14.582'	141° 23.059'	6.6	353.4	330.9
F34	19-Aug-12	04:49:52	48° 14.382'	141° 22.785'	5.8	4.1	334.9
F35	19-Aug-12	04:58:27	48° 14.117'	141° 22.714'	6.7	177.2	331.9
F36	19-Aug-12	06:33:03	48° 13.993'	141° 23.703'	7.4	91.5	309.4
f37	19-Aug-12	06:36:46	48° 13.894'	141° 24.516'	9.7	91.5	292.3
SF22-3	19-Aug-12	07:00:58	48°13.843'	141° 22.993'	8.8	86	321.8
F38	19-Aug-12	07:05:06	48° 13.843'	141° 23.909'	8.8	88.2	302.7
F39	19-Aug-12	07:06:08	48° 13.839'	141° 24.140'	8.7	89.6	311.2
SF22-3	19-Aug-12	07:00:56	48° 13.842'	141° 22.987'	8.9	87	321.8
SF22-4	19-Aug-12	07:20:53	48° 13.982'	141° 23.051'	9.2	271.9	322.3
SF22-5	19-Aug-12	07:21:31	48° 13.982'	141° 22.902'	9.3	270.4	325.3
SF40	19-Aug-12	07:34:56	48° 14.138'	141° 23.507'	9	90	313.7
SF41	19-Aug-12	08:07:39	48° 14.473'	141° 23.587'	8.6	89.2	318.7
f42	19-Aug-12	11:17:58	48° 9.510'	141° 21.986'	5.8	152.4	266.9
F43	19-Aug-12	12:08:32	48° 8.001'	141°18.894'	5.9	146.8	319.7
F44	19-Aug-12	12:31:30	48° 6.029'	141° 20.512'	5.6	190.4	236.1
F45	19-Aug-12	12:43:15	48° 6.023'	141° 18.923'	6.1	275.4	275.7
F46	19-Aug-12	13:34:06	48° 4.177'	141° 18.036'	6	136	279.6
SF47	19-Aug-12	14:47:48	48° 0.994'	141° 16.537'	5.2	144	276.4
F48	19-Aug-12	17:09:09	47° 52.982'	141° 15.678'	5.8	124.8	301.5
F49	19-Aug-12	17:15:44	47° 52.622'	141° 16.468'	5.7	121.1	270.8
f50	19-Aug-12	17:17:54	47° 52.505'	141° 16.728'	5.7	124.9	259
f51	19-Aug-12	17:18:50	47° 52.457'	141°16.841'	5.9	123.7	255.1
f52	19-Aug-12	17:19:34	47° 52.417'	141° 16.930'	6.3	113.8	251.7

f53	19-Aug-12	17:26:35	47° 51.910'	141° 17.104'	5.6	214	252.9
f54	19-Aug-12	17:27:37	47° 51.832'	141° 17.016'	5.7	213.9	257.3
f55	19-Aug-12	17:28:49	47° 51.738'	141° 16.914'	5.7	214.6	265.2
sf56	19-Aug-12	18:17:23	47° 48.861'	141° 17.635'	5.9	108.9	305.7
sf57	19-Aug-12	18:23:32	47° 48.959'	141° 18.238'	4.5	28.4	255.9
F58	19-Aug-12	23:37:04	48° 14.981'	141° 23.608'	0	195.5	328.5
SF25-3	20-Aug-12	06:07:11	48° 14.967'	141° 23.844'	0	310.6	323.6
F26-1	20-Aug-12	06:38:25	48° 15.159'	141° 23.597'	3.5	251.6	332.4
SF30-1	20-Aug-12	06:42:58	48° 14.855'	141° 23.577'	5.1	172.2	324.6
F59	20-Aug-12	07:03:04	48° 13.063'	141° 23.925'	5.5	177.4	291.4
F60	20-Aug-12	07:04:26	48° 12.930'	141° 23.937'	5.8	176	290.4
F61	20-Aug-12	07:05:12	48° 12.855'	141° 23.945'	5.7	177	290.9
F62	20-Aug-12	07:17:01	48° 11.937'	141° 23.753'	5.2	276.3	278.7
SF47-1	20-Aug-12	23:23:27	48° 1.176'	141° 16.551'	11.1	12.9	277.2
SF43-1	21-Aug-12	00:02:12	48° 7.984'	141° 18.895'	7.5	13.3	320.2
F43-2	21-Aug-12	00:21:40	48° 7.983'	141° 18.897'	6.9	124.5	320.7
F43-3	21-Aug-12	00:42:23	48° 7.987'	141° 18.895'	8.6	67.4	320.7
F43-4	21-Aug-12	00:54:50	48° 7.987'	141° 18.915'	6.2	248.6	321.2
F28-2	21-Aug-12	03:55:44	48° 14.851'	141° 24.017'	5.4	30.7	322.1
F28-3	21-Aug-12	04:09:39	48° 14.869'	141° 24.037'	6.7	244.5	323.1
sf30	21-Aug-12	04:14:22	48° 14.669'	141° 23.558'	4	181.6	326.1
F58-1	21-Aug-12	04:22:50	48° 14.937'	141° 23.697'	6.3	295.5	326.5
f63	21-Aug-12	23:08:21	48° 14.661'	141° 22.875'	10.5	180.5	336.2
SF22-6	21-Aug-12	23:12:38	48° 14.004'	141° 22.880'	8.3	177.2	327.8
SF22-5	21-Aug-12	23:24:59	48° 13.979'	141° 22.899'	8.5	339	326.8
SF25-3	23-Aug-12	01:14:53	48° 14.970'	141° 23.842'	5.9	330.7	325.1
F28-4	23-Aug-12	01:54:10	48° 14.973'	141° 23.834'	0	234	325.6

** F – flares distinctly visible, f – flares weakly visible, SF area shallow water flare

4. SAMPLING AND ANALYSES

4.1. Station list of CTD Survey and Coring Operation

N. Nikolaeva, E. Korovitskaya

Date 2012	**Station №**	**Time (ship's), start-on bottom-finish**	**Duration (min)**	**Latitude, N**	**Longitude, E**	**Water depth (m)**	**Recovery (cm)**	**Remarks**
11.08	LV59-01HC	17:47 18:00	13	47º23.988’	143º43.621’	735	304	Terpeniya Bay. Gas saturated black sediments with a lot of carbonate concretions at some horizons.
11.08	LV59-02CTD	18:20 18:50 19:10	50	47º24.228’ 47º24.409’ 47°24.448’	143°43.802’ 143°43.909’ 143°44.264’	745,6		Vertical CTD profiling. 12=744,8 m, 1=733 m, 2=649 m, 3=550 m, 4=450 m, 5=350 m, 6=250 m, 7=150 m, 8=100 m, 9=50 m, 10=24 m, 11=3,7 m.
12.08	LV59-03HC	09:07 09:22	15	47º03.871’	143º52.960’	1050	373	Terpeniya Bay. Carbonate concretions.
12.08	LV59-04CTD	9:28 9:55 10:20	52	47º04.026’ 47º04.032’ 47º04.153’	143º53.131’ 143º53.496’ 143º54.061’	1096		Vertical CTD profiling. 12=1089,4 m, 1=1079,5 m, 2=984,1 m, 3=785,4 m, 4=600,5 m, 5=401,4 m, 6=252,3 m, 7=152,5 m, 8=78,1 m, 9=38,2 m, 10=22,7 m, 11=3,8 m.
12.08	LV59-05HC	12:46 13:02	16	47º03.866’	143º52.970’	1051	366	Terpeniya Bay. Shelly (a lot of large Calyptogena) and concretionary horizons, **gas hydrates** in the catcher of hydrocorer.
12.08	LV59-06CTD	13:31 13:58 14:27	56	47°03.865’ 47°04.048’ 47°04.228’	143°52.946’ 143°52.788’ 143°52.744’	1057		Vertical CTD profiling. 12=1051 m, 1=1037 m, 2=973 m, 3=786 m, 4=600,5 m, 5=400,8 m, 6=250 m, 7=150 m, 8=99 m, 9=34 m, 10=23 m, 11=3,4 m.
12.08	LV59-07HC	18:04 18:16	12	47º13.526’	143º52.908’	904	411	Terpeniya Bay. Background section.
12.08	LV59-08CTD	18:26 18:42 19:06	40	47°13.478’ 47°13.652’ 47°13.798’	143°52.896’ 143°52.762’ 143°52.505’	913		Vertical CTD profiling. 12=908 m, 1=892 m, 2=843 m, 3=615 m, 4=498 m, 5=370 m, 6=270 m, 7=141 m, 8=80 m, 9=48 m, 10=16 m, 11=3,5 m.
13.08	LV59-09HC	10:53 11:04	11	47º23.961’	143º43.662’	725	536	Terpeniya Bay. Gas saturated dark (almost black) sediments. Absence of H_2S smell.
13.08	LV59-10CTD	14:23 14:48 15:09	46	47°23.678’ 47°23.982’ 47°24.217’	143°43.585’ 143°43.648’ 143°43.636’	729		Vertical CTD profiling. 1=721,7 m, 2=712 m, 3=678 m, 4=630 m, 5=580 m, 6=499 m, 7=352 m, 8=199 m, 9=134 m, 10=75 m, 11=25 m, 12=3,7 m.

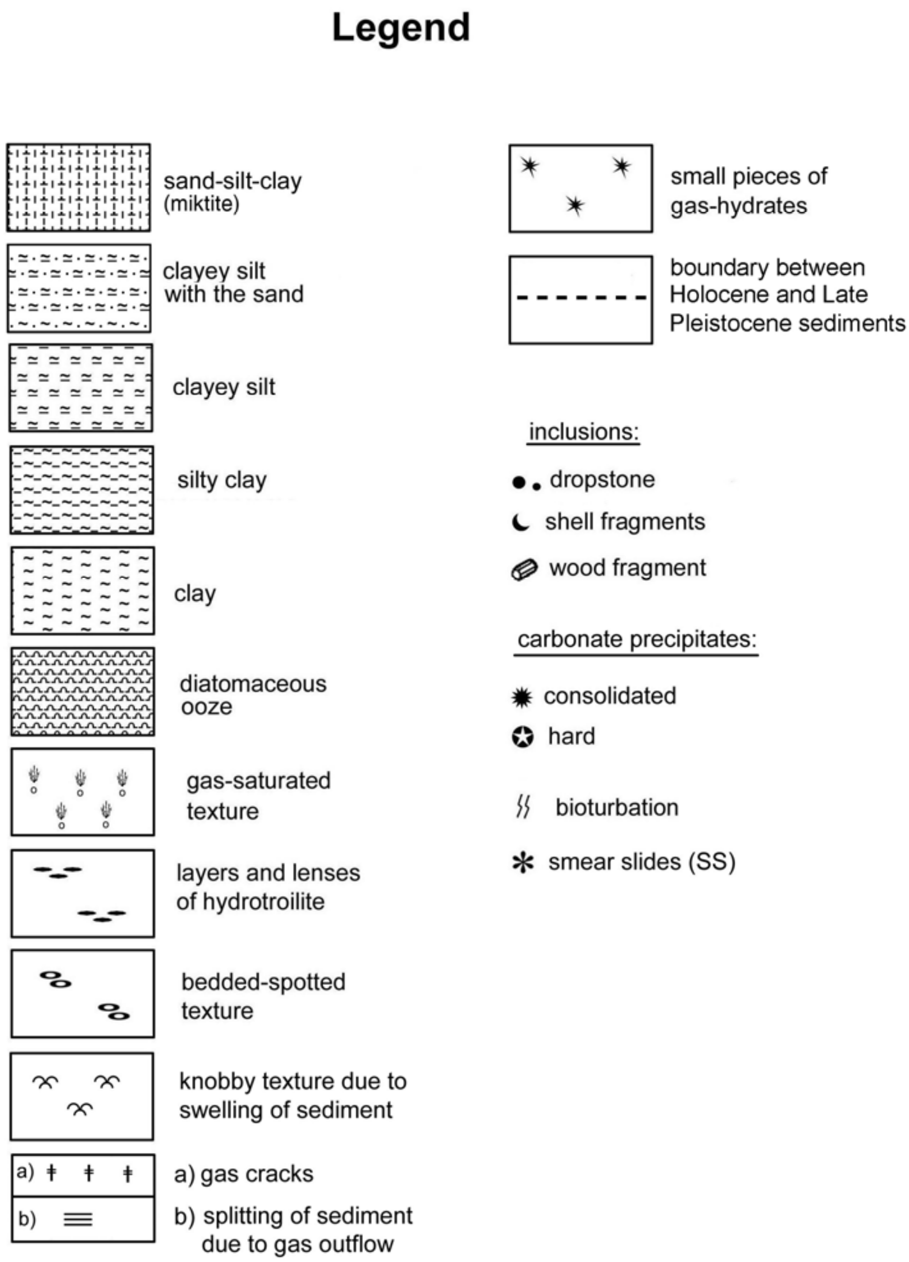
13.08	LV59-11HC	16:47 16:55	8	47º27.374’	143º44.326’	445	512	Terpeniya Bay. Gas saturated dark(almost black) sediments. Absence of H_2S smell.
13.08	LV59-12CTD	17:13 17:27 17:55	42	47º27.404’ 47º27.500’ 47º27.522’	143º44.478’ 143º44.602’ 143º44.881’	459		Vertical CTD profiling. 1=454 m, 2=442 m, 3=420 m, 4=380 m, 5=319 m, 6=238 m, 7=200 m, 8=155 m, 9=98 m, 10=63 m, 11=24 m, 12=3,6 m.
14.08	LV59-13HC	11:27 12:03	36	47º03.881’	143º52.969’	1053	520	Terpeniya Bay. Background section.
14.08	LV59-14CTD	12:10 12:40 13:14	64	47º03.966’ 47º04.267’ 47º04.548’	143º53.327’ 143º53.732’ 143º54.194’	1095		Vertical CTD profiling. 1=1088 m, 2=1077 m, 3=999 m, 4=900 m, 5=801 m, 6=601 m, 7=400 m, 8=251 m, 9=150 m, 10=75 m, 11=23 m, 12=3,6 m.
14.08	LV59-15HC	15:15 15:30	15	47º03.860’	143º52.948’	1053	469	Terpeniya Bay. Background section. Large diagenetic carbonate concretions (not methane-derived).
16.08	LV59-16CTD	10:31 10:59 11:33	62	47º36.998’ 47º37.270’ 47º37.614’	140º48.536’ 140º48.068’ 140º47.935’	1032		Vertical CTD profiling. 1=1030 m, 2=1025 m, 3=1003 m, 4=927 m, 5=800 m, 6=600 m, 7=400 m, 8=250 m, 9=146 m, 10=70 m, 11=36 m, 12=4 m.
16.08	LV59-17HC	10:05 10:19	14	47º36.733’	140º48.917’	1050	530	Tatarsky Strait. Background section.
16.08	LV59-18CTD	14:25 14:53 15:26	61	47º44.302’ 47º44.794’ 47º45.370’	141º04.553’ 141º04.708’ 141º04.850’	963		Vertical CTD profiling. 1=954,5 m, 2=941 m, 3=900 m, 4=701 m, 5=502 m, 6=302 m, 7=213 m, 8=173 m, 9=103 m, 10=62 m, 11=31 m, 12=3,8 m.
16.08	LV59-19HC	14:06 14:18	12	47º44.001’	141º04.361’	980	550	Tatarsky Strait. Background section.
17.08	LV59-20CTD	12:54 13:16 13:42	48	48º00.797’ 48º00.818’ 48º00.848’	141º00.998’ 141º01.258’ 141º01.589’	850		Vertical CTD profiling. 1=844 m, 2=824 m, 3=793 m, 4=701 m, 5=552 m, 6=350 m, 7=237 m, 8=166 m, 9=82 m, 10=53 m, 11=37 m, 12=3,3 m.
17.08	LV59-21HC	12:34 12:44	10	48º00.832’	141º00.813’	859	466	Tatarsky Strait. Background section.
17.08	LV59-22CTD	16:28 16:50 17:17	49	48º00.718’ 48º00.742’ 48º00.839’	141º00.705’ 141º00.599’ 141º00.415’	866		Vertical CTD profiling. 1=861,9 m, 2=853 m, 3=809 m, 4=700 m, 5=570 m, 6=360 m, 7=240 m, 8=158 m, 9=80 m, 10=52 m, 11=34 m, 12=3,5 m.
17.08	LV59-23HC	16:12 16:21	9	48º00.797’	141º00.730’	852	410	Tatarsky Strait. Background section.
18.08	LV59-24CTD	11:47 12:06 12:31	44	48°01,967 48°02,044 48°02,146	141°05,423 141°05,348 141°05,449	749		Vertical CTD profiling. 1=745 m, 2=735 m, 3=701 m, 4=550 m, 5=450 m, 6=349 m, 7=245 m, 8=141 m, 9=76 m, 10=35 m, 11=21 m, 12=3,1 m.
18.08	LV59-25HC	11:20 11:30	10	48º02.027’	141º05.606’	740	497	Tatarsky Strait. Background section.

18.08	LV59-26CTD	17:17 17:27 17:43	26	48°13,971 48°14,156 48°14,470	141°23,108 141°23,200 141°23,614	318		Vertical CTD profiling. 1=313 m, 2=300 m, 3=282 m, 4=216 m, 5=180 m, 6=159 m, 7=135 m, 8=102 m, 9=69 m, 10=49 m, 11=23 m, 12=3,1 m.
18.08	LV59-27HC	16:52 16:57	5	48º13.854’	141º23.013’	322	364	Western slope of Sakhalin Is. Seepage field. A lot of large carbonate concretions and small pieces of **gas hydrates.**
19.08	LV59-28CTD	12:24 12:35 12:52	28	48°14,662 48°14,742 48°14,900	141°23,267 141°23,562 141°23,746	325		Vertical CTD profiling. 1=321 m, 2=315 m, 3=305 m, 4=292 m, 5=262 m, 6=223 m, 7=186 m, 8=122 m, 9=75 m, 10 –surface.
19.08	LV59-28.1 CTD	14:00 14:03 14:09	9	48°15,562 48°15,590 48°25,068	141°24,984 141°25,008 141°25,068	324		Vertical CTD profiling. 1=76 m, 2=42 m, 3=26 m, 4=17 m, 5=17 m, 6 - surface.-
19.08	LV59-29HC	12:13 12:19	6	48º14.568’	141º23.027’	332	405	Western slope of Sakhalin Is. Seepage field. A lot of carbonate concretions and very gas saturated sediments in the lower part of core.
19.08	LV59-30CTD	16:59 17:06 17:22	23	48°13,816 48°13,865 48°13,956	141°23,134 141°23,186 141°23,296	319		Only sounding was conducted.
19.08	LV59-31HC	16:24 16:30	6	48º13.847’	141º22.980’	322	308	Western slope of Sakhalin Is. Seepage field. Carbonate concretions and very gas saturated sediments in the lower part of core.
20.08	LV59-32CTD	10:29 10:37 10:55	26	48°14,997 48°14,978 48°14,932	141°23,579 141°23,632 141°23,638	329		Only surface water was taken.
20.08	LV59-33HC	10:14 10:19	5	48º14.915’	141º23.798’	323	466	Western slope of Sakhalin Is. Seepage field. Two gas saturated horizons - at 21-100 cm and at278-466 cm. Carbonate concretions below 250 cm.
20.08	LV59-34HC	16:49 16:54	5	48º14.881’	141º24.000’	322	354	Western slope of Sakhalin Is. Seepage field. Carbonate concretions and gas saturated sediments.
20.08	LV59-35HC	13:12 13:17	5	48º14.971’	141º23.616’	328	417	Western slope of Sakhalin Is. Seepage field. Carbonate concretions and gas saturated sediments.
21.08	LV59-36HC	12:52 12:56	4	48º07.997’	141º18.880’	318	352	Western slope of Sakhalin Is. Seepage field. Gas saturated sediments and sparse small carbonate concretions at the lower part of core.
21.08	LV59-37CTD	13:19 13:28 13:48	29	48°08,464 48°08,630 48°08,854	141°18,800 141°18,805 141°18,677	323		Only surface water was taken.

21.08	LV59-38HC	16:15 16:20	5	48º14.850’	141º24.016’	322	432	Western slope of Sakhalin Is. Seepage field. Gas saturated sediments and sparse carbonate concretions at the lower part of core.
21.08	LV59-39CTD	16:51 16:59 17:19	28	48°14,947 48°15,023 48°15,220	141°24,455 141°24,581 141°24,810	315		Only surface water was taken.
22.08	LV59-40HC	10:58 11:05	7	48º13.911’	141º22.892’	326	437	Western slope of Sakhalin Is. Seepage field. Gas saturated sediments and a lot of carbonate concretions.
22.08	LV59-41CTD	11:12 11:21 11:37	25	48°13,858 48°13,675 48°13,655	141°22,932 141°22,970 141°23,099	315		Only sounding was conducted.
22.08	LV59-42HC	15:48 15:52	4	48º13.986’	141º22.873’	326	419	Western slope of Sakhalin Is. Seepage field. Very gas saturated sediments and carbonate concretions.
23.08	LV59-43HC	08:50 08:56	6	48º13.947’	141º23.009’	322	380	Western slope of Sakhalin Is. Seepage field. Very gas saturated sediments and a lot of carbonate concretions.
23.08	LV59-44CTD	09:08 09:17 09:29	21	48°13,770 48°13,705 48°13,636	141°23,135 141°23,178 141°23,220	317		Only sounding was conducted.
23.08	LV59-45HC	12:56 13:01	5	48º14.978’	141º23.812’	325	436	Western slope of Sakhalin Is. Seepage field. Slightly gas saturated sediments and sparse carbonate concretions at the lower part of core.
24.08	LV59-46HC	11:08 11:15	7	46º53.462’	139º22.082’	628	475	Reference station.
24.08	LV59-47CTD	11:24 11:40 11:56	32	46°53,507 46°53,549 46°53,606	139°22,078 139°22,045 139°21,980	621		Only sounding was conducted.

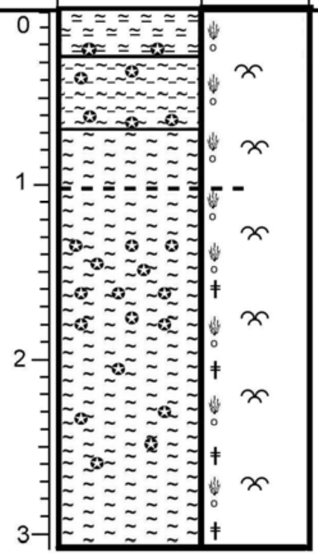
4.2. Core Lithology

A. Derkachev, N. Nikolaeva



Core description : **Lv59-01HC**	Lat: 47°23.988’
Cruise/Leg: RV Akademik M.A.Lavrentyev 59	Long: 143°43.621’ Water depth: 735 m Recovery: 304 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-0.2 cm - thin coat of greenish clayey silt.

0.2-25 cm - dark-gray (almost black) clayey silt, very soft (because of strong water- and gas saturation), at 20-25 cm - small (2-7 mm), dense, branchy carbonate concretions.

25-58 cm - black silty clay, very soft, water saturated, at 35-40 cm - branchy dense carbonate concretions (up to 5 cm of a size).

58-68 cm - dark gray (almost black) silty clay (clay), very soft; at 60-68 cm - a lot of dense, very branchy (dendritic) carbonate concretions.

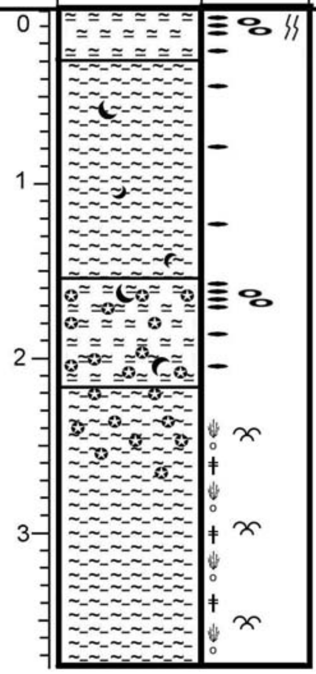
68-140 cm - dark gray (with greenish hue) clay, soft, water- and gas saturated, with pseudobrecciated texture; at 130-139 cm - small (0.5-3 cm), dense, branchy carbonate concretions.

140-304 cm - dark gray (with greenish hue) clay, consolidated, with vertical cracks due to gas outflow, with pseudobrecciated texture; at 140 cm - Calyptogena, at 140-180 cm - a lot of small branchy carbonate concretions, at 205, 235, 250 cm - carbonate concretions of gray-greenish colour and more smoothed, at 260 cm - elongated (up to 6 cm) carbonate concretion of complicated structure (very hard dark inner part and brittle crumbling greenish-olive outer one).

It is necessary mark that almost whole of sediment from this core has specific feature expressed by noise which is clear heard under pressing on sediment; here and there traces of water- and gas outflow expressed as knobby texture and swelling of the sediment, occur. Within upper part (up to 58 cm) much water has been appeared in sediment after its stay in the laboratory some time, and this part became very water saturated.

Core description : **Lv59-03HC** Cruise/Leg: RV Akademik M.A.Lavrentyev 59	Lat: 47°03.871' Long: 143°52.960' Water depth: 1050 m Recovery: 373 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-5 cm - olive-green diatomaceous clayey silt, fluid.

5-15 cm - olive-green (with gray hue) clayey silt with a lot of small lenses and interlayers of hydrotroilite, very soft.

15-30 cm - grayish-green clayey silt, soft, spotted because of an admixture of hydrotroilite, slightly bioturbated.

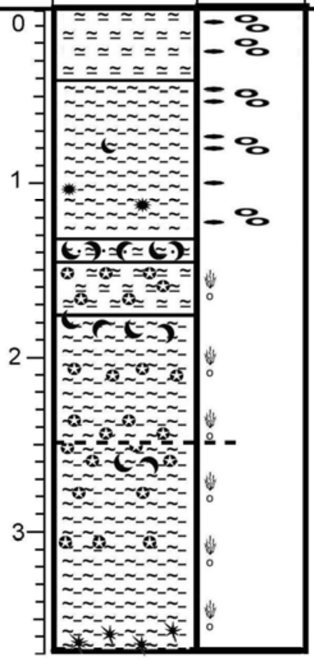
30-155 cm - grayish-green silty clay, homogeneous, consolidated, with little admixture of hydrotroilite; at 60 cm - decomposed shell, at 105 and 143 cm - small unbroken shells.

155-217 cm - grayish-green clayey silt, consolidated (here and there - dense), with admixture of hydrotroilite (especially at 155-186 cm); at 164-180, 190-217 cm - a lot of carbonate concretions of different density, shape and size: branchy (dendritic), smoothed, very dense and with complicated composition (hard inner part and brittle crumby outside); at 163 cm - decomposed shell.

217-373 cm - grayish-green silty clay, gas saturated especially below 240 cm, with vertical cracks and pseudobrecciated texture, here and there knobby texture and swelling of sediment due to gas outflow is marked; at 217-220, 235, 240-250 cm - dense carbonate concretions of whimsical shape; at 275 cm - crust-shaped hard carbonate concretion up to 10 cm of the length; at 250-258 cm - a large slightly decomposed shell.

Core description : **Lv59-05HC**	Lat: 47°03.866'
Cruise/Leg: RV Akademik M.A.Lavrentyev 59	Long: 143°52.970' Water depth: 1051 m Recovery: 366 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-5 cm - olive-green clayey silt, homogeneous, fluid.

5-41 cm - gray with greenish hue clayey silt, soft, spotted because of admixture of hydrotroilite.

41-131 cm - gray with greenish hue silty clay (clay), spotted because of admixture of hydrotroilite especially at 40-57, 72-80 cm; at 81 cm - decomposed shell; at 106-115 cm - soft light green carbonate precipitates (primary stage of concretion formation).

131-145 cm - shelly horizon consisting of numerous large (up to 8 cm) Calyptogena shells and their fragments inside of clayey silt with admixture of sandy particles.

145-176 cm - greenish-gray clayey silt, soft, gas saturated with pseudobrecciated texture, with a lot of large (up to 7 cm) dense, branchy carbonate concretions.

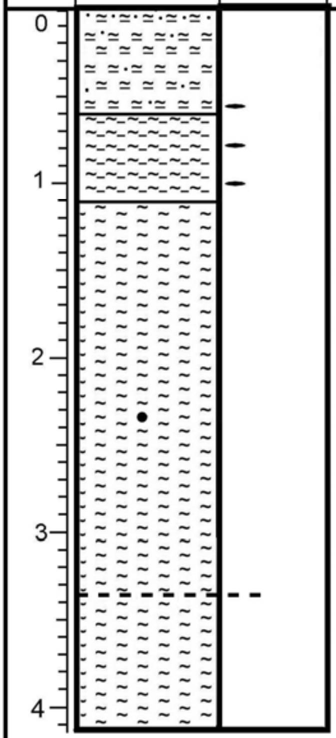
176-336 cm - greenish-gray silty clay, consolidated, gas saturated with intensive pseudobrecciated texture; at 180-190 cm - abundance of Calyptogena shells (by size up to 4 cm), at 260 cm - fragments of Calyptogena shell; at 210-213, 238-260 cm - a lot of small elongated and branchy carbonate concretions, at 280, 307 cm - little small (up to 1.5 cm) carbonate concretions.

The little pieces of **gas hydrates** were found in the catcher of hydrocorer.

Core description : **Lv59-07HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 47°13.526'
Long: 143°52.908'
Water depth: 904 m
Recovery: 411 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-5 cm - grayish-olive clayey silt with admixture of the sand, fluid.

5-60 cm - grayish-green clayey silt (more intensive olive colour is marked at 5-30 cm) with little admixture of the sand, soft, at the base - sparse small interlayers of hydrotroilite.

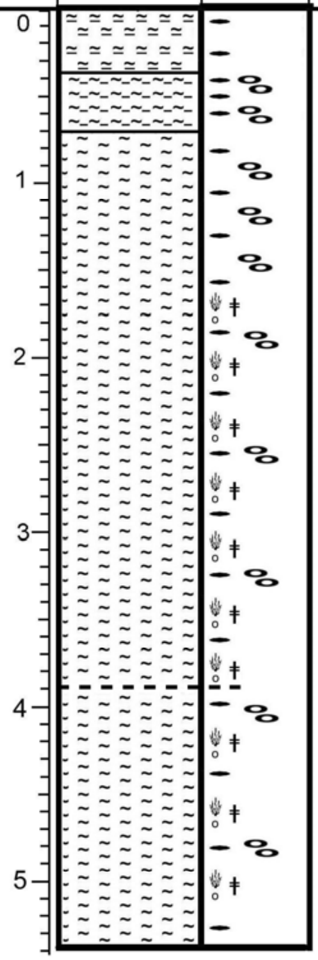
60-110 cm - grayish-green silty clay with sparse small interlayers of hydrotroilite, homogeneous, consolidated, very viscous, plastic.

110-411 cm - grayish-green clay, very homogeneous, consolidated (more dense below 260 cm), very viscous, plastic; at 230 cm - small dropstone.

Core description : **Lv59-09HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 47°23.961'
Long: 143°43.662'
Water depth: 725 m
Recovery: 536 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-37 cm - dark gray (with greenish hue) clayey silt with sparse lenses of hydrotroilite, fluid at the top, soft - below.

37-144 cm - dark gray silty clay at 37-70 cm, below - clay, soft, with numerous small lenses of hydrotroilite, lenticular-spotted that are due to the presence of large uneven lenses and interlayers of sediment by light gray-green colour (especially at 45-66, 90-135 cm).

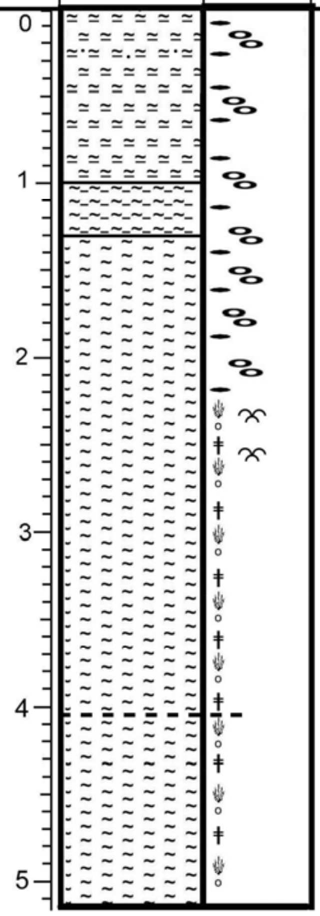
144-536 cm - dark gray clay (with greenish hue) with numerous small lenses of hydrotroilite, soft, lenticular-spotted that are due to the presence of a lot of lenses and interlayers of sediment by both light gray-green colour and variable thickness. This interval is very gas saturated with numerous cracks (oriented in different direction) due to gas outflow, with pseudobrecciated texture intensity of which is increased downwards.

One interesting feature was marked in sediments of this core - absolute absence of H2S smell. It is unusual for such black sediments which form in the environments of hydrosulfuric contamination. The explanation of it may be suggested as following - sulfur from H2S was used for formation of hydrotroilite (FeS?nH2O).

Core description : **Lv59-11HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 47°27.374'
Long: 143°44.326'
Water depth: 445 m
Recovery: 512 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-8 cm - thin coat of olive-green colour is marked at the top, below - dark gray clayey silt, very soft.

8-100 cm - dark gray (almost black) clayey silt (at 25-30 cm increased amount of sandy-silty particles is marked) with a numerous lenses and layers of hydrotroilite that provides for lenticular-spotted texture, soft, viscous.

