Gas Hydrate R&D activities at KIGAM

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Korea Institute of Geoscience and Mineral Resources

KIGAM

KIGAM

- Korea Institute of Geoscience & Mineral Resources
- was established in 1918
  (Office of Geological Survey)

Organization

- 7 Divisions (4 Research Divisions)

Staffs

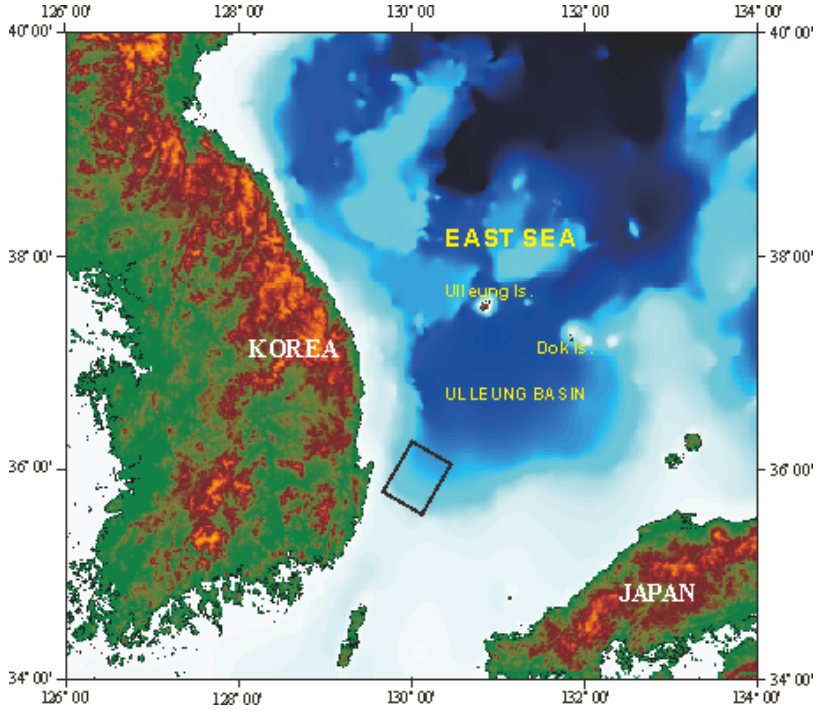
- ca. 450 regular staffs
- ca. 120 temporary staffs & Post Doc.

Organization of KIGAM

Gas Hydrate R&D from 1996 to 1999

- KIGAM's gas hydrate project was launched in 1996.
  - Preliminary research was performed in 1996.

- Basic surveys and geological studies were carried out in the southwestern part of the Ulleung Basin, East Sea of Korea during the period from 1997 to 1999.
  - BSR in the Ulleung Basin was firstly confirmed in 1998.



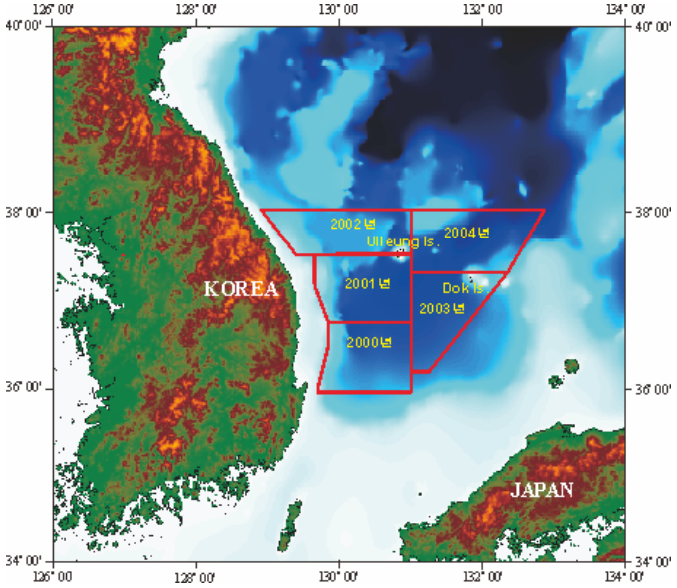
Gas hydrate study area from 1997 to 1999.

Gas Hydrate R&D from 2000 to 2004

- Regional geophysical surveys, and geological and experimental studies on gas hydrate were carried out.
  - to confirm the potential of gas hydrate formation and its distribution in the East Sea of Korea,
  - to obtain the fundamental technologies for gas hydrate development.

- Field data were collected using *R/V TAMHAE II*.
  - 38 piston cores (water depth: 790 ~ 2450 m),
  - 12,366 L-km 2D multi-channel seismic data,
  - 46,300 km^2 multi-beam echo-sounder data.

- Budget
  - 50% from the Ministry of Knowledge Economy (currently Ministry of Trade, Industry and Energy),
  - 50% from the Koreas Gas Cooperation (KOGAS).

