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METHANE DISTRIBUTION IN THE JAPAN AND OKHOTSK SEAS: PROPOSAL FOR GASGEOCHEMICAL STUDY ON EAST SEA OF VIET NAM

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Abstract: Experience for the last 30 years explorations (e.x. KOMEX; CHAOS; SSGH and other projects) in the Japan and Okhotsk Sea regions revealed that natural gases can be direct signs of the deep structures in the marginal seas. Deep faults, tectonic troughs, oil-gas deposits, hot spots, accretion prisms, sources of gas hydrates and mud volcanoes has a number of natural gas features. Helium, hydrogen, methane, hydrocarbon gases, nitrogen, carbon dioxide, sulphur dioxide, stable isotopes of gas compounds, relations of gases can tell us about certain information of deep structures and minerals. Permeability zones also provide the greenhouse gases fluxes (methane-carbon dioxide) from interior into the atmosphere. This article presents also an activity of "Joint Vietnam-Russia Laboratory for marine geosciences and technology" (IMGG VAST – POI FEB RAS).

Key words: *Gaschromatography, Natural Gases, Gashydrates, Oil-gas deposits, Methane flux, Sea of Okhotsk, Japan Sea, East Sea, Viet Nam.*

INTRODUCTION

We use experience from: KOMEX Project (Russia-Germany, 1997-2004) in Okhotsk sea; CHAOS Project (Russia-Japan-Korea, Belgium, Germany, 2003-2005) in Okhotsk Sea; SAKHALIN project (Russia-Japan-Korea, 2005-2006) in Okhotsk Sea; SSGH Project (Russia-Japan-Korea, 2007-2012); MULTISGAS Project (Belgium-Russia, Japan, 2002-2004), Lake Baikal, POI FEB RAS research in East Vietnam Sea in 1980-th, and 40 years research in western Pacific and nowadays in Arctic.

Gasgeochemical studies are the important and key methods for oil-gas and gas hydrate investigation; gas fluxes estimation thru seafloor-sea-air (greenhouse gases); interrelations to earthquakes; oceanography - methane and other gases plumes in water column; gases in marine sediment influence mineralogy and geochemistry; the impact of hydrocarbon gases on biology; coal gases and coastal gases – helps understanding offshore features. For example, concentration analyses of hydrocarbon gases (particular methane) dissolved in seawater column allow us to know the hydrological structure of the ocean or according to temperature and density of the seawater helps us to understand the distribution behavior of dissolved volatile components. Methane anomalies also allow tracing the sea current for many kilometers.

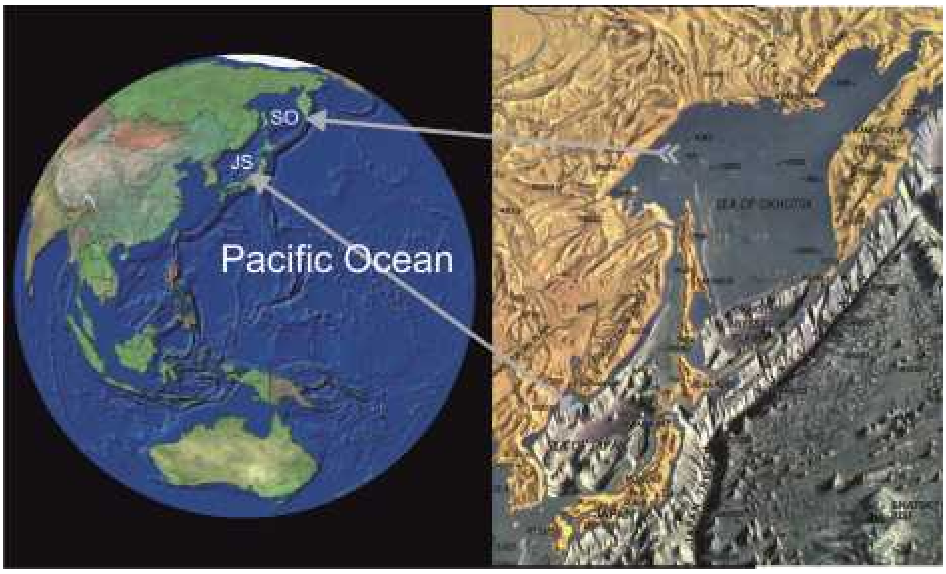

Figure1. The structures of the Japan Sea and Sea of Okhotsk (using the GIS). JS – Japan Sea; SO- Sea of Okhotsk.

According to the listed above gas applications Sea of Okhots and Japan Sea (Fig. 1) are the key marginal seas for study natural gases manifestations related to the deep structures. The Okhotsk Sea belongs to the Okhotsk lithosphere plate, the Kamchatka Peninsula, Sakhalin Island and Tohoku and Hokkaido neighboring with Japan Sea. Recent studies indicate that it is an independent plate and the boundary is a left-lateral moving transform fault zone. On the east, the Okhotsk and Japan Seas are bounded by the Pacific Plate at the Kurile-Kamchatka Trench and the Japan Trench, on the south by the Philippine Sea Plate at the Nankai Trough, on the west by the Eurasian Plate, and possibly on the southwest by the Amur Plate. The boundary between Okhotsk Plate and Pacific Plate is a subduction zone, where Pacific Plate subducts beneath the Okhotsk Plate. Many significant seismo-tectonic events recorded for these seas (Seno et al., 1996; Apel et al., 2006; Arefiev et al., 2006). Many strong megathrust earthquakes occurred here, some of them among the largest on world record, including the Kamchatka earthquakes of 1737 (estimated M9.0~9.3) and 1952 (M9.0). Such strong megathrust earthquakes can also occur near the Kuril Islands, as the M8.3 earthquake of November 15, 2006, Hokkaido, as the M8.3 earthquake of September 26, 2003 and the M9.0 2011 Tohoku earthquake off the coast of Honshu. The boundary between Okhotsk Plate and Amur Plate might be responsible for many strong earthquakes as well as in the Sakhalin Island, such as the MW7.1 (MS7.5 according to other sources) earthquake of May 27, 1995 in northern Sakhalin (Neftegorsk). Other notable intraplate earthquakes such as the 1983 Sea of Japan earthquake and the 1993 Hokkaido earthquake triggered tsunamis in the Sea of Japan, and finally catastrophic – Fukusima Earthquake (March 11, 2011, 8.6M) indicates highest seismicity along the Japan Sea and Sea of Okhotsk tectonic borders. That deep structures activity reflected in the natural gases fluxes from interior to the sea floor, and certain gasgeochemical patterns belongs to the deep geology features. The purpose of artuilce3 is the present an general methane and other gases singularities related to the deep geology issues.

Japan Sea

The gasgeochemical studies on Japan Sea (Fig. 2) resulted in important data of natural gases dissolved in sea water and distributed in sediments. We present the methane distribution in the sea water and sea floor sediments.