100-130 cm - grayish-olive-green silty clay (clay) with small lenses of hydrotroilite, soft, viscous, spotted.

130-137 cm - dark gray clay with lenses of more light grayish-green sediment and with abundance of hydrotroilite, viscous.

137-220 cm - clay of very spotted texture due to chaotic location of lenses and spots of sediment with different colour - grayish-green and dark gray, with a lot of hydrotroilite's spots; sediment is slightly consolidated, viscous, elastic.

220-253 cm - transitional slice to gas saturated sediment; gas outflow is expressed as knobby texture.

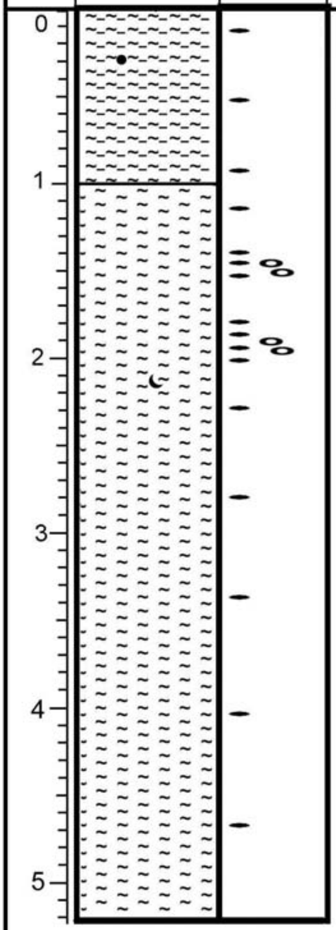
253-512 cm - motley slice consisting of chaotic alternating clayey lenses and layers of different colour - greenish-gray and dark gray with greenish hue; sediment is very gas saturated with both numerous cracks oriented in different direction, and clear expressed pseudobrecciated texture

Like core LV59-09HC, sediment is practically free of H2S smell.

Core description : **Lv59-13HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 47°03.881'
Long: 143°52.969'
Water depth: 1053 m
Recovery: 520 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



Upper part is broken under injection of hydrocorer.

~ 0-100 cm - grayish-green silty clay with sparse small lenses of hydrotroilite, slightly consolidated, homogeneous, viscous; at 30 cm - small dropstone; downwards amount of hydrotroilite is few increased.

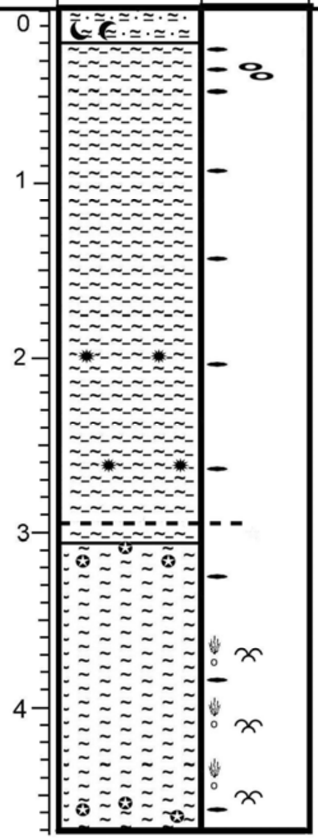
100-210 cm - dark grayish-green clay with lenses of hydrotroilite (especially at 140-155, 180-205 cm), spotted, consolidated, homogeneous, very viscous, plastic.

210-520 cm - dark grayish-green clay with sparse thin interlayers of hydrotroilite, very homogeneous, with variable density (consolidated and dense slices are alternated), very viscous (like plasticine); downward sediment becomes more gray; at 215 cm - small shell fragment.

Core description : **Lv59-15HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 47°03.860'
Long: 143°52.948'
Water depth: 1053 m
Recovery: 469 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-4 cm - olive-green clayey silt with admixture of sandy particles, fluid.

4-20 cm - dark grayish-green clayey silt with the sand (close to mixtite - mixture of clay, silt and sand in approximately equal amounts), soft; at 15 cm - fragments of a large Calyptogena shell.

20-40 cm - dark grayish-green silty clay containing the large lenses of more dark colour (enriched with hydrotroilite).

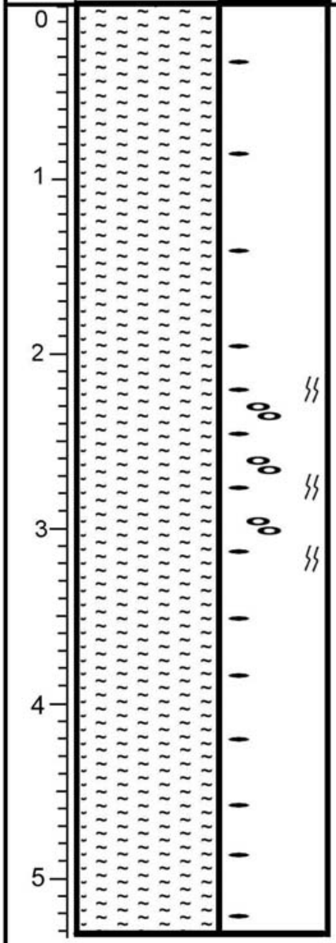
40-305 cm - dark grayish-green silty clay (clay) with sparse small lenses of hydrotroilite, homogeneous, consolidated, very viscous; at 200, 260-262 cm - light green soft carbonate precipitates (primary stage of the carbonate formation).

305-469 cm - dark greenish-gray clay with sparse small lenses of hydrotroilite, homogeneous, consolidated, viscous; below 360 cm knobby texture and swelling of sediment due to gas outflow is marked; at 310-315, 465-469 cm - light green large carbonate concretions of complicated structure (hard inner part and brittle crumby outside) and of size from 4 up to 10 cm.

Core description : **Lv59-17HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 47°36.733'
Long: 140°48.917'
Water depth: 1050 m
Recovery: 530 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



Upper part was destroyed under injection of hydrocorer and lost (~ 5 cm).

~ **5-30 cm** - grayish-green clay, soft.

30-220 cm - grayish-green clay, consolidated, homogeneous, viscous, with sparse lenses of hydrotroilite.

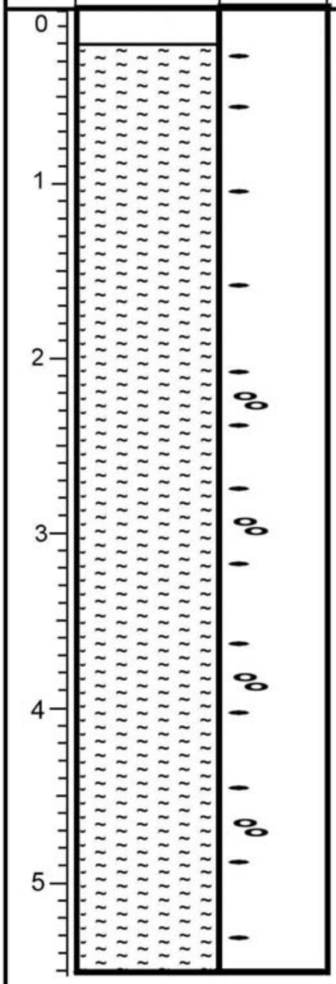
220-315 cm - the same, but spotted due to increased amount of lenses and spots of hydrotroilite, below 215 cm clear signs of bioturbation appear.

315-530 cm - greenish-gray clay, consolidated, viscous, with numerous small spots of hydrotroilite.

Core description : **Lv59-19HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 47°44.001'
Long: 141°04.361'
Water depth: 980 m
Recovery: 550 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



Upper part was destroyed under injection of hydrocorer and lost (~ 15-20 cm).

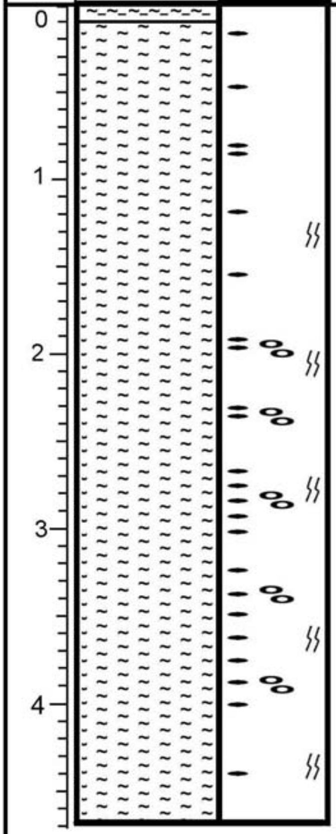
~ 20-210 cm - grayish-green clay, soft (slightly consolidated downwards), viscous, with sparse lenses and spots of hydrotroilite.

210-550 cm - greenish-gray clay, consolidated, very viscous, spotted because of increased amount of hydrotroilite.

Core description : **Lv59-21HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 48°00.832'
Long: 141°00.813'
Water depth: 859 m
Recovery: 466 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-10 cm - grayish-green silty clay, fluid.

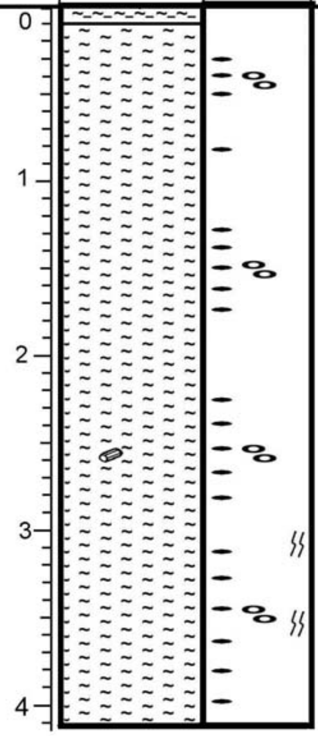
10-130 cm - grayish-green clay, soft, viscous, with sparse lenses of hydrotroilite (especially at 80-85 cm).

130-466 cm - grayish-green clay, homogeneous, consolidated, viscous; a lot of lenses and spots of hydrotroilite occur at 190-198, 230-235, 265-310, 325-400 cm; clear bioturbation is marked at this interval.

Core description : **Lv59-23HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 48°00.797'
Long: 141°00.730'
Water depth: 852 m
Recovery: 410 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-8 cm - grayish-green silty clay, fluid.

8-30 cm - grayish-green clay, soft, homogeneous.

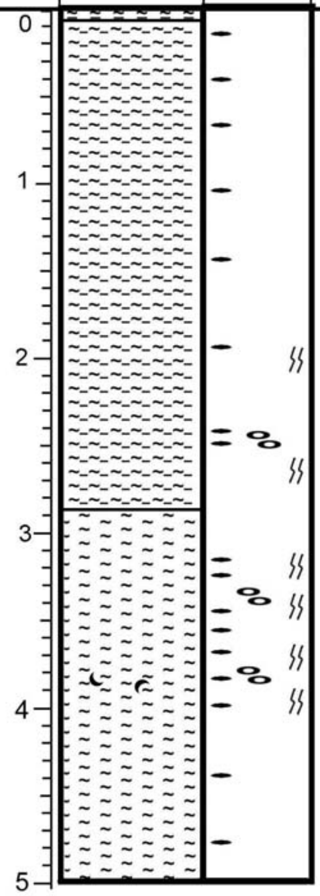
30-133 cm - grayish-green clay, soft, viscous, with large lenses of hydrotroilite especially at 30-50 cm.

133-313 cm - grayish-green clay, consolidated, viscous, with lenses of hydrotroilite especially at 133-170, 225-285 cm.

313-410 cm - the same, but more dense and with increased amount of hydrotroilite; traces of bioturbation are clear expressed at 310-365 cm; at 265 cm - small wood fragment.

Core description : **Lv59-25HC**	Lat: 48°02.027’
Cruise/Leg: RV Akademik M.A.Lavrentyev 59	Long: 141°05.606’
	Water depth: 740 m
	Recovery: 497 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-5 cm - grayish-green clayey silt with little admixture of sandy particles, very soft.

5-65 cm - grayish-green silty clay, soft, with sparse lenses of hydrotroilite.

65-198 cm - the same, but slightly consolidated; lenses of hydrotroilite are marked at some intervals.

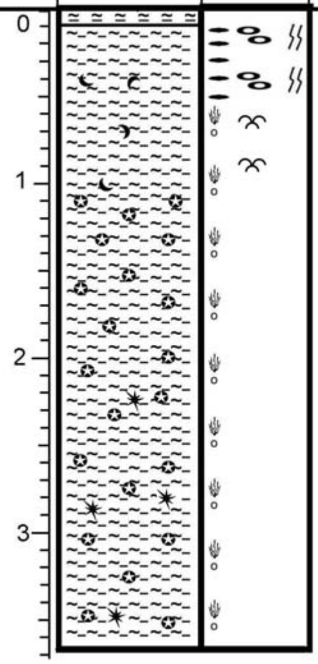
198-287 cm - the same, but with increased amount of hydrotroilite (especially at 240-244 cm) and the traces of bioturbation.

287-497 cm - grayish-green clay, consolidated; both a lot of hydrotroilite and intensive bioturbation are marked at 318-326, 344-400 cm; at 383 cm - small shell fragments.

Core description : **Lv59-27HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 48°13.854'
Long: 141°23.013'
Water depth: 322 m
Recovery: 364 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-1 cm - olive-green clayey silt with admixture of sandy particles, fluid; lower boundary is sharp on colour.

1-10 cm - dark gray (almost black) clayey silt, soft.

10-50 cm - grayish-green silty clay with a lot of spots and lenses of hydrotroilite amount of which is decreased downward, upper part is spotted and bioturbated; at 47 cm - shell fragments.

50-63 cm - transitional horizon from homogeneous to gas saturated sediments - grayish-green silty clay, consolidated, here and there knobby texture is marked due to gas outflow.

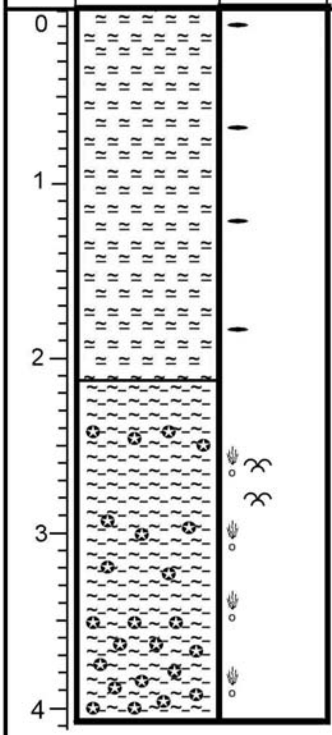
63-364 cm - grayish-green silty clay (almost clay), strongly gas saturated with intensive pseudobrecciated texture; at 65, 100 cm - shell fragments; below 110 cm sediment is filled by numerous large dense carbonate concretions, many of them have elongated shape by the length from 10 up to 20 cm.

Sparse small pieces of **gas hydrates** were found below 200 cm.

Core description : **Lv59-29HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 48°14.568'
Long: 141°23.027'
Water depth: 332 m
Recovery: 405 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-5 cm - grayish-green clayey silt, fluid.

5-212 cm - gray-green clayey silt (here and there it is close to silty clay), consolidated, viscous, with sparse spots of hydrotroilite; at 200-212 cm - soft carbonate precipitates by the size up to 0.3-1 cm.

212-260 cm - grayish-green silty clay, consolidated, viscous; at 240-245 cm - a lot of small carbonate concretions.

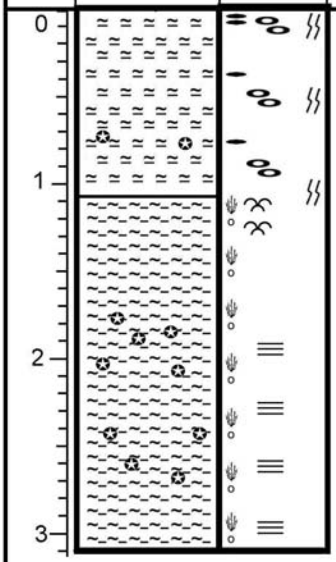
260-273 cm - transitional horizon from homogeneous to gas saturated sediments - grayish-green silty clay, consolidated; gas outflow is expressed as knobby texture.

273-405 cm - grayish-green silty clay, gas saturated with pseudobrecciated texture which is intensified below 330 cm; at 295-338 cm - a lot of small elongated carbonate concretions by the length up to 2-5 cm; horizon 350-385 cm is completely filled by large (up to 8-9 cm) branchy hard carbonate concretions.

Core description : **Lv59-31HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 48°13.847'
Long: 141°22.980'
Water depth: 322 m
Recovery: 308 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-0.5 cm - olive-green fluid clayey silt.

0.5-2 cm - dark gray clayey silt enriched with hydrotroilite, soft.

2-108 cm - grayish-green clayey silt, moderately dense, spotted that due to lenses of hydrotroilite, with traces of bioturbation; at 70-80 cm - small elongated (up to 1-1.5 cm) dense carbonate concretions.

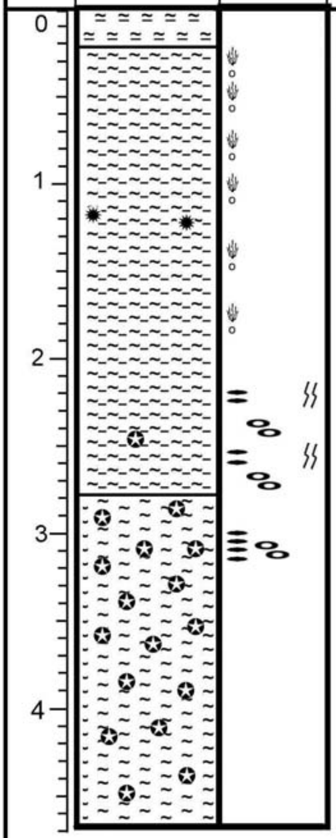
108-115 cm - transitional horizon from homogeneous to gas saturated sediments - grayish-green silty clay with traces of knobby texture due to gas outflow, moderately dense.

115-308 cm - grayish-green silty clay, strongly gas saturated with clear visible horizontal splitting due to gas outflow, especially below 190 cm; some intervals contain carbonate concretions of different shape and size.

Core description : **Lv59-33HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 48°14.915'
Long: 141°23.798'
Water depth: 323 m
Recovery: 466 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-0.5 cm - olive-green fluid clayey silt.

0.5-8 cm - almost black soft clayey silt.

8-21 cm - dark-gray clayey silt with lenses of grayish-green silty clay, soft.

21-100 cm - dark-gray silty clay (more green downwards), soft, very gas saturated with pseudobrecciated texture.

100-178 cm - dark grayish-green silty clay with more light green lenses, gas saturated with pseudobrecciated texture; at 119-122 cm - small soft carbonate precipitates (primary stage of carbonate formation).

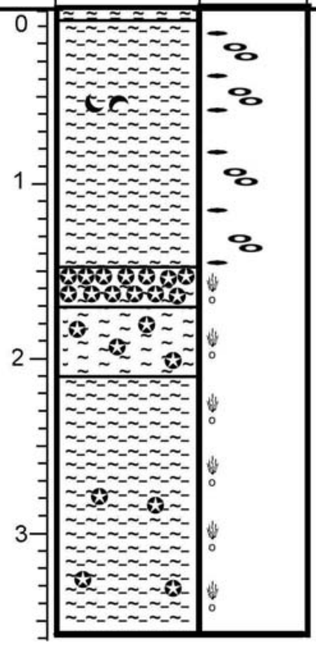
178-278 cm - dark-green silty clay (almost clay), dense, homogeneous, very viscous; large lenses of hydrotroilite and traces of bioturbation are marked at 220, 253-260 cm; at 244 cm - large branchy carbonate concretion.

278-466 cm - dark-green clay, with large (up to 10 cm) lenses of almost black colour (enriched with hydrotroilite) at 300-320 cm, gas saturated with pseudobrecciated texture; almost all interval is filled by carbonate concretions of different size and shape.

Core description : **Lv59-34HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 48°14.881'
Long: 141°24.000'
Water depth: 322 m
Recovery: 354 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-5 cm - olive-green fluid clayey silt.

5-55 cm - dark gray-green silty clay, spotted with chaotic located lenses enriched with hydrotroilite, soft, elastic.

55-62 cm - diluted horizon containing large fragments of Calyptogena shells.

62-140 cm - dark gray-green silty clay (almost clay), dense, spotted with lenses of hydrotroilite.

140-148 cm - the same, slightly gas saturated, with pseudobrecciated texture.

148-170 cm - concretionary horizon, strongly gas saturated, filled by numerous large carbonate concretions.

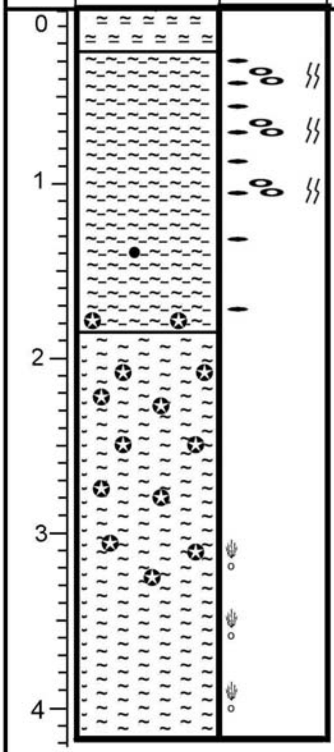
170-210 cm - dark gray-green clay, dense, gas saturated; here and there elongated carbonate concretions are found.

210-354 cm - dark gray-green silty clay, gas saturated, moderately dense; at 280, 330 cm - sparse carbonate concretions.

Core description : **Lv59-35HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 48°14.971'
Long: 141°23.616'
Water depth: 328 m
Recovery: 417 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-23 cm - green clayey silt, at the top - fluid, below - soft, elastic.

23-130 cm - dark grayish-green silty clay, soft, spotted and bioturbated at 23-57 and 68-105 cm.

130-185 cm - grayish-green silty clay with sparse spots of hydrotroilite; at 140 cm - dropstone.

185-219 cm - dark grayish-green clay, consolidated, viscous; at 183, 210 cm - sparse carbonate concretions.

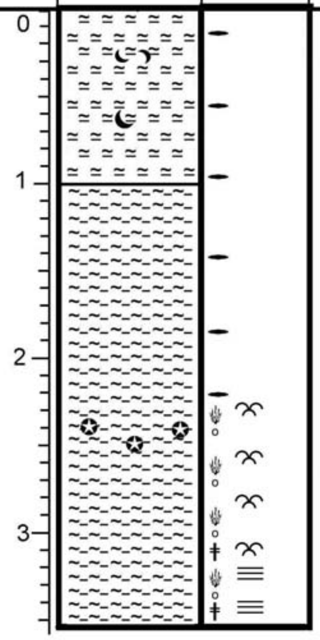
219-310 cm - light-green clay, viscous, homogeneous, filled by large branchy carbonate concretions.

310-417 cm - light-green clay, with the traces of gas saturation and pseudobrecciated texture; at 310-330 cm - carbonate concretions.

Core description : **Lv59-36HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 48°07.997'
Long: 141°18.880'
Water depth: 318 m
Recovery: 352 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-0.5 cm - thin coat of grayish olive-green clayey silt with admixture of sandy particles, fluid; sharp boundary on density with subjacent sediment.

0.5-100 cm - grayish-green clayey silt with little admixture of sandy particles, homogeneous, consolidated (here and there - moderately dense), viscous, with sparse lenses of hydrotroilite; at 30 cm - shell fragments, at 64 cm - Calyptogena shell.

100-226 cm - grayish-green silty clay, homogeneous, moderately dense, viscous, with small sparse lenses of hydrotroilite.

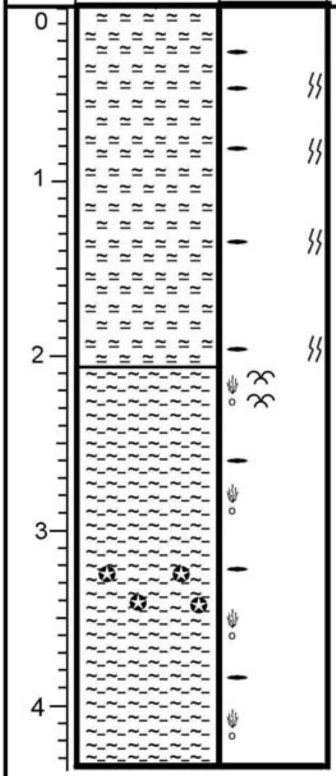
226-310 cm - transitional horizon from homogeneous to gas saturated sediments - grayish-green silty clay with knobby texture due to gas outflow; at 240-250 cm - small branchy carbonate concretions; at the bottom of interval - sparse small horizontal cracks produced by gas outflow.

310-352 cm - grayish-green silty clay (more dark gray at the bottom of interval), gas saturated with pseudobrecciated texture (gas saturation and horizontal splitting are increased downwards).

Core description : **Lv59-38HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 48°14.850'
Long: 141°24.016'
Water depth: 322 m
Recovery: 432 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-5 cm - grayish olive-green clayey silt, fluid-soft.

5-48 cm - grayish-green clayey silt with sparse large lenses of hydrotroilite at 27-29 cm, soft.

48-95 cm - grayish dark-green clayey silt with sparse spots of hydrotroilite and traces of bioturbation at 48-50 cm, soft, viscous, elastic.

95-206 cm - the same, with sparse spots of hydrotroilite and traces of bioturbation.

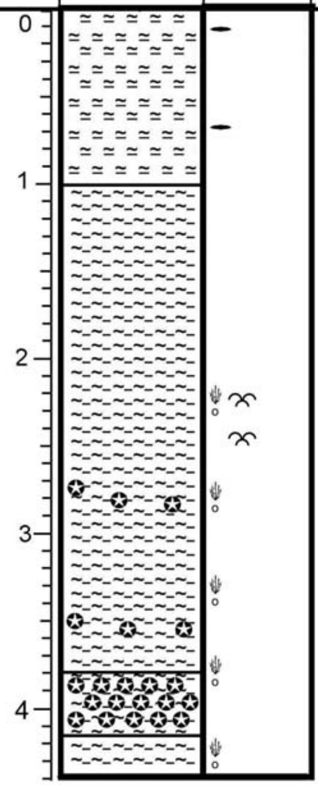
206-216 cm - transitional horizon from homogeneous to gas saturated sediments with traces of knobby texture due to gas outflow - grayish dark-green silty clay.

216-432 cm - grayish-dark-green silty clay (almost clay) with sparse lenses of hydrotroilite, gas saturated with pseudobrecciated texture; at 325-340 cm - large oval carbonate concretions.

Core description : **Lv59-40HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 48°13.911'
Long: 141°22.892'
Water depth: 326 m
Recovery: 437 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-10 cm - grayish olive-green clayey silt, fluid at the top, soft below.

10-100 cm - grayish-green clayey silt, soft, homogeneous, with sparse spots of hydrotroilite.

100-220 cm - grayish-green silty clay, consolidated, homogeneous, viscous.

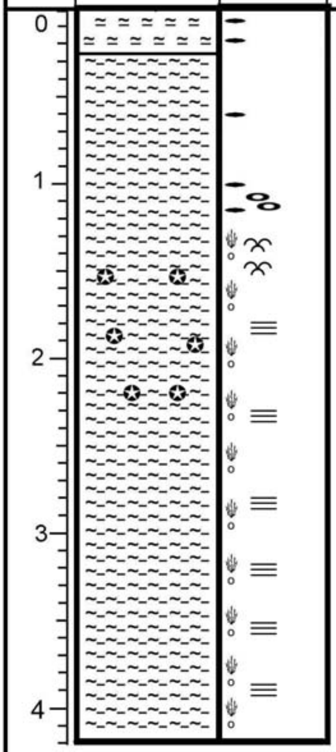
220-250 cm - transitional horizon from homogeneous to gas saturated sediments with traces of knobby texture due to gas outflow - grayish-green silty clay.

250-437 cm - green silty clay, gas saturated with pseudobrecciated texture; at 270-285, 350-360 cm - carbonate concretions; at 380-415 cm - concretionary horizon filled by large carbonate concretions.

Core description : **Lv59-42HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 48°13.986'
Long: 141°22.873'
Water depth: 326 m
Recovery: 419 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-7 cm - grayish olive-green clayey silt, at the top - fluid, below - soft.

7-24 cm - dark gray-green clayey silt with large lenses of hydrotroilite (up to 1.5-2 cm), soft.

24-100 cm - dark gray-green silty clay with sparse lenses of hydrotroilite, soft, homogeneous.

100-136 cm - dark gray-green silty clay (almost clay), lenticular-spotted at 100-120 cm, consolidated, viscous.

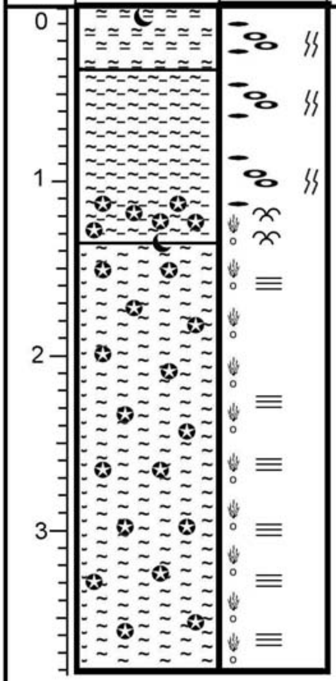
136-143 cm - transitional horizon from homogeneous to gas saturated sediments, with traces of knobby texture due to gas outflow - dark gray-green silty clay (almost clay).

143-419 cm - dark grayish-green silty clay (clay), very gas saturated, with pseudobrecciated texture and horizontal splitting; at 155, 186-195, 224 cm - carbonate concretions.

Core description : **Lv59-43HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 48°13.947'
Long: 141°23.009'
Water depth: 322 m
Recovery: 380 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-8 cm - grayish olive-green clayey silt, very soft.

8-36 cm - dark gray-green clayey silt with spotted texture (large lenses of hydrotroilite), soft; at 13 cm - large living Calyptogena shell (it was broken during injection of hydrocorer).

36-90 cm - dark gray-green silty clay, spotted (with lenses of hydrotroilite) and strongly bioturbated, dense.

90-115 cm - gray-green silty clay, with sparse spots of hydrotroilite; at 113-115 cm - carbonate concretions.

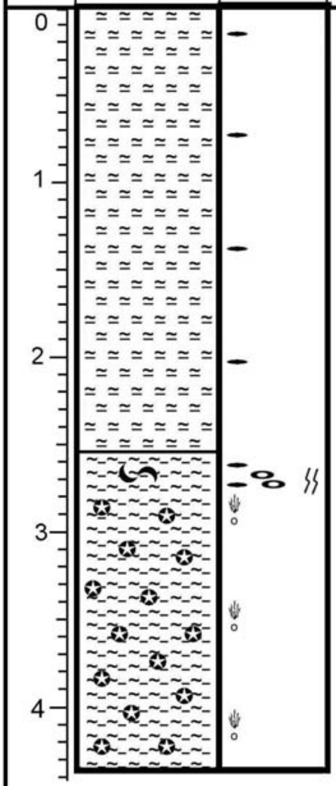
115-135 cm - transitional horizon from homogeneous to gas saturated sediments with traces of knobby texture due to gas outflow - gray-green silty clay, dense, filled by carbonate concretions.

135-380 cm - gray-green clay, strongly gas saturated with pseudobrecciated texture, with traces of splitting; all horizon is filled by carbonate concretions of different shape and size; at 138 cm - Calyptogena shell covered by carbonate crust.

Core description : **Lv59-45HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 48°14.978'
Long: 141°23.812'
Water depth: 325 m
Recovery: 436 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



0-7 cm - grayish olive-green clayey silt, at the top - fluid, below - soft.

7-252 cm - gray-green clayey silt, soft, homogeneous, moderately dense, with sparse spots of hydrotroilite.

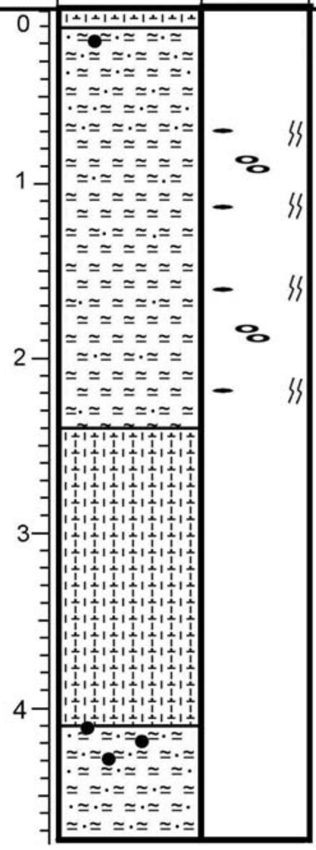
252-285 cm - grayish-green silty clay, consolidated, at 260-278 cm - spotted (admixture of hydrotroilite) and bioturbated; at 270 cm - large fragments of Calyptogena.

285-436 cm - grayish-green silty clay, consolidated, slightly gas saturated with pseudobrecciated texture; at 285-350 cm - numerous small carbonate concretions; at 360-415 cm - abundance of large carbonate concretions.