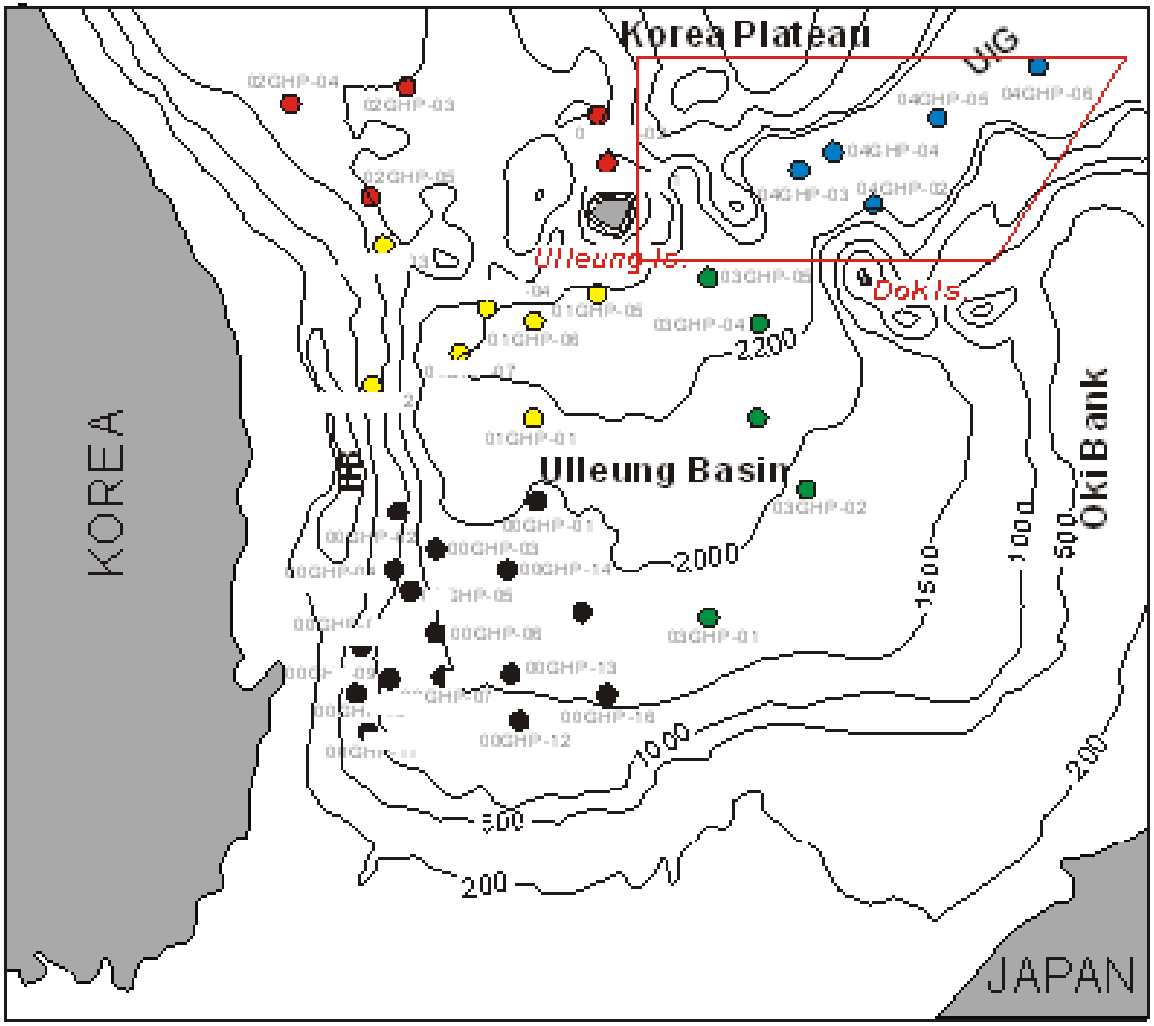


Gas hydrate study area from 2000 to 2004.

Gas Hydrate R&D from 2000 to 2004

Piston corer & cold sample storage
of R/V *TAMHAE II*

Gas Hydrate R&D from 2000 to 2004



Location of piston coring from 2000 to 2004

Gas Hydrate R&D from 2000 to 2004

Gas hydrate survey using *R/V TAMHAE II* (IGT: 2085 t, Length: 64.4 m, Breath: 15 m)

Gas Hydrate R&D from 2000 to 2004

Geological-geochemical analyses

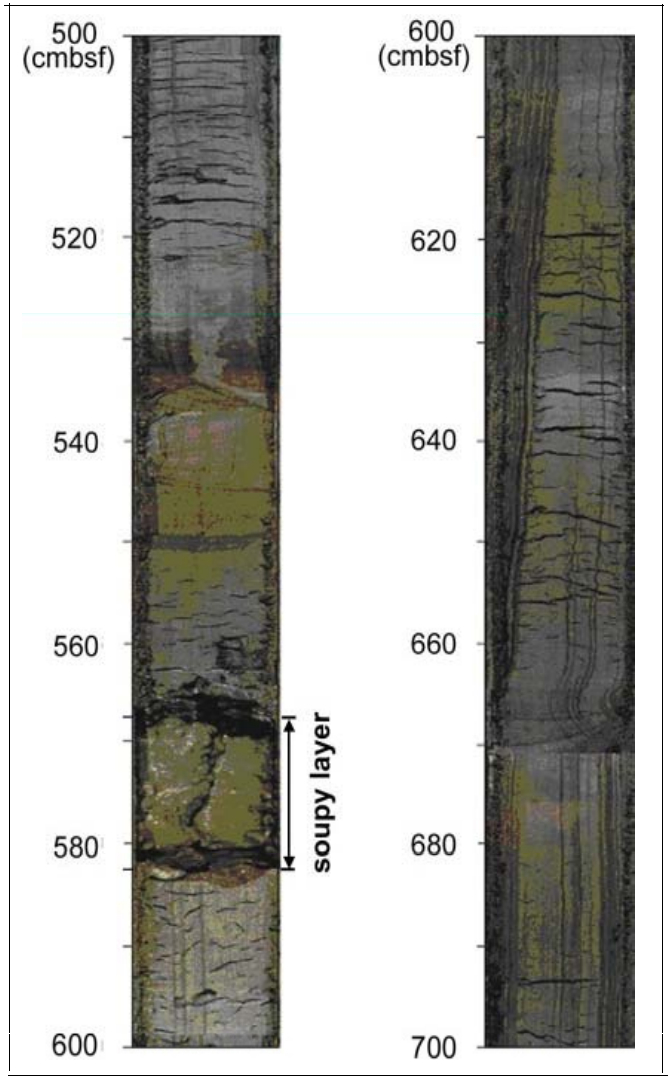
- were performed using piston cores.

=> to determine gas hydrate potential, origin, composition & concentration of gas, amount of upward methane flux

=> to identify geological-geochemical indicators.

: soupy layer

: gas expansion crack, etc.