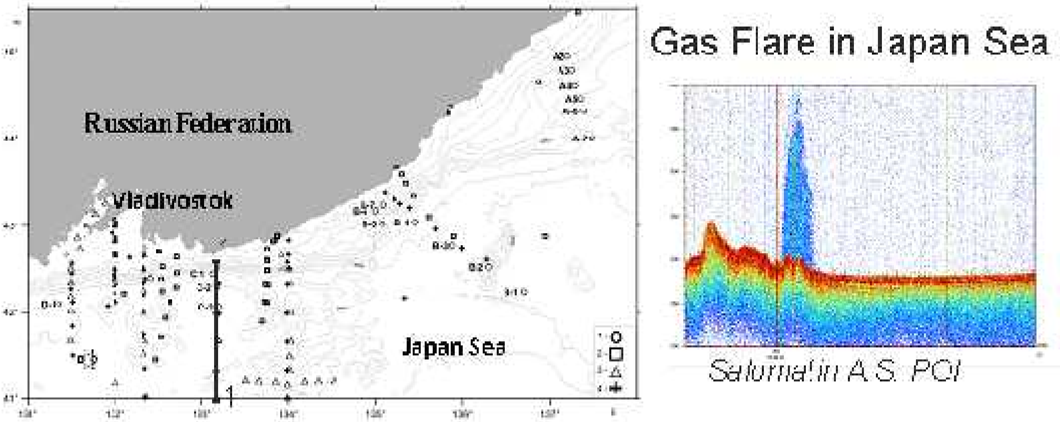

Figure 2. Stations of water sampling: 1 – RV «Academic M.A. Lavrentyev» (cruise 51, August 2010); - 2 - RV «Professor Gagarinskiy» (cruise 30, October 2000); 3 - RV «Professor Gagarinskiy» (cruise 31, April 2001 года); 4 – RV «Academic M.A. Lavrentyev» (cruise 30, April 2003).

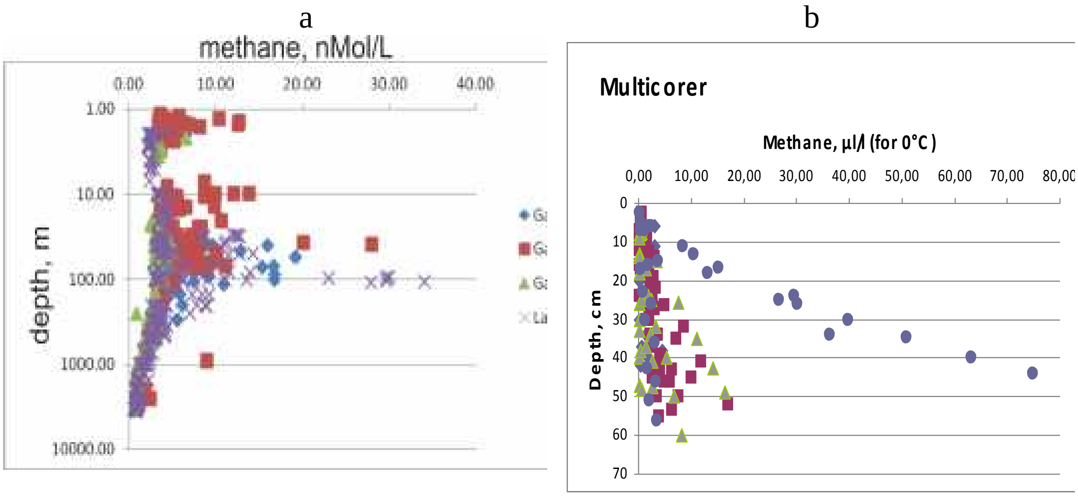

Figure 3. Common vertical profiles of methane in sea water (a) and sediments (b) of Japan Sea (nMol/L) for 2009-2010.. Distribution of CH4 (nmol• L-1) in the subsurface sediments 5-60 cm (Vereshchagina et al., 2013). Profile D show the sharp increase of the methane concentrations within the fault structures.

Maximum of methane concentration were observed on shelf areas (50-200 m depth) and in subsurface water layer on 100-200 meters below sea surface (fig. 3). Minimum methane concentrations 0.5-1.07 nMol/L was found on depth more than 3300 m. In different seasons methane distribution is commonly similar, but has remarkable features in oceanographic phenomena such as eddies, cold water intrusions and depend from geological and seismic state of sea floor. Methane fluxes on sea-atmosphere interface indicates very different fluxes distribution: from 0,01 to 4,4 mol(km^2/day), in average 0,7 mol (km^2/day).

Gas hydrates also recovered by POI in Japan Sea, and certain gas anomalies were traced the deep geological structures (Fig.4).

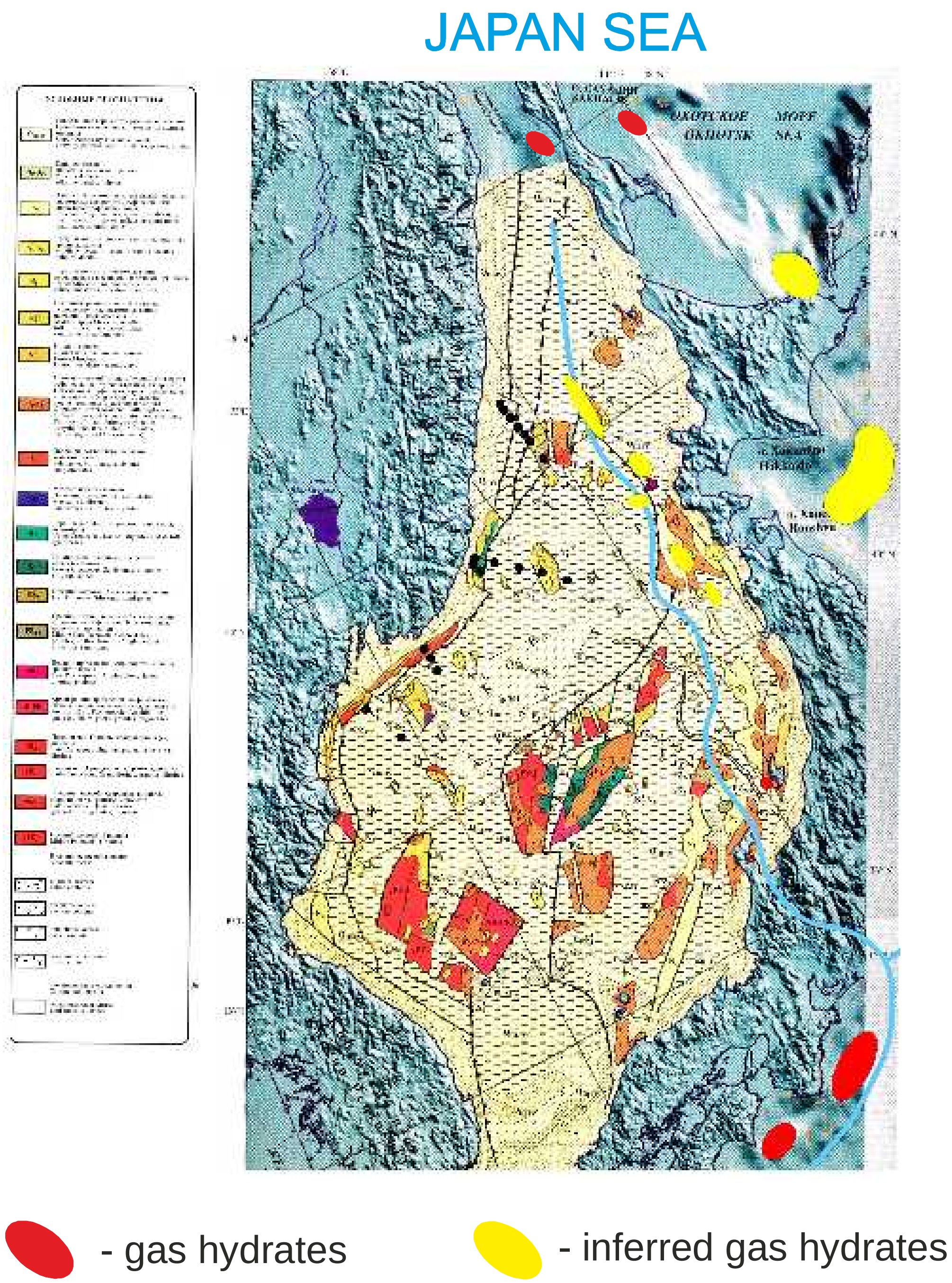

Figure 4. Geology of the Japan according to Lelikov E.P. and Emelyanova T.A., 2004. (POI FEB RAS) and stations of the sediment sampling 2011 (black dots).