Core description : **Lv59-46HC**
Cruise/Leg: RV Akademik M.A.Lavrentyev 59

Lat: 46°53.462'
Long: 139°22.082'
Water depth: 628 m
Recovery: 475 cm

(m)	LITHOLOGY	TEXTURE	DESCRIPTION	SS



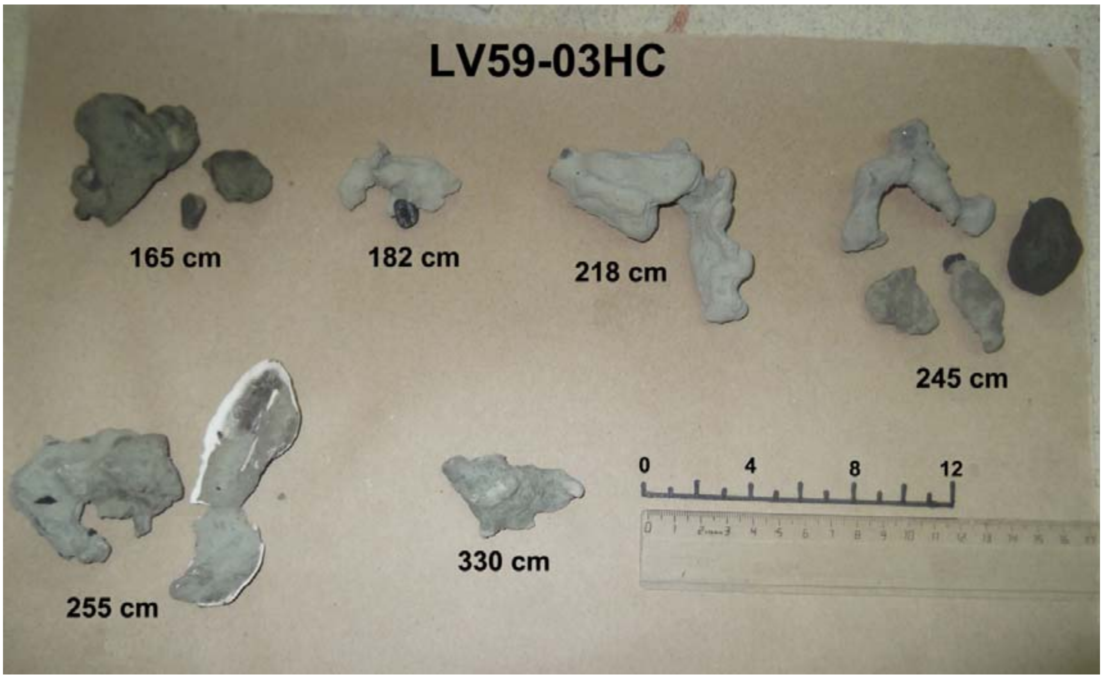
0-10 cm - grayish olive-green sediment representing mixture of sand, silt and clay, soft.

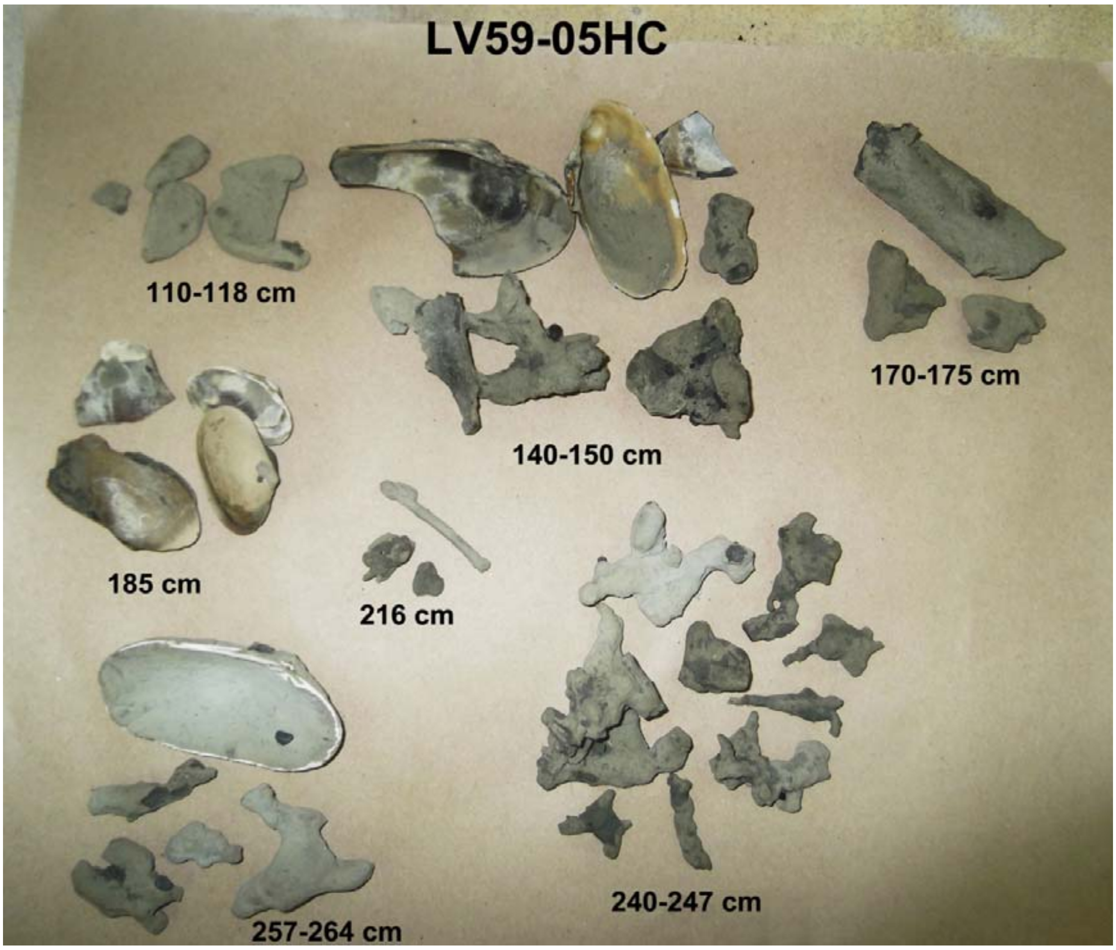
10-70 cm - grayish olive-green clayey silt with admixture of sandy particles, soft (consolidated at the bottom); at 20 cm - dropstone.

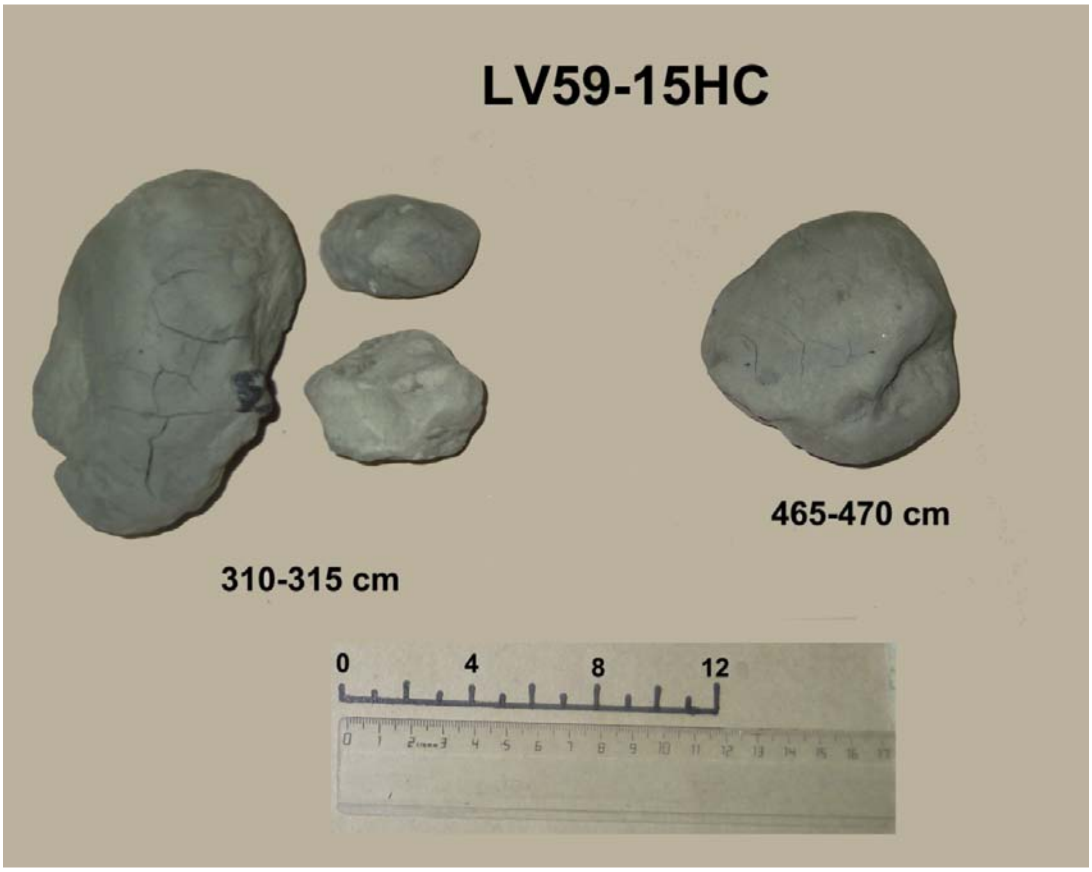
70-240 cm - gray clayey silt with weak greenish hue, dense; here and there sparse small spots of hydrotroilite occur with traces of bioturbation.

240-410 cm - greenish-gray sediment consisting of sand, silt and clay, dense, homogeneous.

410- 475 cm - greenish-gray clayey silt with admixture of sand, dense, homogeneous; at 410, 418, 430 cm - dropstone.


LV59-03HC
165 cm
182 cm
218 cm
245 cm
255 cm
330 cm
0
4
8
12


LV59-05HC
110-118 cm
140-150 cm
170-175 cm
185 cm
216 cm
240-247 cm
257-264 cm


LV59-15HC
310-315 cm
465-470 cm
0
4
8
12

4.3. Core Analyses

4.3.1. Gas Analysis (POI)

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Concentrations of hydrocarbon gases and CO_2 were measured from sediment cores in the area 3 (Terpenia Bay, Kuril Basin of Okhotsk Sea) and area 4 (Tatarsky Strait, Japan/East Sea) (Fig. 4.1). Gas analyses were made at total 26 core stations. Headspace method and gas chromatographic analysis were conducted onboard to determine methane content in the sediments.

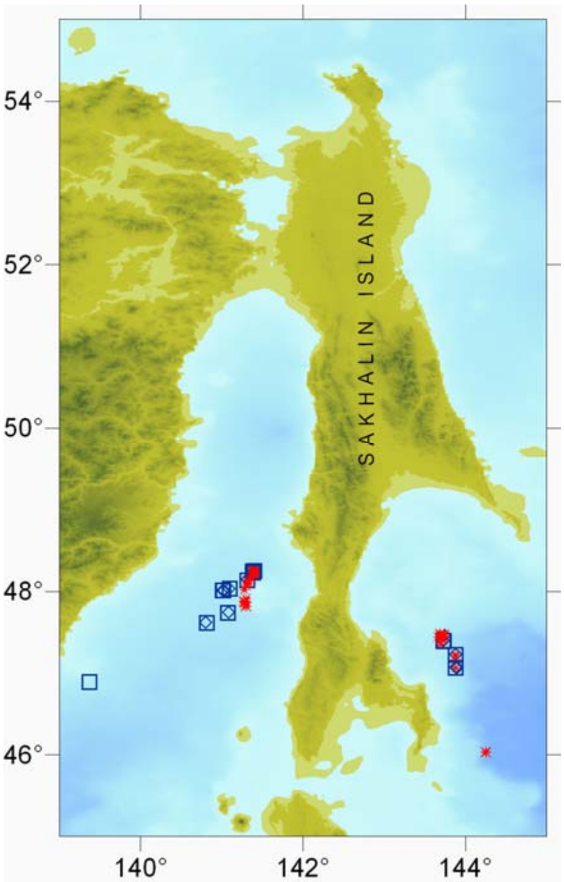


Fig. 4.1. Scheme of the stations in the expedition LV-59: blue diamonds are CTD stations, blue rectangles are sediment core stations, and the red stars are the gas flare sites.

Gas geochemical studies included:

1. Taking of bottom sediments from cores to measure relative concentration and composition of gas
2. Chromatographic gas analysis
3. Interpretation of the data obtained.

Methods and instruments

The sediments were sampled with 12 ml plastic syringes at 20 cm interval, and then transferred into 68 ml airtight bottles filled with a saturated water solution of NaCl containing 0.5ml of bigluconate chlorhexidine (0.05%). Then a little of NaCl solution was added and the bottles were immediately capped with rubber stoppers using a needle to remove the water and air excess. The next step (adding helium into the closed bottle and then shaking) in the same way as described above. Calculation of methane in the sediments yielded values without the dissolved fraction.

Results of gas investigation.

Gas-rich layers were observed in all sedimentary columns in the areas of research, Okhotsk and Japan/East Seas. Methane concentration is usually rich (~0.01-0.1 ml/l) in subsurface sediment (0-50 cm). It sharply increases at depths of 50-400 cm to larger than 100 - 150 ml/l, especially in core sediment at stations where gas hydrate was found (e.g., station LV59-05HC). Methane concentration profile in the sediments in West Kuril Basin and Tatarsky Strait is very similar both in trend and value (Fig. 4.2 and Table 4.1). Concentrations of ethane and CO_2 in the sediments were measured as 50-150 μl/l and 5-10 ml/l, respectively.

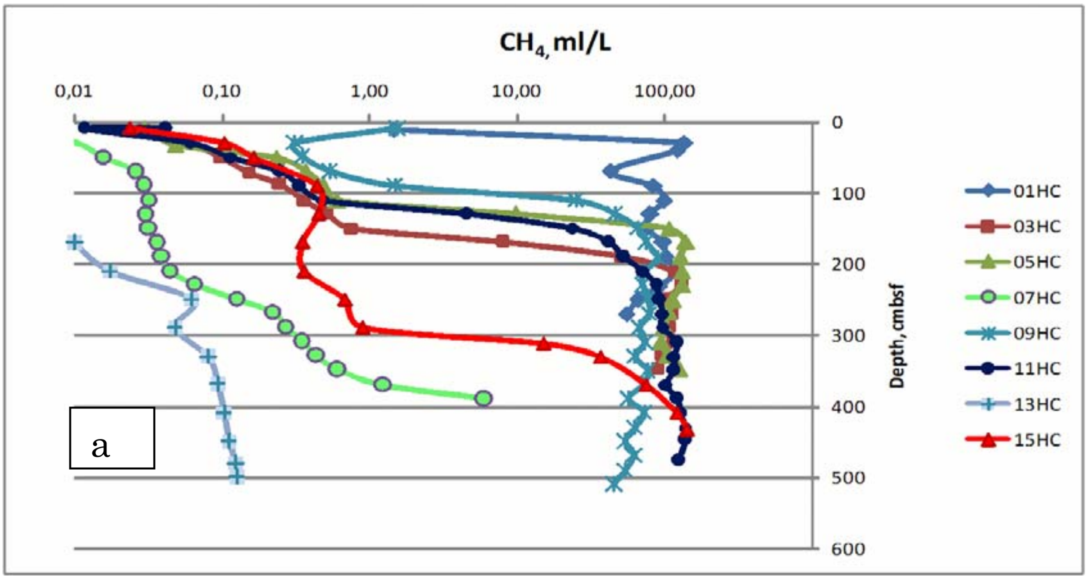
Conclusion

Methane concentrations in the water column on West Kuril Basin (Terpeniya area) on South Okhotsk Sea vary in a range of 5 to 50nM/l with water depth (0-1000 m). In Tatarsky Strait on North Japan Sea values are somewhat small (5-7 nM/l). Anomalously high values (80-100 nM/l) were found in area where gas flares (methane bubbles) occurred in bottom water. Change in methane concentration in the water column seems to be determined by different water masses with depth. The change in the sediments both in West Kuril Basin and Tatarsky Strait are drastic: values increase with depth by 10000 times from the seafloor to just 4 meters below the seafloor. In particular, methane concentration is very high of 100-150 ml/l at stations where gas hydrates occur. Such methane concentration profile in the sediments may be characterized by presence of gas hydrates or their destruction through the emission of methane into the water.

References

Vereshchagina Olga F., Korovitskaya Elena V., Mishukova Galina I. Methane in water columns and sediments of the north western Sea of Japan, Deep Sea Research Part II: Topical Studies in Oceanography, http://dx.doi.org/10.1016/j.dsr2.2012.08.017

Wiesenburg Denis A. and Guinasso Norman L, Jr. Equilibrium Solubilities of Methane Carbon Monoxide, and Hydrogen in Water and Sea Water// Jornal of Chemical and Engineering Data, 1979, Vol. 24, No 4, p 356-360



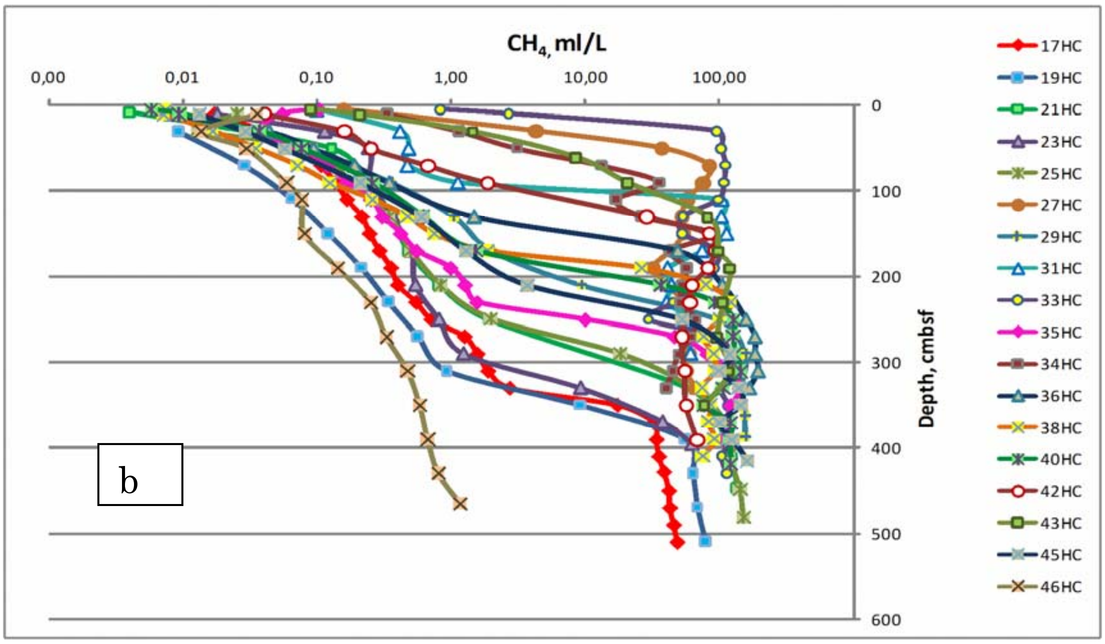
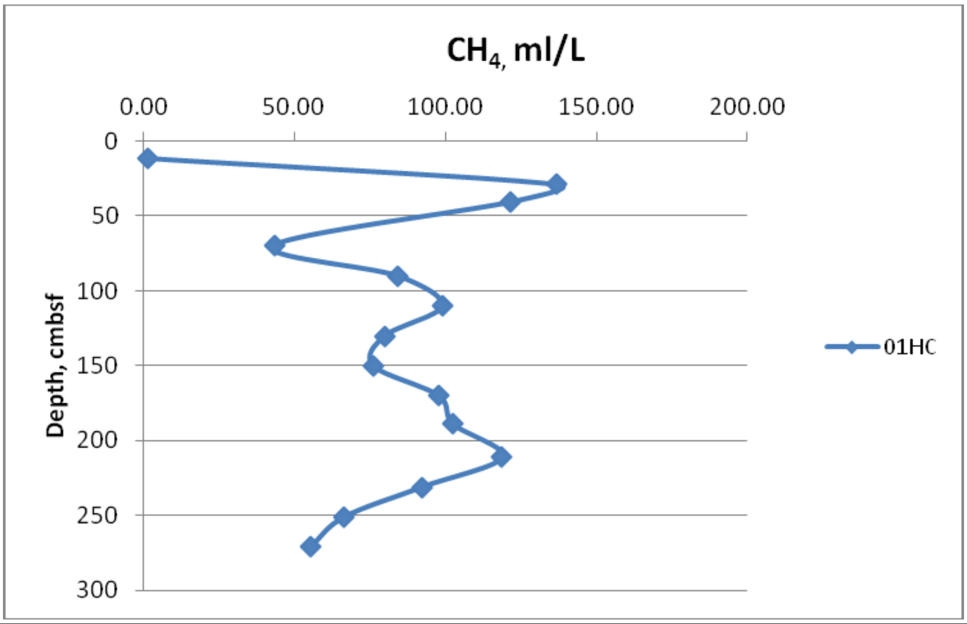


Fig. 4.2. Methane distribution in the sediments from: a – West Kuril Basin; b – Tatarsky Strait Methane distribution in the sediments from: a – West Kuril Basin; b – Tatarsky Strait

Table 4.1. Methane concentration in the sediments.

Core description: lv59-01HC				Lat: 47º23.988’ Long: 143º43.621’	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
11.5	1.48	65890	339	20.4	1.53
29	136.72	6103380	0	89.4	6.20
40.5	121.71	5433265	0	59.6	4.71
69.5	43.23	1929715	0		6.80
90	84.08	3753784	0	63.8	7.22
110	98.83	4412100	0	64.4	5.06
130	79.88	3565863	0	38.8	5.31
150	75.99	3392239	0	35.3	4.77
170	97.59	4356881	0	49.5	6.35
189	102.36	4569679	0	63.1	6.82
211	118.71	5299642	0	48.7	7.03
231	92.35	4122603	0	34.5	7.02
251	66.51	2969268	0	26.3	7.50
271	55.25	2466386	0	21.0	8.45

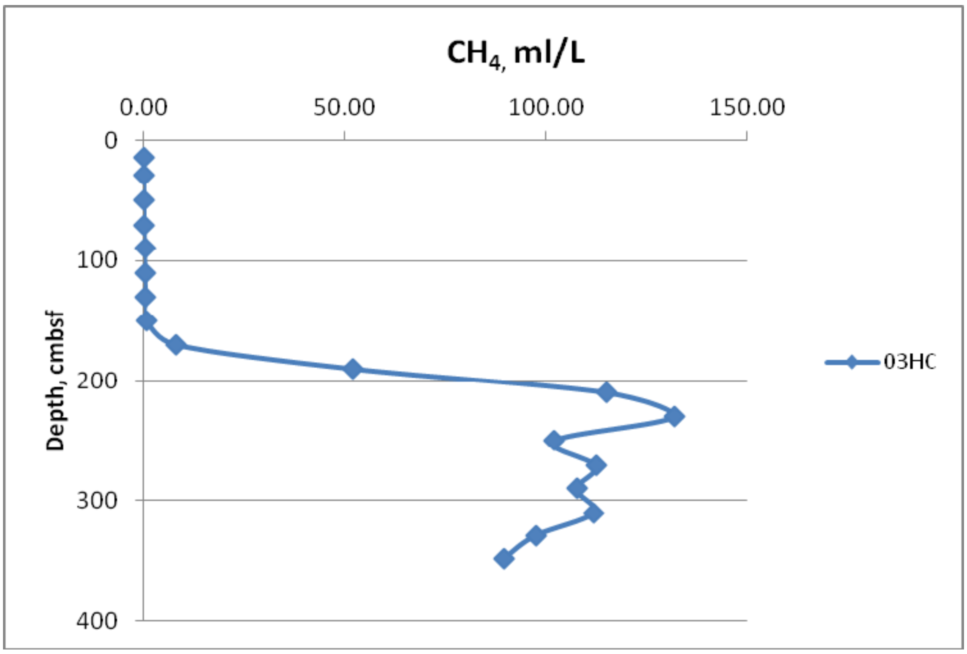


Core description: lv59-03HC

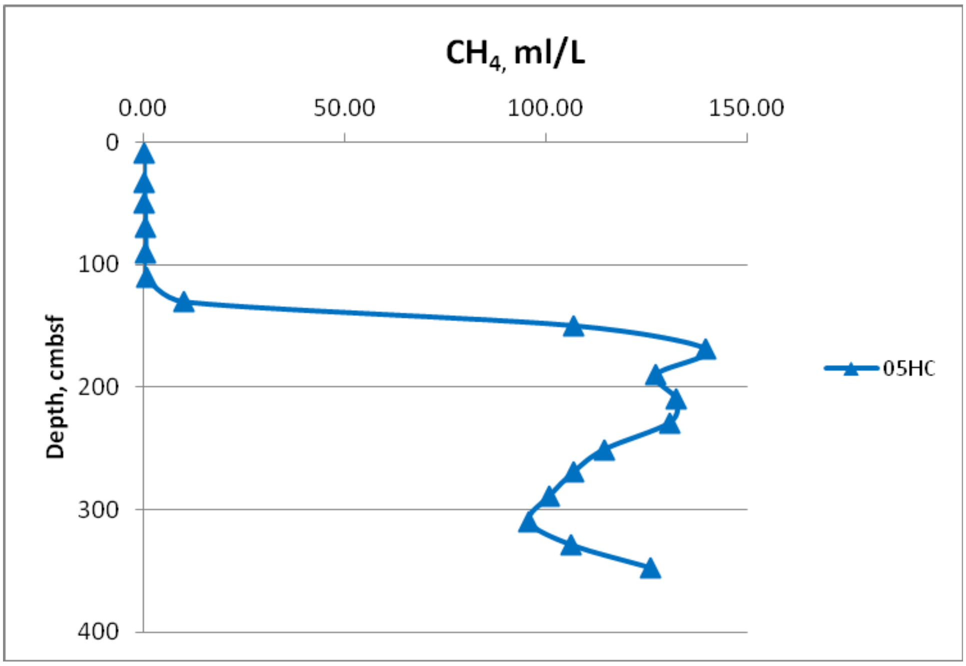
Lat: 47º03.871’

Long: 143º52.960’

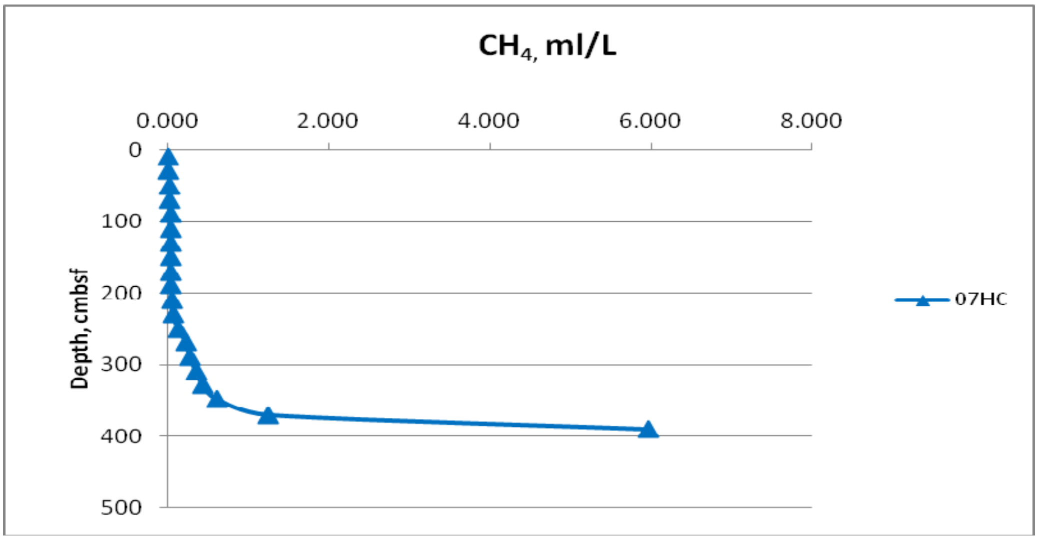
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
14	0.03	1347	2272	0.9	0.14
29	0.06	2637	2185	1.3	1.70
50	0.10	4498	2272	1.0	1.50
71	0.15	6788	1385	1.2	1.60
89	0.25	11122	2926	2.1	1.71
110	0.36	16191	1382	3.2	2.78
130	0.52	23065	710	6.8	3.49
150	0.76	33897	437	13.3	4.52
170	7.97	355974	631	33.6	3.39
190	51.90	2317150	249	60.9	4.36
210	114.97	5132639	0	103.4	4.73
230	131.81	5884339	0	114.0	4.85
250	102.00	4553369	0	99.2	3.47
271	112.35	5015666	0	105.4	2.98
290	107.60	4803449	0	104.1	3.13
310	111.96	4998435	0	110.2	2.89
329	97.40	4348435	0	105.1	2.73
348	89.41	3991587	0	104.7	2.83



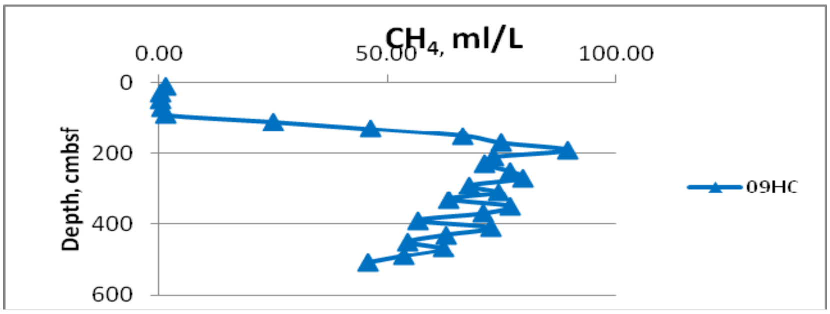
Core description: lv59-05HC				Lat: 47º03.866’ Long: 143º52.970’	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
9	0.03	1340	611	0.4	1.82
33	0.05	2154	1359	0.8	2.21
50	0.23	10445	3326	1.7	3.19
69	0.37	16596	2317	2.5	3.75
90	0.49	21745	1816	3.5	4.72
110	0.61	27234	1337	6.2	5.00
130.5	9.94	443936	275	20.9	7.09
150	106.79	4767208	0	90.2	6.59
169	139.66	6234750	0	114.0	5.75
190	127.29	5682471	0	109.4	5.92
210	132.22	5902686	0	120.1	4.91
229	130.68	5833925	0	117.4	5.12
251	114.38	5106340	0	111.3	5.62
269	106.84	4769463	0	108.8	3.88
289	100.67	4494368	0	109.1	5.19
310	95.60	4267943	0	107.9	5.05
329	106.02	4732962	0	120.9	4.17
348	125.96	5623432	0	206.9	5.22



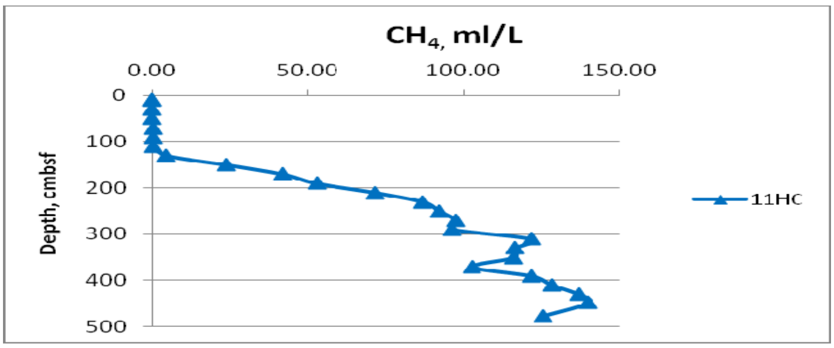
Core description: lv59-07HC				Lat: 47º13.526’ Long: 143º52.908’	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
9	0.00	157	1677	0.4	2.95
28.5	0.01	444	2748	0.4	1.27
50	0.02	710	1917	0.4	1.28
70	0.03	1174	2061	0.7	1.36
89	0.03	1349	1877	0.7	1.41
110	0.03	1447	1499	0.7	1.14
130	0.03	1383	2061	0.5	1.57
150	0.03	1426	2061	0.5	1.46
170	0.04	1639	2537	1.0	1.63
189	0.04	1746	2459	0.9	1.53
210	0.05	2022	2255	0.8	1.51
229	0.07	2947	2604	1.2	1.65
250	0.13	5662	1718	1.6	2.20
268	0.22	10027	1988	2.0	2.33
289	0.27	12136	1954	2.8	3.09
309	0.35	15672	2094	3.5	3.60
329	0.44	19555	1874	4.1	3.95
348	0.61	27298	1988	4.8	3.90
370	1.24	55294	1924	5.6	3.63
390	5.97	266694	1924	6.5	4.85