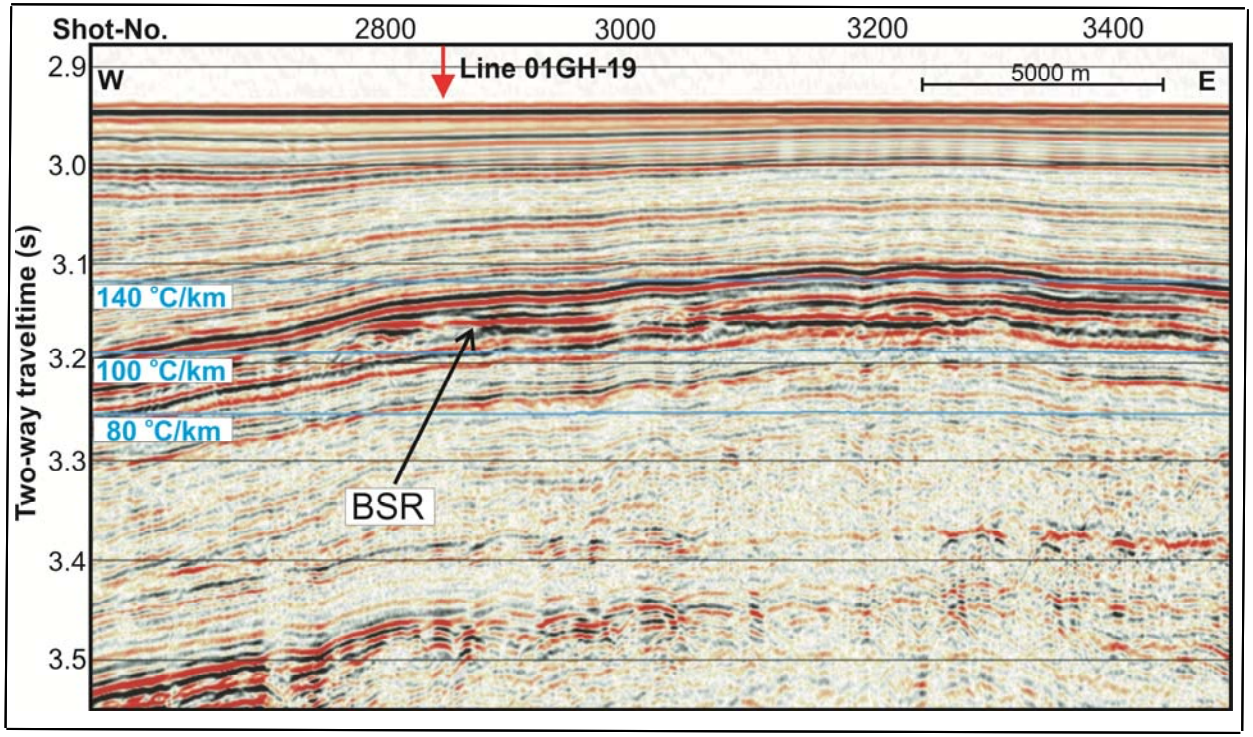
Gas expansion crack and soupy layer
(Ryu et al., 2004)

Gas Hydrate R&D from 2000 to 2004

Geophysical data analyses

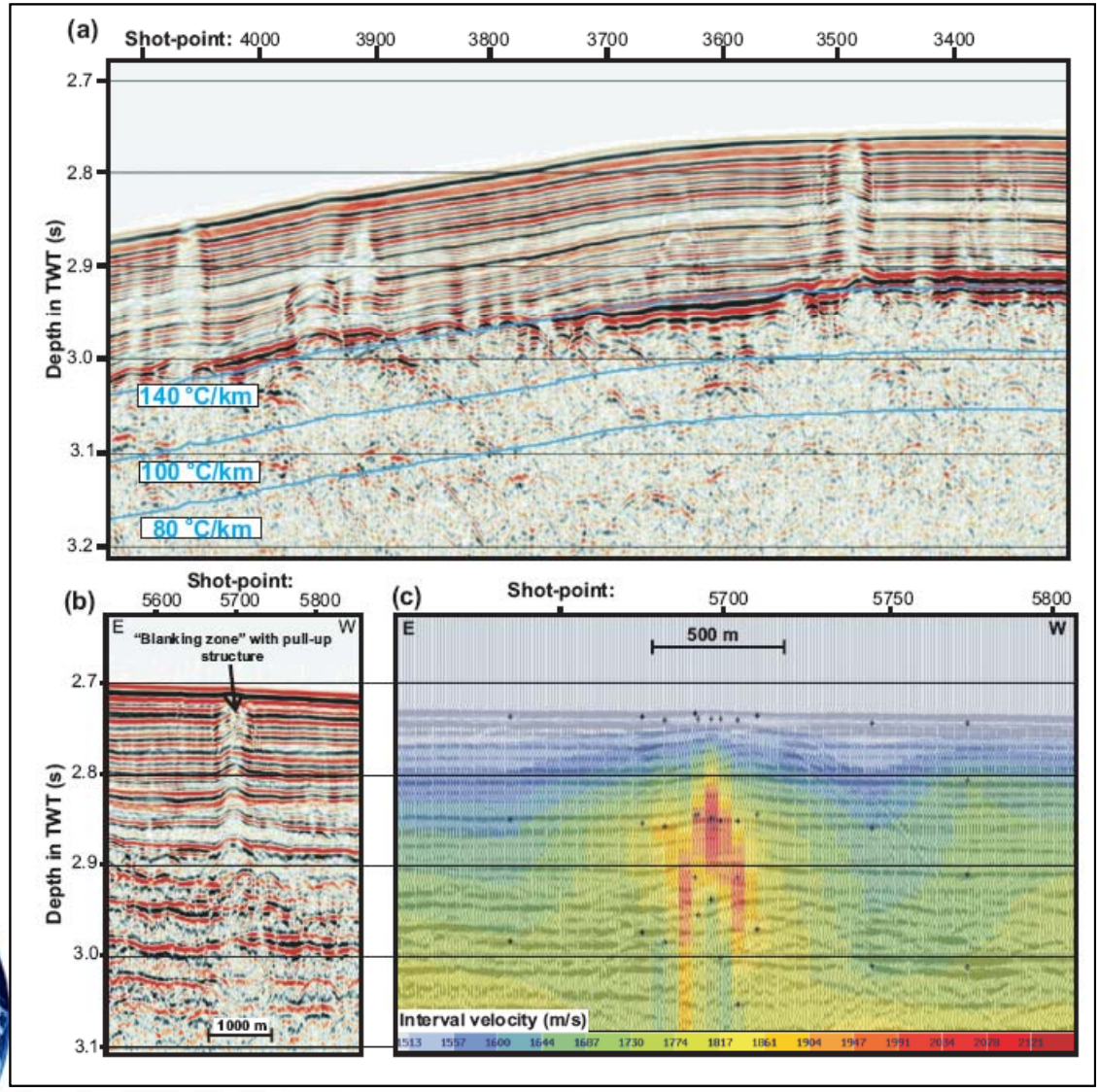
- were performed using geophysical data.

