

# RUSSIAN-JAPANESE COLLABORATION IN THE FIELD OF GAS HYDRATES RESEARCH: PROVEN EXPERIENCE AND FUTURE CHALLENGE

**Tatiana Matveeva**

*Head of Laboratory for the Unconventional Hydrocarbon Resources*

**Academician I.S. Gramberg All-Russian Research Institute for Geology and  
Mineral Resources of the Ocean (I.S. Gramberg VNIIOkeangeologia)**



MINISTRY OF NATURAL RESOURCES AND ECOLOGY  
OF THE RUSSIAN FEDERATION  
FEDERAL AGENCY FOR MINERAL RESOURCES  
RUSSIAN ACADEMY OF SCIENCES



ACADEMICIAN I.S.GRAMBERG ALL-RUSSIA RESEARCH INSTITUTE FOR GEOLOGY AND MINERAL RESOURCES OF THE OCEAN (I.S.Gramberg “VNIIOkeangeologia”)



Scientific Institute Departments

Laboratory for the Unconventional Hydrocarbon Resources



- International Scientific collaboration
- Systematic Geological-Geophysical Studies
- Geological Mapping
- Geology of Solid Economic Minerals of Arctic
- Oil and Gas Content of Arctic and the World Ocean
- Information Systems
- Geology and Mineral Resources of the Ocean
- Geology and Mineral Resources of Antarctic
- Stratigraphy
- Lithology and Geochemistry
- Marine Seismic Prospecting
- Techniques and Technologies of the Marine Geological-Geophysical Investigations
- Geophysical Investigations
- System Geo-Ecological Investigations
- Laboratory of Multilevel Geophysical Monitoring



**ACADEMICIAN I.S. GRAMBERG RESEARCH INSTITUTE FOR  
GEOLOGY AND MINERAL RESOURCES OF THE OCEAN  
(I.S. Gramberg “VNIIOkeangeologia”)**



## Priority scientific directions

- ✓ Hydrocarbon resources of the Ocean
- ✓ Estimation of the petroleum potential of Russian continental shelf
- ✓ Geological substantiation of the external boundary of the continental shelf of Russia
- ✓ Geology of the solid commercial minerals
- ✓ Studies and prospecting for the exploration of oceanic mineral resources
- ✓ **Comprehensive investigation of natural gas hydrates and estimation their resource potential**
- ✓ Geological and geophysical investigations of the Antarctic
- ✓ Geo-ecology and monitoring of geological environment



**ACADEMICIAN I.S.GRAMBERG RESEARCH INSTITUTE FOR  
GEOLOGY AND MINERAL RESOURCES OF THE OCEAN  
(I.S.Gramberg “VNIIOkeangeologia”)**



**Wide international scientific cooperation in field marine geology of  
Arctic, Antarctic, and the World Ocean**

- in frameworks of multi-national organizations
  - Scientific Committee on Antarctic Researches (SCAR)
  - International Arctic Scientific Committee (IASC)
- on double-sided basis with leading scientific marine and polar organizations of
  - China, Germany, USA, Canada, Australia and other countries

**Cooperation projects in field of investigations in the Ocean and Polar  
areas of the Earth**

- Russian ministries and departments
  - Russian Academy of Sciences and Ministry of Science
  - Industry and Technologies of RF
  - Ministry on Extraordinary Situations
- Russian and foreign companies and corporations (on contract basis)
  - Gazprom, Gasfleet, Giprospeetsgas, YUKOS, Rosneft, LUKOIL, Exxon Mobil, Sevmorneftegas

**Scientific collaborators of VNIIOkeangeologia take part in projects  
financed both Russian (RFFI, Integration) and foreign (INTAS, CRDF)  
scientific funds**

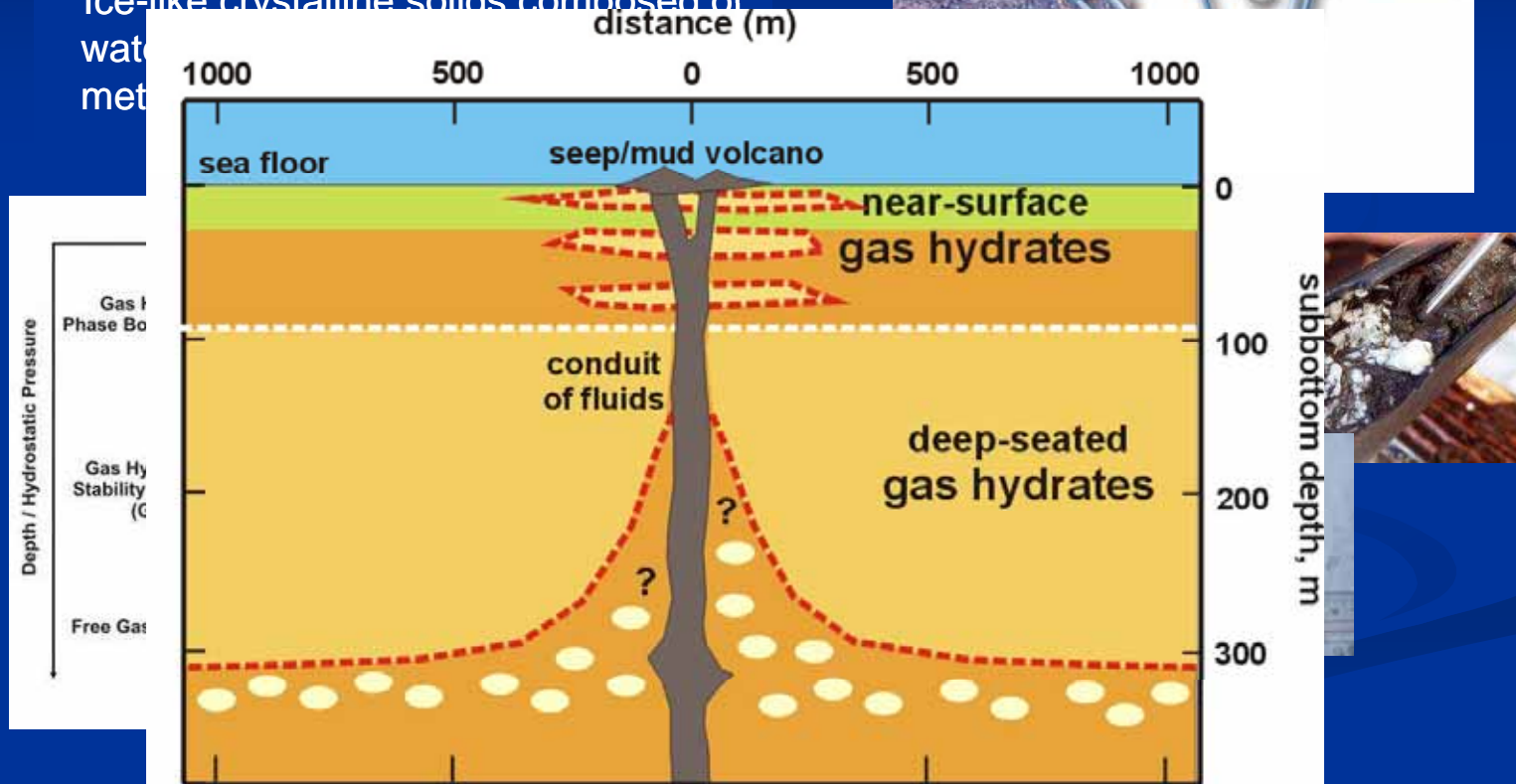
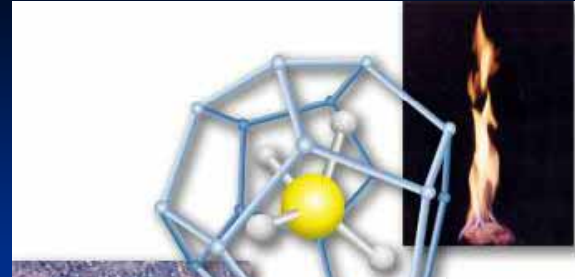
# *Russian-American Long-term Census of the Arctic: RUSALCA*