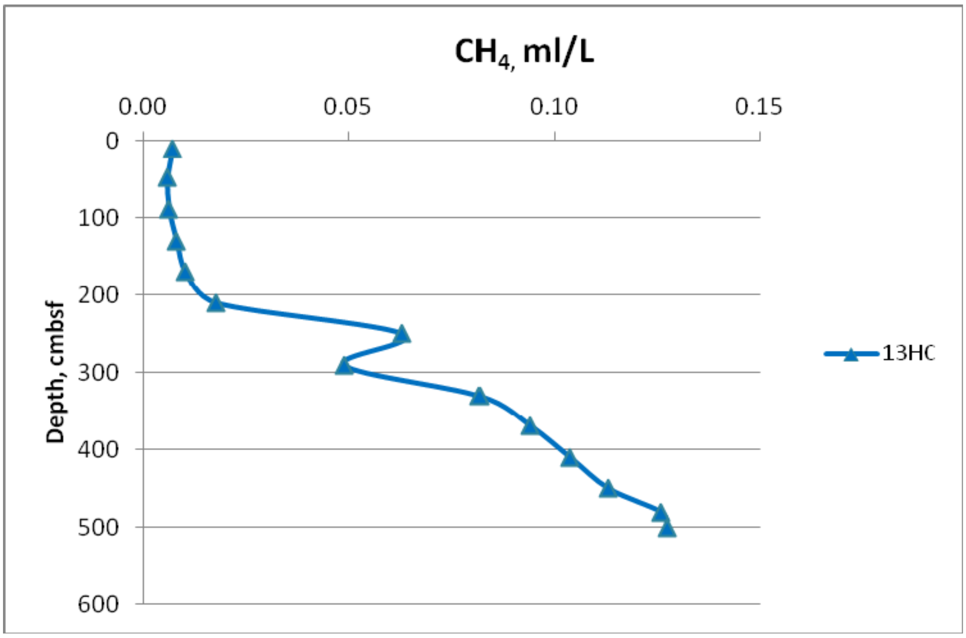
Core description: lv59-09HC					Lat: 47º23.961', Long: 143º43.662'
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
10	1.56	69616	144	0.1	9.97
30	0.31	14024	105	0.1	10.26
49	0.35	15717	789	0.3	12.62
70	0.55	24333	284	0.3	16.29
90	1.51	67547	142	0.1	11.25
110	25.13	1121913	0	1.2	15.32
130	46.35	2069167	0	1.9	12.93
150	66.47	2967324	0	2.9	14.46
170	74.76	3337689	0	3.3	15.16
191	89.34	3988591	0	4.4	15.50
210	73.24	3269752	0	4.2	13.99
230	71.17	3177448	0	4.5	14.94
250	76.72	3425102	0	5.2	13.57
270	79.49	3548496	0	6.0	15.56
290	67.81	3027065	0	5.7	15.33
311	74.36	3319781	0	6.8	15.05
330	63.42	2831411	0	6.3	13.81
350	76.89	3432770	0	7.9	15.21
370	71.05	3171679	0	7.8	14.12
390	56.60	2526698	0	6.6	15.53
410	72.62	3241971	0	7.9	16.13
430	62.73	2800656	0	7.2	14.51
450	54.53	2434476	0	6.7	13.37
470	62.13	2773643	0	7.6	15.55
491	53.65	2394952	0	7.0	15.61
510	45.65	2037804	0	6.2	14.42



Core description: lv59-11HC			Lat: 47°27.374’, Long: 143°44.326’		
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
9	0.04	1868	137	0.1	3.05
10	0.01	521	122	0.1	2.88
30	0.06	2714	141	0.1	4.23
50	0.12	5202	131	0.1	5.59
70	0.25	11100	122	0.1	7.99
90	0.34	15167	137	0.1	9.88
110	0.50	22183	134	0.1	11.66
130	4.62	206399	122	0.1	12.67
150	24.13	1077440	0	0.1	14.83
170	41.93	1871854	0	0.1	15.18
190	52.81	2357402	0	0.0	14.64
210	71.78	3204611	0	0.0	15.06
230	86.95	3881770	0	0.0	17.05
250	92.17	4114711	0	0.0	16.07
270	97.56	4355458	0	0.0	15.92
289	96.26	4297300	0	0.0	16.94
310	121.76	5435529	0	0.0	17.53
330	116.56	5203652	0	0.0	18.57
350	116.26	5190098	0	0.0	20.16
370	102.59	4579978	0	0.0	19.08
390	121.93	5443192	0	0.0	21.00
410	128.47	5735416	1235	0.4	25.66
430	137.11	6121099	1191	0.4	27.34
448	139.97	6248800	1267	0.0	26.58
476	125.63	5608645	0	0.0	30.48

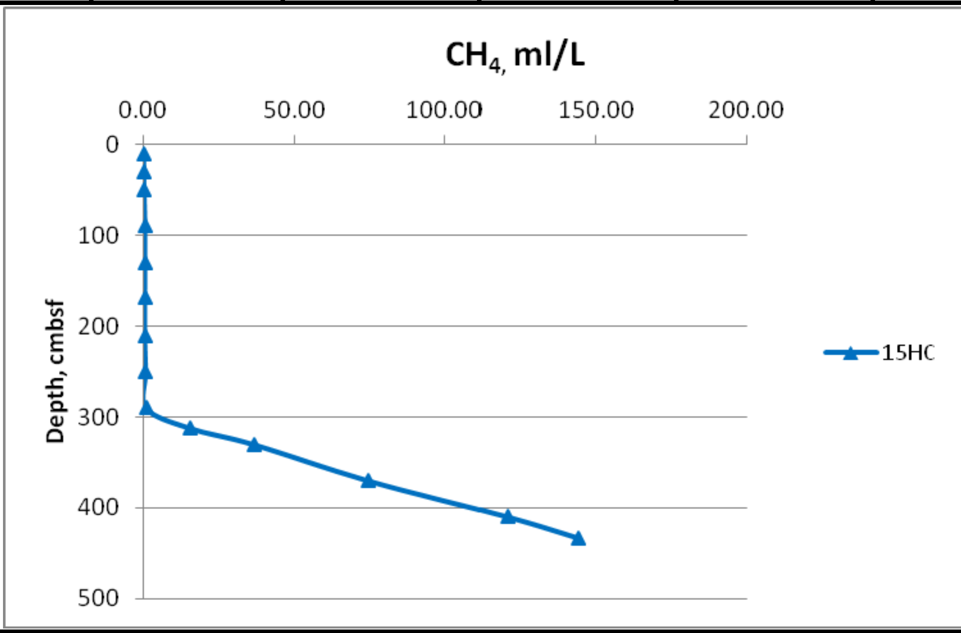


Core description: lv59-13HC					Lat: 47º03.881’ Long: 143º52.969’
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
10	0.01	313	2689	0.6	1.44
49	0.01	256	1617	0.4	1.64
89	0.01	274	1925	0.3	1.55
130	0.01	357	2191	0.3	1.26
170	0.01	454	1704	0.2	1.24
210	0.02	788	1586	0.7	1.48
250	0.06	2809	1696	1.0	1.63
290	0.05	2174	1603	1.2	2.29
330	0.08	3647	1470	1.5	2.90
369	0.09	4192	1418	1.7	3.16
410	0.10	4626	1957	2.0	2.80
450	0.11	5045	797	1.6	3.95
480	0.13	5613	1534	2.0	3.90
500	0.13	5678	1137	2.0	3.90

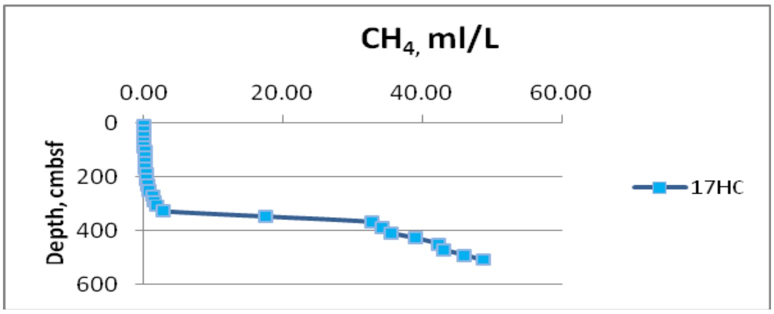


Core description: lv59-15HC Lat: 47º03.860’ Long: 143º52.948’

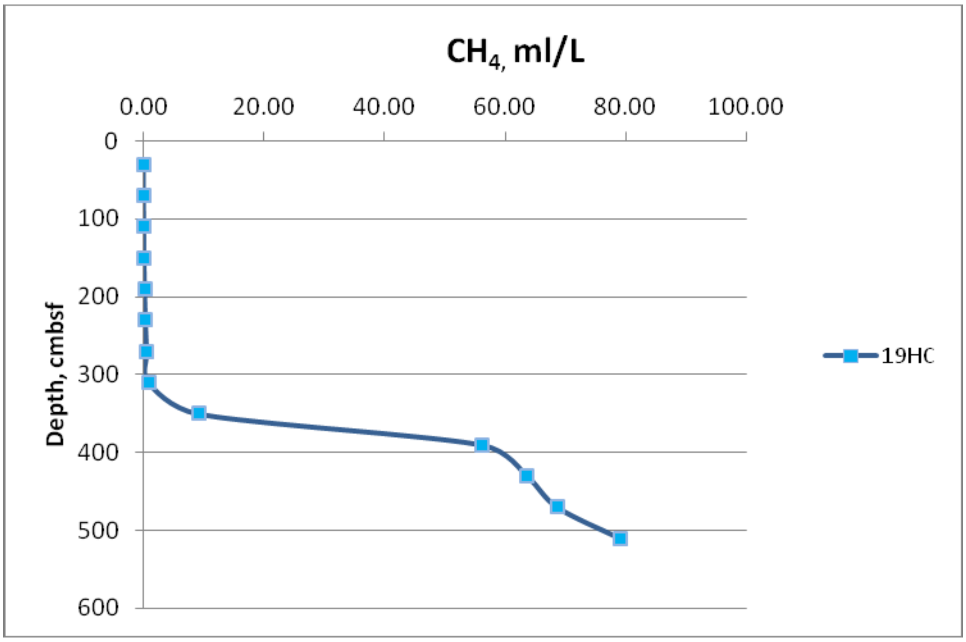
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
10	0.02	1083	1330	0.4	1.51
30	0.11	4697	2373	1.3	1.74
50	0.17	7423	2310	1.4	1.29
90	0.44	19652	1914	1.1	1.14
130	0.45	20145	1097	1.0	1.70
169	0.36	15892	2780	2.0	1.46
210	0.36	16116	1783	1.8	1.51
250	0.69	30943	2058	4.0	2.15
290	0.92	40975	1783	14.1	3.99
312	15.26	681039	803	121.3	4.71
330	36.56	1632083	722	181.2	6.05
370	74.65	3332615	0	459.3	7.43
410	120.75	5390579	0	760.9	7.01
433	143.95	6426260	0	832.4	6.09



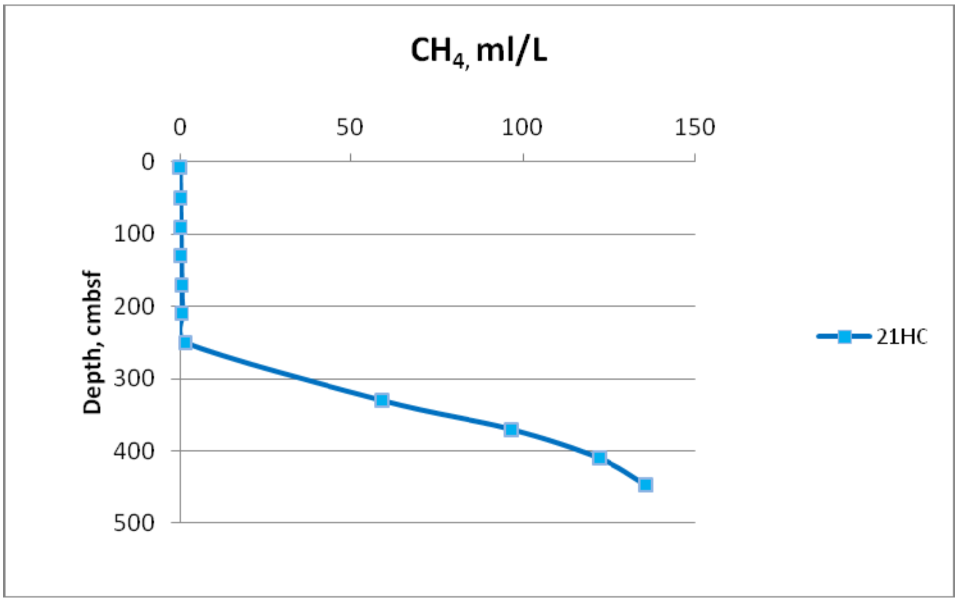
Core description: lv59-17HC				Lat: 47º36.733', Long:140º48.917'	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
10	0.02	773	3136	0.5	3.62
30	0.04	1859	3610	0.6	2.47
50	0.08	3461	2905	0.6	1.51
70	0.11	4818	2888	1.0	1.92
90	0.14	6144	2221	1.0	2.22
110	0.17	7528	2814	1.3	2.24
130	0.22	9701	2251	1.4	2.89
150	0.25	11089	2673	1.8	2.69
170	0.29	13130	2008	2.0	2.86
190	0.36	16024	2058	2.6	2.57
210	0.40	18016	1284	2.7	2.00
230	0.55	24646	1284	3.2	2.34
250	0.72	31990	2827	3.2	1.43
270	1.27	56660	1914	4.3	1.81
290	1.58	70538	2090	4.3	1.99
310	1.90	84807	1341	4.3	2.50
330	2.76	123045	1585	5.2	2.28
350	17.51	781538	1071	6.2	2.36
370	32.72	1460708	1235	6.0	2.26
390	34.20	1526599	976	5.7	2.60
410	35.61	1589694	1097	5.6	2.22
428	38.94	1738368	1071	6.3	2.81
450	42.37	1891576	1432	6.3	2.90
470	43.02	1920476	1120	6.3	3.15
490	46.03	2054875	1404	6.5	2.91
510	48.84	2180431	1219	6.8	3.37



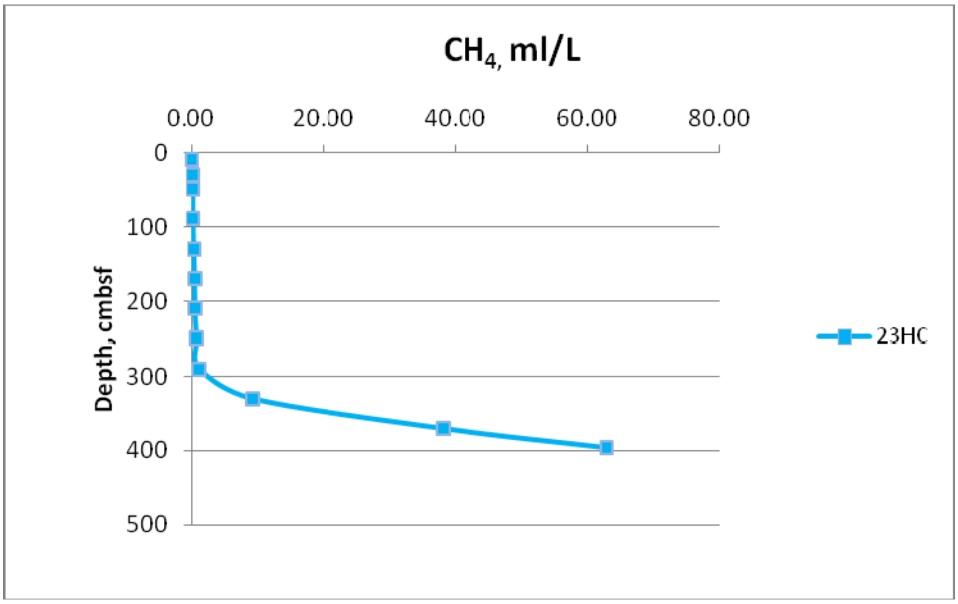
Core description: lv59-19HC				Lat: 47º44.001’ Long: 141º04.361’	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
30	0.01	413	3559	0.4	4.13
70	0.03	1283	3136	0.5	3.20
109	0.06	2894	3246	0.5	2.01
150	0.12	5439	2482	1.2	3.50
190	0.21	9562	3063	1.7	4.80
230	0.34	15191	3136	1.7	5.65
270	0.57	25271	2543	4.1	6.88
310	0.93	41642	2076	8.2	9.02
350	9.16	408866	2166	13.9	8.28
390	56.18	2508041	1106	18.9	6.74
430	63.63	2840776	960	19.8	6.66
470	68.69	3066435	768	20.5	5.90
510	79.09	3530809	1408	21.4	5.81



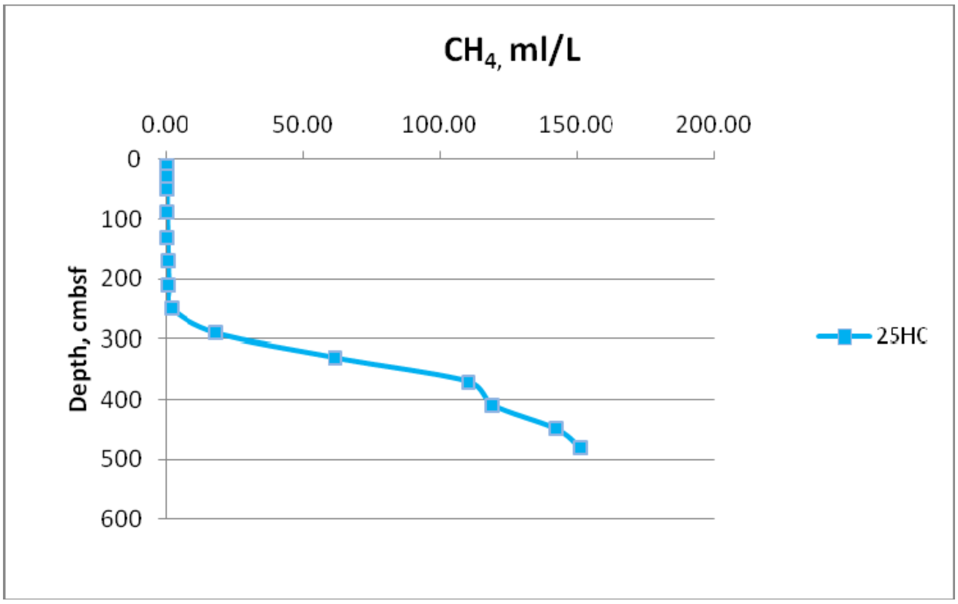
Core description: lv59-21HC				Lat: 48º00.832’ Long: 141º00.813’	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
8	0.0039	176	3559	0.6	3.87
50	0.13	5685	1787	0.9	2.26
90	0.24	10891	0	0.0	3.72
130	0.36	15960	1793	0.9	6.06
170	0.48	21252	2022	1.0	6.34
210	0.81	36094	1646	1.1	7.68
250	1.89	84564	624	1.0	8.66
330	58.83	2626502	114	1.0	11.49
370	96.54	4309746	125	1.0	9.42
410	122.13	5452360	137	1.4	8.20
447	135.87	6065751	0	1.4	8.88



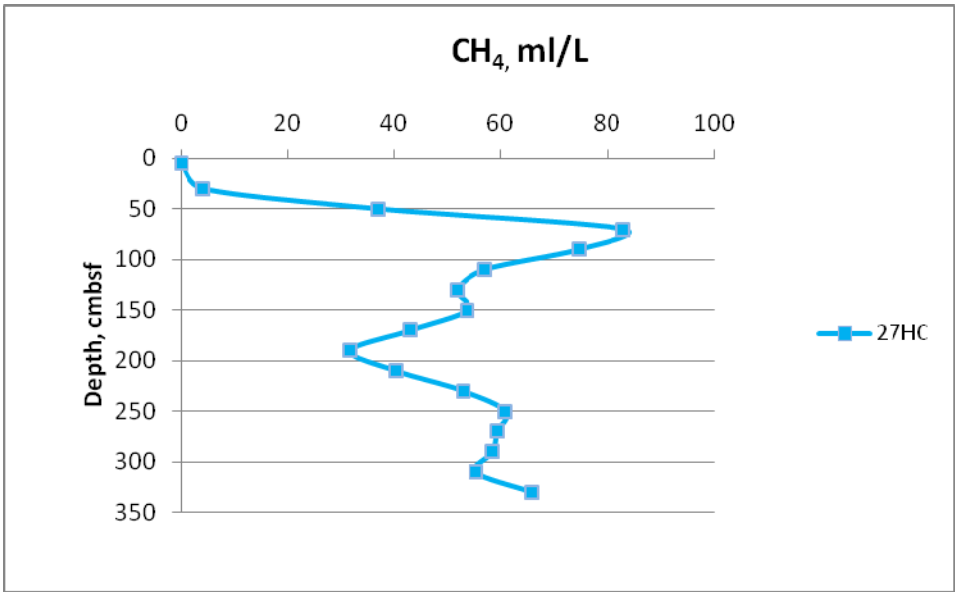
Core description: lv59-23HC				Lat: 48º00.797’ Long: 141º00.730’	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
10	0.02	796	3292	0.5	5.14
30	0.11	5057	2425	0.5	1.78
49	0.24	10775	2421	1.3	2.04
89	0.25	11172	2120	1.4	3.23
130	0.37	16307	2455	2.0	4.10
170	0.51	22583	1568	2.5	4.00
210	0.54	24165	2979	2.7	4.30
250	0.81	36209	3028	4.2	3.77
290	1.24	55276	2744	4.8	5.38
330	9.29	414640	2378	6.2	7.27
370	38.06	1698892	937	6.6	7.76
396	62.98	2811552	725	7.7	6.45



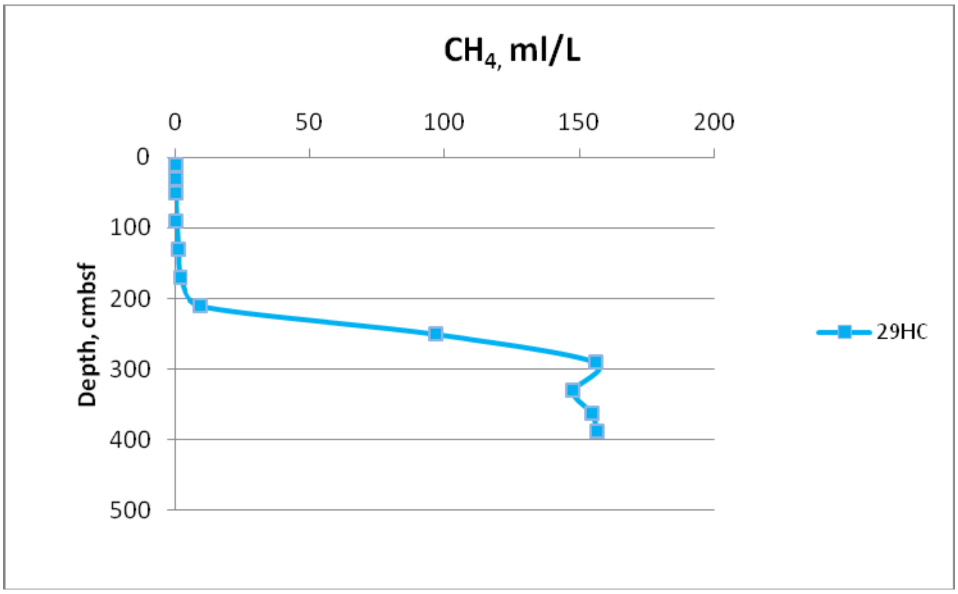
Core description: lv59-25HC				Lat: 48º02.027’ Long: 141º05.606’	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
10	0.03	1145	3321	0.6	4.01
28	0.01	576	2909	0.5	2.80
50	0.09	4059	2569	0.7	1.56
89	0.18	7895	1437	0.5	2.24
130	0.35	15472	1904	0.9	3.91
170	0.50	22414	1646	0.8	5.56
210	0.83	37272	1585	0.7	8.63
249	1.98	88310	1675	0.8	7.82
290	18.33	818414	1890	0.9	7.53
330	61.81	2759289	399	0.5	14.19
370	110.62	4938384	396	0.7	17.24
409	119.27	5324612	388	0.8	15.21
449	142.23	6349745	415	0.8	14.03
481	151.22	6750765	385	0.9	13.38



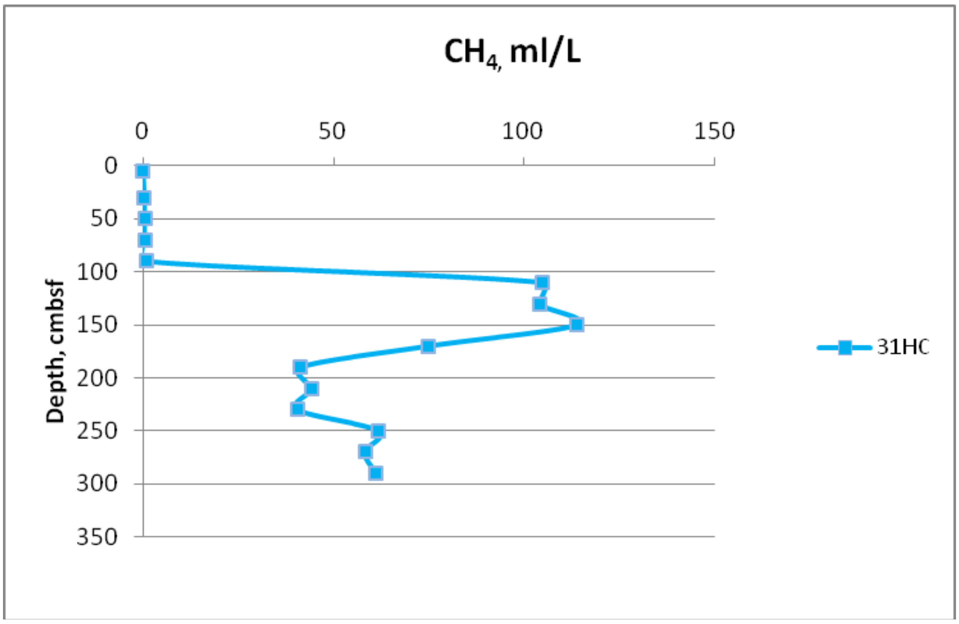
Core description: lv59-27HC Black Gas Hydrate				Lat: 48º13.854' Long: 141º23.013'	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
5	0.16	7118	1536	2.4	5.76
30	4.26	190165	549	62.4	3.11
50	37.11	1656902	0	128.5	4.67
70	82.96	3703770	0	112.7	3.46
90	74.62	3331078	0	93.9	4.07
110	57.00	2544461	392	65.3	3.21
130	51.87	2315534	314	67.9	4.53
150	53.71	2397652	0	68.5	4.95
170	42.96	1917722	708	78.2	5.24
190	31.88	1423291	568	62.3	5.77
210	40.36	1801924	117	67.3	7.79
230	53.01	2366589	1045	75.0	4.26
250	60.94	2720746	333	69.0	7.03
270	59.37	2650504	878	86.7	5.90
290	58.50	2611699	549	82.7	7.25
310	55.39	2472684	358	86.8	8.83
330	65.97	2945287	732	127.7	7.50



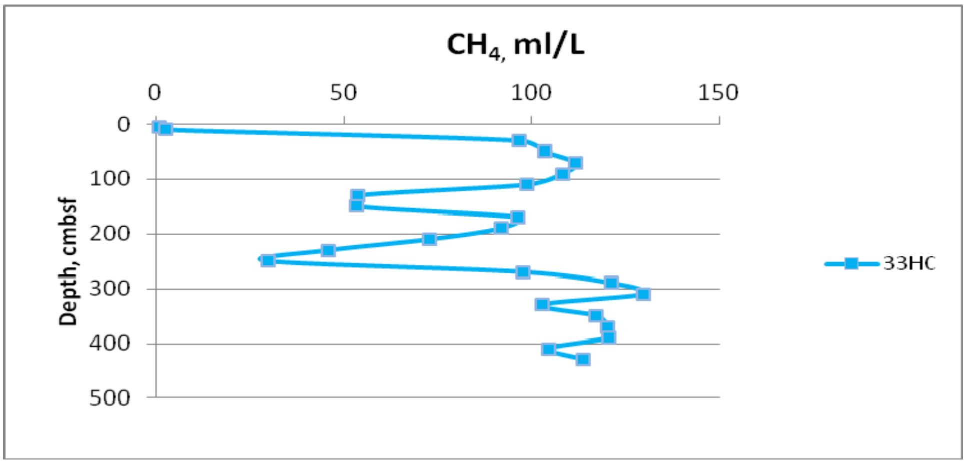
Core description: lv59-29HC				Lat: 48º14.568’ Long: 141º23.027’	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
10	0.01	389	3298	0.6	3.97
30	0.04	1647	2498	0.5	1.62
50	0.08	3775	2199	0.5	1.38
90	0.36	16158	1570	1.3	0.82
130	1.06	47104	1885	4.2	1.85
170	2.03	90467	1446	10.4	0.33
210	9.40	419471	868	32.4	4.72
250	96.74	4318725	0	89.3	6.43
290	156.00	6964291	335	127.5	5.46
330	147.62	6590333	0	129.5	6.17
362	154.67	6904804	0	134.6	5.23
387	156.34	6979441	0	140.1	5.96



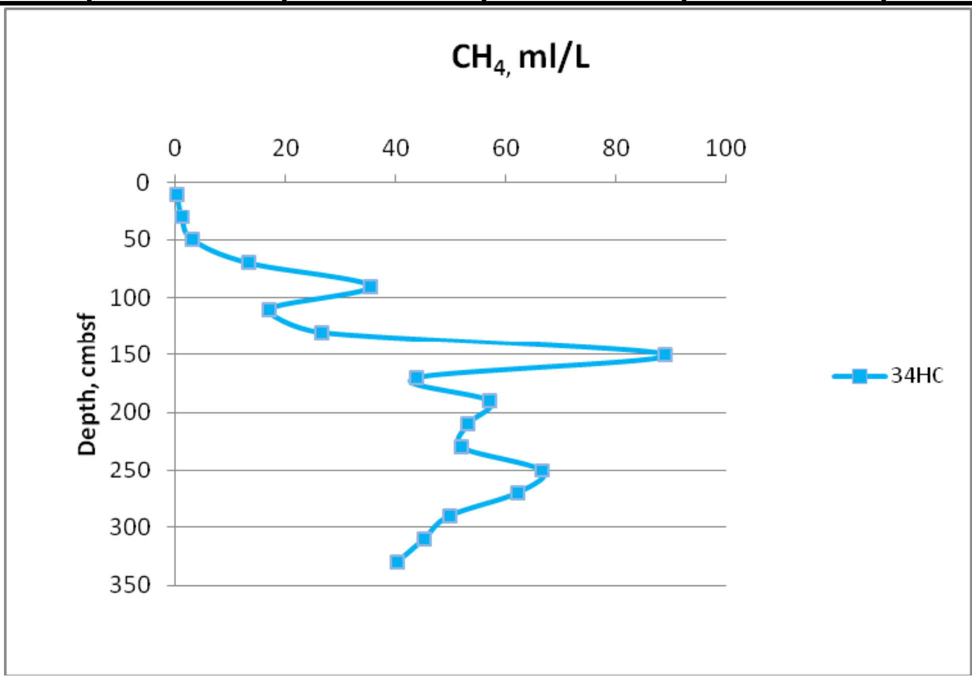
Core description: lv59-31HC					Lat: 48º13.847’ Long: 141º22.980’
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
5	0.10	4420	3481	1.1	3.02
30	0.42	18567	1486	1.2	0.82
50	0.48	21485	2042	2.4	0.86
70	0.47	21035	2011	5.4	0.84
90	1.12	50146	1073	13.8	2.45
110	104.86	4681168	0	88.4	5.49
130	104.13	4648778	0	80.9	3.92
150	113.89	5084587	0	88.1	4.53
170	74.99	3347744	0	75.4	5.53
190	41.34	1845446	0	60.6	1.86
210	44.27	1976477	289	61.9	5.16
230	40.66	1815329	297	61.1	5.38
250	62.04	2769555	314	73.7	4.73
270	58.48	2610671	434	68.7	4.67
290	61.39	2740468	0	72.6	5.42



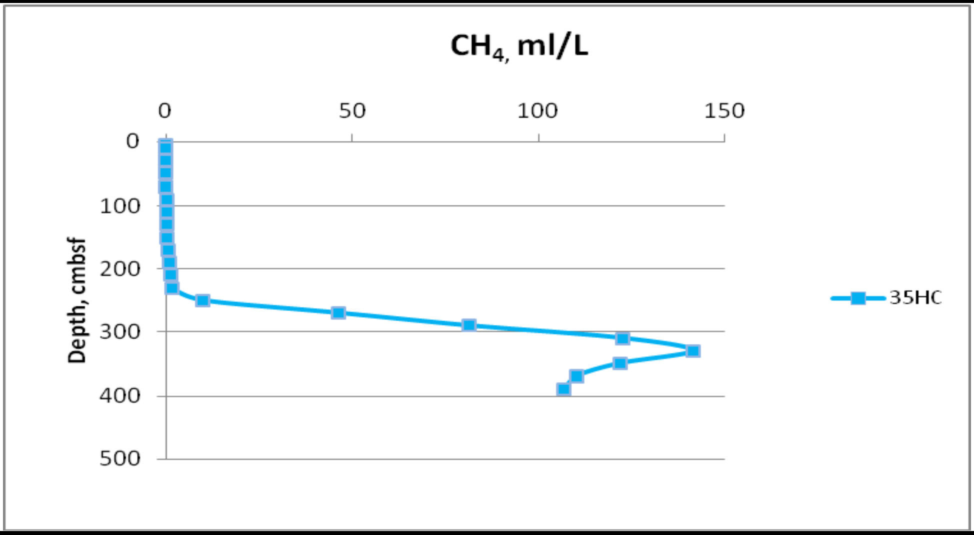
Core description: lv59-33HC				Lat: 48º14.915’, Long: 141º23.798’	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
5	0.83	37231	1588	9.9	1.78
10	2.70	120545	767	59.3	1.73
30	96.69	4316650	0	171.8	3.15
50	103.64	4626690	0	179.8	4.01
70	111.58	4981268	0	196.8	4.08
90	108.18	4829266	0	182.6	3.71
110	98.68	4405534	0	149.2	3.74
130	53.78	2401100	270	86.7	3.69
150	53.55	2390419	0	83.3	4.24
170	96.48	4306927	0	131.7	4.49
190	91.73	4095011	0	138.6	4.62
210	72.85	3252047	0	93.9	4.30
230	45.96	2051939	1731	61.3	3.71
250	29.74	1327858	304	41.9	5.98
270	97.62	4358020	156	90.0	4.74
290	121.24	5412425	0	108.1	4.73
310	129.85	5796761	0	117.3	4.25
330	102.64	4582280	0	111.8	4.45
350	117.19	5231765	404	134.4	3.82
370	120.24	5367798	0	140.8	5.34
390	120.47	5378097	0	142.2	3.67
410	104.58	4668785	0	133.9	4.40
430	113.78	5079664	0	146.6	5.12