=> to identify geophysical indicators
: BSR,
: chimney structure, etc.



BSR in the East Sea (Ryu et al., 2009)

Gas Hydrate R&D from 2000 to 2004



Chimney showing pull-up structure & high velocity in the Ulleung Basin (Ryu et al., 2009)

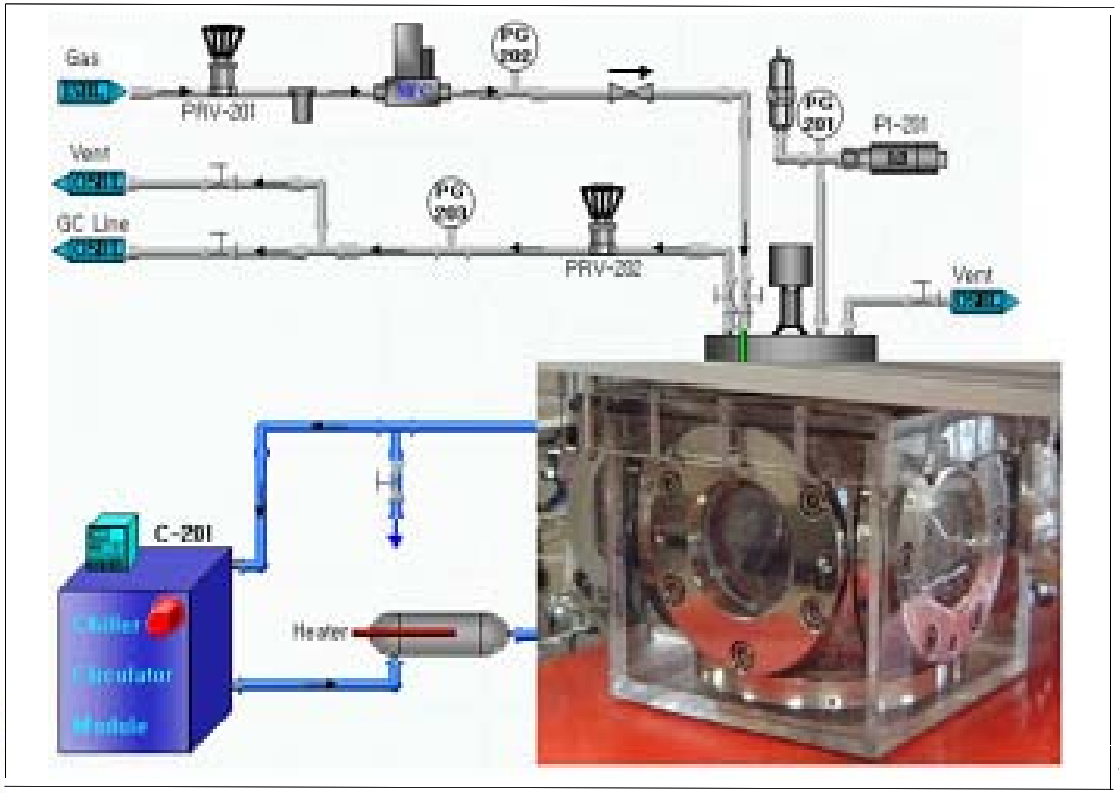
Gas Hydrate R&D from 2000 to 2004

Laboratory studies

- were performed through experimental and simulation studies.

=> to determine thermodynamic & kinetic characteristics of gas hydrate,

=> to develop the production technologies.

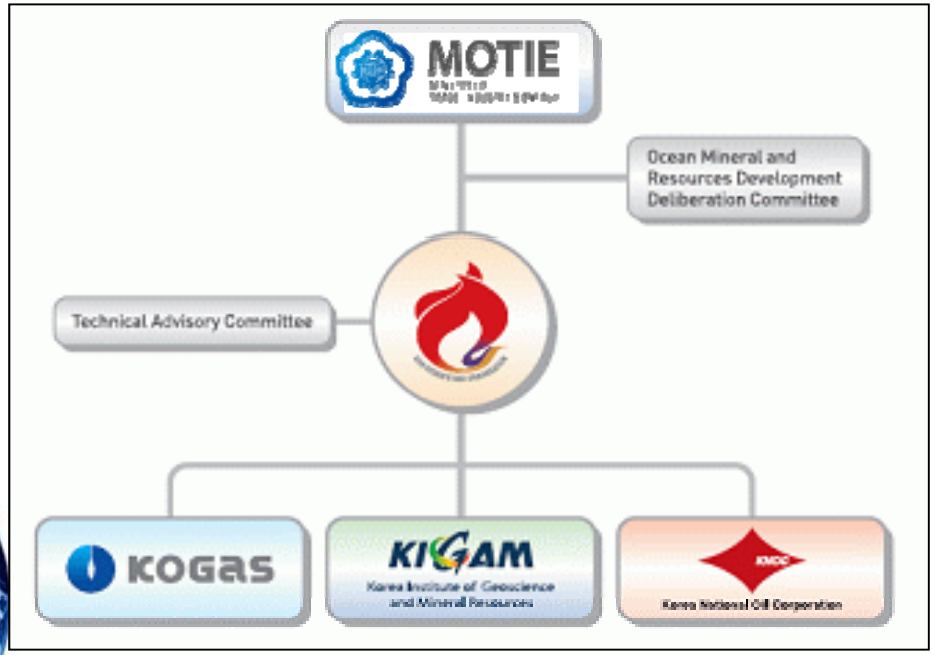


Gas hydrate
formation / dissociation system

Gas Hydrate R&D from 2005 to 2009

Korean National Gas Hydrate Program

- has been launched in 2005.
- has been managed by “Gas Hydrate R&D Organization (GHDO)”.
- has been funded through the Ministry of Trade, Industry and Energy (MOTIE).
- Researches mainly have been performed by KIGAM.
- Data acquisition (seismic & drilling) have been operated by KNOC.