1. Methane in surface water layer and its fluxes on water-atmosphere boundary on Japan Sea, 2010

According to measured data of LV-51 (fig. 5) a surface water layer presented warm water with lower salinity of summer modification. Temperature of most part of region was 21-24°C which decreasing to 18°C in northern field. Salinity of water changed from 33.0-33.6 ‰ in open part to 32.1-32.8‰ in nearest to coast stations. Equilibrated methane concentrations varied within from 1.9 nmol·L^{-1} to 2.5 nmol·L^{-1} according to measured temperature and salinity of water and atmospheric methane concentration.

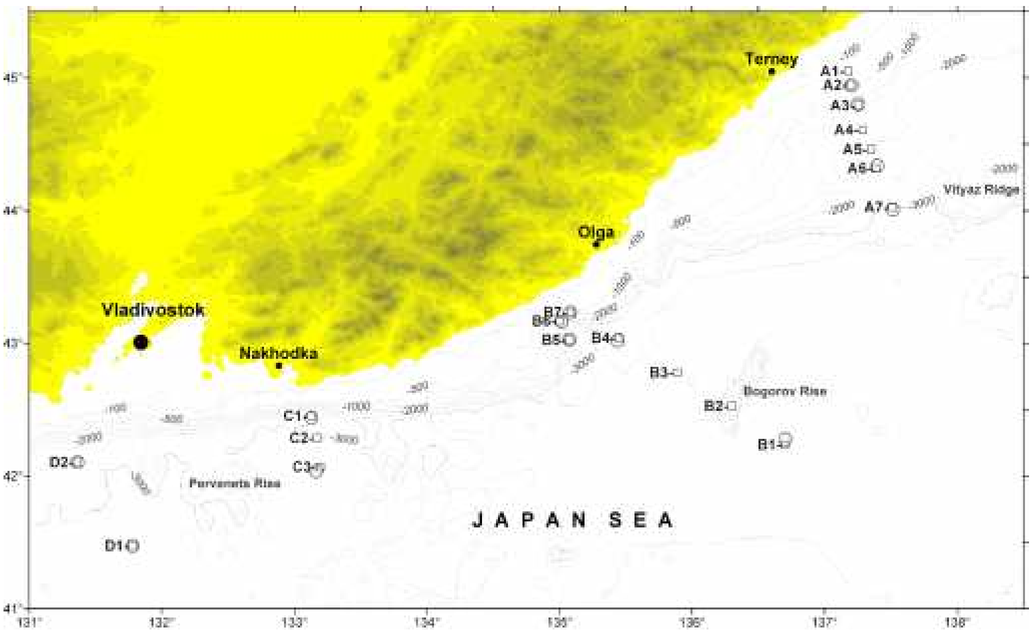

Figure 5. Map of sampling sites LV-51, August 2010: rectangle - CTD-stations, circles – multicorer stations.

The range methane concentration at the surface 2.2 – 4.8 nmol·L^{-1} (mean- 2.7 nmol·L^{-1}) is comparable to the average concentration of 2.8 nmol·L^{-1} in the surface layer of the section along 165° E from 34° to 40° N in the Pacific Ocean (Watanabe et al.,1995). Because of the strong dependence of the solubility of methane from the temperature the average percentage of oversaturation was 21% beside station B3 with ~121% supersaturating for the north-western part of the Sea of Japan during the warm season. Mean data are lower than it in eastern part of the Sea of Japan (Gamo et al., 2012) and in the northwestern Pacific Ocean in 1991 (Watanabe et al., 1995). Lower methane concentrations in surface waters than in subsurface water layer were connected with intensive emission of methane to atmosphere.

Value of ΔCH4 is the different between the measured concentration and equilibrium with the atmosphere, which was already shown to be 0.5 ±0.3 (nmol·L^{-1}) beside station B3 - 2.6 (nmol·L^{-1}). Calculation of methane fluxes at the water-atmosphere boundary showed the heterogeneity of its spatial distribution in the studied sections (Table 1). Variations ranged from 0.0 to 4.4 mol·(km^2·day)$^{-1}$ - average 0.7 mol·(km^2·day)$^{-1}$. The highest methane flux was observed at station B3–4.4 mol·(km^2·day)$^{-1}$. These fluxes were lower than in eastern part of the Sea of Japan (Gamo et al., 2012). Winter temperature of water in November 1995 (R/V "Akademik M.A. Lavrentyev) resulting from the under saturation of surface waters about 50% and net flux was observed from atmosphere to the Sea of Japan.

Strong winds about 10-15 m/s during measurement at A5-A7 stations decreased the methane concentrations in surface and subsurface waters by intensive mixing of water column and fall of methane flux to lowered values.

Magnetic susceptibility of sediment

Samples of near-surface sediments are selected in the north-western sector of the Japan Sea basin and in the Coastal Zone in the area of the continental slope of Peter the Great Bay and the southern base of Sikhote-Alin folded region. The continental slope of Peter the Great Bay of geomorphologic features is divided into two parts: very steep section of rugged underwater canyons allocated between the lower edge of the shelf and to a depth of 2000 m (Station C-1) and the lower part - a large base (station D-2), formed as a result of sedimentation processes (Lipkin, 1973). Station B-4, 5, 6, 7 were located on relatively steep part of the continental slope, which is a submarine canyon in the southern part of the base Sikhote-Alin folded region. Station A-2, 3, 6, 7 are located in the zone of wedging of the continental slope (near the Tatar Strait) on the flat section whose width is nearly three times the width of the continental slope in the vicinity of an underwater canyon. Sampling at stations B-4, C-3, D-1 was carried out on the deep-level areas of the basin. Magnetic susceptibility (æ) of near surface sediment measured in the subtle 10 cm thick layer with the magnetic susceptibility meter (susceptimeter) PIMV-M (Russia). Measuring range æ is $1 \cdot 10^{-5}$ - 1 SI units. Relative measurement error is of <10%. The results of measurements are presented in table 2. In the analysis of the measurements were taken into account the results of the particle size analysis and the content of organic carbon (TOC) in the sediment. Magnetic susceptibility of the sediment is small and is characterized by the values that fall into the interval (0.1-1) $\cdot 10^{-3}$ SI. The most intensive magnetize material, selected in the upper part of the continental slope at a depth of approximately 500 m, station and is 2-5, B-7-2 (Fig. 5). These sandy and silty deposits have an admixture of sand. Additionally marked by the high values of the magnetic susceptibility in a sample taken at a depth of 980m (station B-6-4), represented by small clayey silt. Clay-silt rainfall, selected on the big depth 2600-3660 m (stations B-5, B-1, B-4, D-1, A-7, C-3) are characterized by the lowest in our sample values of the magnetic susceptibility. Increased in 2 - 3 times value of magnetic susceptibility of this sediments were noted only in the base of the layer where the allocated scattered include more large - particle small and medium-grained sands. However, the increase in the dimensionality of the sludge is not always accompanied by the increase of magnetic susceptibility. In the samples taken from plants with A-1 and D-2, the magnetic susceptibility of the sediment on the whole height of the columns does not practically change, although in clayey silt material present the silty miktite.