# Gas hydrates

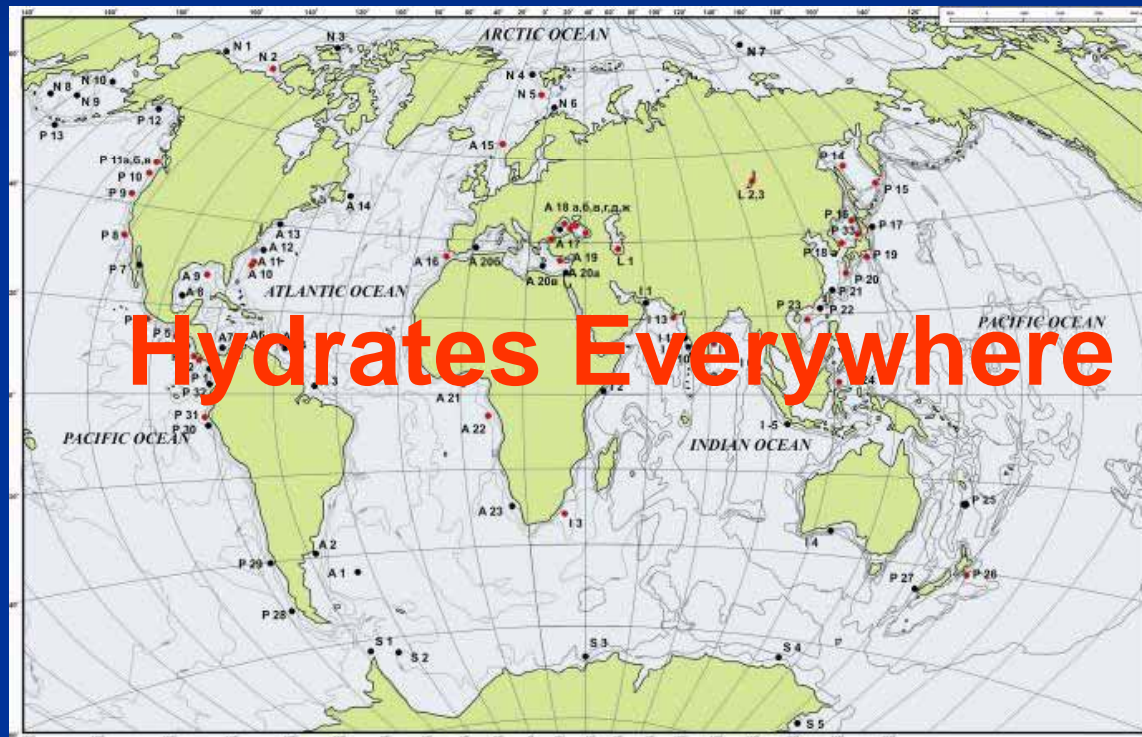
## o What are hydrates?

Ice-like crystalline solids composed of water and methane



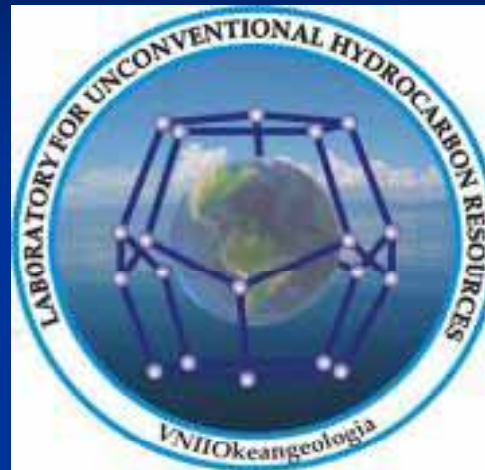
## o Where do hydrates occur naturally?

- Direct observations: 47 Gas Hydrate Accumulations
- Indirect evidences observations: 52 Gas Hydrate Accumulations





## Laboratory for the Unconventional Hydrocarbon Resources



- o Investigation of natural gas hydrates for more than 25 years
- o Studies of a wide range of problems related to submarine gas hydrates
- o More than 20 National and International expeditions focused on the discovery and investigation of gas hydrates of the Ocean





## Laboratory for the Unconventional Hydrocarbon Resources



### The most important problems we study are:

- ✓ Definitions of the size and shape of separate gas hydrate accumulations and development of geological models of their formation
- ✓ Sources and composition of gas hydrate forming fluids (water and gas)
- ✓ Mechanisms of natural gas hydrate formation
- ✓ Thermodynamic and physical-chemical features of natural gas hydrate formation
- ✓ Forecast mapping of gas hydrate-prone water areas of the Ocean
- ✓ Hydrate gas inventory in local and regional scales
- ✓ Noble gases study
- ✓ Authigenic carbonate formation within fluid discharge areas