Core description: lv59-34HC				Lat: 48º14.881’ Long: 141º24.000’	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
10	0.33	14914	2587	1.5	2.51
30	1.15	51138	2748	10.3	1.08
50	3.12	139211	2061	19.7	1.16
70	13.25	591433	1570	76.0	2.50
90	35.39	1580052	1832	55.3	2.62
110	16.90	754468	1013	19.8	2.73
130	26.47	1181690	687	34.4	4.82
150	89.01	3973557	149	121.1	4.09
170	43.65	1948731	211	85.8	3.68
190	57.02	2545448	314	120.5	4.52
210	53.07	2369295	289	111.8	4.06
230	51.93	2318091	149	113.8	4.07
250	66.57	2971865	0	126.3	3.69
270	62.20	2776627	500	128.6	2.90
290	49.74	2220739	500	127.9	4.06
310	45.09	2013111	289	119.0	3.82
330	40.23	1796029	229	125.3	4.31



Core description: lv59-35HC Carbonate					Lat: 48º14.971' Long: 141º23.616'
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
5	0.10	4635	2611	1.2	3.55
10	0.05	2451	2901	0.8	3.73
30	0.04	1645	2321	0.5	2.28
50	0.07	3296	1832	0.7	1.80
70	0.12	5337	1588	0.7	1.23
90	0.17	7388	2487	1.4	1.65
110	0.25	11236	2061	2.2	1.45
130	0.31	13667	2374	2.6	1.56
150	0.42	18761	2011	3.9	1.90
170	0.55	24602	2525	5.6	2.11
190	0.99	44214	3298	12.3	3.20
210	1.27	56716	942	17.4	3.77
230	1.56	69777	785	21.2	3.75
250	10.03	447653	550	39.2	5.15
270	46.39	2070885	252	89.9	7.21
290	81.37	3632764	335	139.0	7.00
310	122.61	5473636	0	189.8	5.85
330	141.37	6311142	0	229.0	5.82
350	121.80	5437592	0	204.4	4.84
370	110.28	4923233	0	217.3	5.90
390	106.94	4774131	0	231.0	6.51

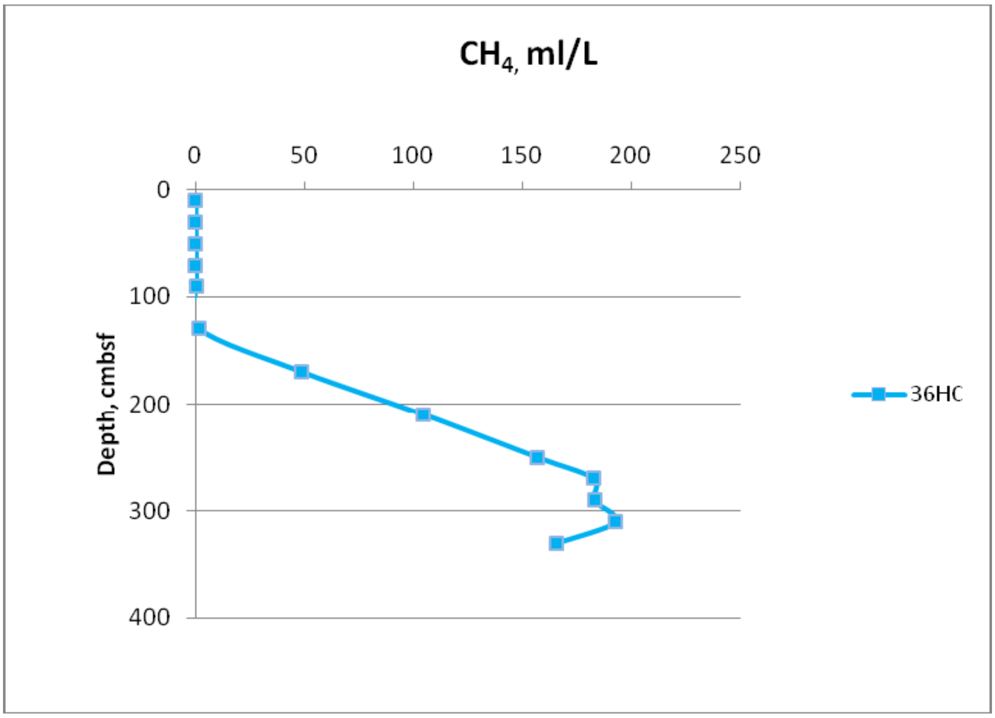


Core description: lv59-36HC

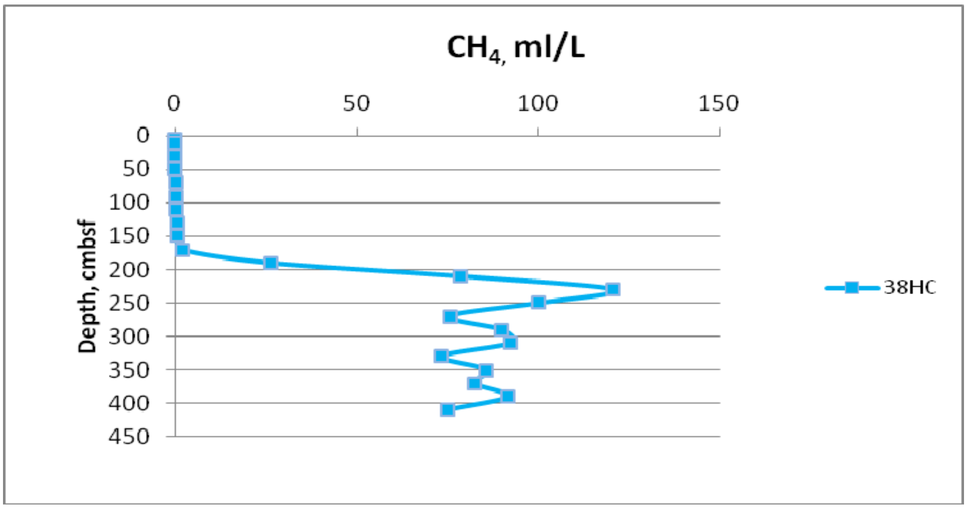
Lat: 48º07.997’

Long: 141º18.880’

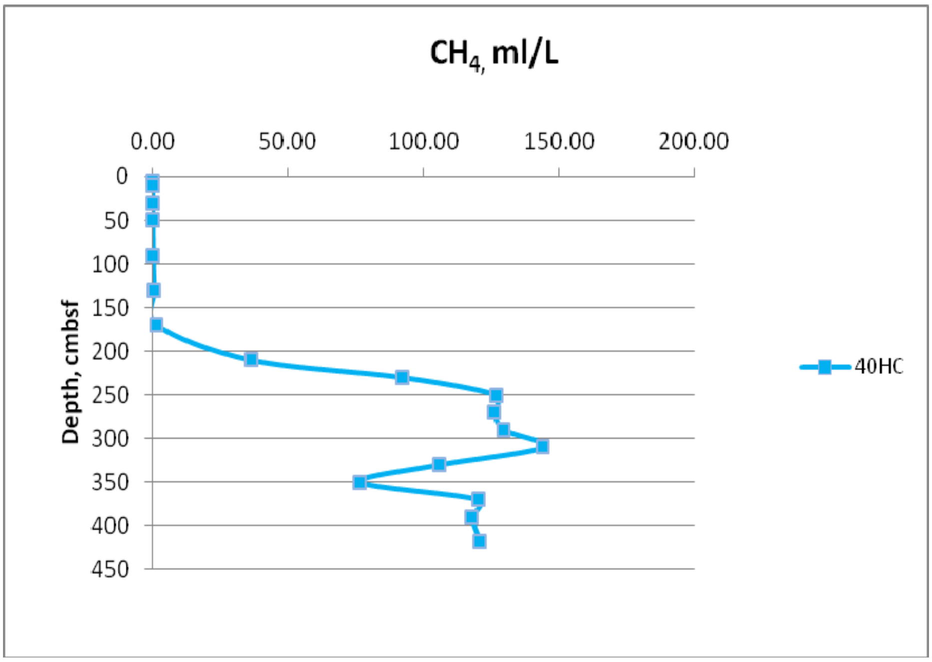
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
10	0.01	362	2228	1.3	1.49
30	0.04	1948	1237	1.5	0.81
50	0.09	4175	1237	1.9	0.95
70	0.19	8438	1534	2.9	1.29
90	0.34	15297	2128	6.0	1.60
130	1.47	65647	564	15.5	3.40
170	48.59	2168999	0	81.1	4.46
210	104.39	4660185	147	127.2	4.03
250	156.64	6992777	0	175.8	3.97
270	182.59	8151318	0	193.9	4.11
290	183.11	8174634	0	192.1	3.52
310	192.80	8607149	0	202.5	3.67
330	165.90	7406396	0	185.6	3.52
390	70.78	3159908	0	133.3	9.47



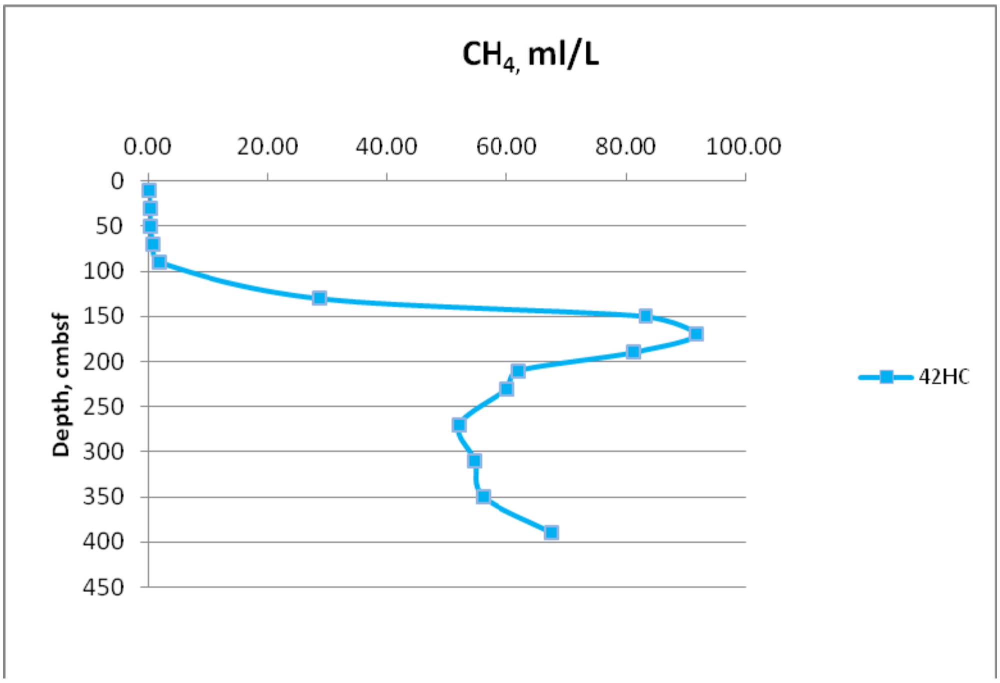
Core description: lv59-38HC				Lat: 48º14.850’ Long: 141º24.016’	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
5	0.01	330	3652	0.7	2.47
10	0.01	320	3384	0.5	2.06
30	0.02	737	2813	0.4	1.98
50	0.03	1562	2191	0.6	1.13
70	0.07	3162	2191	0.9	0.98
90	0.12	5555	4657	2.2	0.93
110	0.26	11521	2568	2.6	1.18
130	0.47	21044	2397	4.5	1.49
150	0.75	33324	1992	8.3	2.26
170	1.85	82766	1217	16.4	3.37
190	26.21	1170239	1014	54.4	3.79
210	78.49	3504219	1191	167.9	2.50
230	120.69	5387882	953	290.1	2.67
250	100.15	4471092	978	281.0	2.25
270	75.64	3376593	843	274.1	1.75
290	90.00	4018080	183	326.0	1.86
310	92.28	4119735	228	332.3	1.79
330	73.38	3275851	1264	319.2	1.65
350	85.68	3824931	1217	349.2	1.74
370	82.37	3677256	1198	362.3	2.14
390	91.47	4083525	1096	366.5	1.88
410	75.09	3352031	637	304.2	1.86



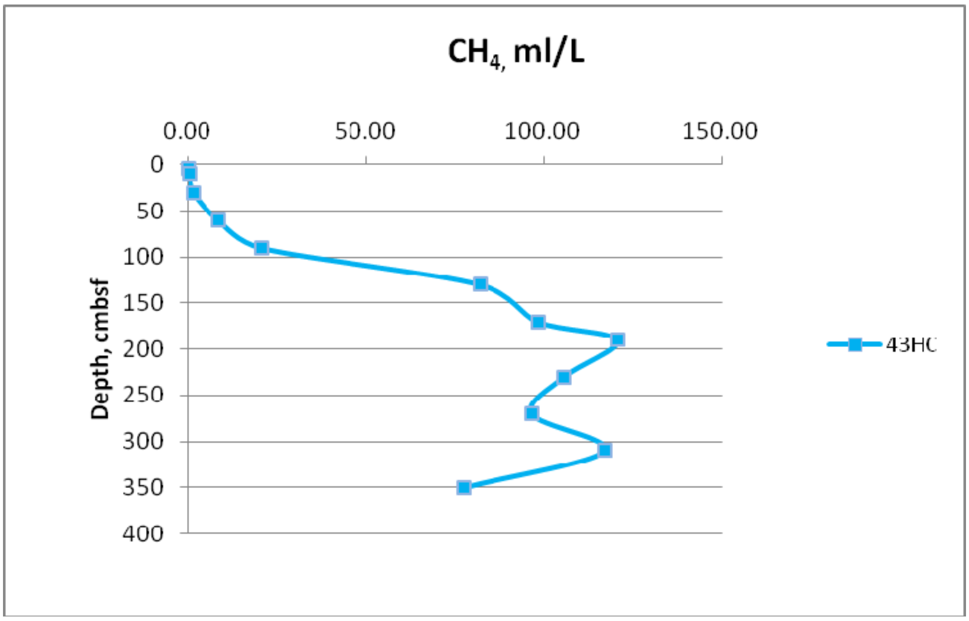
Core description: lv59-40HC				Lat: 48º13.911’ Long: 141º22.892’	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
5	0.01	259	1908	0.3	2.75
10	0.01	419	2051	0.4	2.94
30	0.04	1658	2871	0.5	1.97
50	0.08	3416	1914	0.4	1.37
90	0.26	11549	2474	2.0	1.85
130	0.62	27605	2051	3.6	3.64
170	1.53	68451	2188	10.9	5.61
210	36.41	1625621	798	44.8	9.83
230	92.41	4125581	598	72.8	10.00
250	126.88	5664466	438	94.1	10.40
269	126.06	5627621	438	92.9	10.92
290	129.63	5787195	438	93.3	9.23
310	143.95	6426457	438	98.6	11.78
330	106.11	4737255	729	84.6	11.14
350	76.63	3421048	1531	68.7	6.24
370	120.35	5372624	481	89.5	13.86
390	117.83	5260254	864	88.9	9.87
418	120.90	5397122	640	89.8	13.14



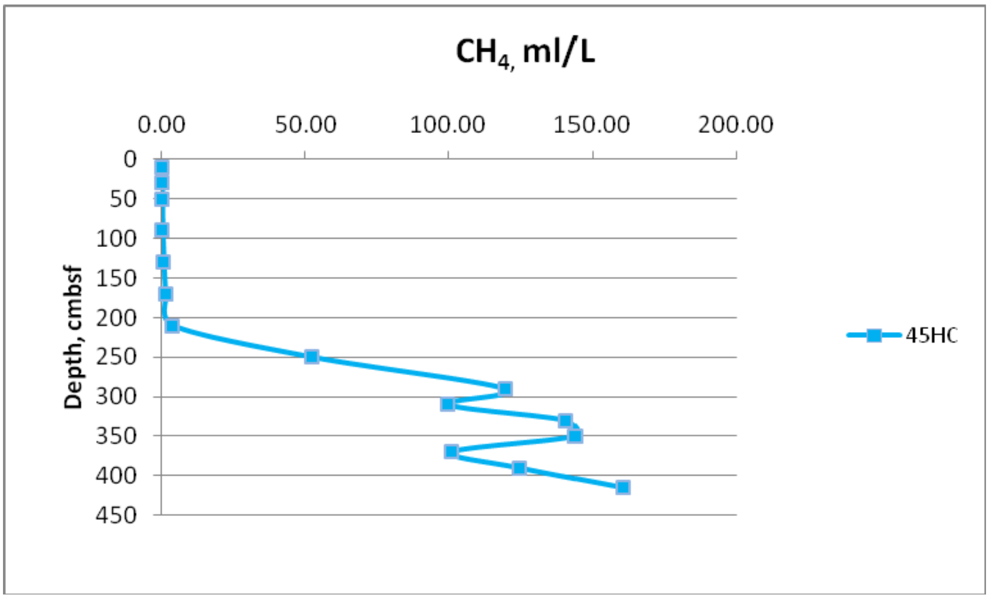
Core description: lv59-42HC				Lat: 48º13.986’ Long: 141º22.873’	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
10	0.04	1816	2744	0.9	2.51
30	0.16	7115	2665	1.3	0.88
50	0.25	11187	1509	1.0	0.81
70	0.67	29876	2038	2.5	0.93
90	1.85	82777	1871	10.2	1.02
130	28.59	1276475	822	75.6	4.33
150	83.28	3717670	137	87.7	4.97
170	91.97	4105848	432	90.7	5.19
190	81.16	3623260	255	80.9	5.89
210	62.10	2772329	444	73.3	5.89
230	60.06	2681154	411	70.4	6.75
270	52.04	2323266	299	68.1	9.81
310	54.64	2439315	578	65.7	9.33
350	56.11	2504744	772	66.8	9.62
390	67.54	3015127	539	82.1	10.89
4	0.09	4018	2696	0.7	2.39



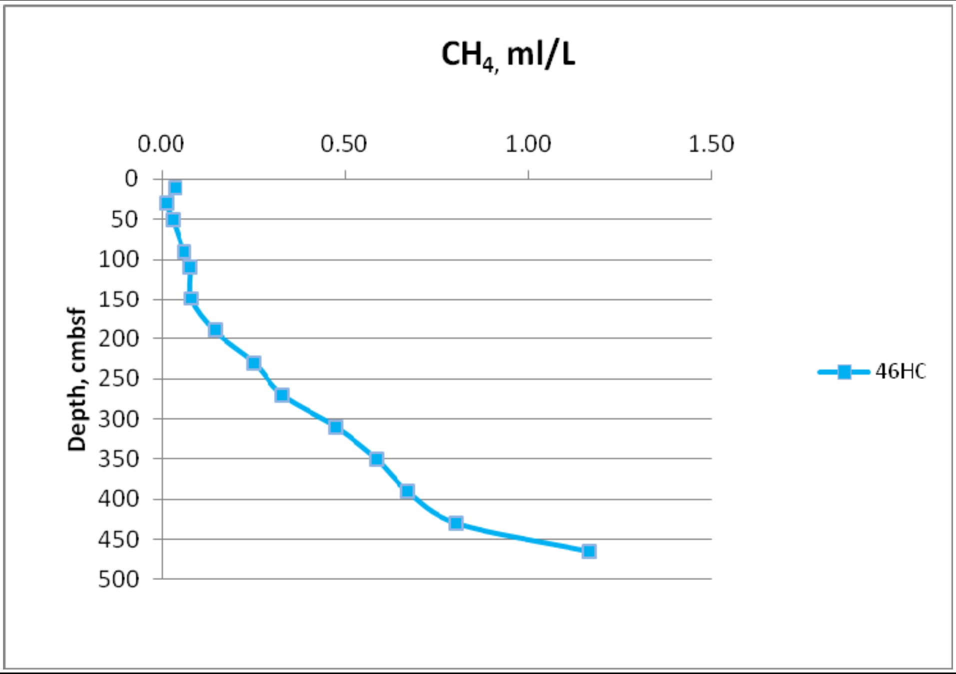
Core description: lv59-43HC					Lat: 48°13.947’ Long: 141°23.009’
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
10	0.21	9390	2675	1.3	1.72
30	1.46	65190	1779	17.2	1.54
60	8.56	382327	1747	72.6	2.87
90	20.78	927791	1631	121.4	3.45
130	82.14	3666999	0	220.2	5.24
170	98.41	4393149	0	295.4	5.09
190	120.68	5387336	0	334.4	4.27
230	105.67	4717388	0	332.5	4.93
270	96.75	4319114	0	324.9	5.40
310	117.07	5226230	0	359.7	7.16
350	77.66	3467135	0	318.9	8.96
10	0.01	596	2725	0.5	2.40



Core description: lv59-45HC				Lat: 48º14.978’ Long: 141º23.812’	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
30	0.03	1314	2128	0.5	0.23
50	0.06	2569	1874	0.4	1.35
90	0.21	9341	1779	1.1	1.11
130	0.60	26826	1401	3.2	1.59
170	1.29	57706	2095	9.0	2.48
210	3.71	165541	1557	22.8	4.44
250	52.49	2343263	654	62.2	4.65
290	119.61	5339732	493	113.7	4.40
310	99.68	4449874	131	101.7	3.91
330	140.59	6276369	146	130.4	4.03
350	143.71	6415769	0	139.0	3.62
370	100.95	4506671	0	114.5	3.37
390	124.47	5556838	0	127.9	4.03
415	160.47	7164017	0	154.4	4.73



Core description: lv59-46HC				Lat: 46º53.462’ Long: 139º22.082’	
Depth, cm	CH_4, ml/L	CH_4, nM/L	C_2H_4, nl/L	C_2H_6, ul/L	CO_2, ml/L
10	0.04	1598	2595	0.4	3.72
30	0.01	610	2261	0.8	2.18
50	0.03	1325	2383	1.2	1.01
90	0.06	2649	890	0.6	0.54
110	0.08	3450	763	1.0	0.45
150	0.08	3600	934	1.1	0.50
190	0.14	6403	763	3.2	0.72
230	0.25	11211	1302	4.8	0.91
270	0.33	14671	1367	6.7	1.16
310	0.47	21202	1094	12.4	0.97
350	0.58	26097	931	16.3	1.14
390	0.67	29885	1262	22.3	1.00
430	0.80	35890	796	26.9	1.80
465	1.16	51985	751	48.3	2.02



4.3.2. Gas Analysis (KIT)

A. Hachikubo, T. Kotake

In the LV-59 cruise we got dissolved gas in pore water, hydrate-bound gas, gas hydrate crystals and carbonates as shown in Table 4.2. The research target is to estimate gas origin and to check isotopic fractionation between hydrate-bound and dissolved gases using molecular and isotopic compositions of hydrocarbons (from C_1 to C_3), CO_2 and H_2S. Gas hydrate crystals provide information of cage occupancy and hydration number by a Raman spectroscopic analysis, and their thermal properties are obtained by a calorimetry. A carbon isotope ratio of authigenic carbonates relates with that of methane ascending from the deep layer of sediment.

Sampling methods are described by Jin *et al.* (2010) and Hachikubo *et al.* (2010; 2011a). Hydrate-bound gases were collected using a funnel and plastic bucket filled with water. Gas hydrate samples were dissociated in water and their gases were stored in 5-mL vials sealed with butyl septum stoppers. In this cruise, we obtained two hydrate samples (LV59-05HC and LV59-27HC) from the Terpeniya Ridge and the Tatarsky Strait, respectively. However, these crystals were small (about 5mm in size) and their quality was not good. The dissolved gases in the pore water were extracted by a headspace gas method whereby 10-mL of sediment and a 10-mL saturated aqueous solution of NaCl were introduced into a 25-mL vial to create headspace. A 0.3-mL preservative (benzalkonium chloride (Waseda and Iwano, 2007), 50 wt% aqueous solution) was introduced into the 25-mL vial. The headspace was flushed by helium and the vials were then thoroughly shaken and stored overturned. Gas hydrate crystals were stored in a dryshipper at the temperature of liquid nitrogen. Carbonate nodules were sampled in plastic bags.

Gas composition of hydrocarbons (from C_1 to C_3), CO_2 and H_2S were measured in KIT using a gas chromatograph (GC-14B, Shimadzu Corp.) equipped with thermal conductivity and flame ionization detectors coupled with a packed column (Sunpak-S, Shimadzu Corp.). The thermal conductivity detector (TCD) is to measure air components (N_2, O_2 and Ar: they are not separated), CO_2, H_2S and high concentration of C_1. The flame ionization detector (FID) is to measure minor (low concentration) hydrocarbons because of its high sensitivity for $C_{2\text{-}3}$. Carbon and hydrogen isotopes of hydrocarbons were measured using a CF-IRMS (DELTA plus XP, Thermo Finnigan) employing a Carboxen-1006 PLOT capillary column (30 m × 0.32 mm I.D., Supelco). To avoid air contamination in low concentration cases of C_1, a Carboxen-1010 PLOT capillary column (30 m × 0.32 mm I.D., Supelco) were also used. The lower limit of determination in the case of C_1 $\delta^{13}C$ is 0.02% in the headspace gas. A backflush system of GC coupled with CF-IRMS enables us to resolve low concentrations of C_2 and C_3 (less than 0.1%) from C_1 and measure their isotopic composition.

The quality of gas hydrate pieces was enough for Raman spectroscopy. The Raman spectra of them (LV59-05HC and LV59-27HC) showed typical C_1-rich hydrates, and small peaks at 2595 cm^{-1} indicated that small amount of H_2S were encaged in the crystals. Their crystallographic structure belonged to the cubic structure I. Microbial gas was dominant in the region of Terpeniya Ridge, but the data of C_2 $\delta^{13}C$ suggested that small amount of thermogenic gas mixed. On the contrary, thermogenic gas was found in the area of Tatarsky Strait, around the site of LV59-27HC (GH core) and LV59-29HC (about 2 km north from the 27HC). These gases are depleted in C_2 and C_3, same as the case of off Joetsu, eastern margin of Japan Sea/East Sea (Hachikubo *et al.*, 2011b; 2012).

References

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Table 4.2. Sample list for gas analyses in the LV-59 cruise.

Date	Core	Place	Hydrate-bound gas	Dissolved gas in pore water		Hydrate	Carbonate for isotope δ13C of CO2
			5mL vial	25mL vial	for check 25mL vial / 5mL vial	20mL plastic bottle	plastic bag
2012/8/10							
2012/8/11	LV59-01HC	TR F3		13			
2012/8/12	LV59-03HC	TR F2		16			
2012/8/12	LV59-05HC	TR F2	1	17		1	
2012/8/12	LV59-07HC	TR F5		10			
2012/8/13	LV59-09HC	TR F3		13			
2012/8/13	LV59-11HC	TR F8		12			
2012/8/14	LV59-13HC	TR F2		12			
2012/8/14	LV59-15HC	TR F2		12			3
2012/8/16	LV59-17HC	Tatarsky		24			
2012/8/16	LV59-19HC	Tatarsky		13			
2012/8/17	LV59-21HC	Tatarsky		10	1		
2012/8/17	LV59-23HC	Tatarsky		8			
2012/8/18	LV59-25HC	Tatarsky		10			
2012/8/18	LV59-27HC	Tatarsky	1	9		4	
2012/8/19	LV59-29HC	Tatarsky		8	*1*		
2012/8/19	LV59-31HC	Tatarsky		7	*1*		
2012/8/20	LV59-33HC	Tatarsky		9			
2012/8/20	LV59-35HC	Tatarsky		9	1		
2012/8/20	LV59-34HC	Tatarsky		8			
2012/8/21	LV59-36HC	Tatarsky		7	*1*		
2012/8/21	LV59-38HC	Tatarsky		8	*1*		
2012/8/22	LV59-40HC	Tatarsky		9	*1*		
2012/8/22	LV59-42HC	Tatarsky		9	*1*		
2012/8/23	LV59-43HC	Tatarsky		7			
2012/8/23	LV59-45HC	Tatarsky		8			
2012/8/24	LV59-46HC	Tatarsky 4-2		10	1		
	total		**2**	**278**	**9**	**5**	**3**

4.3.3. Pore Water Analysis (KIT)

H. Minami, Y. Kawagishi, K. Kubo, T. Kotake

Pore water sampling

The pore water was sampled on board from 26 cores (Table 4.3) using two squeezers designed and constructed at the Kitami Institute of Technology (KIT). A 10-cm depth interval of each sediment core (normally every 10 or 20 cm) was taken into a zippered plastic bag and was kept in a refrigerator in the R/V until squeezing process was started (not more than half day). The sediment sample in the zippered plastic bag was drawn into the squeezer, and pore water was then directly collected into a polyethylene syringe connected to the discharge tube of the squeezer. The other end of the syringe was connected to a membrane filter cartridge containing a polytetrafluoroethylene (PTFE) 0.2-μm membrane filter. The pore water samples were filtrated by passing through the membrane filter and were collected into polypropylene bottles. The pore water samples were kept under chilled temperature (refrigerator in the R/V) during the cruise. All water samples were stored in polypropylene bottles at 2 °C (refrigerator in the R/V) during the cruise.

Water samples to be measured

The water samples obtained during in this cruise are 731 samples including (i) pore water samples, and (ii) bottom seawater samples.

Bottom seawater samples were obtained from the top of the corer and CTD water sampler. All water samples were filtered through 0.2-μm filters, and then stored in polypropylene bottles at 2 °C (refrigerator in the R/V) during the cruise.

Chemical and isotopic analyses of pore water

The determination of the concentrations of sulfate ion, chloride ion, hydrogen carbonate ion, calcium, potassium, sodium and magnesium in the pore- and seawater samples will be carried out at Kitami Institute of Technology, Japan. The concentrations of anions will be determined by ion chromatography. The concentrations of sodium and magnesium will be determined by inductively coupled plasma atomic emission spectrometry. The concentrations of potassium and calcium will be determined by flame atomic absorption spectrometry.

Stable isotope ratios of oxygen and hydrogen of the pore water and seawater samples will be analyzed by mass spectrometry. The results of the isotopic measurements of the water samples will be presented in per-mil delta notations ($\delta^{18}O$ and δD) relatively to Vienna Standard Mean Ocean Water (VSMOW) and Standard Light Antarctic Precipitation (SLAP) issued from International Atomic Energy Agency (IAEA).

The pH values of the water samples described above were measured on board using a pH meter just after obtaining the water samples.

Table 4.3. List of SSGH 12 pore water samples.

Core name	Sampling interval (cm)	Number of samples
LV59-01HC	10, 20, 40	15
LV59-03HC	10, 20	20
LV59-05HC	10, 20	23
LV59-07HC	10, 20, 30	20
LV59-09HC	10, 20, 30	22
LV59-11HC	10, 20, 30	25
LV59-13HC	10, 20, 30	25
LV59-15HC	10, 20	28
LV59-17HC	10, 20, 30	26
LV59-19HC	10, 20, 30	29
LV59-21HC	10, 20	27
LV59-23HC	10, 20	28
LV59-25HC	10, 20	27
LV59-27HC	10, 20	31
LV59-29HC	10, 20	29
LV59-31HC	10, 20	24
LV59-33HC	10, 20	29
LV59-34HC	10, 20	26
LV59-35HC	10, 20	30
LV59-36HC	10, 20	22
LV59-38HC	10, 20	33
LV59-40HC	10, 20	26
LV59-42HC	10, 20	31
LV59-43HC	10	33
LV59-45HC	10	38
LV59-46HC	20	21

4.3.4. Sediment Analysis (KIT)

R. Miura, S. Yamashita

In order to examine the soil properties of sea-bottom sediments and to evaluate the effect of the vaporization of dissolved gas in the pore water on the strength properties, two kinds of on-board tests were performed for the samples retrieved by a hydro corer. Additionally, the concentrations of dissolved gas in the pore water will be measured.