In the samples taken in the senior D-1, C-1, B-5 noted the high content of organic carbon in the surface layers of the sediment - the high content of methane. Magnetic susceptibility of the precipitation is characterized by low and middle values. In the framework of the tasks of the greatest interest is a sample of precipitation and A-3-7 raised from the depth of 1500 m. Here are allocated clayey silt deposits in the upper part of which noted the slight decrease in the size of the particles, characterized by increased in 2-3 times the values of the magnetic susceptibility. The high concentrations of methane and organic carbon was noted in the near-surface sediments (Fig.6).

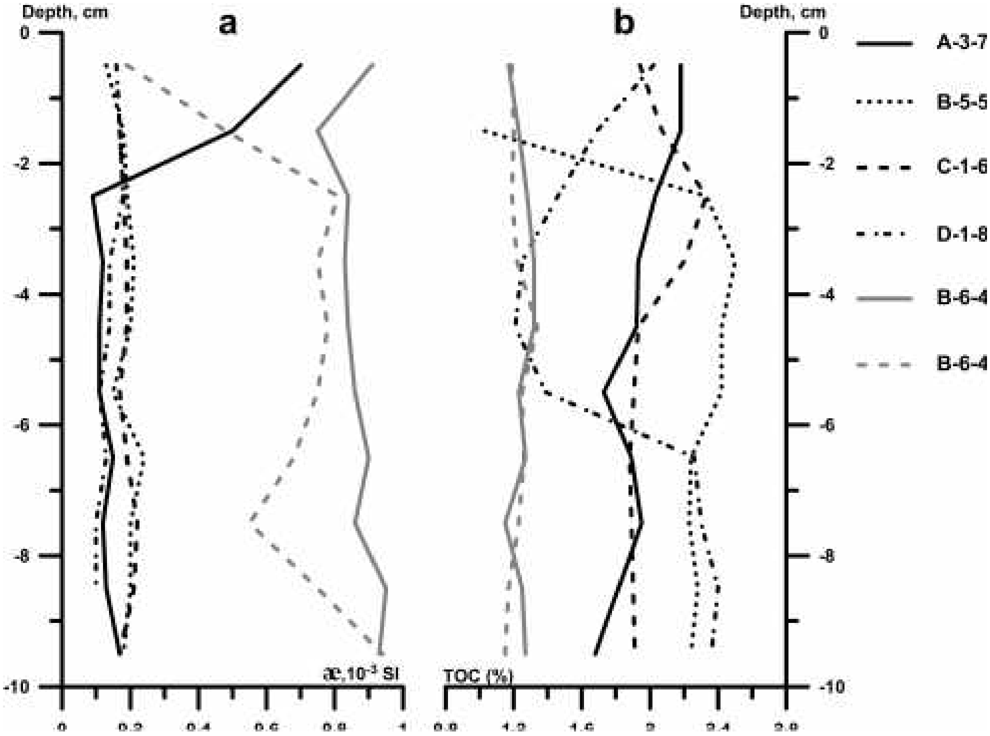

Figure 6. Magnetic susceptibility (a) and organic carbon content (b) of the upper part of the sediment with a capacity of 10 cm (North-Western part of the Sea of Japan).

Some of the gasgeochemical methane anomalies, mapped by gasgeochemistry lab of POI FEB RAS in the Japan Sea belonging to the deep faults are published in Geological maps of the USSR (Fig. 7).

Helium and hydrogen anomalies

Additionally, we added certain information of the helium and hydrogen importance in the deep structures studies. **Helium** – indicator of deep fluids. Helium anomalies are linked to the deep fault zones and also interrelated to the metamorphic rocks. Helium can migrate by deep ground waters and with thermogenic hydrocarbon gases. Helium content in natural gases consist 7 % vol. and rarely higher. Helium has a highest migration activity gas, originated by alpha-reactions in the interior and captured by upraised natural gases flux, e.x.

methane flux. Largest helium accumulation related to hydrocarbon gases: 1) Helium anomalies in the oil-gas deposits (Savchenko, 1935); 2) Oil-gas basins of pre-Paleozoic basement; 3) along margins of oil-gas basins with sediment thickness less than 3 kilometers (e.x. slope of Terpenia Bay basin). In the 1969 the relation of helium anomalies with deep faults were awarded as discovery No. 68 (Russian ministry of natural resources). There are no any data for helium originated in the surface sediments. **Hydrogen** – indicator of active faults and geothermal, hydrothermal and volcanic gases. Free hydrogen is very rare gas and in the air 0,00005 %.

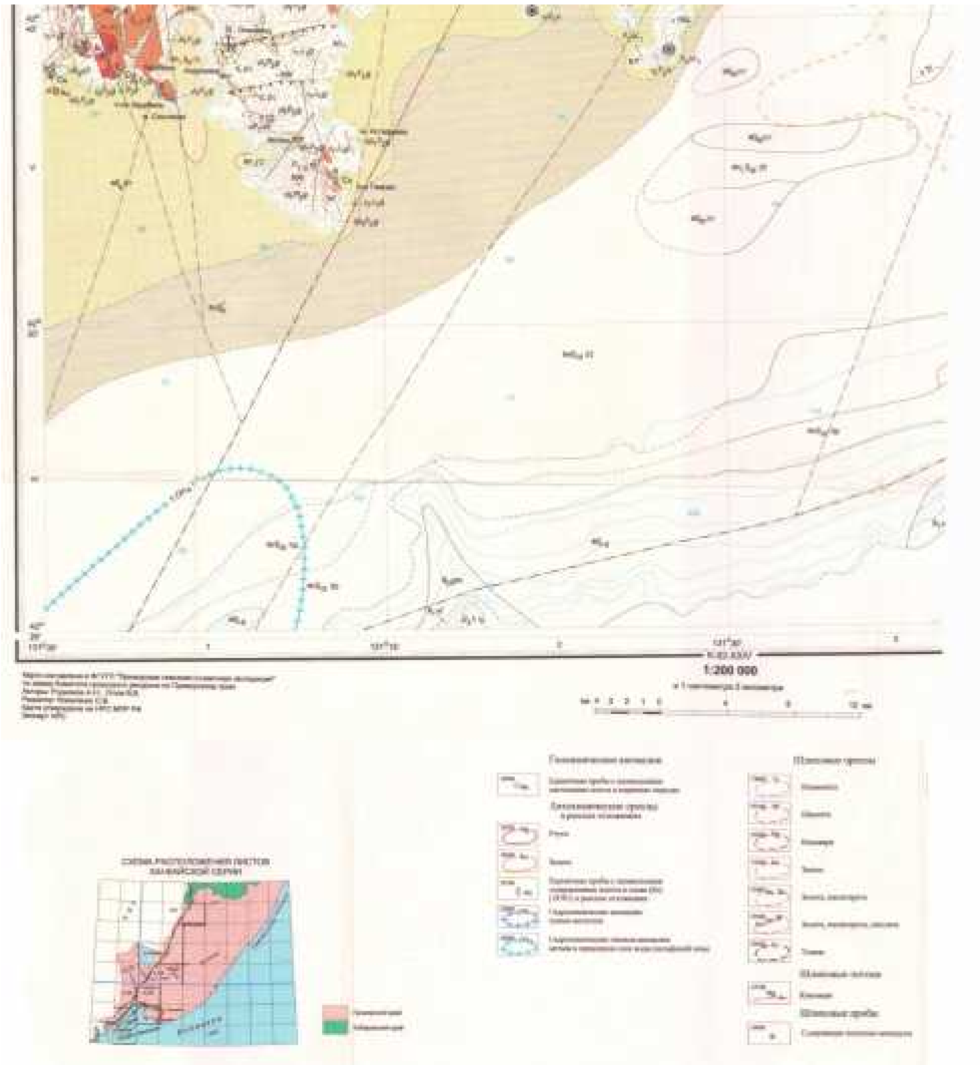

Figure 7. Methane anomaly southward Gamov Cape in south-west of Japan Sea.