## Laboratory for the Unconventional Hydrocarbon Resources



### Diagnostic methods for hydrocarbons and gas hydrate survey:

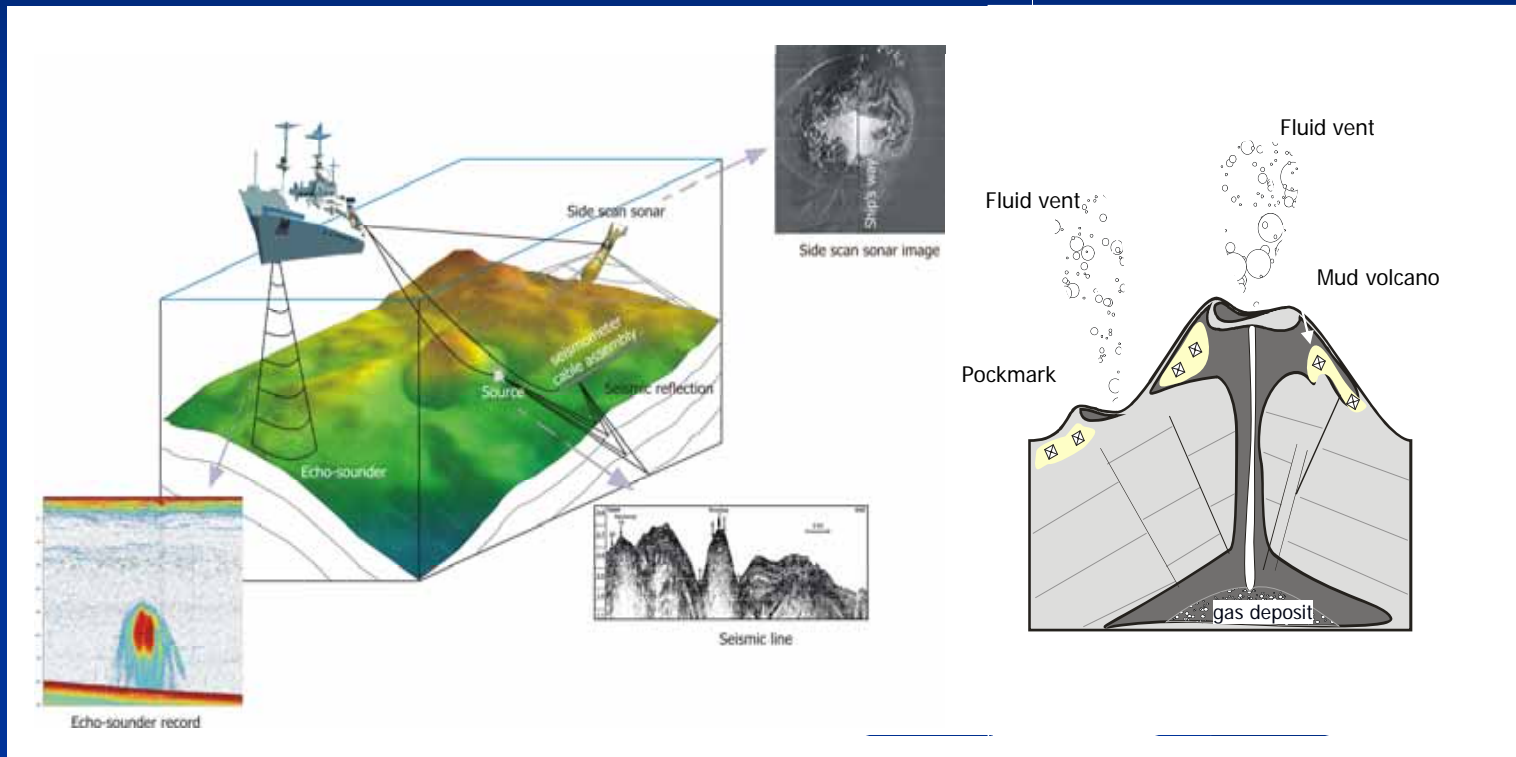
- Side Scan Sonar profiling combined with subbottom profiling
- Seismic profiling
- Echosounder profiling
- CTD profiling with methane sensor
- Heat-flow measurements
- Gravity coring
- Geochemical studies