On-board Tests

To measure the strength of sediments immediately after recovery, the following two kinds of tests were performed onboard.

a) Vane shear test

The test was conducted by using shear vanes of 10 mm in diameter, D, and 20 mm in height, H, attached to a compact torque driver. The vane shear test was conducted at 20 to 40 cm intervals on the longitudinally cut core surface (see Fig. 4.3). The maximum torque, M, is measured by rotating the torque driver while penetrating the vane in the core. The vane shear strength, τ_v, is calculated from the following equation.

$$\tau_v = \frac{M}{\pi(\frac{D^2 H}{2} + \frac{D^3}{6})}$$

b) Cone penetration test

The device used is a force gage type compact cone penetration meter (see Fig. 4.4). The diameter, length, and apex angle of the cone are 9 mm, 18 mm, and 30 degrees. As for the vane shear test, the cone meter was applied to the longitudinally cut core surface at 20 to 40 cm intervals to measure the penetration load, p. The cone penetration resistance, q_c, is obtained using the following equation.

$$q_c = \frac{p}{A} \qquad \text{(A: the sectional area of the cone)}$$

Sub-sampling

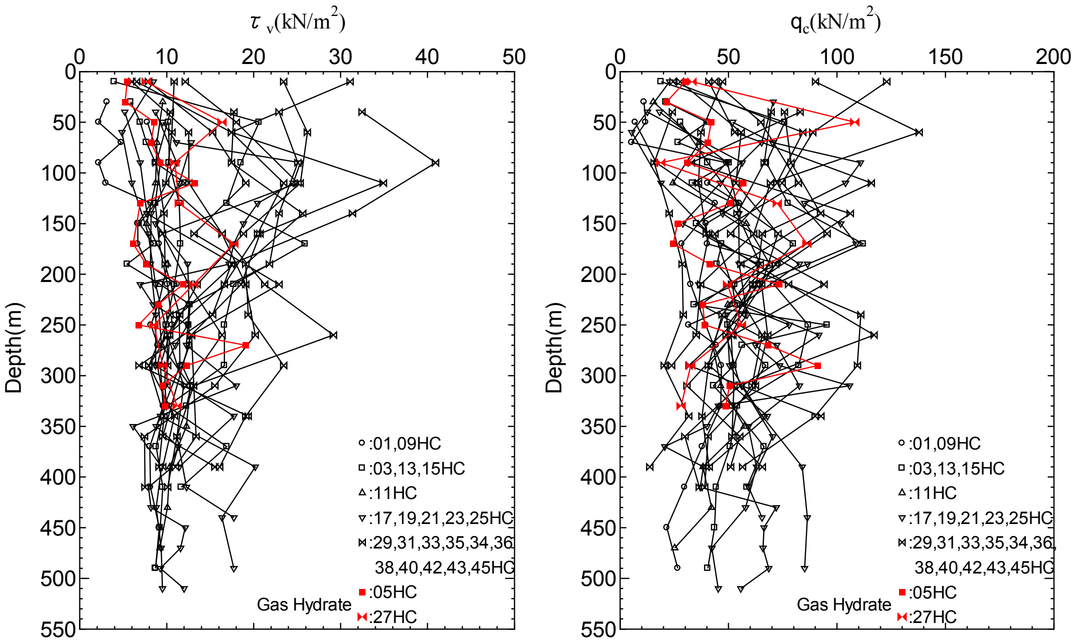
For measurement of the water content, 20 to 40 cm interval samples (total 275) were taken. About 5 mL sediment was sampled from the sediment core using a syringe (5 mL size) and put into a 20 mL vial bottle.

Fig. 4.3. Vane shear test

Fig. 4.4. Cone penetration test

Test results

The Fig. 4.5 shows the typical vane and cone penetration test results.



(a) (b)

Fig. 4.5. Typical onboard test results; (a) vane shear test, (b) cone penetration test

4.3.5. Sediment Analysis (POI)

A. Derkachev, N. Nikolaeva

Method

One type of corers is employed for sediment sampling. It is hydrocorer (HC) with diameter of 138 mm. Its length is 575 cm. To rapidly extract sediment column from the corer, special flexible plastic 2-sectional liners with diameter of 125 mm are used (Fig. 4.6).

After retrieval of a hydrocorer on the deck, liners with sediments are moved in the laboratory, and sediment column is split on two parts for subsequent operational processing. Time interval from the retrieval of corer on the deck to the split of sediment in laboratory is about 10-15 minutes. Following sedimentological study of the sediment is conducted with the use of standard scheme including description of structure, texture, color, density, inclusions (concretions, shells, dropstone), as well as gas-hydrates and character of contacts between layers. Smear slides are prepared for microscopic investigations with the aim of preliminary determination of sediment components.

Fig. 4.6. Hydrocorer.

Sedimentological features of study areas

Investigation of sedimentary section was carried out within two areas: on the western slope of the Kurile basin (on the boundary with the Terpeniya Bay, Okhotsk Sea) and in the Tatarsky Strait (Japan Sea/East Sea). 26 sediment cores of length from 3 to 5.5 m were taken in total (see Station list): 8 cores in the former area and 18 cores in the latter area. Gas hydrates were found in two cores.

Terpeniya Bay

This area is located on the western slope of Kuril Basin close to Terpeniya Cape (Fig. 4.7). The main objective of sediment sampling in this area was in search of gas hydrates among sites where either gas flares, carbonate concretions and/or gas-saturated sediments were found in the previous expeditions. 8 sediment cores by length from 304 to 536 cm were taken here in total; one of them (LV59-05HC) recovered gas hydrates in the form of small lenses.

Sedimentary section recovered in this area is typical for the Okhotsk Sea, and it is represented by silty clay of greenish-gray or grayish-green colour with characteristic lenticular-spotted texture due to both the lenses and spots of hydrotroilite and bioturbation. Sediment cores taken at sites with gas emanations may contain carbonate concretions and Calyptogena shells within sediments.

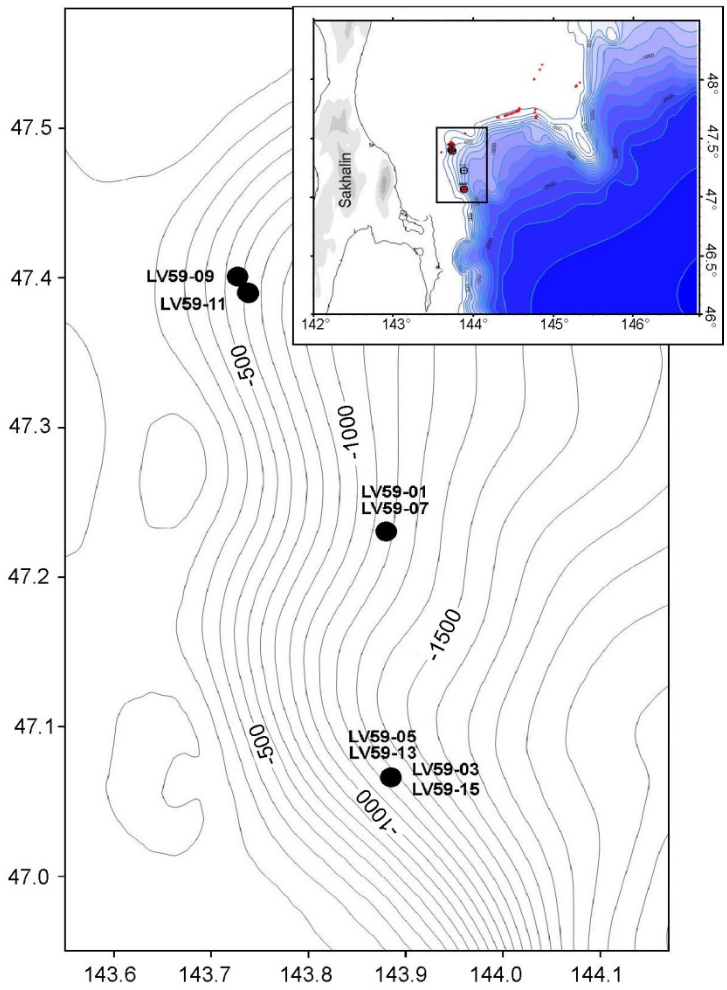


Fig. 4.7. The location of sediment stations in the Terpeniya Bay.

Three sediment cores of unusual composition were raised in this area (LV59-01HC, LV59-09HC and LV59-11HC). The sediments are presented of dark almost black silty clay (enriched with hydrotroilite) without H_2S odor. On our opinion, the sulfur as a part of hydrogen sulfide was adopted on the formation of hydrotroilite during the geochemical processes of diagenesis; that is why hydrogen sulfide odor is absent.

Tatarsky Strait

Based on results of hydroacoustic and geophysical surveys done prior to the sampling, sampling sites were chosen as locations where gas flares were discovered (Fig. 4.8). 18 sediment cores of length from 308 to 550 cm were taken in total. Most of recovered cores were within the area of gas emanations, countered by the results of hydroacoustic survey on the western slope of the Sakhalin Island.

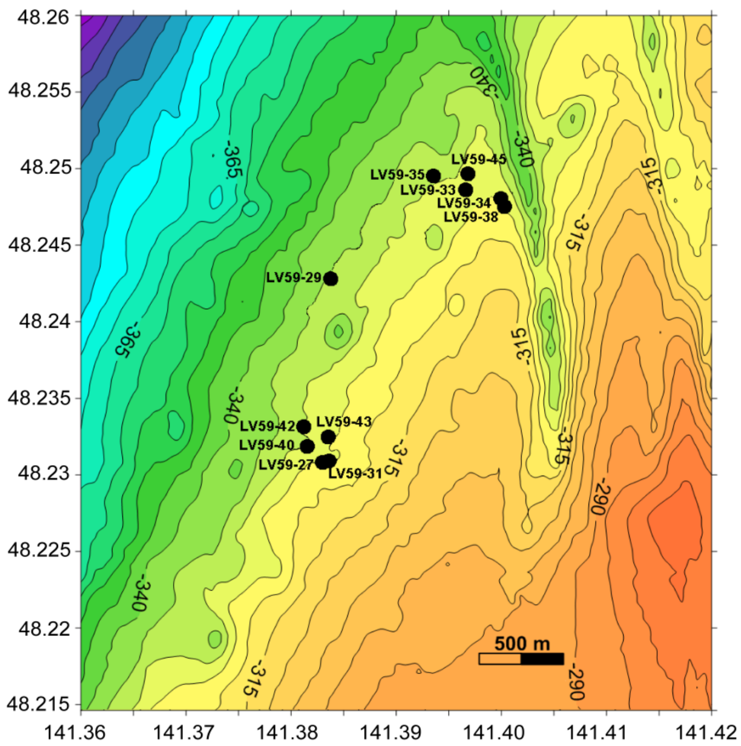


Fig. 4.8. The location of sediment stations in the Tatarsky Strait.

Practically all sediment cores contain a large amount of carbonate concretions. They are also strongly gas-saturated (particularly in the lower parts) and are broken by the numerous cracks oriented in the various directions (in some cores - sub-horizontal). Swelling and crackling due to bursts of gas bubbles are sometimes observed (Fig. 4.9).

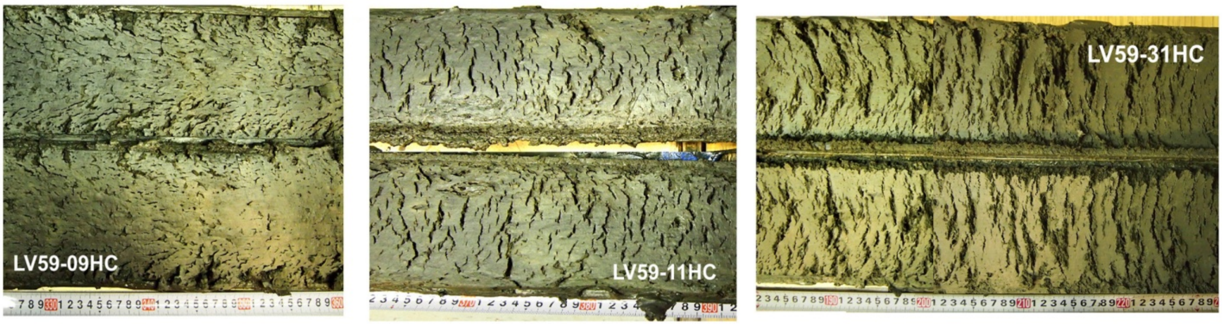


Fig. 4.9. Types of gas-saturated sediments.

The cores taken outside of this area may play role of reference sections without any signs of presence of gas emanations.

Carbonate precipitates

Two types of carbonate precipitates were found in the sediments of the study areas: methane-related and diagenetic. The former was formed at the expense of carbon from microbial methane (they were found in most of cores) and the latter as a result of organic matter decomposition (they were discovered only at stations LV59-15HC, LV59-38HC).

Methane-derived carbonate precipitates have different size, shape and density varying from small soft spots and lenses up to large dense concretions and crusts. The few types of them were found within study areas (Fig. 4.10):

1) soft (or crumbly) light green precipitates representing the initial stage of carbonate formation
2) dense rough concretions with numerous small acute or smoothed cusps, concretions of irregular or angular shape - all of them have complicated structure: hard nuclear and brittle crumbling outer part of light green colour consisting of sediment pierced by carbonate; some concretions contain inclusions of small shells and their fragments as well gravel
3) concretions of oval and round shape
4) flat carbonate crusts; often they grow on the pebble or mollusk shells.

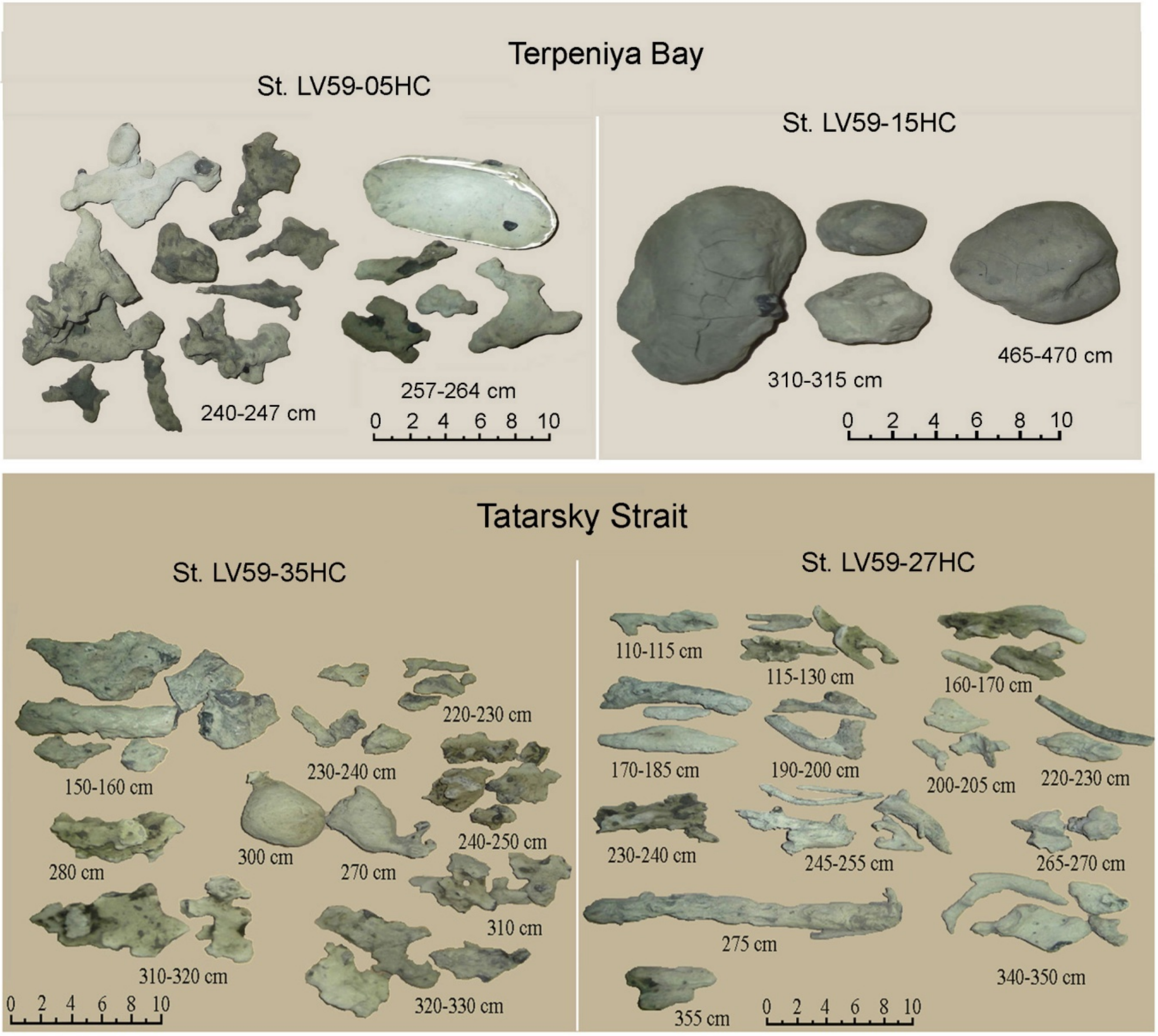


Fig. 4.10. Types of carbonate precipitates.

Results

A number of lithological-mineralogical signs indicating the manifestations of methane emanations on a sea bottom were revealed earlier within northeast slope of the Sakhalin Island (Derkachev, Nikolaeva, 2007; Derkachev, Nikolaeva, 2009; Minami et al., 2012; Nikolaeva et al., 2009; Nikolaeva et al., 2010). The results of sedimentological researches carried out in Criuse_59 showed that the same signs are surely observed at other areas in the Sakhalin Island, and particularly in the Terpeniya Bay and on a northwest slope of the Sakhalin Island, the Japan Sea/East Sea. It may support that geochemical and sedimentary processes at all Sakhalin slope are similar and related to methane emanations from the sediments into the water column. Typical sedimentary cores for this region were recovered: clayey with admixture of diatoms (~5-10 %), clayey homogeneous, clayey with signs of the insignificant content of gas and clayey gas-saturated with a pseudobrecciated structure. Besides, unusual sediments, representing strongly reduced sedimentary environment, were recovered closed to methane emanations at the seafloor in the Sakhalin Island slope of the Terpeniya Bay (St. LV59-01HC, LV59-09HC, LV59-11HC). Here, slice of reduced hydrotroilitic black and dark-gray sediments with thickness more than 500 cm lies directly at the seafloor, and it contains carbonate concretions.

Textural sediment signs are important because they are indicators of existence of the flux centers for methane emanations on the seafloor. First of all, it is pseudobrecciated gas-saturated texture. The upper boundary of its distribution strongly varies from 5 to 230 cm in the Terpeniya Bay and from 90 to 310 cm in the Tatarsky Strait (see Appendix) that depends, possibly, on intensity of gas flows. As a rule, carbonate concretions of different morphological shapes occur with variable quantity in these gas-saturated sediments. In rare cases (St. LV53-03HC, LV59-35HC, LV59-29HC, L59-43HC), small carbonate concretions (usually they represent an initial stage of formation) occur outside of gas-saturated sediment slice.

The estimation of Holocene-Late Pleistocene boundary was difficult, particularly within Tatarsky Strait, because of small amount of diatoms which is an indicator of the boundary. That is why the boundary was determined only for cores from Terpeniya Bay (see Appendix).

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4.3.6. Paleoceanological Analysis (KOPRI)

Y. K. Jin, B.-J. Cho

It is well known that the sedimentation rates on the Sakhalin slope are remarkably high (Cruise Report, 1999, 2003; Gorbarenko et al., 2002), which allows us to get high resolution records of the climate, surface water conditions, sea-ice cover and varying productivity. To investigate the influence of Amur River on the paleoceanography and sedimentation in the Tartarsky strait during the Late Pleistocene – Holocene, Core LV59-46HC was taken at the western slope of the strait (53° 30.958'N 144°23.022'E) at 628 m in water depth (Table 4.4 and Fig. 4.11) in the selected site (smooth bed, no flare, no gas chimney). We used hydro-corer (HC) with the diameter of 138 cm and the length 550 cm for coring. The recovery length of sediments is 475 cm. No H_2S odor, no carbonate concretion and no shell fragments are observed. A core depth of 90 cm is expected to be the Holocene-Pleistocene boundary. Drop-stones occurred below a core depth of 410 cm.

Sampling procedure is as followings:

1. Sediment recovery was performed with hydro-corer (HC): Maximum length of 550 cm with the diameter of 138 cm
2. Sediment core was splitted. One half was used for description, geochemical analysis (gas and pore water), the other half was sampled for paleoceanlogical analysis
3. Sediments in the half core were sliced by 1 cm-interval using spatula
4. Each 1 cm-thick sediment slice was sampled and stored in a sealable vinyl bag
5. All vinyl bags were packed in plastic boxes for shipping to KOPRI.

Sampling was done by Young Keun Jin and Beom-Jun Cho onboard during the expedition. Actual analysis will be conducted at KOPRI after delivery.

Sedimentological description of LV59-46HC made by A.Derkachev and N. Nikolaeva is as followings;

<u>0-10 cm</u> – grayish olive-green sediment representing mixture of sand, silt and clay, soft.

<u>10-70 cm</u> – grayish olive-green clayey silt with admixture of sandy particles, soft (consolidated at the bottom); at 20 cm – dropstone.

<u>70-240 cm</u> – gray clayey silt with weak greenish hue, dense; here and there sparse small spots of hydrotroilite occur with traces of bioturbation.

<u>240-410 cm</u> – greenish-gray sediment consisting of sand, silt and clay, dense, homogeneous.

<u>410- 475 cm</u> – greenish-gray clayey silt with admixture of sand, dense, homogeneous; at 410, 418, 430 cm – dropstone.

Table 4.4. Information on Core LV59-46HC for paleoceanological analysis.

Coring No.	Location (Lat. / Lon.)	Water Depth (m)	Date (LT)	Recovery Length (cm)	Sampled range (cmbsf*)
LV59-46HC	46° 53.462´ N 139° 22.082´ E	628	Aug. 24 11:18	475	3-475

* cm below the seafloor when assuming that the top of a core is coincident with the seafloor

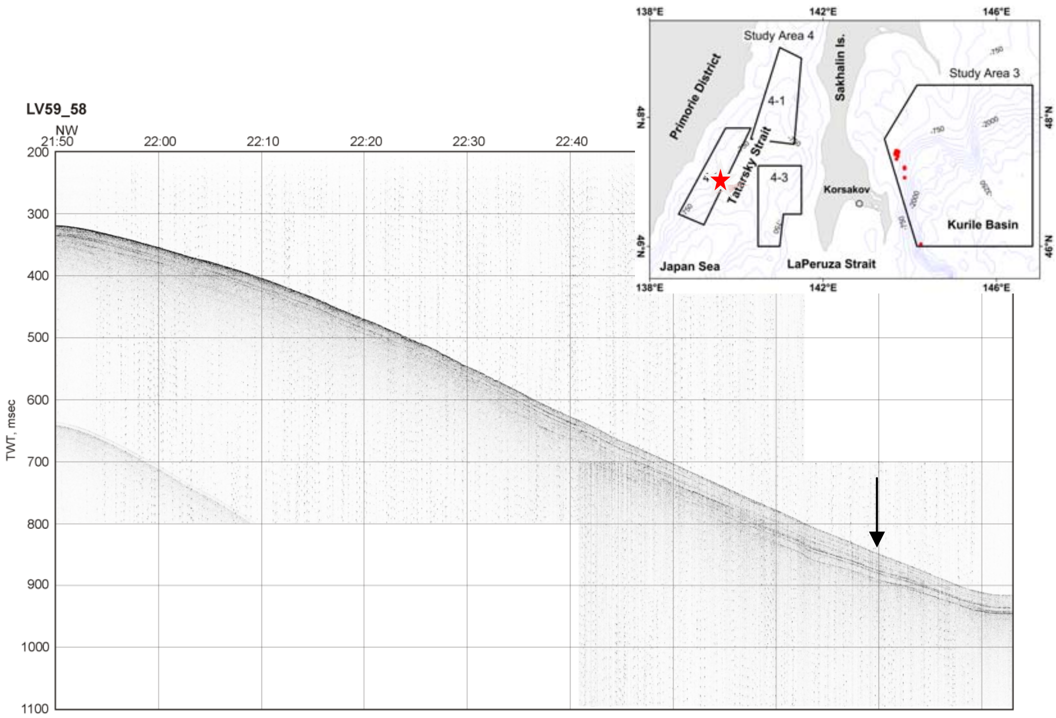


Fig. 4.11. Seismic profile LV59_58 and the location of LV59-46HC (a black arrow in the profile and a red star in the inset) obtained in SSGH-12 cruise for paleoceanological analysis.

4.4. CTD operation and analysis

4.4.1. Hydrological Researches

A. Karnaukhov, V. Ponomarev

Equipments and technique of observations

Oceanological observations during 59-th Cruise of R/V "Academic M.A. Lavrentyev" were carried out with the use of CTD probe "SBE 9plus" (Fig. 4.12). Water sampling was conducted with the help of 12-positional Rosette by plastic bathometers "Niskin" with the volume of 5 liters on 12 set horizons (Fig. 4.13). Sampling was done depending on concrete conditions and depth of a site. All observations ran to the seafloor. The special attention was given to investigation of near-bottom structures of water masses in areas of intensive methane emanations.

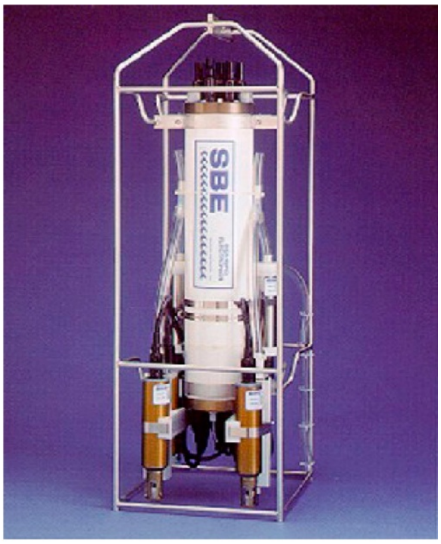


Fig. 4.12. CTD probe "SBE 9plus".

Fig. 4.13. CTD probe in the complete set with Rosette.

The main difference of Sea Bird Electronics profilograf is that the main sensors are positioned in the other chamber separated from one with a compulsory water pump capable of pumping with constant speed. In this case, on the device two chambers are established. Such configuration excludes "sticking" of a capillary film so that stability of sensors is increased and casual noise is cleaned. Below the main characteristics of sensors are provided in the Table 4.5.

Table 4.5. Specification of CTD used in the SSGH-12 expedition.

	Temperature (°C)	Conductivity (S/m)	Pressure	A/D Inputs
Measurement Range	-5 to +35	0 to 7	0 to full scale range (in meters of deployment depth capability): 1400 / 2000 / 4200 / 6800 / 10500 meters	0 to +5 volts
Initial Accuracy	0.001	0.0003	0.015% of full scale range	0.005 volts
Typical Stability	0.0002/month	0.0003/month	0.018% of full scale range/year	0.001 volts/month
Resolution at 24 Hz	0.0002	0.00004	0.001% of full scale range	0.0012 volts
Sensor Calibration (measurement outside these ranges may be at slightly reduced accuracy due to extrapolation errors)	-1.4 to +32.5	2.6 to 6 S/m, plus zero conductivity (air)	Paroscientific calibration, plus Sea-Bird temperature correction	-
Time Response (single pole approximation including sensor and acquisition system contributions)	0.065 seconds	0.065 seconds	0.015 seconds	5.5 Hz 2-pole Butterworth Low Pass Filter
Master Clock Error Contribution (Based on 5-year worst-case error budget, including ambient temperature influence of 1 ppm total over -20 to +70 °C plus 1 ppm first year drift plus 4 additional year's drift at 0.3 ppm/year)	0.00016 °C	0.00005 S/m	0.3 dbar with 6800 m (10,000 psia) pressure sensor	-
Auxiliary Voltage Sensors	Power available for auxiliary sensors: 1 amp at +14.3 volts			
Seacable Inner Conductor Resistance	350 ohms or less			
Main Housing Material	Up to 6800 meter (22,300 ft) - aluminum Up to 10500 meter (34,400 ft) - titanium			
Weight (including all standard sensors and cage)	With aluminum main housing - *In air* 25 kg (55 lbs) *In water* 16 kg (35 lbs) With titanium main housing - *In air* 29 kg (65 lbs) *In water* 20 kg (45 lbs)			

Preliminary results of researches

21 hydrological stations were fulfilled during expedition. Profiles of distribution for temperature, salinity, dissolved oxygen, turbidity and fluorescence of sea water from a surface to the bottom are obtained. Seven stations were chosen on a slope in the southern sector of the Terpeniya Bay, the others in the Tatarsky Strait, the Sea of Japan/East Sea (Fig. 4.14).

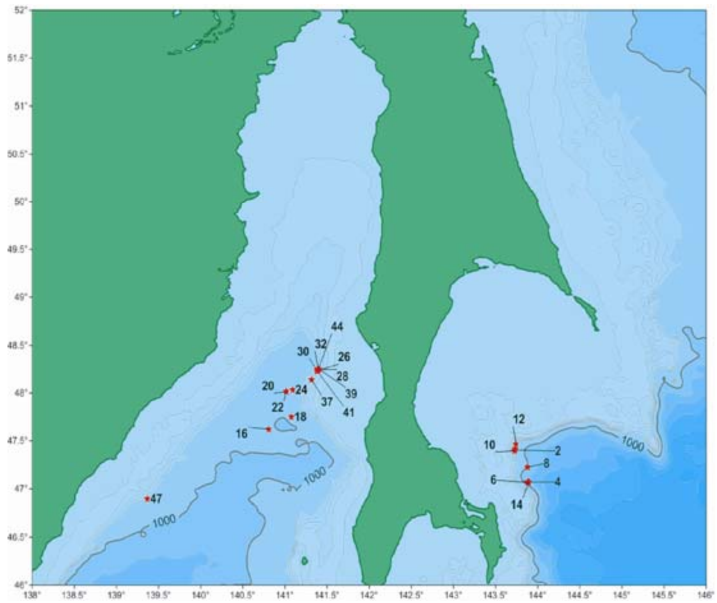


Fig. 4.14. Scheme of location for hydrological stations.

Characteristic feature of a vertical profile for temperature at the stations observed in the Terpeniya Bay is an existence of a cold intermediate layer - the main indicator of Subarctic structure of waters in the northern Pacific Ocean and the adjacent seas (Fig. 4.15a). In the Sea of Okhotsk characteristics of this layer vary largely both on a depth, and by quantity of extrema in it. All these support considerable dynamic activity on the intermediate horizons of the sea. Stratification of water vertical structure is well noted at station LV59-12CTD by a turbidity profile.

The second area of researches was located in the Tatarsky Strait of the Sea of Japan/East Sea, 14 CTD stations were executed here. Although this water area belongs to the Subarctic water structure as in the Sea of Okhotsk, the cold intermediate layer is less developed (Fig. 4.15b). The core of cold intermediate layer has temperature (+1°C) higher than in the Sea of Okhotsk (-1°C). This layer occupies, apparently, only northern part of Tatarsky Strait.

As for other characteristics, they qualitatively don't differ in studied areas: 1) salinity monotonously decreases with depth, 2) the layer of jump coincides with a seasonal thermocline, and 3) maximum values of fluorescence and oxygen occur at similar depths, that is, below a layer showing jump of temperature and salinity. The maximum values of fluorescence are observed at LV59-30CTD and LV59-44CTD stations in the Tatarsky Strait (Fig. 4.16).

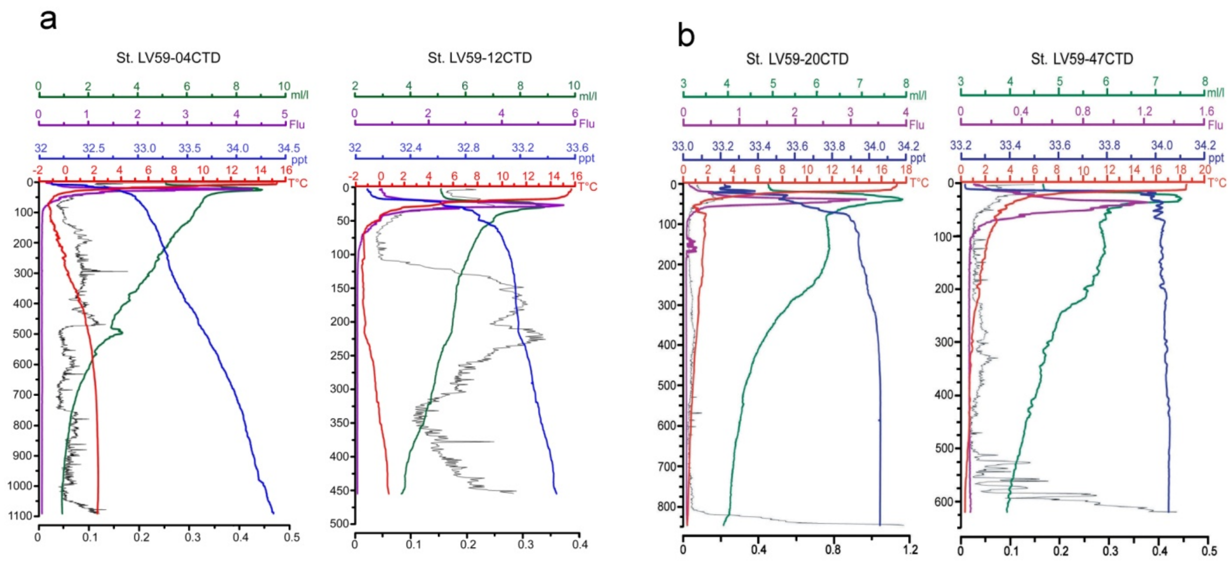


Fig. 4.15. Vertical profiles of the temperature (red), salinity (dark blue), dissolved oxygen (green), fluorescence (violet) and turbidity (black) in the Terpeniya Bay (a) and in the Tatarsky Strait (b).

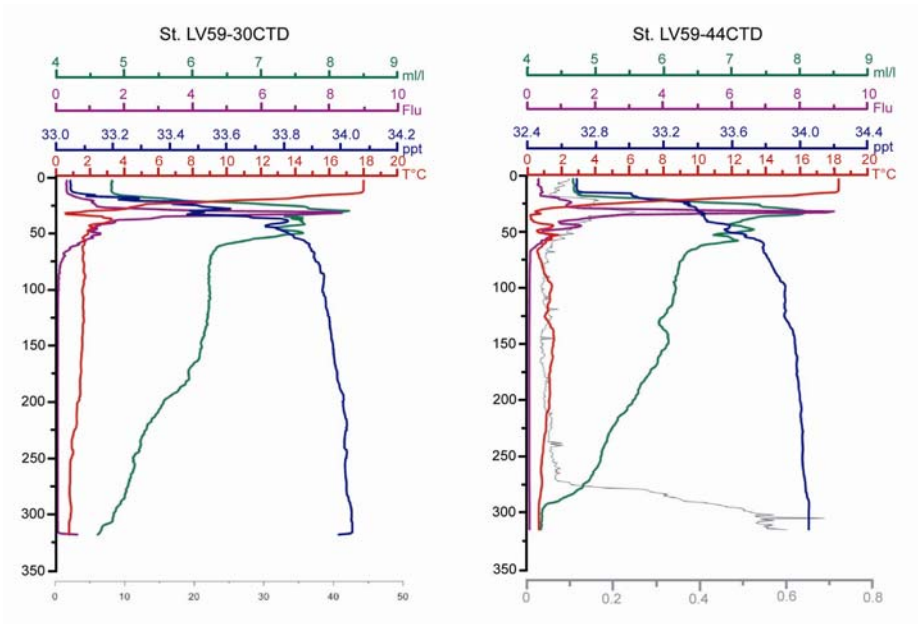


Fig. 4.16. CTD stations with the maximum values of fluorescence.