25 sediment cores were sampled for helium and hydrogen analyses in total in 2012 (fig. 8-9) head of expedition Prof. Obzhirov A.I.). In the Okhotsk Sea (Terpeniya Bay) 8 sediments cores were sampled, and 17 sediment cores were sampled in the Japan Sea (Tatar Strait). 190 gas samples in headspace were collected for He and H_2 GC analyses.

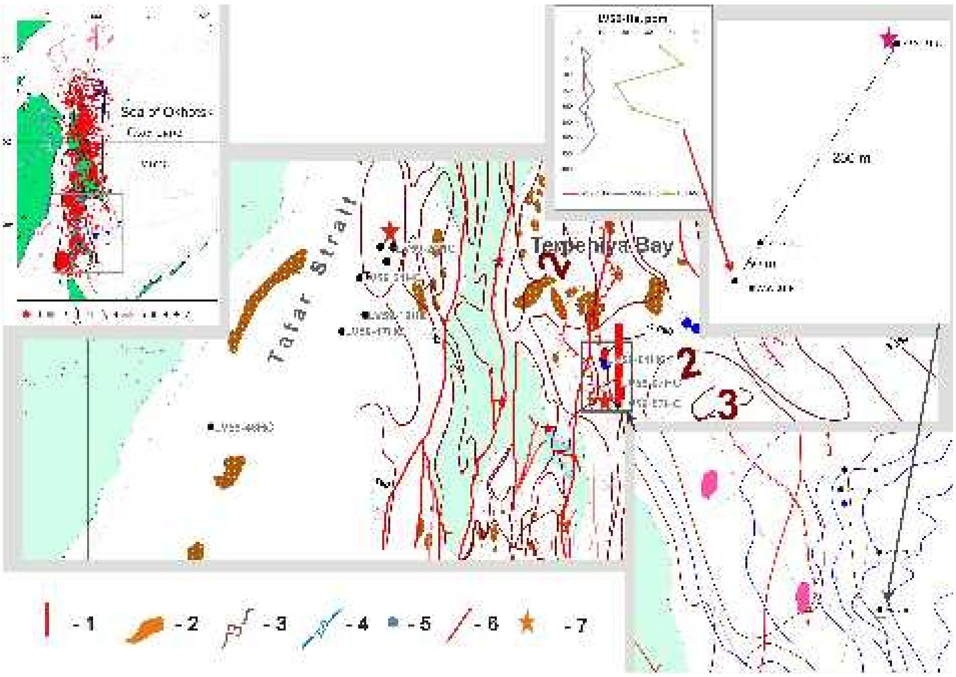

Figure 8. Map of sediment cores (black dots), gas hydrate findings and helium anomaly on the slope of Terpeniya Bay and Tatar Straight. Legend: 1 – bars of methane concentrations (nanoliters/liter) in the sea water near bottom; 2 – local structures; 3 – sediment strata thickness; 4 – depth; 5 – gas flares; 6 – faults (certain); 8 – gas hydrate cores.

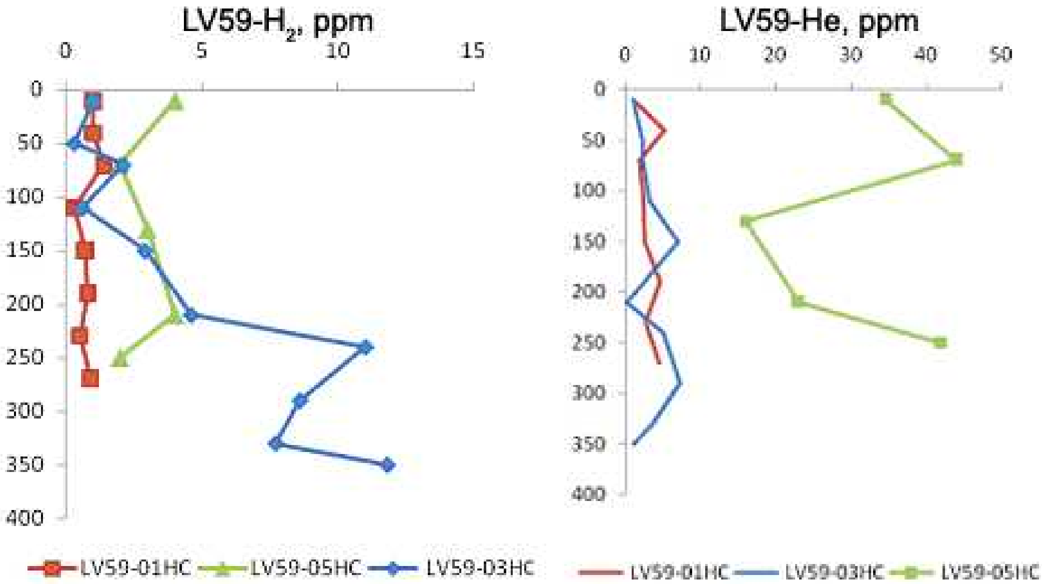

Figure 9. Helium and hydrogen distribution in the 3 sediment cores from the north-west side of Kurile Basin (SE slope of Terpeniya Bay, Sea of Okhotsk).

Very valuable data obtained from the gas hydrate bearing cores(fig. 8 and 9). He and H_2 were measured from the top of this core downward 250 cm. The definitely high helium contents 16-60 ppm (12 samples), ten times exceeded than in LV59-01HC and LV59-03HC cores, and found along 250 cm of core length (fig. 8). Gas hydrate core LV59-05HC is located in the site near the thrust fault. In the end of core the gas hydrate crystals was recovered. The tube sampler (hydrocorer) doesn’t not penetrate gas hydrates bearing dense sediments downward gashydrate interval. Huge concentrations of the methane detected along the whole core. Helium, originated in the deep interior, migrates through the gas (methane) saturated sediments of north-west Kurile Basin. High content of hydrocarbon gases in the sediments of Kurile Basin was reported since late 70-th (Geodekyan, 1979). Hydrocarbon’s generation in 1-3 km sediment thickness relatively high in this area, but organic matter mainly produces the low maturity natural gases (Gretskaya et al., 1992). The helium anomaly clearly supports deep origin of upraised gas flux in the NW side of Kurile Basin. According to the literary data helium is originated in the deep interior and involved to the methane flux, and both lifted up to the seafloor. Helium anomaly in the gas hydrate bearing core proves a deep origin of natural gases (methane and high hydrocarbon gases) which is supplied the hydrate stability zone and crystallized as methane hydrates in the surface sediments in the Sea of Okhotsk. Same time, hydrogen measurements exposed low content 2-4 ppm, and indicate relatively low seismicity in this area as a first consideration according to literary data and gasgeochemistry data set of POI. Thus, helium and hydrogen measurements contribute effective method and important data to the gasgeochemical study of gashydrate bearing sites and deep faults in the Sea of Okhotsk. Preliminary, helium anomaly in the gashydrate bearing core indicates deep origin of the gas flux from the NW margin of Kurile Basin.

Okhotsk Sea

Methane and hydrocarbon gases anomalies in the water column of Sea of Okhotsk we classified according to geological structures and hydrology features as follows. There is the Penetrating Steady abnormal methane fields (AMF) (as a rule 1,000-4,000 nl/l – by 2 orders higher than background) in the Eastern shelf of Sakhalin Isl. including the Terpeniya Bay (Fig. 10). Its distribution allow to conclude, that such type of AMF is the characteristic feature for the shallow water (<200 m) of eastern Sakhalin shelf carrying oil and gas deposits. The one of the most interesting fact is that the maximum of methane concentrations in near bottom water column is being increased evidently from the shallow waters up to the shelf edge. Methane concentrations 500-1,000 nl/l are mostly registered at depths of 50-100 m and 3,000 – 4,000 nl/l- at 100-200 m depths.