Gas Hydrate R&D from 2005 to 2009

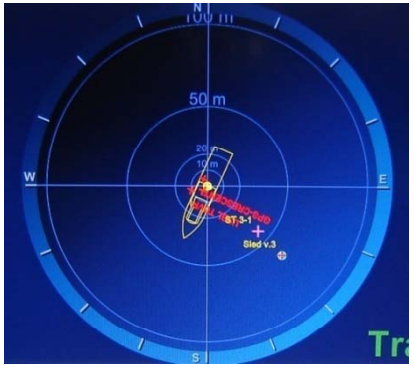
Geological-geochemical analyses

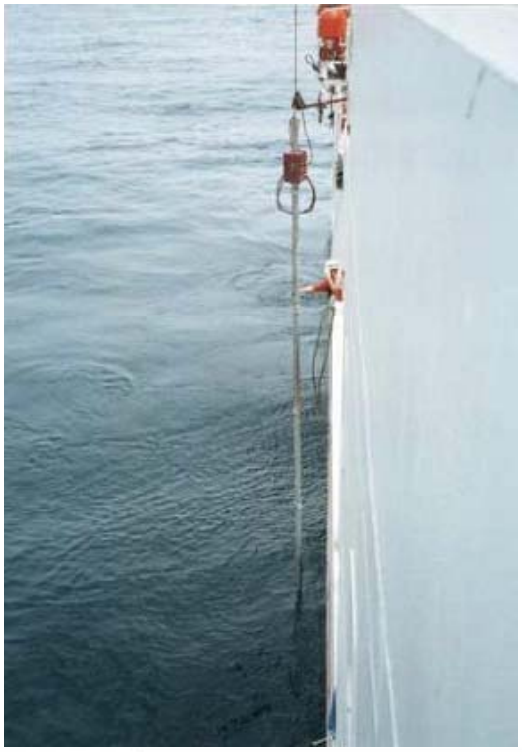
- were performed using 61 piston & 3 PROD cores.

=> to determine methane flux & origin of gas hydrate,

=> to identify geological-geochemical indicators.
: soupy layer,
: gas expansion crack,
: pore water freshening,
: authigenic carbonate, etc.

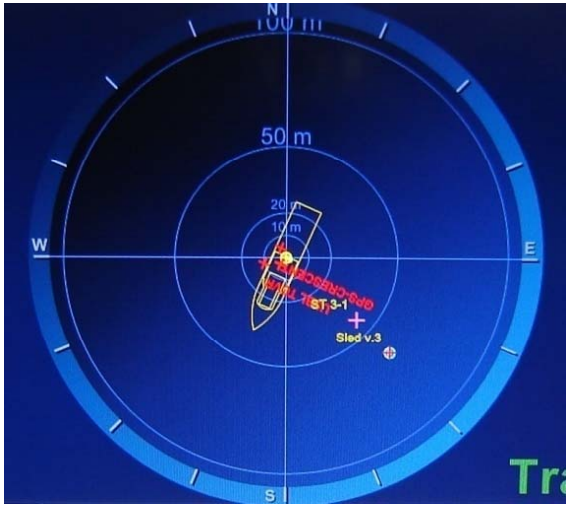
Gas hydrate recovered by using piston corer (KIGAM, 2007)