Near-bottom CTD measurements

Sounding was made at LV59-02CTD station in the Sea of Okhotsk to the horizon of 744.8 m, above by 20 cm from the seafloor on altimeter data. Values of temperature and salinity on this horizon are 2.19°C and 29.11 ppt, respectively. Lower weakly-indignant near-bottom layer with thickness of about 50 cm is allocated on profiles of T° and S at the bottom of an interface by thickness of 1 m. Through the interface, such values change from 29.11 to 29.39 ppt in salinity, and by an order of 10^{-3} in temperature (Fig. 4.17).

Oscillations of salinity and temperature, up to 34.02 ppt and 2.19°C, respectively, are observed in the overlying indignant turbulent layer with thickness of 50 cm. Values of temperature and salinity reach 2.17°C and 34.02 ppt on the horizon above by 1 meter shallower than the seafloor.

Essential decrease of salinity in a thin near-bottom layer is probably caused by inflow of pore waters from the surface sediment layer. The density of pore sediment waters is less than that of surrounding sea water, and the pore water can result in hydrodynamic instability of a near-bottom interface leading to convection. The salinity and temperature pulsations, which occur above the weakly-indignant near-bottom intermediate layer and adjacent to the surface sediment border as well, are characteristic of turbulent convective layer. The turbulent layer becomes steadily stratified at near-bottom interface.

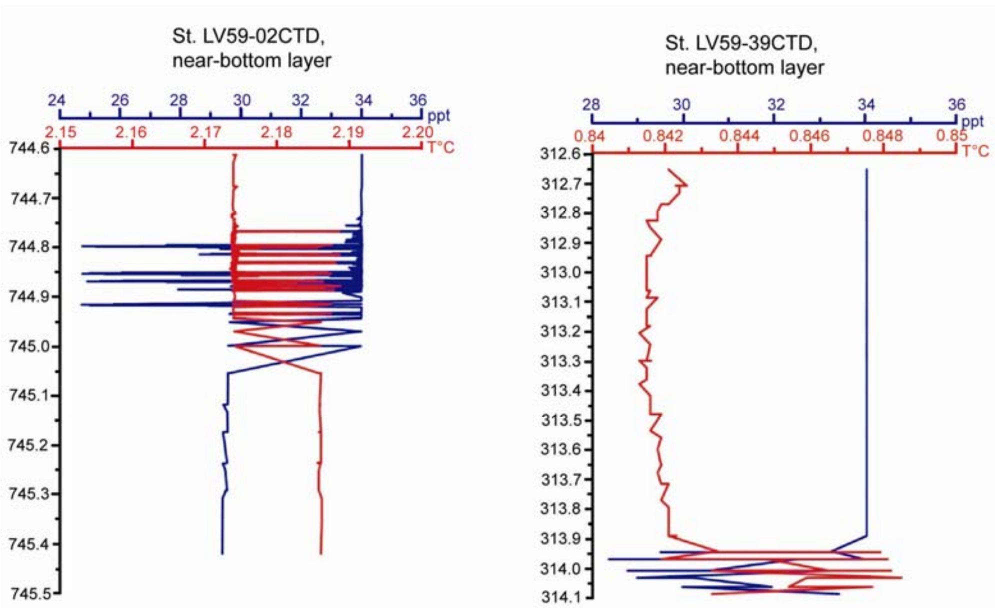


Fig. 4.17. Oscillations of salinity and temperature within near-bottom layer in the Terpeniya Bay (St. LV59-02CTD) and in the Tatarsky Strait (St. LV59-39CTD).

Oscillations of the salinity shown on vertical profiles (Fig. 4.17) can be connected with the indignations caused by streams of both methane bubbles and a suspension, being displaced with near-bottom turbulent currents. Let's note that only the preliminary analysis of CTD data is made. Therefore, both the executed measurements of thin structure and the assumption about inflow of pore waters from subbottom sediments demands careful check and consideration of possible mistakes. This means that further researches are necessary for confirmation of influence of a suspension and methane bubbles using conductance sensors.

Similar but narrower vertical structure of salinity and temperature in near-bottom interface is observed at station LV59-39CTD in Tatarsky Strait within Sakhalin slope, where methane flares were also found. At this CTD station, sounding is executed to depth above by 70-90 cm from the seafloor. In Fig. 4.17, trends of salinity and temperature are, respectively, decrease and increase with depth despite of fluctuations from each average value in vertical profile above.

4.4.2. Gas Geochemical Investigation

O. Vereshchagina, E. Maltseva, A. Obzhirov

Hydrocarbon gases, CO_2 concentrations were measured in water column in the area 3 (Terpeniya Bay, Kuril Basin of Okhotsk Sea) and area 4 (Tatarsky Strait, Japan/East Sea) (Fig. 4.1). Gas was determined for 26 core-stations. Head Space method and gas chromatographic analysis of methane content in the sediments were conducted used on board of Akademik M.A. Lavrentyev.

Gas geochemical studies included:

1. Sampling of water from bathometers at different water depths from the sea surface to the seafloor to extract gas for its further analysis
2. Chromatographic gas analysis
3. Interpretation of the data obtained.

Methods and instruments

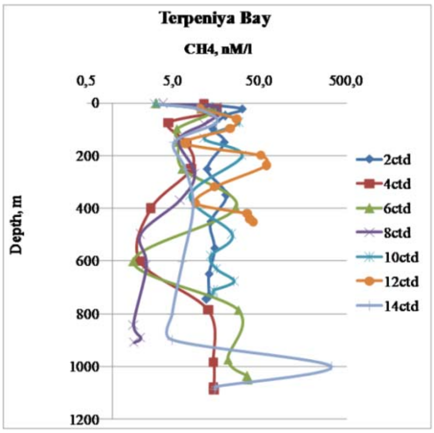
In different depths water were sampled for CH_4 concentration analysis using the ship's CTD/Niskin bottle rosette. All sample bottles for gas analyses were flushed with 2 volumes of water from Niskin bottles and filled completely to eliminate bubbles. Then 0.5mL of bigluconate chlorhexidine (0.05%) was added for preservation of the sample and bottles were immediately capped with rubber stoppers using a needle to remove excess of water and air. Pure helium was used as the gas phase. Gas bag Tedlar Bag Dual Valve used to add the helium into sample bottle. To do this, one valve of the gas bag was connected to the gas cylinder. The second valve is provided with a needle to add helium into the sample bottle through the cap. Each time, selecting the same sample volume syringe from the sample bottle, we add the same amount of helium at atmospheric pressure without contact with air. Gas sample is injected into the chromatograph after intensive manual shaking and stirring on the mixer LS110 during four and more hours. Gas chromatograph "Cristall – Lux 4000M" (Russia) equipped with a flame ionization detector and two thermal conductivity detectors (FID/2 TCD) used for gas chromatographic analysis the gas composition on board. Methane concentration was calculated as the sum of the dissolved fraction (Wiesenburg et al., 1979) and methane gas phase. The precision of the analysis was 5%.

Results of gas investigation.

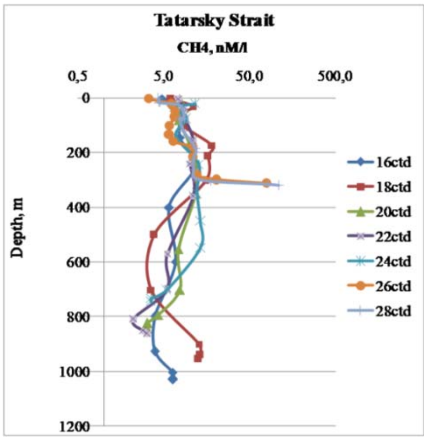
Methane concentration profiles of water columns in West Kuril Basin on South Okhotsk Sea and Tatarsky Strait on North Japan Sea are distinguished from each other. Probably the hydrodynamic processes in flare area are the reason for such variability. Maximum values of methane concentration near the seafloor vary from 12.3 nM/l (station 02-CTD, depth 745 m) to 335 nM/l (station 14-CTD, depth 999 m) (Fig. 4.18, Table 4.6).

Anomalously high values of methane concentration generally occur in near-bottom layers.

Near-surface methane maximum was found at the density gradient layer on station LV59-02CTD (31.4 nM/l, depth 24m). Range of near-surface methane concentration is 10.0-31.4 nM/l in West Kuril Basin. For Tatarsky Strait it is 6.5-10.9 nM/l. Anomalies of methane concentration (about 80 nM/l) were found in bottom water at station LV59-26CTD. Such a great anomaly in bottom water connects with fluxes of methane bubbles from sediment to water. Fig. 4.19 shows the acoustic patterns with the distribution of methane in the water column at some stations.

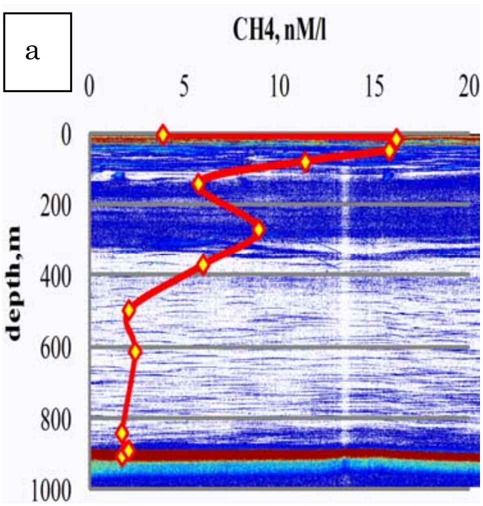


(A)



(B)

Fig. 4.18. Methane distribution (nM/L) in water columns in (A) the West Kuril Basin (area Terpeniya Bay), (B) and Tatarsky Strait.



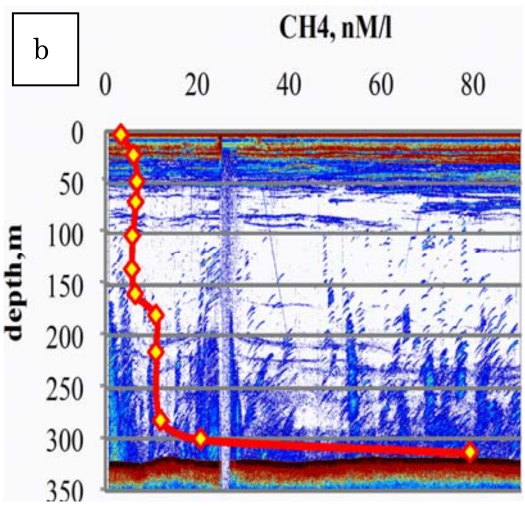


Fig. 4.19. Examples of methane distribution (nM/L) on the stations LV59-08CTD (a) in West Kuril Basin and LV59-26CTD (b) in flare area of Tatarsky Strait.

Conclusion

Methane concentrations in the water column on West Kuril Basin (Terpeniya area) on South Okhotsk Sea vary in general from 5 to 50nM/l with depths of 0-1000 m. In Tatarsky Strait on North Japan Sea it is somewhat small (5-7 nM/l). Anomalous values of 80-100 nM/l are found in area with methane bubbles flux in bottom water. Methane concentration in the water column is likely determined by the layered different water masses. Methane concentrations in the sediments of both West Kuril Basin and Tatarsky Strait vary significantly with depth from surface to depth of 4 m. In particular, it reaches 100-150 ml/l at station where gas hydrates occur. Such methane concentration profile in the sediments may be characterized by presence of gas hydrates or their destruction through the emission of methane into the water.

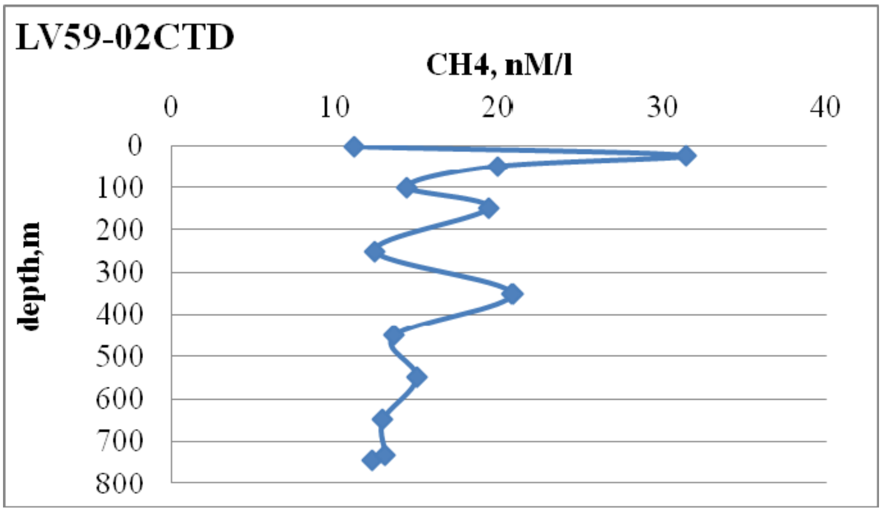
References

Vereshchagina Olga F., Korovitskaya Elena V., Mishukova Galina I. Methane in water columns and sediments of the north western Sea of Japan, Deep Sea Research Part II: Topical Studies in Oceanography, http://dx.doi.org/10.1016/j.dsr2.2012.08.017

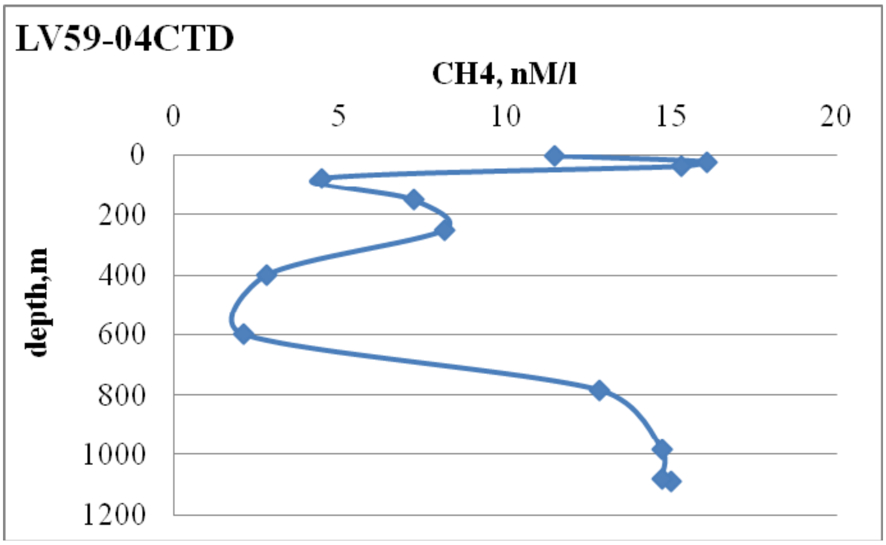
Wiesenburg Denis A. and Guinasso Norman L, Jr. Equilibrium Solubilities of Methane Carbon Monoxide, and Hydrogen in Water and Sea Water// Jornal of Chemical and Engineering Data, 1979, Vol. 24, No 4, p 356-360

Table 4.6. Methane concentration in the water column

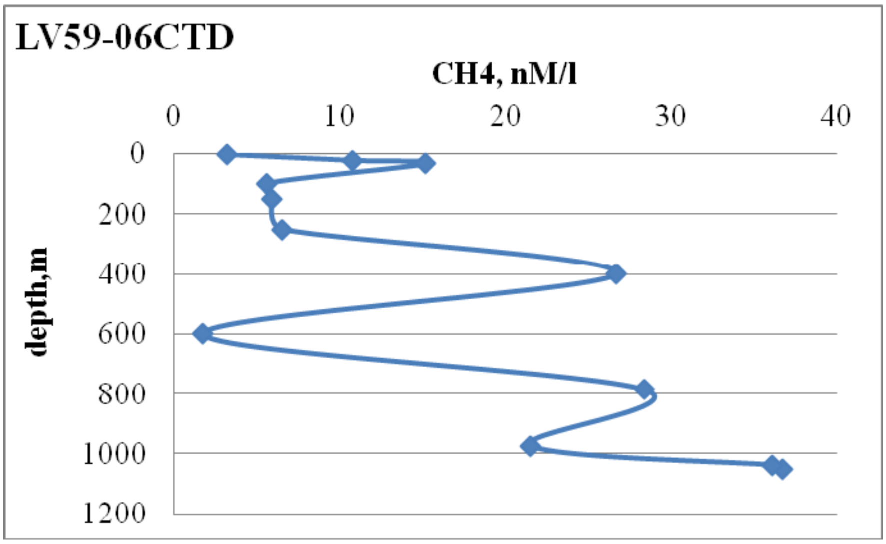
Station: **lv59-02ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
47°24.448’	143°44.264’	4	250	11.2
		24	703	31.4
		50	446	19.9
		100	322	14.4
		150	434	19.4
		250	279	12.5
		350	466	20.8
		450	305	13.6
		550	336	15.0
		649	289	12.9
		733	292	13.1
47°24.409’	143°43.909’	745	275	12.3



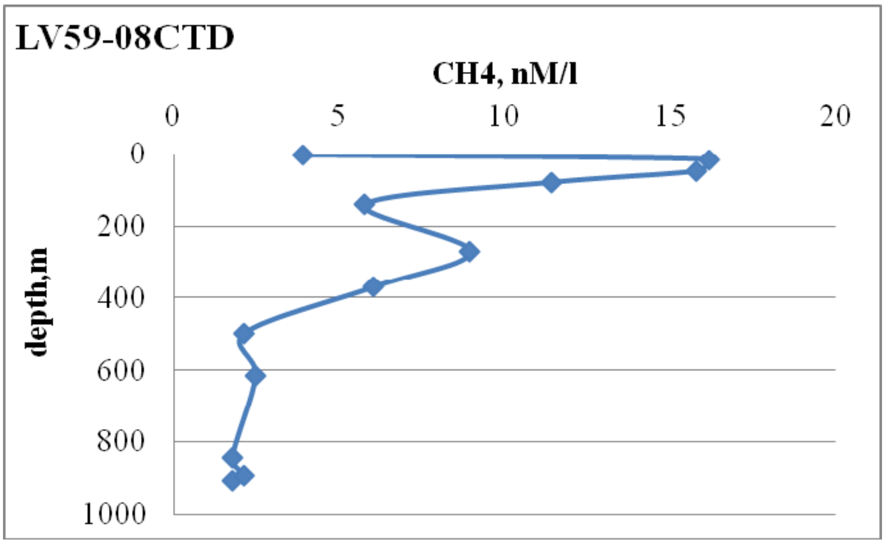
Station: **lv59-04ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
47°04.153’	143°54.061’	4	258	11.5
		23	360	16.1
		38	343	15.3
		79	100	4.4
		153	162	7.2
		252	183	8.2
		401	62	2.8
		601	47	2.1
		785	288	12.9
		984	330	14.7
		1080	330	14.7
47°04.032’	143°53.496’	1089	336	15.0



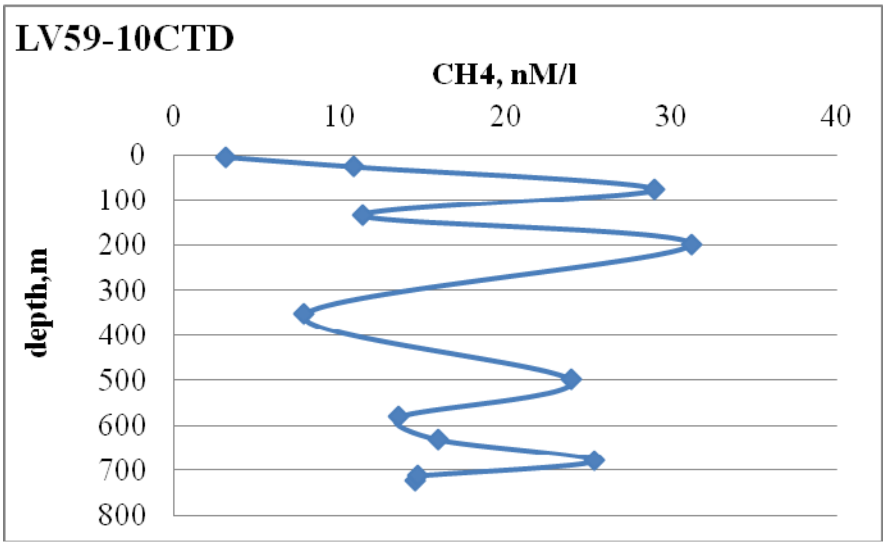
Station: **lv59-06ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
47°04.228’	143°52.744’	3	71	3.2
		23	241	10.8
		34	340	15.2
		99	125	5.6
		150	132	5.9
		250	145	6.5
		401	598	26.7
		601	39	1.8
		786	636	28.4
		973	483	21.5
		1037	809	36.1
47°04.048’	143°52.788’	1051	823	36.7



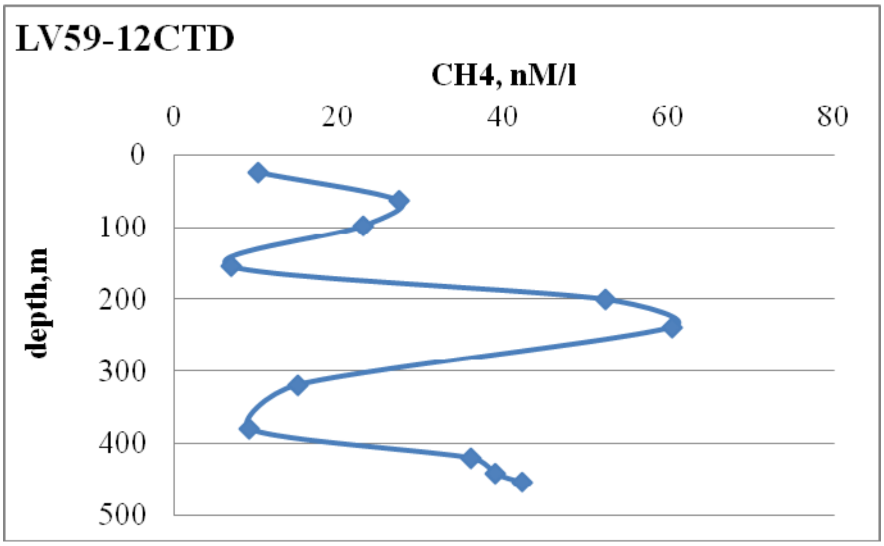
Station: **lv59-08ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
47°13.798'	143°52.505'	4	88	3.9
		16	362	16.2
		48	354	15.8
		80	255	11.4
		141	129	5.8
		270	200	8.9
		370	135	6.0
		498	48	2.1
		615	55	2.5
		843	39	1.8
		892	47	2.1
47°13.652'	143°52.762'	908	40	1.8



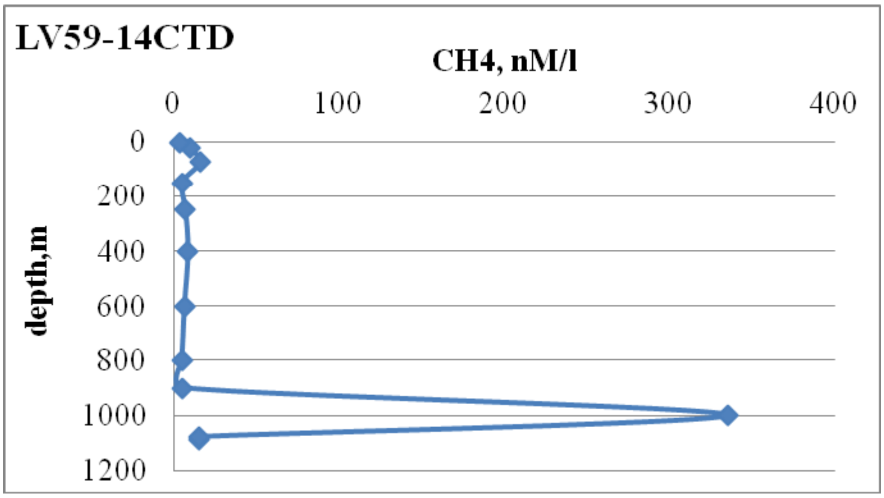
Station: **lv59-10ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
47°24.217’	143°43.636’	4	69	3.1
		25	243	10.9
		75	650	29.0
		134	255	11.4
		199	700	31.2
		352	176	7.9
		499	537	24.0
		580	304	13.6
		630	357	15.9
		678	569	25.4
		712	330	14.7
47°23.982’	143°43.648’	722	325	14.5



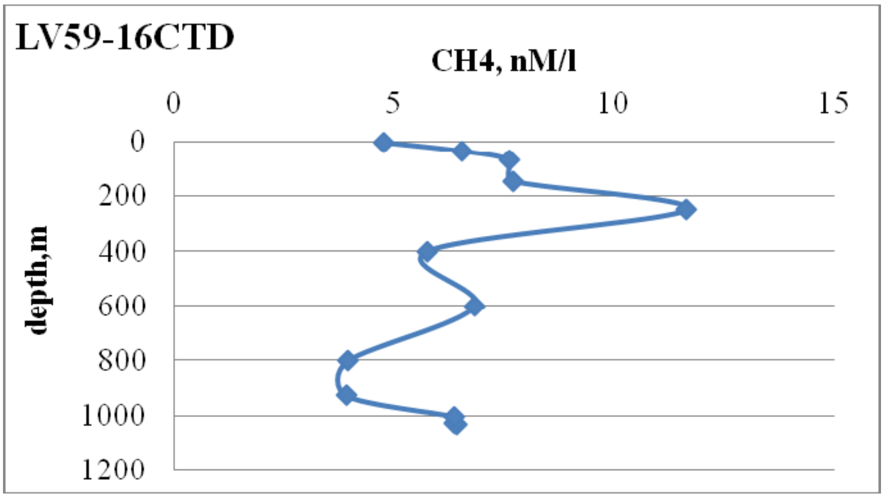
Station: **lv59-12ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
47º27.522’	143º44.881’	24	231	10.3
		63	612	27.3
		98	513	22.9
		155	158	7.0
		200	1171	52.3
		238	1353	60.4
		319	337	15.1
		380	206	9.2
		420	807	36.0
		442	873	39.0
47 º27.500’	143 º44.602’	454	946	42.2



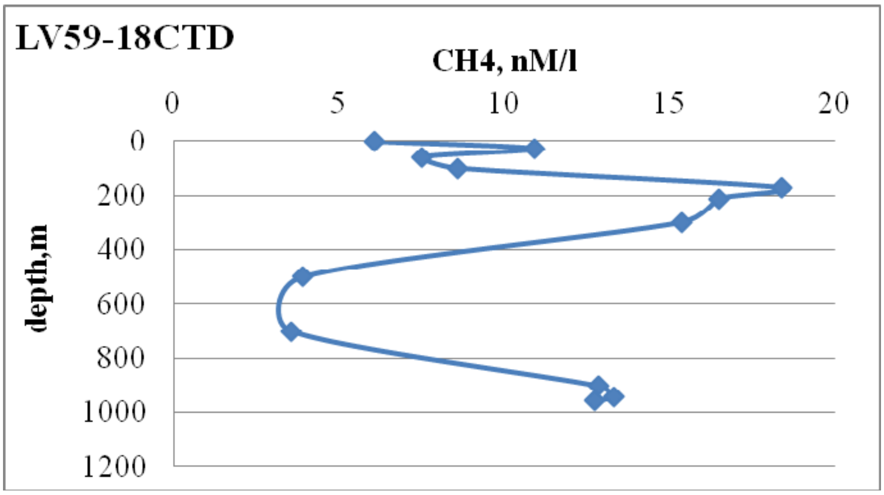
Station: **lv59-14ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
47º04.548’	143º54.194’	4	78	3.5
		23	218	9.7
		75	350	15.8
		150	115	5.1
		251	158	7.0
		400	192	8.6
		601	143	6.4
		801	109	4.9
		900	109	4.9
		999	7504	335.0
		1077	350	15.6
47 º04.267’	143 º53.732’	1088	342	15.3



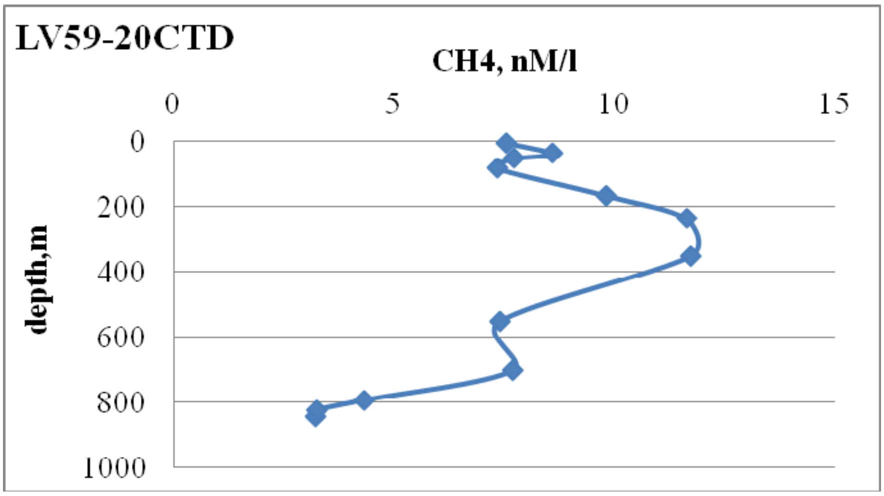
Station: **lv59-16ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
47º37.614’	140º47.935’	4	107	4.8
		36	147	6.5
		70	171	7.6
		146	173	7.7
		250	261	11.6
		400	129	5.8
		600	153	6.8
		800	89	4.0
		927	88	3.9
		1003	143	6.4
		1025	143	6.4
47 º37.270’	140 º48.068’	1030	144	6.4



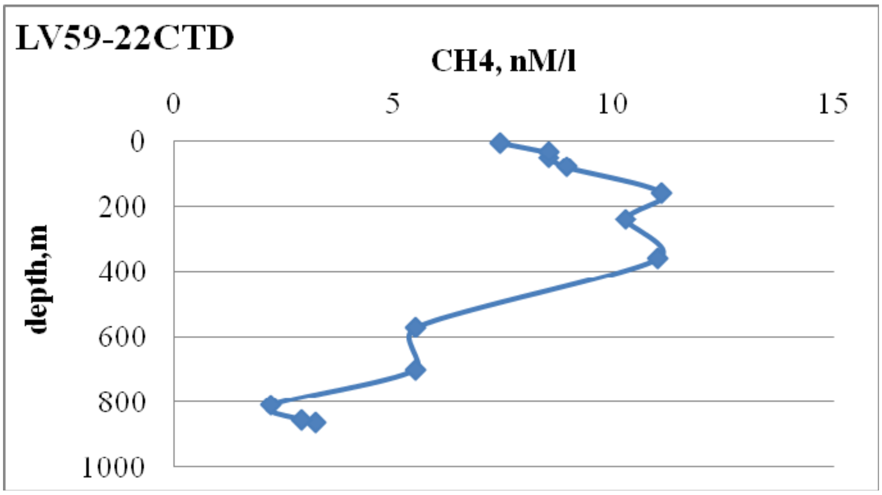
Station: **lv59-18ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
47º45.370’	141º04.850’	4	136	6.1
		31	245	10.9
		62	168	7.5
		103	192	8.6
		173	412	18.4
		213	370	16.5
		302	344	15.4
		502	87	3.9
		701	80	3.6
		900	288	12.9
		941	299	13.3
47 º44.794’	141 º04.708’	955	286	12.7



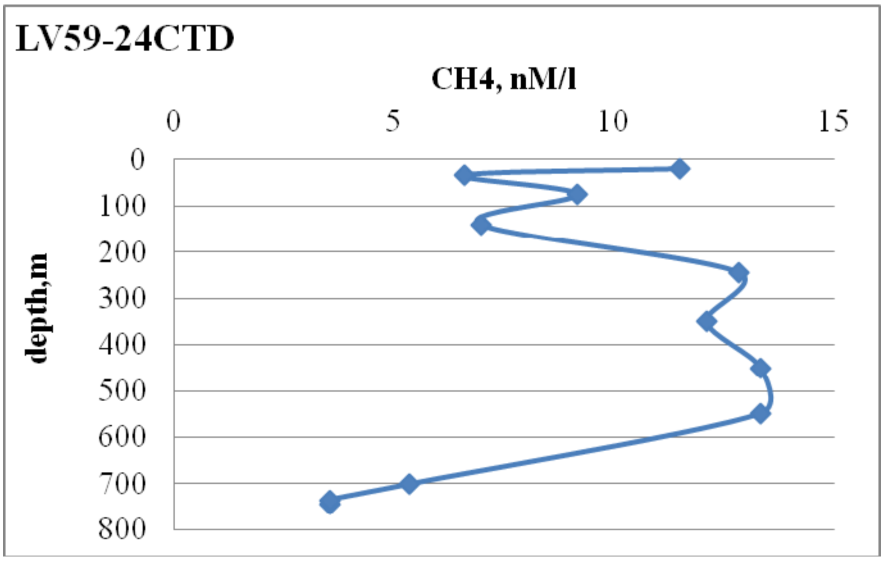
Station: **lv59-20ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
48º00.848’	141º01.589’	3	169	7.5
		37	192	8.6
		53	173	7.7
		82	164	7.3
		166	220	9.8
		237	261	11.6
		350	263	11.7
		552	166	7.4
		701	173	7.7
		793	97	4.3
		824	73	3.2
48 º00.818’	141 º01.258’	844	72	3.2