The Near-Bottom Steady AMF. The most representative AMF of this type was discovered in the northeastern flank of the Derugin Basin (“Barite Mounds” area). Methane concentrations of 900-5,700 nl/l were measured here in the near-bottom 100 m water layer . In upper layers and outside this area BMF were found only.

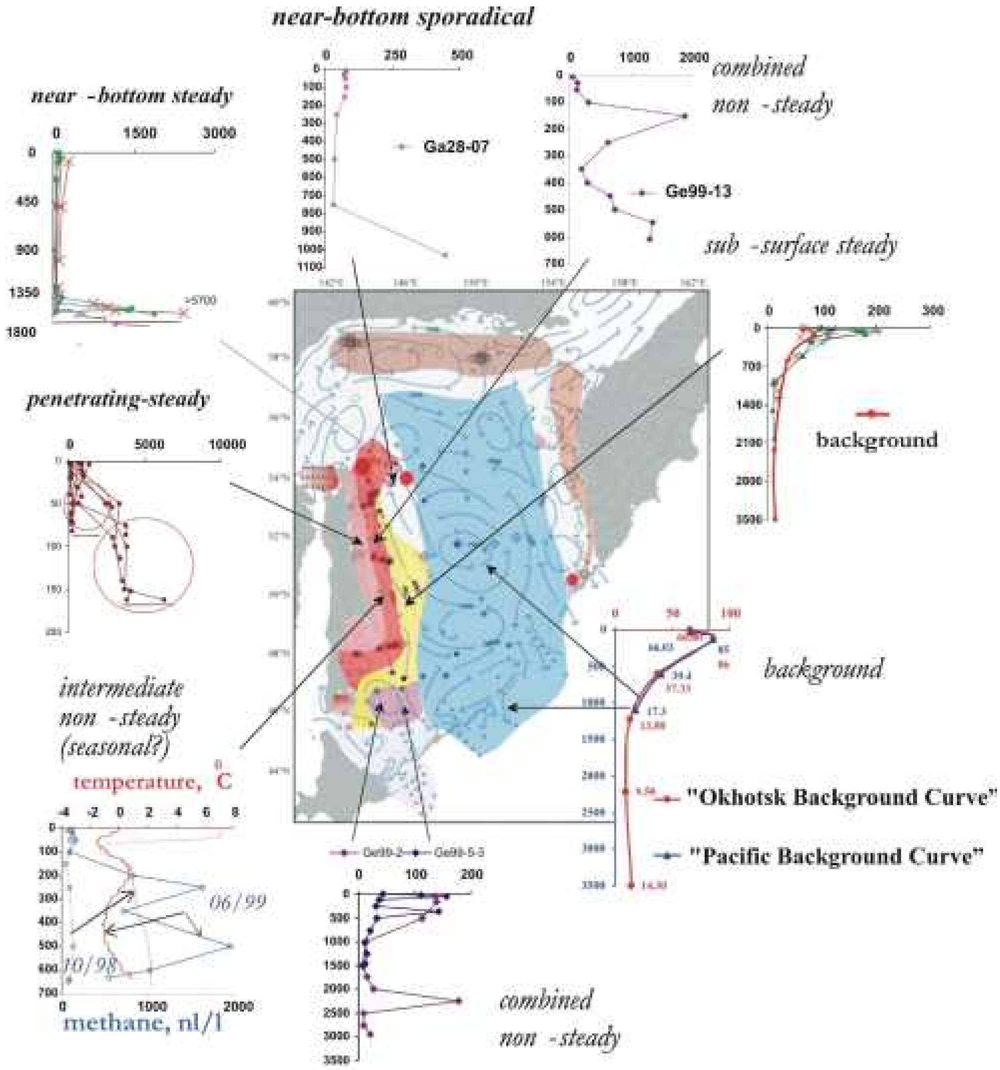

Figure 10. Pattern of the anomalous and background methane fields distribution in the water column of the Sea of Okhotsk. Diagrams: axe X – methane concentrations (nl/l), axe Y – depth (m).

The Penetrating type of AMF is transformed to the Intermediate and Combined non-steady types over the East and South-East Sakhalin slope (depths 200-700 m) and they can be mutually changed at the different periods of observations. The values of methane anomalies are being greatly changed for some time in the intermediate water layers on East Sakhalin slope. For example, the values of AMF observed in late spring (May, 1999) are greatly prevailed the last one in autumn. These differences like to be caused by the seasonal characteristics in the hydrological state and the water dynamic in this area and vertical temperature profiles for these seasons confirms this supposition. Deep AMF are sometimes observed in the western part of the Okhotsk Sea. For example, in the western side of the Kurile Basin the slight Deep methane anomalies were detected repeatedly during several surveys in deep water mass (below 1000 m level). The Subsurface Steady AMF is observed in the subsurface cold layer of the East and South East areas around Sakhalin slope (900-1500 m depth). In that areas the slight but stable increase of methane concentrations by 70-150 nl/l over the background values are recognized during observations. Surface Steady AMF were never traced alone, but they are always recognized in the surface waters of Eastern Sakhalin shelf and slope inside the Penetrating and Combine AMF. Penetrating and Combined AMF also typical for gas hydrates (Fig. 11). The methane anomalous fields are gradually transformed to the background field with the subsequent decrease of the methane concentrations in the near-bottom, deep, intermediate, subsurface and surface water masses from eastern Sakhalin shelf and slope toward deep areas in the Okhotsk Sea and Kurile Basin. The basic pattern of anomalous and background methane fields distribution are illustrated on the Fig. 10.