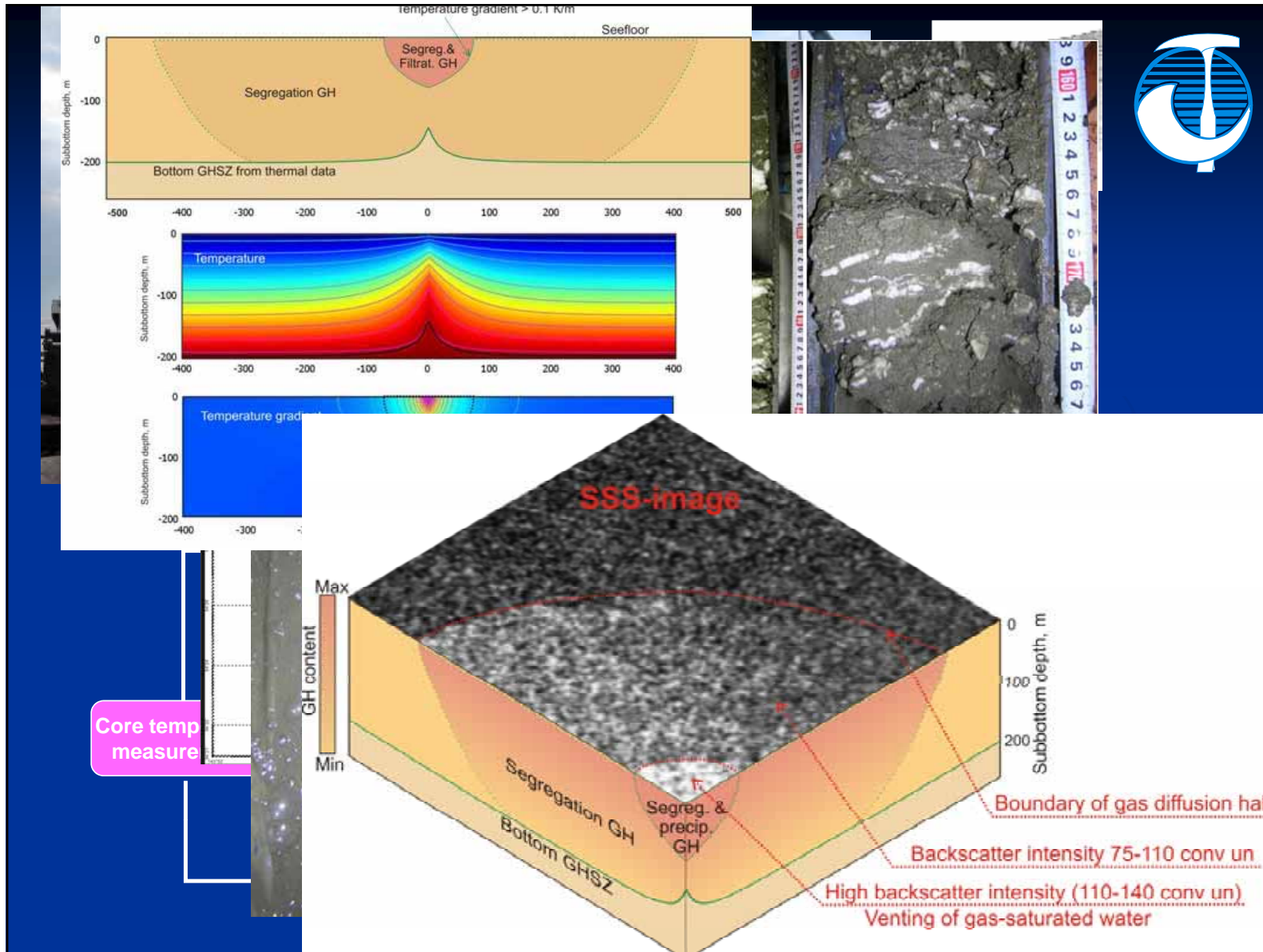


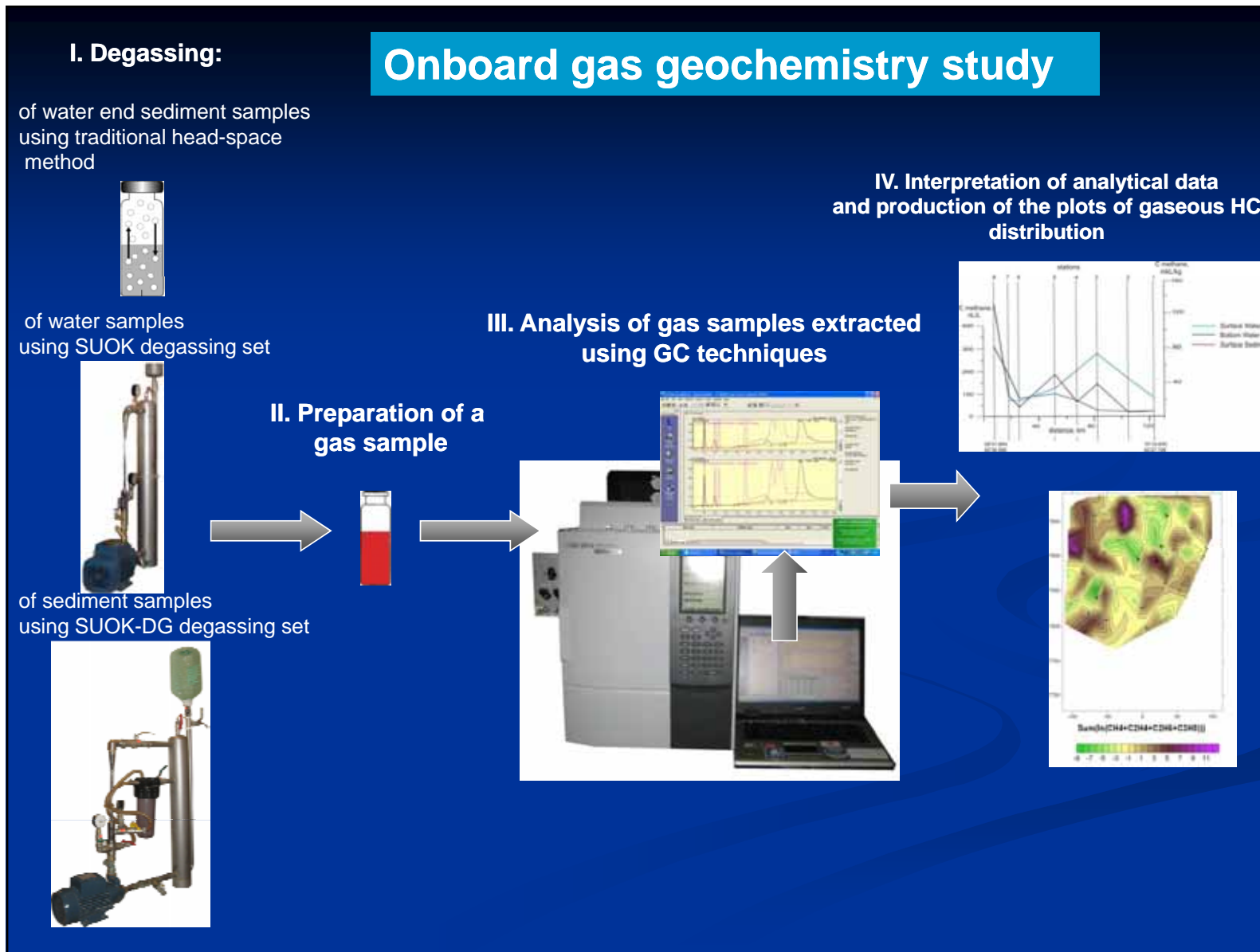
# Laboratory for the Unconventional Hydrocarbon Resources