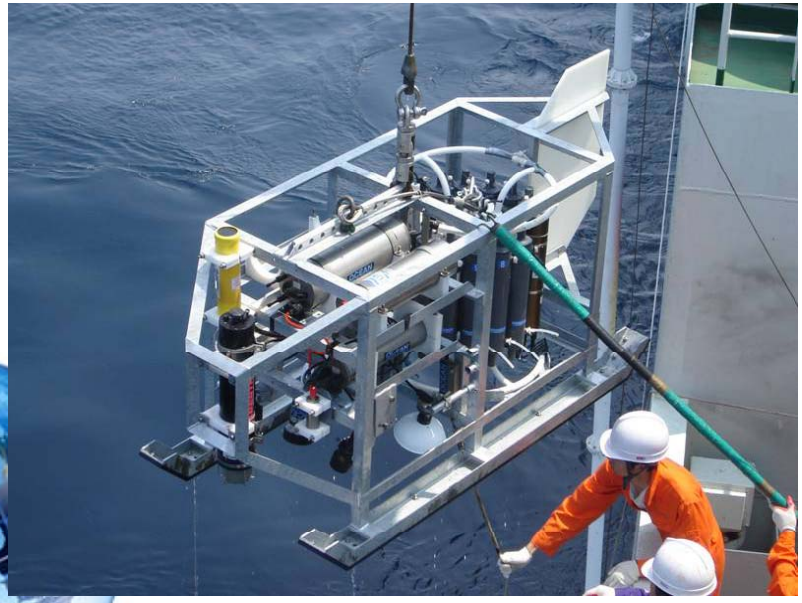


USBL-guided piston coring

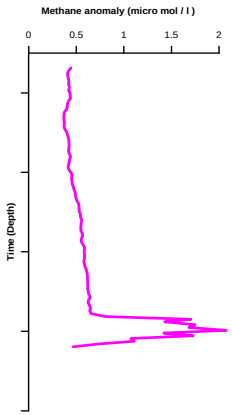
Gas Hydrate R&D from 2005 to 2009



Abnormal color of seafloor



USBL-guided sled operation



Methane sensing

Water sampling

Gas Hydrate R&D from 2005 to 2009

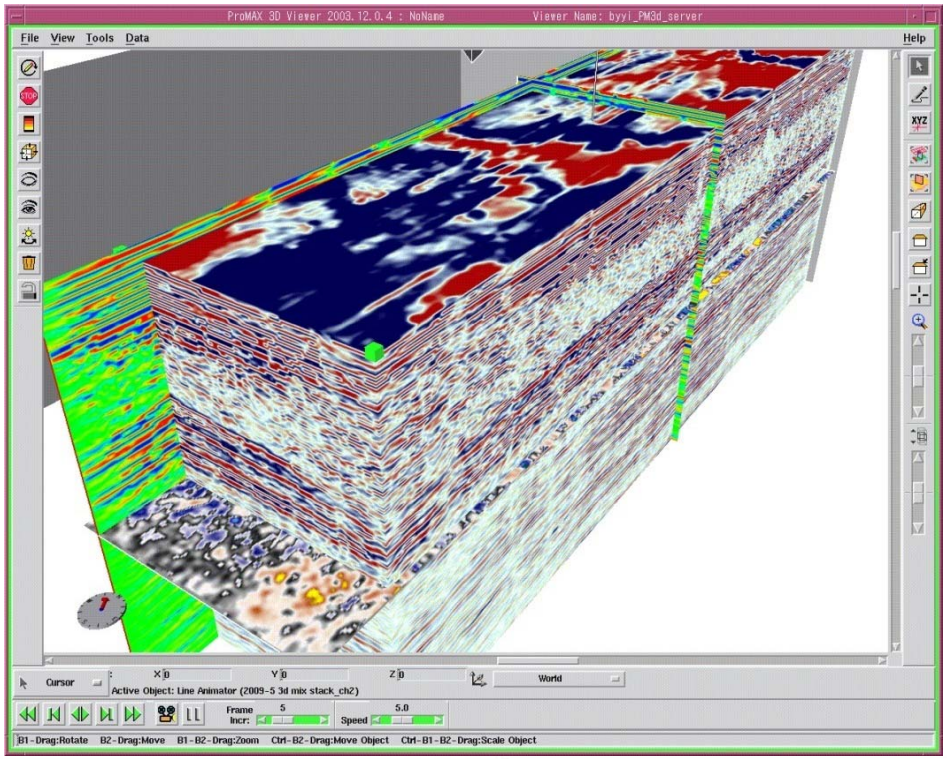
Geophysical data acquisition, processing & interpretation

- Data were collected by using *R/V TAMHAE II.*
  - : 6,690 L-km 2D multi-channel seismic data in 2005,
  - : 700 km^2 3D seismic data in 2006 and 2008,
  - : high resolution Chirp & echo-sounder data from 2005 to 2009.

=> to identify geophysical indicators,

=> to select drill sites,

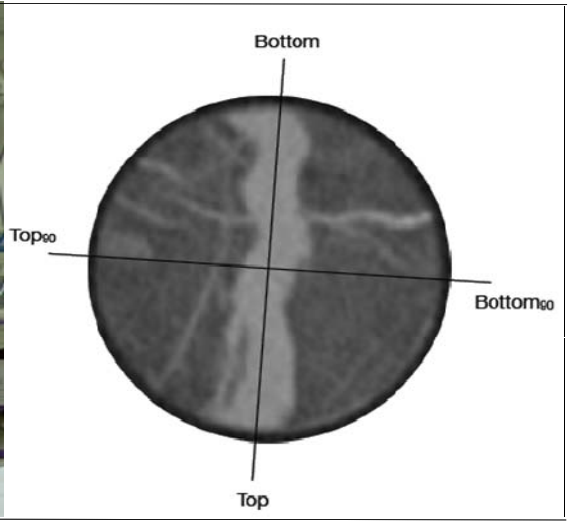
⇒ to estimate in-place gas hydrate resources.



3D seismic cube

Gas Hydrate R&D from 2005 to 2009

Combustion of gas hydrate recovered from UBGH1 (UBGH1 scientists, 2007)



CT-scan of pressure core recovered from UBGH1 (left) & CT-image (right)

Gas Hydrate R&D from 2005 to 2009

1st gas hydrate drilling expedition (UBGH1)

- was performed in 2007.
  : 20 September ~ 17 November (59 days),
  : using *M/V Rem Etive* (multi-purpose offshore support vessel),

  => to confirm the gas hydrate presence in the Ulleung Basin.

- LWD: 5 sites
- Coring: 3 sites, 5 holes
- WL/VSP: 1 site

M/V Rem Etive
4,300 Te big, 93.5 m long, 19.7 m wide

Gas Hydrate R&D from 2005 to 2009

- Site selection for the 2nd gas hydrate drilling expedition (UBGH2)
  - was performed in 2009.
  - data used for selection of UBGH2 sites
    - mainly
      : 6,690 L-km 2D seismic data acquired in 2005,
      : 700 km^2 3D seismic data acquired in 2006 and 2008,
      : UBGH1 data obtained in 2007.
    - additionally
      : 12,366 L-km 2D seismic data acquired from 2000 to 2004,
      : high resolution seismic profiling data,
      : multi-beam echo-sounder data,
      : EK-60 echo-sounder data,
      : dissolved methane sensing data.

❖ all data were collected by using *R/V TAMHAE II* .

Gas Hydrate R&D from 2005 to 2009

Development & production studies

- were performed through laboratory work and numerical simulation.

=> to measure properties of gas hydrate-bearing sediment (p-wave velocity, etc.),

=> to study on gas hydrate kinetics and thermodynamics,

=> to apply various production methods,

=> to estimate recovery rate, etc.