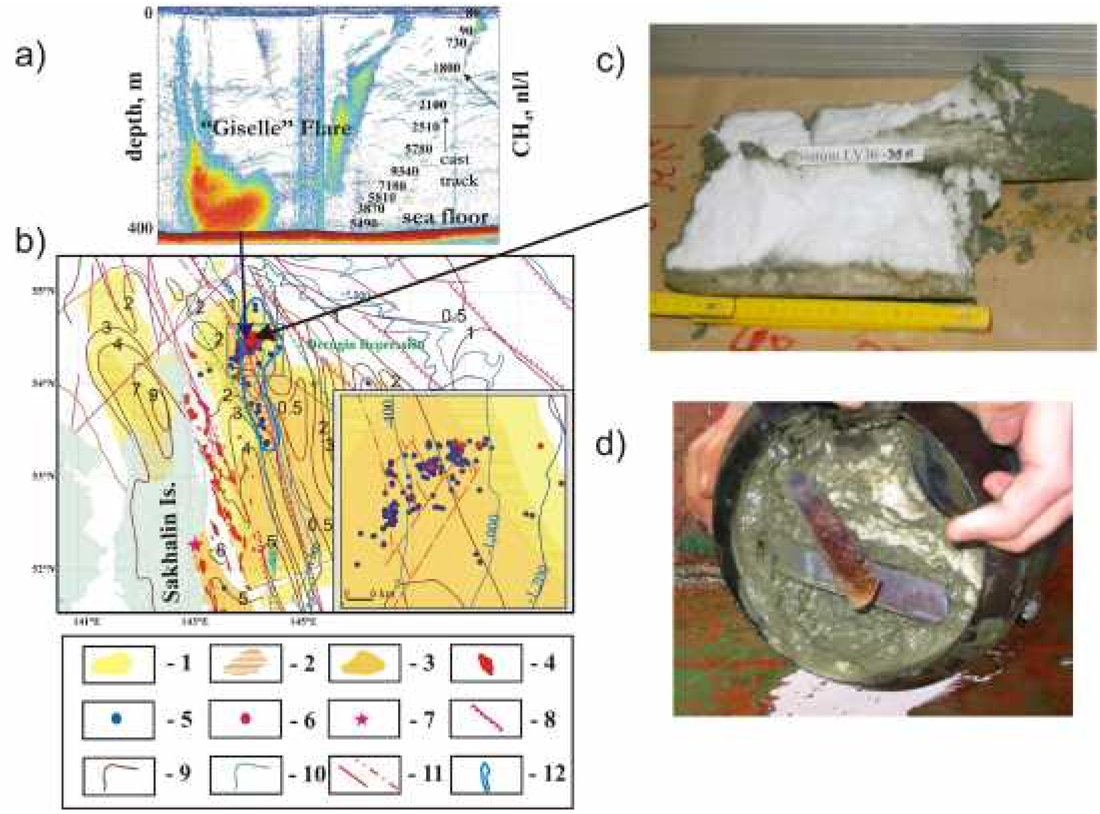

Figure 11. Gashydrates in the Sea of Okhotsk (NE slope of Sakhalin Island). a – gas flare; b – geological structure of gashydrate cluster; c – piece of gashydrate; d – gas hydrate bearing sediment core.

2. Effective methods and equipment for gasgeochemical and environmental studies in Vietnamese waters

Our purpose is to suggest an contribution to the analytical methodology for ongoing and planned joint Vietnam-Russia (IMGG VAST-POI FEB RAS) onland and offshore studies in nearest future.

Gasgeochemical studies contains evidently important and leading methods for oil-gas searching; gas hydrate search and study; gas fluxes estimation seafloor-sea-air (greenhouse gases); interrelations to earthquakes; oceanography - methane and other gases plumes in water column; gas in marine sediments influence mineralogy and geochemistry; hydrocarbon gases affects biology; coal gases; coastal gases – helps understand offshore features. For example, in oceanography analyses of hydrocarbon gases (particular methane) dissolved in water column related to hydrological structure and according to temperature and density helps understand the feature of dissolved volatile components distribution behavior. Also, methane anomalies allow tracing a sea current for many kilometers (Fig. 12).

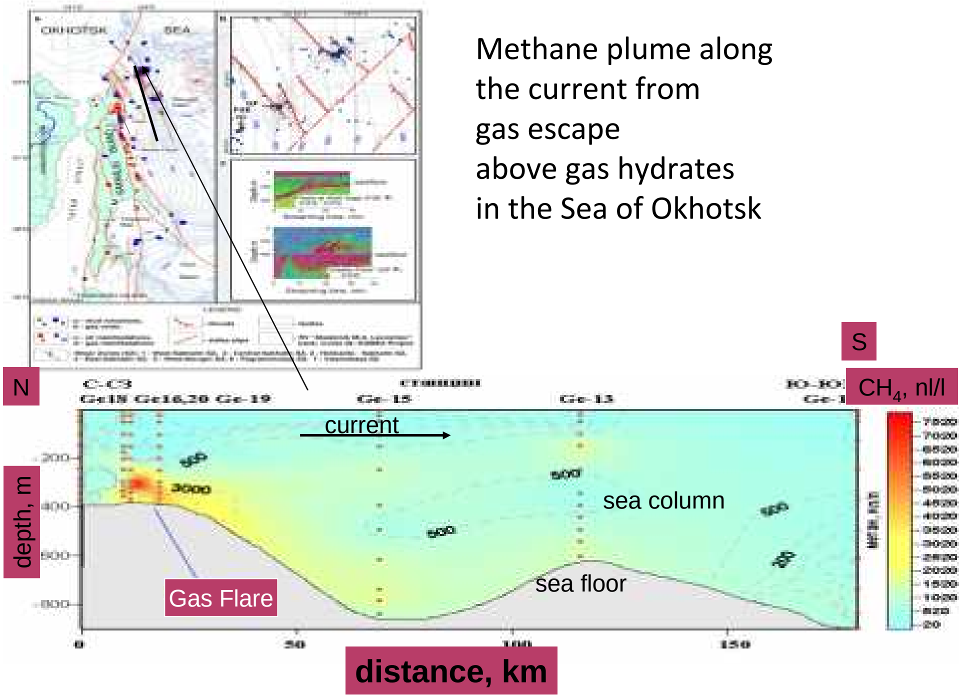

Fig 12. Methane distribution along the current in Sea of Okhotsk.

Gasgeochemical fields interrelated to earthquakes: gas flux and compositions increased during/after seismic events – earthquakes.

We suggest to measure next gases for application in Vietnam waters: Methane and HYC (δ^{13}C-CH4) – oil-gas, gashydrates, coal gases, shale gases, gas in marine sediments, greenhouse gas….;CO_2 ($\delta^{13}C$-CO_2) - volcanoes, faults mapping, mud volcanoes, carbonate system, gold deposits, greenhouse gas…;O_2-Ar – N_2 – environment, oil-gas system, mud volcanoes…; He (δ3/4He) faults mapping, depth of shear zones…; H_2 – activity of faulting…; H_2S – redox in sediments, modern-biogenic gas in sediments; SO_2 – volcanic gases… NO, NO_2 – volcanoes, anthropogenic pollution….; CO – volcanic gases, carbonate system, anthropogenic pollution…; Radon gas – very informative Alfa-active gas for fault mapping. All these gases can be analyzed in 3 steps: 1) – gas sampling; 2) gas extraction ; 3) gas analyses. We can provide in detail sea sediment sampling (gravity coring, hydrocoring, box coring, grab sampling..); water sampling (Niskin bottles and unique water samplers); air sampling (pumping et cet.).

Gas extraction from water Gas extraction equipment (maid by Lab of Gasgeochem., POI and already installed in IMGG VAST): ultrasonic-shaking, vacuum, headspace and heat vacuum extraction systems.

Main analytical method: **GC – Gaschromatography; modern gas chromatography replaces chemical and other methods transform physical or chemical properties of gases to electric signal (**separation of gas components; identification of components; quantity estimation of each component) based on separation of 2 and more gas components in 2 flow gas phases (carrier gas and gas sample); sorption (inside long column (tubular) 0,5-6 meters by sorption on solid sorbent grains); jumped passive flow of sorbat (sample of gases); from one active centre on sorbent to other. We propose to use GC’s available in POI (Kristal Lyuks 4000M 9flame ionization and 2 conductivity detectors); AkhTTI; SRI; Ekho EW-PID; Gasochrom 2000 (conductivity and thermochemical detectors); RGA-500 (alfa-active gases measurements)) and to develop such equipment to IMGG VAST.

Gaschromatography can be applied in offshore cruises and onland directly after sampling and avoid the samples transformation during storage. Also we provide chromato-mass-spectrometry based on Shimadzu GCMS QP 2010 Ultra - Unity (NIST 800000 organic compounds, Fig. 13).

Figure 13. Shimadzu GCMS QP 2010 Ultra in Gasgeochemistry Lab., POI FEB RAS.

Our data clearly indicates that gasgecohemistry is very effective but poorly applied on East Sea of VietNam, especially in the deep areas, gashydrates and submarine seepage expected to be distributed in these areas. Some gasgeochemistry anomalies of methane has similar nature comparably to Sea of Okhotsk (Fig. 14).