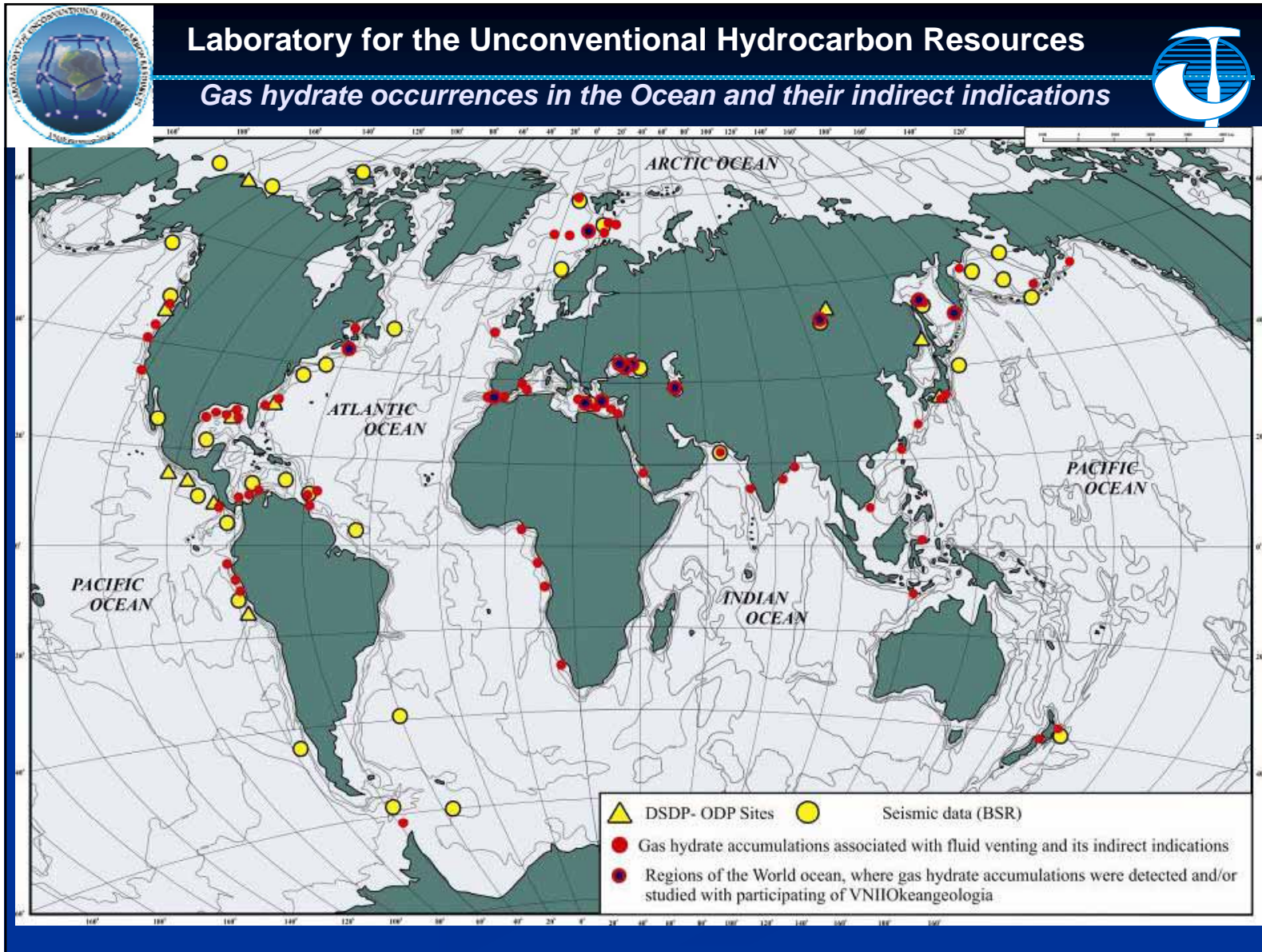


## Shallow gas hydrate survey







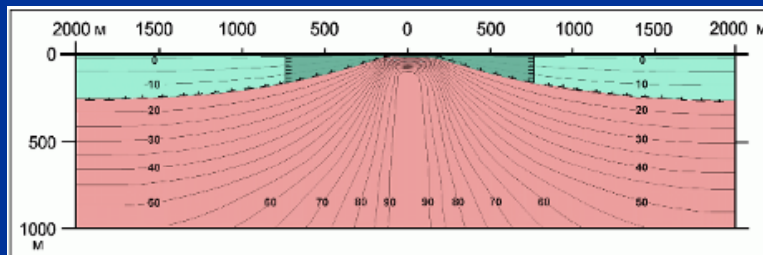
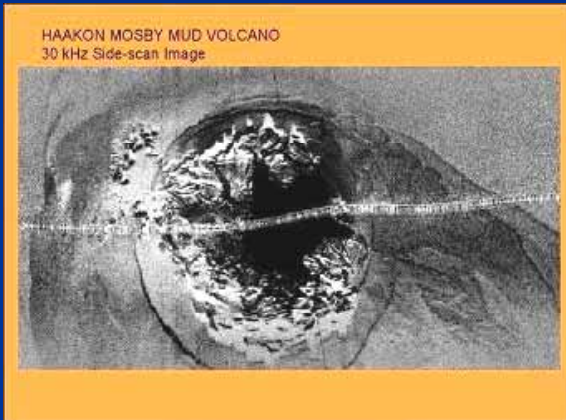




# Laboratory for the Unconventional Hydrocarbon Resources



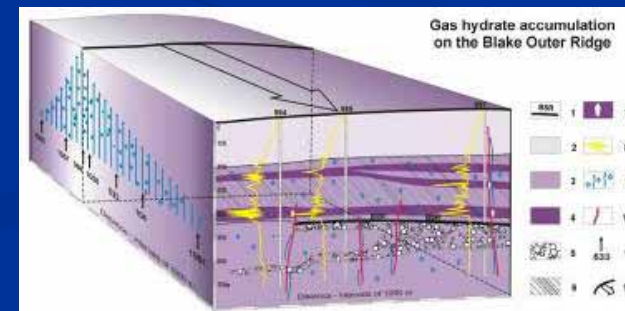
## Norwegian and Barents seas



## Lake Baikal (Siberia)



## Black Outer Ridge

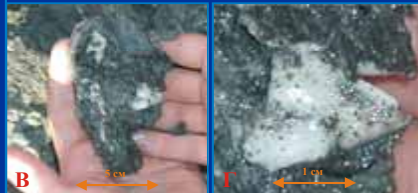
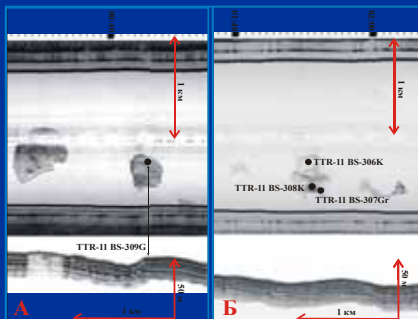
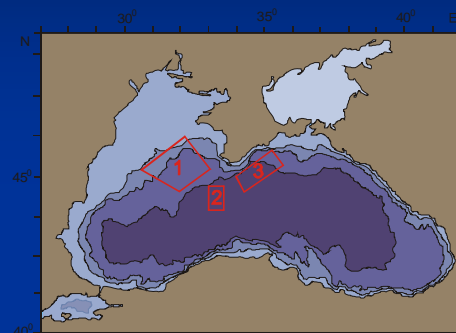




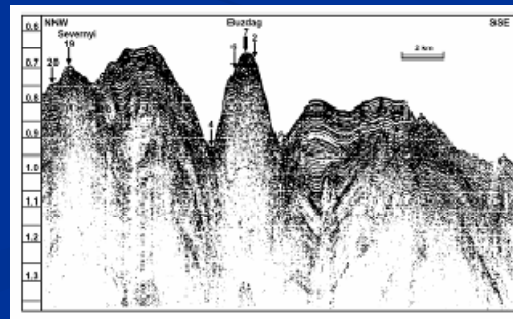
# Laboratory for Unconventional Hydrocarbon Resources