Gas hydrate making system

Volume change measurement equipment

Gas Hydrate R&D from 2005 to 2009

Resistivity measurement equipment

P-wave velocity measurement equipment

CO_2 exchange production equipment

Permeability measurement equipment

Gas Hydrate R&D in 2010

- 2nd gas hydrate drilling expedition (UBGH2)
  - was performed in 2010.
    : from July 7 to August 30 (84 days)
    : by using *D/V Fugro Synergy*

    => for site selection for test production in the Ulleung Basin,

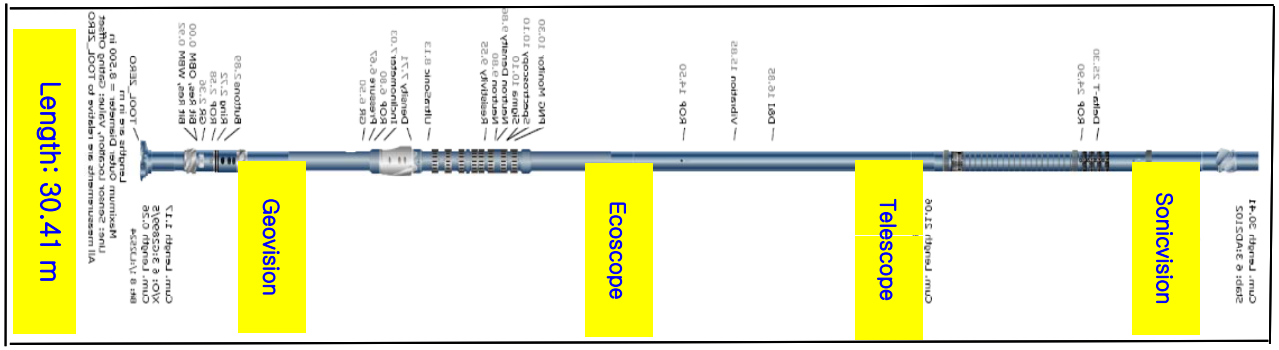
    => for resource assessment in the Ulleung Basin.

  - LWD/MWD: 13 sites
  - Coring: 10 sites, 18 holes
  - WL/VSP: 2 sites

D/V Fugro Synergy
5,200 Te big, 103.7 m long, 19.7 m wide

Gas Hydrate R&D in 2010

- UBGH2 LWD/MWD Operation
  - was performed from 8th July to 8th August.
  - Data were collected from 13 sites using Schlumberger tools.
    : SonicVision,
    : GeoVision,
    : Telescope,
    : EcoScope.



LWD tool

❖ During LWD/MWD Phase
- equipments for onboard analyses and measurements were installed,
- exercises on core handling and analysis were performed,
- based on the LWD/MWD data, coring and borhole plan were devised.

Gas Hydrate R&D in 2010

- UBGH2 WL/VSP Operation
  - was performed from15th to 21st September.
  - WL data were collected using FAOL tool.
  - VSP data were collected using 150 inch^3 air-gun (receiver interval: 10 m, 5 m & 2.5 m).

WL tool (slime-line tool, length: 4.4 ~ 7.7 m)

Air-gun used for collecting the VSP data

Gas Hydrate R&D in 2010

- UBGH2 ROV Operation
  - was performed during LWD/MWD and Coring Phases.

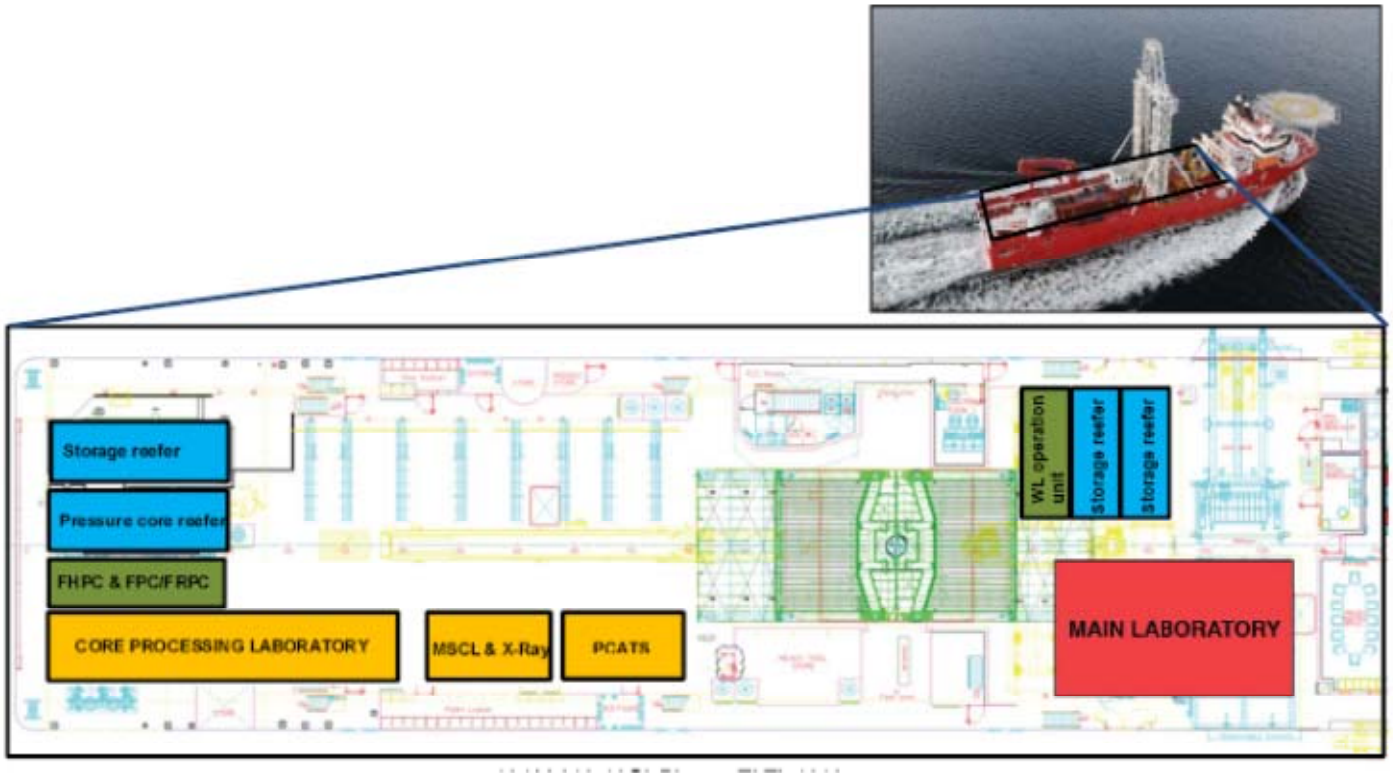
  - Data were collected using FCV3000-ROV.
    : seafloor morphology,
    : dissolved methane concentration of near seafloor water,
    : push cores.