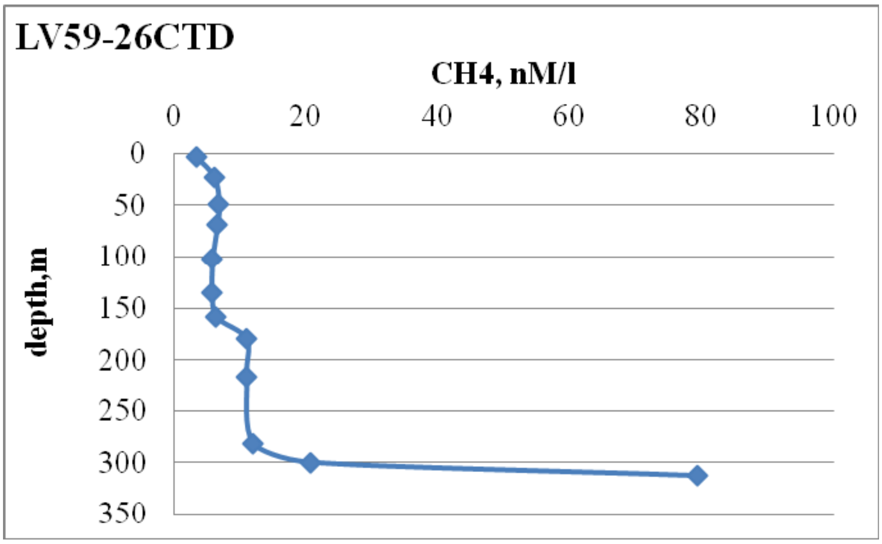
Station: **lv59-22ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
48º00.839’	141º00.415’	4	166	7.4
		34	191	8.5
		52	191	8.5
		80	200	8.9
		158	249	11.1
		240	230	10.3
		360	247	11.0
		570	123	5.5
		700	123	5.5
		809	50	2.2
		853	65	2.9
48º00.742’	141º00.599’	862	72	3.2



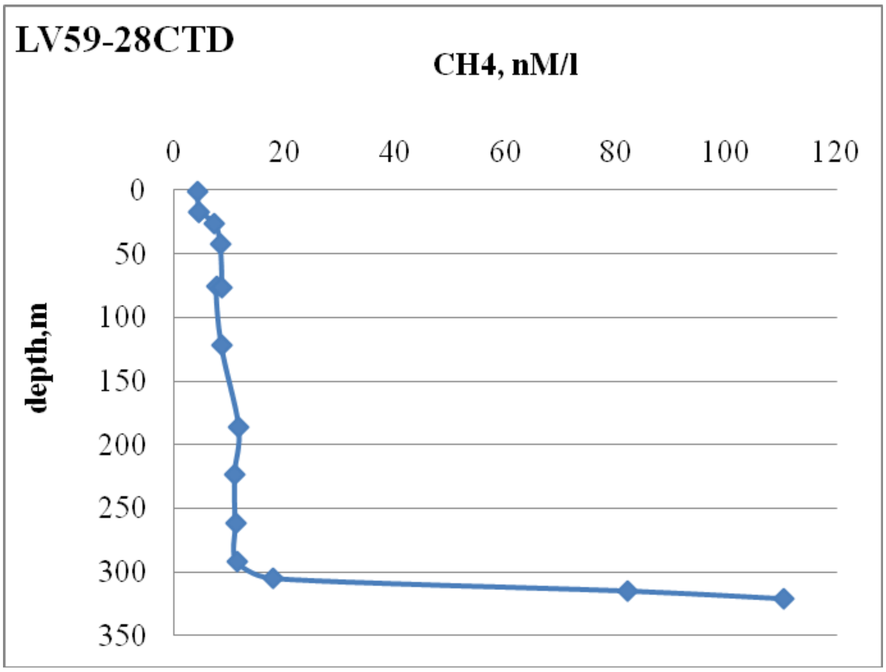
Station: **lv59-24ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
48°02,146	141°05,449	21	257	11.5
		35	148	6.6
		76	205	9.2
		141	156	7.0
		245	288	12.8
		349	271	12.1
		450	299	13.3
		550	299	13.3
		701	120	5.4
		735	79	3.5
48°02.044’	141°05.348’	745	79	3.5



Station: **lv59-26ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
48°14,470	141°23,614	3	76	3.4
		23	137	6.1
		49	153	6.9
		69	148	6.6
		102	132	5.9
		135	129	5.8
		159	145	6.5
		180	247	11.0
		216	247	11.0
		282	269	12.0
		300	464	20.7
48°14.156'	141°23.200'	313	1776	79.3



Station: **lv59-28td**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
48°14,900	141°23,746	75	171	7.6
		122	192	8.6
		186	263	11.7
		223	247	11.0
		262	249	11.1
		292	255	11.4
		305	399	17.8
		315	1841	82.2
48°14.742'	141°23.562'	321	2473	110.4



Station: **lv59-28.1ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
48°25,068	141°25,068	1	100	4.3
		17	101	4.4
		17	165	4.5
		26	188	7.3
		42	197	8.4
48°15.590’	141°25.008’	76	171	8.7

Station: **lv59-32ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
48°14,932’	141°23,638’	1	81	3.6

Station: **lv59-37ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
48°08,854’	141°18,677’	1	75	3.4

Station: **lv59-39ctd**				
Latitude, N	Longitude,E	depth,m	CH4, nl/l	CH4 nM/L
48°15,220’	141°24,810’	3	82	3.7
		3	81	3.6
		3	81	3.6

5. APPENDIX

5.1. Daily Situation Report

H. Shoji

Aug 07 Tue		Laventyev left Vladivostok.
Aug 09 Thu		Lavrentyev arrived at Port Korsakov in Aniva Bay.
Aug 10 Fri	11:30	KOPRI (Jin, Cho) and KIT (Shoji, Minami, Hachikubo, Kotake, Li, Miura, Kubo, Kawagishi) members got on board at Pier No.1. Cloudy but calm. Customs Clearance prepared. Meal Time announced (7:30 Breakfast, 11:30 Lunch, 15:30 Tea, 19:30 Dinner).
	16:00	Customs Clearance prepared.
	19:00	Lavrentyev moved a small distance toward the land at the same Pier according to the request of Cusstoms Clearance Office.
	21:00	Twelve passengers visited Customs Clearance Office for Passport Control, while Lavrentyev was inspected by officers of Customs Clearance for departure.
	22:30	Customs Clearance completed. Lavrentyev started to sail to Study Area No. 3 (Terpeniya). Slightly rainy. A birthday party for HM at core laboratory.
Aug 11 Sat	06:30	Foggy and slightly windy.
	08:30	Hydro-acoustic survey showed a new flare (F1) at 2220 m WD (46º01.989'N, 144º15.249'E) within Study Area No.3. Lavrentyev sailed continuously to the north for the three flare sites which were observed during SSGH-11.
	09:00	Plenary Meeting for introducing members and general schedule of SSGH-12. Security Lecture. Sub Bottom Profiler will be used instead of Sparker due to the delay of fixed beamer to be delivered from St. Petersburg.
	14:00	Hydro-acoustic survey showed a flare (F2) at 1065 m WD as observed last year. Operation Meeting (AO, HS, YJ, BB, AS, NN, AD, HM and others) for detailed operation schedules of SSGH-12, including SSGH-12 report writing plan. Expected recovery time of the first core from a site at about 740 m WD will be later than 17:00. CTD measurement is planned immediately after the coring. After Hydro-acoustic survey during the night, coring would be made at F2.
	16:15	Hydro-acoustic survey showed a flare (F3) at 736 m WD as observed last year.
	18:00	LV59-01HC core on deck (304 cm long, 47º23.988'N, 143º43.621'E, 735 m WD) at F3. Entirely black-colored core (hydrotroilite) with Caliptogena and carbonate concretions. No visible GH observed. Crackling sound observed (small GH particles?).

18:23 LV59-02CTD started at F3.

19:25 LV59-02CTD completed.

19:50 Hydro-acoustic survey by 8 kts started for F3, F4candidate (flare No.94 in SSGH-11) and F2 area for precise coordinates and new flare search during the night.

20:33 A new flare was observed (F4; 47º27.130'N, 143º44.400'E, 467 m WD). This is not the same flare No.94 as observed last year.

22:49 A new flare was observed (F5; 47º13.543'N, 143º52.859'E, 902 m WD).

Aug 12 Sun 06:30 Clear sky and calm.

09:00 Operation Meeting (AO, HS, YJ, BB, NN, AD, HM).

09:22 LV59-03HC core on deck (373 cm long, 47º3.871'N, 143º52.960'E, 1050 m WD) at F2. Normal core including carbonate concretions. No visible GH observed.

9:29 LV59-04CTD started at F2.

10:20 LV59-04CTD completed.

10:30 Detailed survey was performed by using hydro-acoustic device around the LV59-03HC core site.

13:02 LV59-05HC core on deck (366 cm long, 47º3.866'N, 143º52.970'E, 1050 m WD) at F2. A few small GH particles (about 5 to 10 mm in size) were included in the sediment core within core catcher. Carbonate concretions and shell fragments were observed in the core. This is the sixteenth discovery of GH region offshore Sakhalin.

13:30 LV59-06CTD started at F2.

14:27 LV59-06CTD completed.

14:40 Sub Bottom Profiler (SBP; GeoAcoustics) was prepared and put into water to a depth of about 3 m below the sea surface. Lavrentyev sailed to next coring site at F5, checking SBP performance for about one hour.

16:05 SBP test showed only ship engine noise. SBP device depth was changed from 3 m to about 15 m below the sea surface.

16:15 A new flare was observed (F6; 47º12.253'N, 143º52.855'E, 978 m WD).

16:26 Lavrentyev arrived at F5 region.

17:10 SBP test showed no improvement by changing the device depth in water. SBP device was moved from the rear side to the front side of Lavrentyev (near CTD apparatus) for the second test to be started around 21:00. Cloudy.

18:16 LV59-07HC core on deck (411 cm long, 47º13.526'N, 143º52.908'E, 904 m WD) at F5. No GH observed. Greenish colored core included gas saturated layers near the top and worm hole in the middle. Normal core.

18:20 LV59-08CTD started at F5.

19:13 LV59-08CTD completed.

20:30 Hydro-acoustic and Bathymetric surveys, and SBP test started for the night.

Aug 13 Mon 06:30 Cloudy and rainy.

09:00 Operation Meeting (AO, HS, YJ, BB, NN, AD, HM). Twelve new flares were observed during the last night survey. Six of them would be below 400 m WD. Next coring would be at F3.

11:04 LV59-09HC core on deck (536 cm long, 47º23.961'N, 143º43.662'E, 725 m WD) at F3. No GH observed. Almost Black colored (hydrotriolite) core. No visible GH. No H_2S odor. No carbonate observed. No shell fragments.

11:36 LV59-10CTD started at F3. Winch trouble at a depth of about 500 m while descending.

12:00 LV59-10CTD stopped.

14:30 Winch for CTD measurements fixed. LV59-10CTD re-started. A new flare (F3a) was observed near F3 flare while drifting for CTD measurements.

15:10 LV59-10CTD completed. Next coring would be at F8 which has a strong flare image in echogram.

16:12 A new flare (F19) was observed while approaching to F8.

16:55 LV59-11HC core on deck (512 cm long, 47º23.374'N, 143º44.326'E, 445 m WD) at F8. No GH observed. Almost Black colored (hydrotriolite) core. No visible GH. No H_2S odor. No carbonate observed. No shell fragments.

17:08 LV59-12CTD started at F8.

17:55 LV59-12CTD completed.

18:17 Lavrentyev moved toward F2 region by 10 knots.

20:50 Hydro-acoustic, Bathymetric and SBP surveys started around F2 region for the night operation after adjusting SBP winch. Beautiful sunset.

Aug 14 Tue 06:30 Blue sky and calm sea surface.

09:00 Operation Meeting (AO, HS, YJ, BB, NN, AD, HM). No new flare was observed during the last night survey. Next coring would be at F2. Low pressure system passing through north of Sakhalin.

12:03 LV59-13HC core on deck (520 cm long, 47º03.881'N, 143º52.969'E, 1053 m WD) at F2. No GH observed. No visible GH. No H_2S odor. No carbonate observed. No shell fragments. Main Winch cable trouble.

12:10 LV59-14CTD started at F2.

13:10 LV59-14CTD completed. There is a possibility that F2 flare is of two flares.

13:30 Lavrentyev moved toward east to find a deeper place for cable rewinding.

14:12 Cable rewinding completed. Lavrentyev moved back to F2 for the next coring.

15:30 LV59-15HC core on deck (469 cm long, 47º03.860'N, 143º52.948'E, 1053 m WD) at F2. No GH observed. No visible GH. Slight H_2S odor. Carbonate observed, but quite possibly, formed from organic matter (not methane). Shell fragments observed. The flare was confirmed of F2 and F2a. No CTD to be measured at F2 region.

Lavrentyev moved toward F1 region. Flare No.1 was found to locate within Area of Explosives. Coring plan at F1 was cancelled. Lavrentyev sailed toward Study Area No.4 (Tatarsky).

Aug 15 Wed 06:30 Cloudy and slightly windy.

07:30 Lavrentyev sailed at 45º50.136'N, 142º11.082'E by 10.6 kts for Study Area No.4 (Tatarsky).

09:00 Operation Meeting (AO, HS, YJ, BB, NN, AD, HM). Discussed about basic plan for Study Area No.4 (Tatarsky).

13:00 Hydro-acoustic, Bathymetric and SBP surveys started at Study Area No.4-3.

14:00 Operation Meeting (AO, HS, YJ, BB, NN, AS, BP, AD, HM). Discussed about basic plan for Study Area No.4 (Tatarsky) by using survey line plan. The first coring site would be determined at the next Operation Meeting at 9:00 on Aug.16.

17:30 Introduction to GIS by Dasha.

18:18 Lavrentyev sailed at 46º30.062'N, 141º0.041'E toward north during surveys by 6.2 kts in Study Area No.4-3.

Aug 16 Thu 06:30 Clear sky and slightly windy.

09:00 Operation Meeting (AO, HS, YJ, BB, NN, AD, HM). Hydro-acoustic, Bathymetric and SBP surveys showed no flare and no gas chimney except for one or two weak chimneys at the beginning in the Study Area No.4-3. Hydro-acoustic survey along two seismic survey lines at the southern part of Study Area No. 4-1 showed no flare even at the gas chimney locations reported. The first coring site would be H1 (mound No.1) at the south end of Study Area No.4-1 near gas chimney location along the seismic line.

10:19 LV59-17HC core on deck (530 cm long, 47º36.733'N, 140º48.917'E, 1050 m WD) at H1. No GH observed. No visible GH. Strong H_2S odor. No carbonate/shell fragments observed. Normal core.

10:32 LV59-16CTD started at H1.

11:34 LV59-16CTD completed. Lavrentyev moved toward NE to a site of three gas chimneys reported by seismic survey. Sunny and clear sky.

13:20 Lavrentyev arrived at H3 region.

14:18 LV59-19HC core on deck (550 cm long, 47º44.001'N, 141º04.361'E, 980 m

WD) at H3. No GH observed. No visible GH. Strong H_2S odor. No carbonate/shell fragments observed. Normal core.

14:25 LV59-18CTD started at H3.

15:28 LV59-18CTD completed.

15:40 Hydro-acoustic, Bathymetric and SBP surveys started along about 50 nautical miles long survey line which would cross eleven gas chimney locations reported.

20:15 Lavrentyev sailed at 47º50.019'N, 141º10.676'E toward east during surveys by 5.7 kts in Study Area No.4-1.

Aug 17 Fri 06:30 Clear sky.

09:00 Operation Meeting (AO, HS, YJ, BB, NN, AS, AD, HM). Hydro-acoustic survey showed no flare except for one or two weak flares at the shallower places (about 200 m WD). SBP survey showed no new gas chimney except for those already reported by seismic surveys by POI. Foggy but calm.

09:45 Hydro-acoustic, Bathymetric and SBP surveys stopped, SBP device pulled up from the water, and Lavrentyev moved to H1.3 Gas Chimney (the widest chimney along Line 1 by seismic survey) location by 10.1 kts. H1.3 Gas Chimney is about 400 m in width, and the mound is about 7 m high.

11:10 Lavrentyev arrived at H1.3 (the third gas chimney along the seismic profile Line 1) region.

12:44 LV59-21HC core on deck (466 cm long, 48º00.832'N, 141º00.813'E, 856 m WD) at H1.3. No GH observed. No visible GH. Slightly H_2S odor. No indication of gas seep. Glendonite?

12:50 LV59-20CTD started at H1.3.

13:50 LV59-20CTD completed.

14:00 Sonic velocity for Hydro-acoustic survey was adjusted to 1465 m/s to be equivalent to CTD measurement. Previously 1480 m/s was used for HA.

16:21 LV59-23HC core on deck (410 cm long, 48º00.797'N, 141º00.739'E, 852 m WD) at H1.3. No GH observed. No visible GH. Slightly H_2S odor. No indication of gas seep.

16:23 LV59-22CTD started at H1.3.

17:18 LV59-22CTD completed.

17:30 Hydro-acoustic, Bathymetric and SBP surveys started by 6 kts.

20:36 Lavrentyev sailed at 48º17.224'N, 141º01.418'E toward north during surveys by 5.9 kts in Study Area No.4-1.

Aug 18 Sat 06:30 Cloudy

07:15 Hydro-acoustic, Bathymetric and SBP surveys stopped, and Lavrentyev moved to H2.3 region (third gas chimney along seismic line No.2) for Bathymetric survey before coring.

09:00 Operation Meeting (AO, HS, YJ, BB, NN, AD, HM). SBP survey showed two new gas chimneys at about 700 m WD during night survey. Hydro-acoustic survey at western part of Delanglya Bay showed two or more weak flares at about 320 m WD without gas chimney by SBP.

11:30 LV59-25HC core on deck (410 cm long, 48º02.027'N, 141º05.606'E, 740 m WD) from a mound at H2.3. No GH observed. No visible GH. Slightly H_2S odor. No indication of gas seep.

11:50 LV59-24CTD started at H2.3.

12:35 LV59-24CTD completed.

12:44 Lavrentyev moved toward east to a site of 400 m water depth to conduct a zigzag flare search to the flare site as observed by night survey.

15:35 Lavrentyev arrived at SF22 region. Bathymetric survey started. Six flares (at least) located within 600 m area, and more flares were distributed in about 2 mile area.

16:57 LV59-27HC core on deck (364 cm long, 48º13.854'N, 141º23.013'E, 322 m WD) at SF22-1. GH observed in core catcher. Several GH particles were observed at 222, 276 and 346 cm core depths. H_2S odor. Carbonate concretion and shell fragments observed. This is the seventeenth discovery of GH region offshore Sakhalin.

17:17 LV59-26CTD started at SF22.

18:08 LV59-26CTD completed. Bottom temperature was about 0.8 ºC.

18:10 Hydro-acoustic, Bathymetric and SBP surveys started for the night.

20:28 Lavrentyev sailed at 48º22.650'N, 141º07.021'E toward NW during surveys by 5.8 kts in Study Area No.4-1.

Aug 19 Sun 06:30 Clear sky.

07:15 Hydro-acoustic, Bathymetric and SBP surveys stopped. Lavrentyev sailed to SF22 region.

08:03 Lavrentyev sailed at 48º32.660'N, 141º16.792'E toward south to SF22. Cloudy and slightly windy.

09:00 Operation Meeting (AO, HS, YJ, BB, NN, AD, HM, AH). SBP survey showed two new gas chimneys and 180 m deep channel/canyon during night survey. Hydro-acoustic survey showed no flare. Next coring would be at sf21-1 (about one mile north from SH22, 330 m WD). There might be more flares near sf20. Low pressure system crossing north of Sakhalin.

10:03 Lavrentyev arrived at sf21-1. Hydro-acoustic surveys started by crossing the flare several times.

11:29 Flare name F29 was put to the Flare sf21-1.

12:19 LV59-29HC core on deck (405 cm long, 48º14.568'N, 141º23.027'E, 332 m WD) at F29(sf21-1). No GH observed. H_2S odor. Carbonate concretion observed.

12:24 LV59-28CTD started at SF22. Troubles of Water Sampler.

14:25 LV59-28CTD completed.

14:30 Hydro-acoustic, Bathymetric and SBP surveys started at SF22/F29 region.

15:27 Survey stopped. Lavrentyev sailed to SF22 region. Foggy

16:30 LV59-31HC core on deck (308 cm long, 48º13.847'N, 141º22.980'E, 322 m WD) at SF22-1. No GH observed. H_2S odor. Carbonate concretions and shell fragments observed.

16:52 LV59-30CTD started at SF22.

17:24 LV59-30CTD completed.

17:30 Bathymetric survey at SF22/F29 region started.

20:23 Bathymetric survey completed.

20:30 Hydro-acoustic, Bathymetric and SBP surveys started along a zigzag line between 250 and 400 m water depth to sf20 region.

Aug 20 Mon 06:30 Clear sky and calm sea surface.

06:40 Hydro-acoustic, Bathymetric and SBP surveys stopped. Several flares were observed during the zigzag survey around a water depth of 300 m. Lavrentyev sailed to SF25-2.

09:00 Operation Meeting (AO, HS, YJ, BB, NN, AD, HM, AH). General operation plan for next two days.

10:19 LV59-33HC core on deck (466 cm long, 48º14.915'N, 141º23.798'E, 323 m WD) at SF25-1. No GH observed. H_2S odor. Carbonate concretion observed. Black layer at the top, and crackling sound near the bottom. A new flare (F58) was observed while drifting after coring.

10:31 LV59-32CTD started at SF25-2 without water sampling due to the closure trouble.

10:55 LV59-32CTD completed.

13:17 LV59-35HC core on deck (417 cm long, 48º14.971'N, 141º23.616'E, 328 m WD) at SF58. No GH observed. H_2S odor. Carbonate concretion observed. A lot of bioturbations along the core, and crackling sound near the bottom.

15:00 CTD survey operation after coring was cancelled for fixing water sampler device.

16:54 LV59-34HC core on deck (354 cm long, 48º14.881'N, 141º24.000'E, 322 m

WD) at F28. No GH observed. H_2S odor. Carbonate concretion and shell fragments observed. Sediment dropped from core catcher into the water formed lots of gas bubbles. This might be indirect indication of GH in the sediment. Difficulties in pulling out the core tube from the corer due to the gas expansion.

17:34 Hydro-acoustic, Bathymetric and SBP surveys started toward the western slope in Study Area No.4-1.

Aug 21 Tue 06:30 Cloudy and windy.

09:00 Operation Meeting (AO, HS, YJ, BB, NN, AD, HM, AH). Hydro-acoustic, Bathymetric and SBP surveys showed no flare last night, but one gas chimney (or diaper) in the center of Tatarsky Trough. Lavrentyev arrived at sf20 region. Echograms (HA) showed many weak flare-like (fish?) images at shallower area (shallower than 300 m water depth) at sf20 region. Next coring would be at F43, about 12 miles north from sf20 region. Oceanological core for KOPRI would be taken from Study Area No.4-2.

09:32 Hydro-acoustic, Bathymetric and SBP surveys stopped within sf20 region. Lavrentyev sailed to F43 region. Foggy.

12:56 LV59-36HC core on deck (352 cm long, 48º07.997'N, 141º18.880'E, 318 m WD) at F43 (two flares in a pockmark-like hole). No GH observed. One Caliptogena observed. No Carbonate. A worm at Top. No indication of gas.

13:20 LV59-37CTD started at F43.

13:50 LV59-37CTD completed.

14:00 Lavrentyev sailed to F28.

16:20 LV59-38HC core on deck (432 cm long, 48º14.850'N, 141º24.016'E, 322 m WD) at F28. No GH observed. Carbonate concretion observed. Gas saturated features observed in the deeper half.

16:48 LV59-39CTD started at F28.

17:19 LV59-39CTD completed. Water sampler got closure troubles at deeper places.

19:10 Hydro-acoustic, Bathymetric and SBP surveys started for northern area in Study Area No.4-1 until about 9:00 in the morning when Lavrentyev would return to SF22.

Aug 22 Wed 06:30 Foggy and calm.

08:45 Hydro-acoustic, Bathymetric and SBP surveys finished. Lavrentyev started to move to SF22 region.

09:00 Operation Meeting (AO, HS, YJ, BB, NN, AD, HM, AH). Hydro-acoustic, Bathymetric and SBP surveys during the last night showed no flare but one gas chimney (diapir?) structure. Surveys showed that North channel is of asymmetrical cross section. General schedule plan for the rest of cruise.

Lavrentyev would arrive at SF22 region around 10:15.

11:05 LV59-40HC core on deck (437 cm long, 48º13.911'N, 141º22.892'E, 326 m WD) at SF22-5. No GH observed. Carbonate concretion observed. Gas saturated features observed in the deeper half.

Lavrentyev got the front engine trouble while coring. Ship direction could not be controlled. Cored site might be off from the flare center.

11:14 LV59-41CTD started at SF22-5.

11:40 LV59-41CTD completed without water sampling. Lavrentyev engine for ship direction was going to be fixed.

14:45 Engine was fixed. Lavrentyev started to move to SF22-5.

15:52 LV59-42HC core on deck (419 cm long, 48º13.986'N, 141º22.873'E, 326 m WD) at SF22-5. No GH observed. H_2S odor. Carbonate concretion observed. Black layer (hydrotroilite) near the top. Gas saturated features observed in the deeper half. No CTD survey followed.

17:25 Lavrentyev started to move, but had the same engine trouble again. Tried to fix the engine. Fine rain.

19:00 Engine problem was not solved yet. Coring was postponed to the next morring. Hydro-acoustic, Bathymetric and SBP surveys at NE slope for the night were going to be performed as soon as the engine was fixed.

21:00 Hydro-acoustic and Bathymetric surveys started for a northern zigzag line at shallower depths (300 to 400 m WD).

Aug 23 Thu 06:50 Beautiful Sunrise with clouds.

07:30 Hydro-acoustic and Bathymetric surveys finished. Lavrentyev stopped for engine adjustment.

08:02 Lavrentyev started to move to SF22-1 site.

08:56 LV59-43HC core on deck (380 cm long, 48º13.947'N, 141º23.009'E, 322 m WD) at SF22-1. No GH observed. H_2S odor. Carbonate concretion and Calyptogena observed. Gas saturated features observed in the deeper half.

09:10 LV59-44CTD started at SF22-1.

09:30 LV59-44CTD completed without water sampling. Bottom temperature by CTD was about 0.7 ºC. Salinity was observed to decrease a little bit near the bottom.

09:30 Operation Meeting (AO, HS, YJ, BB, NN, AD, HM). No flares were observed along the zigzag line of 300 m WD during the night surveys. Lavrentyev should be at Korsakov around 9:00 of August 26 for customs preparation.

13:01 LV59-45HC core on deck (436 cm long, 48º14.978'N, 141º23.812'E, 325 m WD) at SF25-3. No GH observed. H_2S odor. Carbonate concretion and shell fragments observed. Gas saturated features observed in the deeper places. No

CTD surveys were followed.

13:45 Lavrentyev sailed to Study Area No.4-2, Hydro-acoustic and Bathymetric surveying..

16:00 Operation Meeting (AO, HS, YJ, BB, AD). Survey route for Study Area No.4-2 and 4-3 was modified a little.

18:45 Hydro-acoustic, Bathymetric and SBP surveys started at Study Area No.4-2.

20:16 Lavrentyev sailed at 47º45.473'N, 140º9.986'E toward SW by 5.7 kts.

Aug 24 Fri 06:50 Beautiful Sunrise.

09:00 Operation Meeting (AO, HS, YJ, BB, NN, AD, AS, HM). No flare but Gas Chimney (one or two) were observed along the zigzag line during the night survey in Study Area No.4-2. One paleoceanological core would be taken at a site between 500 and 600 m WD, and CTD survey would be followed. Surveys in Study Area No.4-3 would be completed around 17:00 of August 25 at latest, and Lavrentyev should arrive at Korsakov by 9:00 of August 26. Group photo would be taken at Korsakov around 10:00 of August 26. SSGH-12 report drafts would be collected at noon of August 26.

10:20 A site for paleoceanological coring was selected.

10:28 SBP device pulled up. Lavrentyev started to move to the coring site.

10:58 Lavrentyev arrived at the coring site.

11:15 LV59-46HC core on deck (475 cm long, 46º53.462'N, 139º22.082'E, 628 m WD) at the selected site (smooth bed, no flare, no gas chimney). No H_2S odor. No carbonate concretion and no shell fragments observed. Top 90 cm is Holocene and Pleistocene below. Drop-stones below a core depth of 410 cm.

11:25 LV59-47CTD started at LV59-46HC site.

11:58 LV59-47CTD completed without water sampling.

12:04 Lavrentyev started to sail to Study Area No.4-3 while engine cleaning up.

16:22 Lavrentyev arrived at Study Area No.4-3. Hydro-acoustic, Bathymetric and SBP surveys started.

19:10 Diapir-like structures (twin) observed by Hydro-acoustic and SBP profiles during the survey.

21:00 A birthday party for YG.

Aug 25 Sat 06:50 Beautiful sunrise.

09:00 Operation Meeting (AO, HS, YJ, BB, NN, AD, HM, AH). Hydro-acoustic, Bathymetric and SBP surveys showed no flare but diaper-like structures at the north part during the last night survey. Lavrentyev should leave Study Area No.4-3 at 13:00 to be at Port Korsakov before seven o'clock of August 26. Dr. Minami presented a talk on pore water chemistry.

	10:14	Fault images were observed by Hydro-acoustic and SBP surveys.
	16:30	A large fault (Western Sakhalin Fault; 200 m offset) was observed.
	17:00	Group Photo.
	18:00	Hydro-acoustic, Bathymetric and SBP surveys completed in Study Area 4-3. Lavrentyev sailed toward Port Korsakov. Dasha presented a talk about GIS project operation.
	20:10	Hydro-acoustic survey showed two flares at shallower places (145 and 130 m WD).
	21:33	Hydro-acoustic survey showed four flares at shallower places (118 m WD) near the end of Study Area No.4-3. Lavrentyev stopped (engine adjustment).
	23:30	Lavrentyev started to sail to Korsakov.
Aug 26 Sun	06:40	Foggy.
	07:25	Lavrentyev arrived at Korsakov Bay.
	09:00	Lavrentyev arrived at a pier of Port Korsakov. Preparations for Customs Clearance started.
	10:00	Customs Clearance and Passport Control.
	12:00	SSGH-12 report drafts collected.
Aug 27 Mon	13:00	Korean team (Jin, Cho) got off Lavrentyev, and left for Incheon by air.
Aug 28 Tue	07:30	Japanese team (Shoji, Minami, Hachikubo, Kotake, Li, Miura, Kubo, Kawagishi) got off Lavrentyev, and left for Wakkanai by ferry. Lavrentyev left Korsakov for Vladivostok.
Aug 29 Wed		Lavrentyev sailed for Vladivostok.
Aug 30 Thu		Lavrentyev arrived at Port Vladivostok.

5.2. List of Participants

Institution	No.	Participants	Task
KIT	1	HITOSHI SHOJI	Co-Chief of Expedition
	2	HIROTSUGU MINAMI	Water Chemistry
	3	AKIHIRO HACHIKUBO	Gas Analysis
	4	YOHEI KAWAGISHI	Water chemistry
	5	TSYOSHI KOTAKE	Gas analysis
	6	KEISUKE KUBO	Water chemistry
	7	RYUJI MIURA	Technician
	8	SHUNYAO LI	Water chemistry
KOPRI	1	YOUNG KEUN JIN	Co-Chief of Expedition
	2	BEOM-JUN CHO	Geophysics
POI	1	ANATOLY OBZHIROV	Chief of Expedition
	2	NATALIYA NIKOLAEVA	Co-Chief of Expedition
	3	ALEXANDER SALOMATIN	HA operation (head)
	4	ALEXANDER DERKACHEV	Coring operation (head)
	5	ANDREY YATSUK	Coring operation
	6	MIKHAIL SAVENKO	Winch operation
	7	VIKTOR KALINCHUK	Coring operation
	8	ALEXANDER KARNAUKHOV	Hydrology (head)
	9	VLADIMIR PONOMAREV	Hydrology
	10	OLGA VERESHCHAGINA	Gas geochemistry
	11	ELENA KOROVITSKAYA	Gas geochemistry
	12	RENAT SHAKIROV	Gas geochemistry
	13	VLADIMIR PROKUDIN	Profiler operation (head)
	14	EVGENY SUKHOVEEV	Profiler operation
	15	ANDREY KOPTEV	Bathymetry
	16	YURIY TELEGIN	Helper for KIT
IO (Moscow)	1	BORIS BARANOV	Geophysics
	2	DAR’YA RUKAVISHNIKOVA	HA operation

5.3. Group Photo

SSGH Project 2012, August 25
Tatarsky Strait
R/V «Akademik M.A. Lavrentyev»