## Black Sea



## Caspian Sea

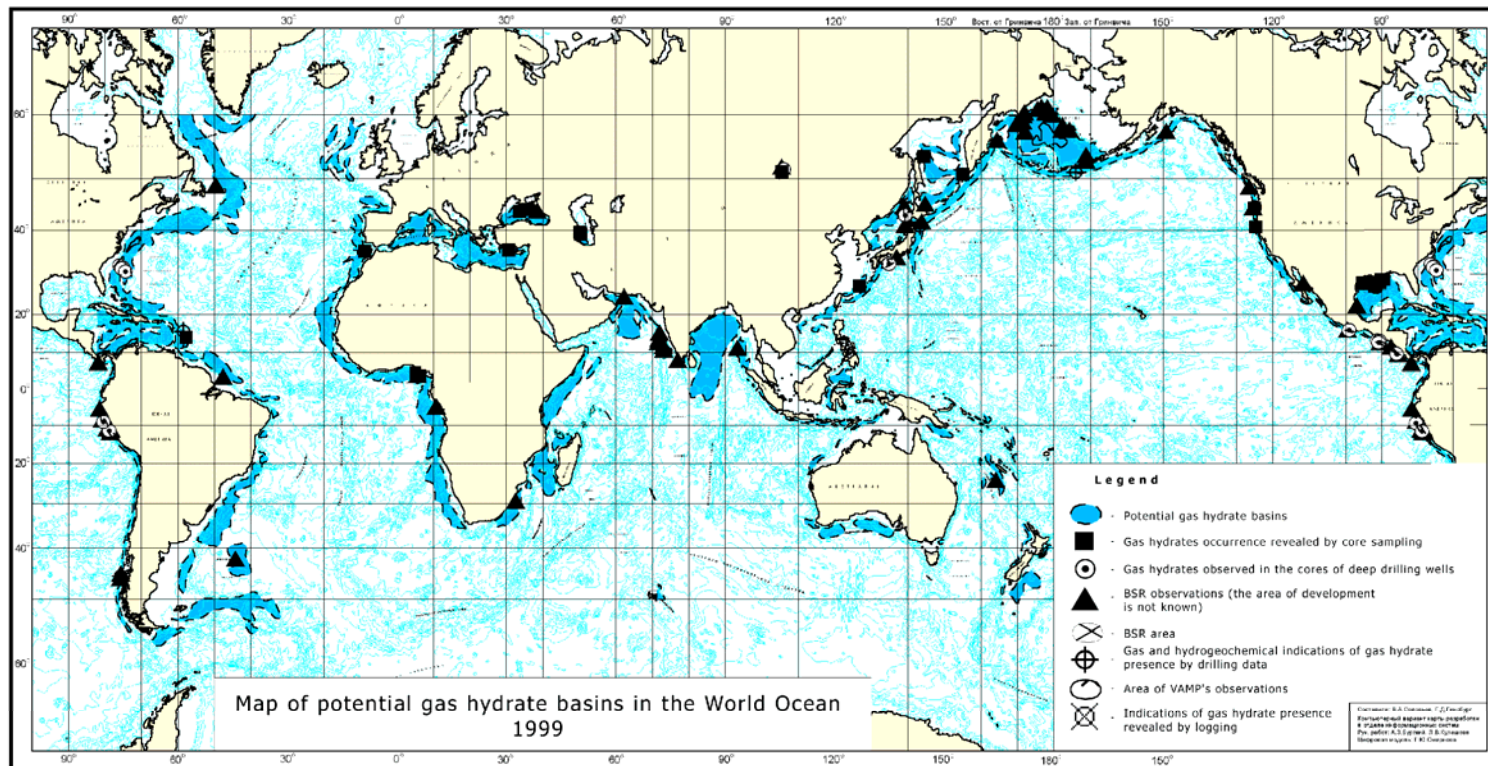




# Hydrate resource estimations



## Potential gas resources in the gas hydrates of the Ocean



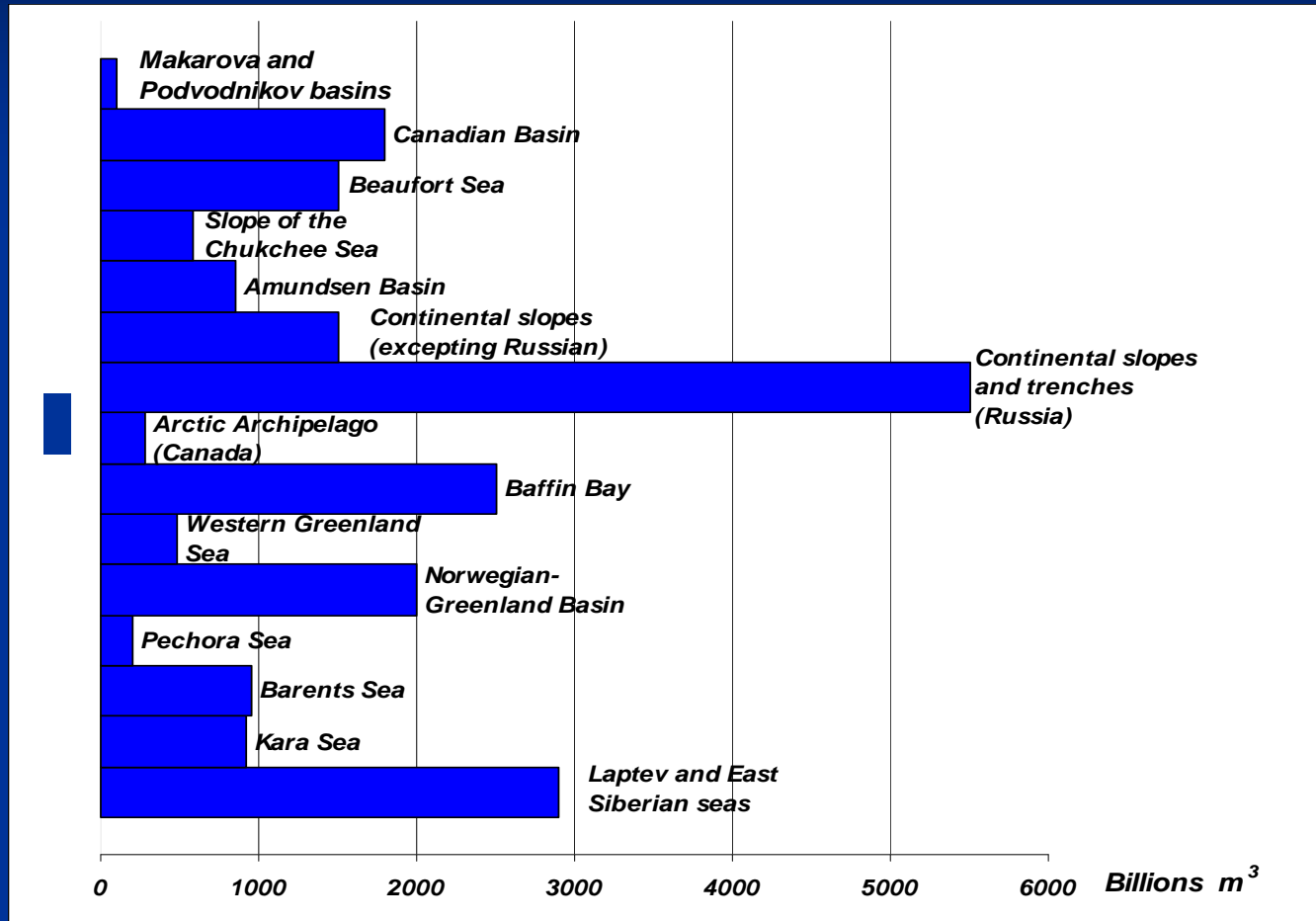
# Resources

## *Global evaluation of methane content in gas hydrates of the Ocean*

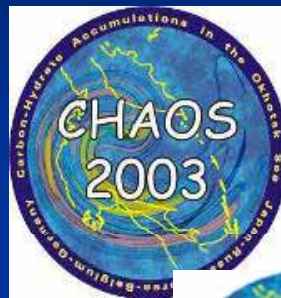
№1	Methane volume, m <sup>3</sup>	Year	Authors
1	$5 \cdot 10^{15} - 2.5 \cdot 10^{16}$	1977	Trofimuk et al.
2	$7.6 \cdot 10^{18}$	1981	Dobrynin et al.
3	$3,1 \cdot 10^{15}$	1981	McIver
4	$4 \cdot 10^{16}$	1988	Kvenvolden, Claypool
5	$1 \cdot 10^{16}$	1988	Makogon
6	$2.1 \cdot 10^{16}$	1988	Kvenvolden
7	$2.1 \cdot 10^{16}$	1990	Mac Donald
8	$2.6 \cdot 10^{16} - 1.4 \cdot 10^{17}$	1994	Gornitz, Fung
9	$2.3 \cdot 10^{16} - 9.1 \cdot 10^{16}$	1995	Harvey, Huang
10	$1 \cdot 10^{15}$	1995	Ginsburg, Soloviev
11	$7 \cdot 10^{15}$	1996	Holbrook et al.
12	$1.5 \cdot 10^{16}$	1997	Makogon
13	$2 \cdot 10^{15} - 2 \cdot 10^{16}$	1997	Dickens et al.
14	$1.8 \cdot 10^{14} = 180\,000$ billions	1999	Soloviev



# Potential resources of gas in hydrates of the Arctic



# Hydro-Carbon Hydrate Accumulations in the Okhotsk Sea (CHAOS)



CHAOS cruise - Institutes and participants 페이지 1 / 2

Institutes and participants' list		
Institute	Participants	Responsibility aboard
 <b>Kitami Institute of Technology, Kitami/ Japan</b> <a href="http://www.kitami-it.ac.jp">http://www.kitami-it.ac.jp</a>	Shoji, Hiroshi Minami, Hirotsugu Sakagami, Hirotsushi Hachikubo, Akhiro Hyakutake, Kinji	co-chief scientist water chemistry gas chemistry physical observations video observations
 <b>Korea Ocean Research &amp; Development Institute, Seoul/ Korea</b> <a href="http://www.kordi.re.kr">http://www.kordi.re.kr</a>	Jin, Young Geun Cho, Jin-Hyung Um, In Kwon	geophysics, acoustics geochemistry, sedimentology paleoceanography, water sampling
 <b>V.I. Il'ichev Pacific Oceanological Institute FEB RAS, Vladivostok/ Russia</b> <a href="http://www.poi.dvo.ru">http://www.poi.dvo.ru</a>	Obshirov, Anatoly Vereshchagina, Olga Derkachev, Alexander Bofus, Anatoly Gorbarenko, Sergey Salyuk, Anatoly Sosenik, Valery Salomatkin, Alexander	co-chief scientist methane measurements mineralogy, sedimentology mineralogy, sedimentology mineralogy, sedimentology oceanography oceanography hydroacoustics