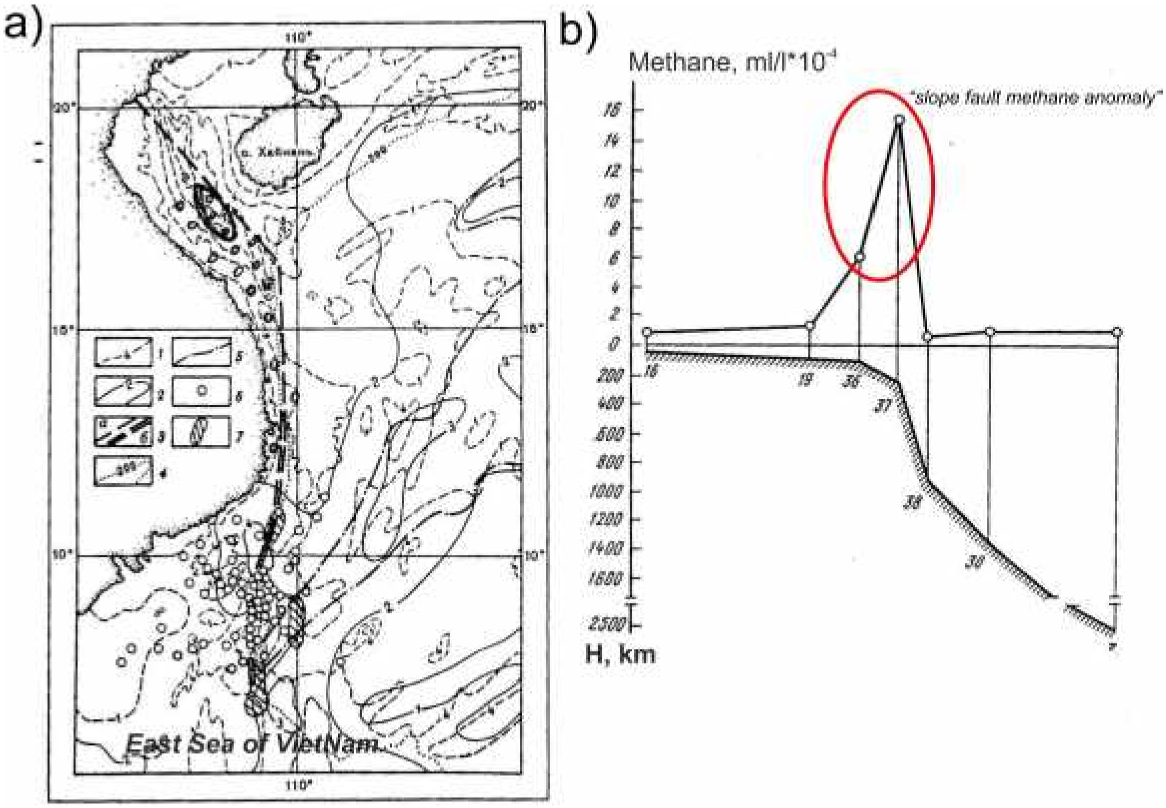

Figure 14. Scheme of gasgeochemical study in the East sea of VietNam during 1983;1989 (head of expeditions Prof. Anatoly Obzhirov). Map of gasgeochemical study on east sea of VietNam in 1989. a) 1 – acoustic basement; 2 – heat flux; 3 – faults; 4 – depth 200 m; 5 – sub-oceanic crust; 6 – gasgeochemical stations; 7 – ultra basic rocks (by geophysical data; b) – methane distribution across South-KonShon Basin (1989).

CONCLUSIONS

The amount of methane in sediments of Japan and Okhotsk Seas Sea increases with depth.

The clay material and sediments composition is a favorable barrier to deep gas, the methane remains trapped at greater depths. At depths of 2000 m CH_4 content in the sediments is higher than at depths exceeding 3,000 m. This effect is probably due to the different processes of sedimentation on the slope and abyssal plain. In addition, the possible slight seepage of methane on the shelf and slope through the thick layers of fine-grained sediments.

Other hydrocarbon (HC) gases are presented in trace amounts in the samples with concentrations below the integration level. The value of unsaturated hydrocarbon gases (ethene and propene) exceeded the level of ethane and propane. Perhaps they are formed in the process of sampling and preparing samples for analysis in contact with oxygen dissolved in saline. In the columns of the station D-2 the alkene concentrations decrease with increasing depth, but alkane increases.

The highest methane concentrations observed in coastal and offshore areas. In the open waters near the surface layer is formed by a maximum of methane in the depth range 20-250 m

With increasing water depth decreases its concentration. For the open waters of the central part of the Sea of Japan found lower concentrations of methane, that along with this water temperature causes a weak saturation of seawater with respect to methane in equilibrium with the atmosphere.

Gasgeochemical fields interrelated to deep geological structures of the Japan Sea and Sea of Okhotsk: gas flux and compositions increased during/after seismic events – earthquakes. Methane and HYC ($\delta^{13}C$-CH4) – oil-gas, gas hydrates, coal gases, shale gases, gas in marine sediments, greenhouse gas….;CO_2 ($\delta^{13}C$-CO_2) - volcanoes, fault mapping, mud volcanoes, carbonate system, gold deposits, greenhouse gas…;O_2-Ar – N_2 – environment, oil-gas system, mud volcanoes…; He - fault mapping, depth of shear zones…; H_2 – seismic activity of faulting…; H_2S – redox in sediments, modern-biogenic gas in sediments; SO_2 – volcanic gases… NO, NO_2 – volcanoes, anthropogenic pollution….; CO – volcanic gases, carbonate system.

The methane anomalies and high hydrocarbom concentrations are linked to the deep gas-fluid fluxes from deep interior structures.

The highest methane concentrations observed in coastal and offshore areas of Japan Sea, and the max peak is always detected in the gashydrate bearing sediments with contrasted amount of thermogenic gases.

Helium and hydrogen is direct indicators of deep and active fault zones.

Comparably, East Sea of VietNam is most promising for methane and other hydrocarbon gases study due to oil-gas deposits distribution, gashydrate promising areas and biological production. Methane anomalies were found in 80-th by POI FEB RAS (Obzhirov A.I.) above the slope area off Viet Nam according to the tectonics pattern. Thus, we suggest renewing gasgeochemical researches and including gasgeochemistry to the ongoing and future oceanographic joint projects.

We suggest developing a Gasgeochemistry in Vietnam in cooperation with colleagues because this is a scientifically important and cost effective method.

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REFERENCES

1. Apel, E. V.; Bürgmann, R.; Steblov, G.; Vasilenko, N.; King, R.; Prytkov, A (2006), "Independent active microplate tectonics of northeast Asia from GPS velocities and block modeling", Geophysical Research Letters (American Geophysical Union) 33 (L11303), Bibcode 2006GeoRL..3311303A, doi:10.1029/2006GL026077
2. Arefiev, S.S. et al. (2006). "Deep structure and tomographic imaging of strong earthquake source zones". Izvestiya Physics of the solid Earth 42 (10): 850–863. Bibcode 2006IzPSE..42..850A. doi:10.1134/S1069351306100090.
3. Seno, Tetsuzo; Sakurai, Taro; Stein, Seth (1996). "Can the Okhotsk plate be discriminated from the North American plate?". Journal of Geophysical Research 101 (B5): 11305–11315. Bibcode 1996JGR...10111305S. doi:10.1029/96JB00532.
4. 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 (2012), http://dx.doi.org/10.1016/j.dsr2.2012.08.017. *In Press, Corrected Proof, Available online 7 August 2012.*
5. Wu, G.H., Cao, S.S., Chen, S.R., Cao, F.T., 2011. Accumulation and remobilization of metals in superficial sediments in Tianjin, China. Environ. Monit. Assess. 173, 917–928.