 <b>VNIIOkeangeologiya, St.-Petersburg/ Russia</b> <a href="http://www.vnio.nw.ru">http://www.vnio.nw.ru</a>	Gladyshev, Vyacheslav Srnimov, Boris Matveeva, Tatyana Mazurenko, Leonid Kaulic, Vitaliy Sigacheva, Anna Prokopovich, Polha	side scan sonar side scan sonar geology-geochemistry (sedimentology) geology-geochemistry (sedimentology) CTD, physical properties measurements geology-sedimentology water chemistry
 <b>P.P. Shirshov Institute of Oceanology RAS, Moscow/ Russia</b> <a href="http://www.sio.rssi.ru">http://www.sio.rssi.ru</a>	Baranov, Boris Bourtman, Maria	bathymetry, tectonics mineralogy, sedimentology
 <b>Limnological Institute Irkutsk SB RAS, Irkutsk/ Russia</b> <a href="http://www.lin.irk.ru">http://www.lin.irk.ru</a>	Khlystov, Oleg	video observations
 <b>Renard Center of Marine Geology, Gent/ Belgium</b> <a href="http://allserv.rug.ac.be/~phenrie/">http://allserv.rug.ac.be/~phenrie/</a>	Poort, Jeffrey Verduyssen, Jeroen	heat flow heat flow
 <b>Tethys Geosensuiling GmbH, Kiel/ Germany</b>	Blaschke, Michael	sedimentology, plankton sampling
<b>GEOMAR Research Center for Marine Geosciences, Kiel/</b>	Georgel, Katharina	sedimentology, plankton sampling

[http://www.geomar.de/~kgeorgel/CHAOS\\_cruise/participants.html](http://www.geomar.de/~kgeorgel/CHAOS_cruise/participants.html) 03-06-21

## **Hydro-Carbon Hydrate Accumulations in the Okhotsk Sea (CHAOS)**

### **Main goal:**

Detail study of submarine gas hydrate formation and accumulation within fluid (gas and water) discharge areas in the Sea of Okhotsk

### **CHAOS expectations:**

- ✓ **Further development of fruitful International collaboration**
- ✓ **Create a basis for further investigations aimed to answered on the following questions:**
  - *How the natural gas hydrates formed and accumulated?*
  - *What is the gas hydrate accumulations?*
  - *What kind of geological environments control these accumulations?*
  - *How much hydrocarbon gases concentrate in separate hydrate accumulations?*
  - *What is the possible cost effectiveness of natural gas production from hydrate accumulations?*
- ✓ **One of the important targets is geology-geophysical basis for Russian-Japanese Proposal on deep-sea drilling (IODP) in the Sea of Okhotsk**

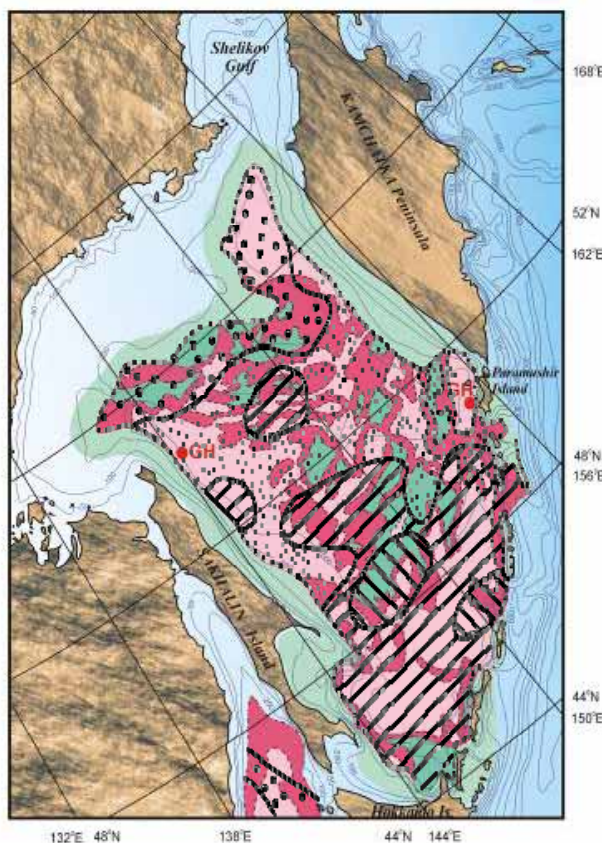




## Laboratory for the Unconventional Hydrocarbon Resources



### Gas hydrate environment of the Sea of Okhotsk and potentially gas hydrate-bearing water areas



Projection: conic equidistant  
 Standard parallels: 21°N and 66°N  
 Central meridian: 140°E  
 Scale 1:7 500 000

#### LEGEND:

I Areas, where hydrocarbon gas hydrates could not exist due to absence of:

- necessary thermobaric conditions
- necessary gas quantity

II Regions, where accumulation of gas hydrates is possible:

- filitrogenous type mainly from catagenous gas
- filitrogenous type mainly from biochemical gas

III Thickness of stability zone of gas hydrates (m):

- < 100
- 100-200
- 200-300
- 300-400

IV Others:

- GH visual observing of hydrates
- The limit of PT stability zone of methane hydrates
- The limit of zone with absence of enough quantity of gas for hydrate formation
- The limit between regions with different thickness of gas hydrate stability zone
- The limit between regions of different types gas hydrate distribution
- Coastline
- Isobaths



## Laboratory for the Unconventional Hydrocarbon Resources



Square, thousands km <sup>2</sup>	Areas, where GH could not exist				Potentially GH-bearing areas				
	Absence of PT-conditions		Absence of necessary gas quantity		Square, thousands km <sup>2</sup>	% from sea square	% from area of GH stability zone	Average sickness of GH stability zone	Max value of GH stability zone, thousands km <sup>3</sup>
	Square, thousands km <sup>2</sup>	% from sea square	Square, thousands km <sup>2</sup>	% from sea square					
<b>1603</b>	<b>753</b>	<b>47.0</b>	<b>130</b>	<b>8.1</b>	<b>720</b>	<b>44.9</b>	<b>84.7</b>	<b>up to 0.2</b>	<b>144</b>

**The quantity of methane in Okhotsk gas hydrate accumulations has been estimated as much as  $10^{12}$ - $10^{13}$  = 1-100 trillions m<sup>3</sup>**

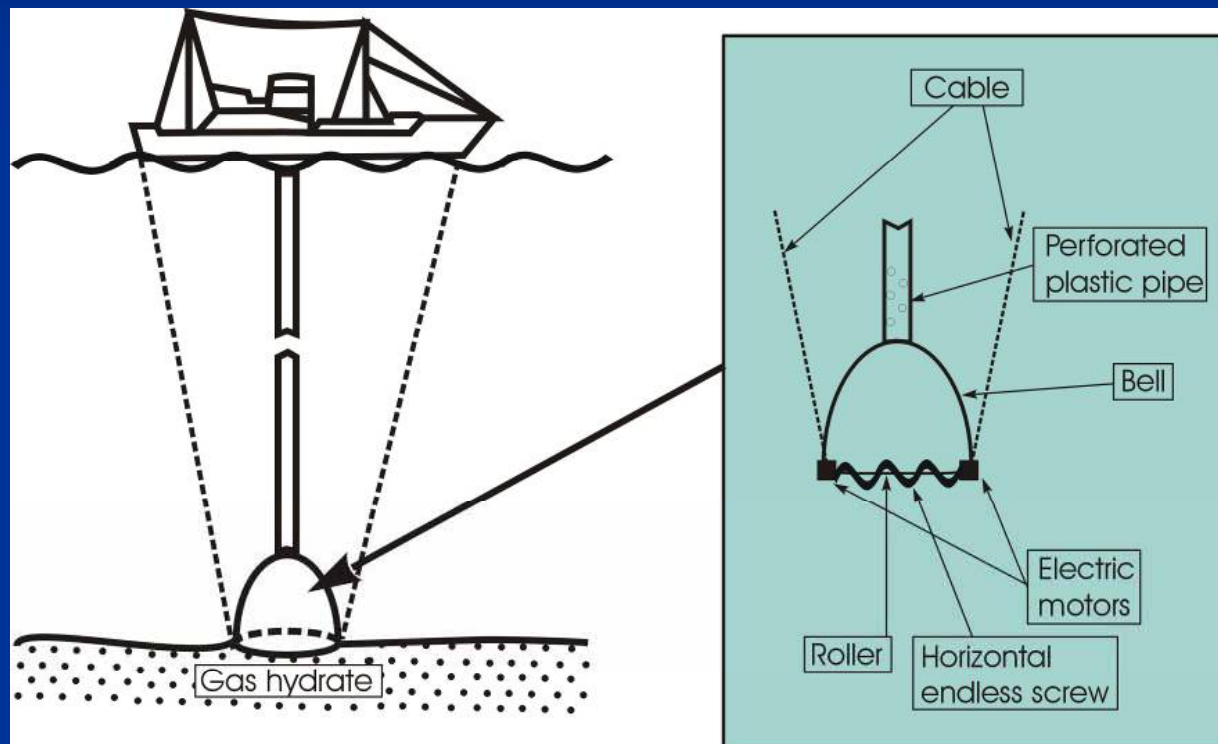




## Laboratory for the Unconventional Hydrocarbon Resources



### Methods of exploration of gas hydrate accumulation GAS HYDRATE EXPLORATION BELL



## **RUSSIAN-JAPANESE COLLABORATION: FUTURE CHALLENGE**

### ***Goals and objectives:***

- ✓ **Investigations of the location, geologic character and volume of methane hydrate in the Pacific Rim water areas**
- ✓ **Development of multi-national research and coordination for the information exchange**
- ✓ **Contribution of knowledge needed for future production of methane from hydrate**
- ✓ **Focus on bilateral theoretical, experimental, marine expedition investigations directed on achievement of specific targets with the development of a new equipment and geophysical methods directed, first of all, on investigation and (quite possible) to exploration in the nearest future of gas hydrates at deep water areas**