FCV3000-ROV


ROV operation unit

Gas Hydrate R&D in 2010

- UBGH2 Coring Operation
  - was performed from 9th August to 30th September.
  - Data were collected from 18 holes of 10 sites.
  - On-board analyses were performed mostly in “Main Lab.” by 23 scientists.



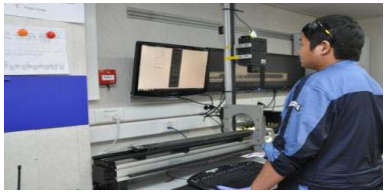
D/V Fugro Synergy and facilities for onboard analyses and measurements

Gas Hydrate R&D in 2010

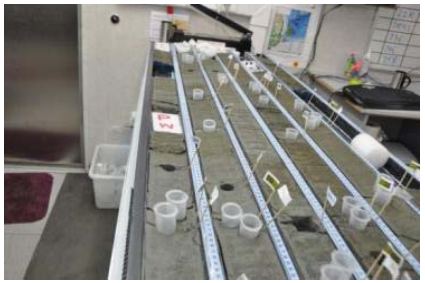
- UBGH2 Sedimentological Analyses
  - Workscope
    - : MSCL-IR / XCT image analysis.
    - : MSCL-CIS scanning.
    - : core description.
    - : smear slide observation.
    - : sub-sampling for post-cruise analysis.

Smear slide observation

Core splitting



MSCL-CIS scanning

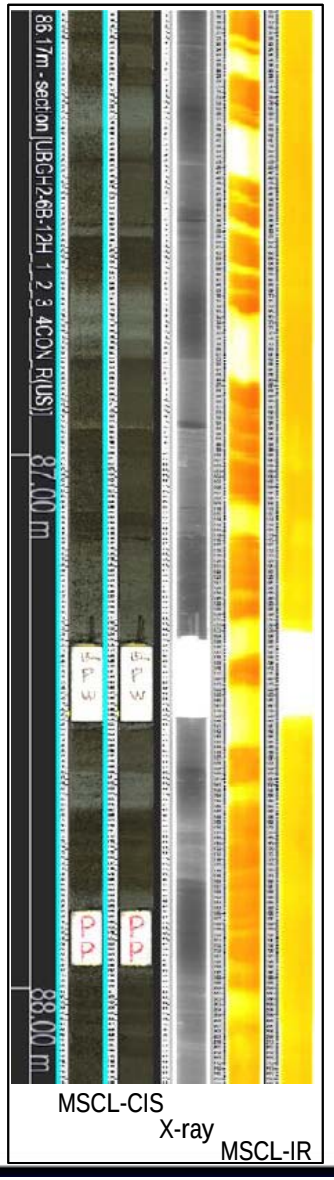


Sub-sampling

Grain size analysis

SP sample analysis

Packing



MSCL-CIS
X-ray
MSCL-IR

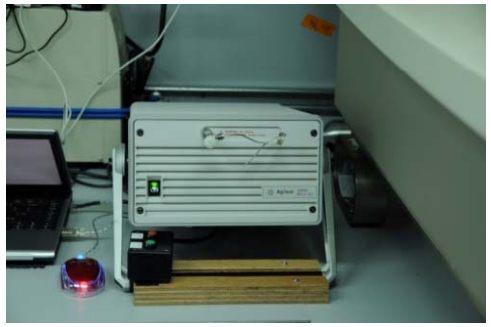
Core analysis (UBGH2 scientists, 2010)

Gas Hydrate R&D in 2010

- UBGH2 Geochemical Analyses
  - Workscopes
    : gas hydrate analysis,
    : pore water analysis,
    : headspace gas analysis,
    : void gas analysis,
    : bound gas analysis,
    : sub-sampling for post-cruise analysis (trace elements, isotope analysis etc.).

Gas hydrate collected during UBGH2 (left),
gas hydrate sample for bound water analysis (right)

Pore water squeezer



Micro-GC

Gas Hydrate R&D in 2010

- UBGH2 Physical Property Measurements
  - Workscopes
    : index property (bulk & grain density, porosity, color spectrometry) measurement,
    : geophysical property (resistivity, P-wave velocity, magnetic susceptability) measurement,
    : shear strength measurement,
    : thermal conductivity measurement.

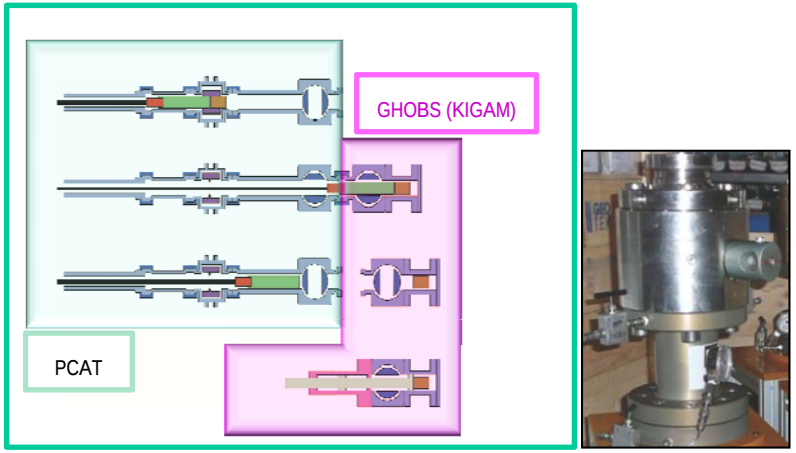
MSCL-XZ

Resistivity measurement equipment

MAD pycnometer (left) & weighing balance (right)

Gas Hydrate R&D in 2010

- UBGH2 Pressure Core Analyses
  - Workscopes
    : MSCL-P scanning (P-wave velocity & gamma density measurement, X-ray image),
    : slow depressurization (calculation of gas hydrate saturation),
    : gas hydrate sub-sampling and transfer to GHOBS,
    : on-board production test using GHOBS.



PCATS core cutting and transfer to GHOBS

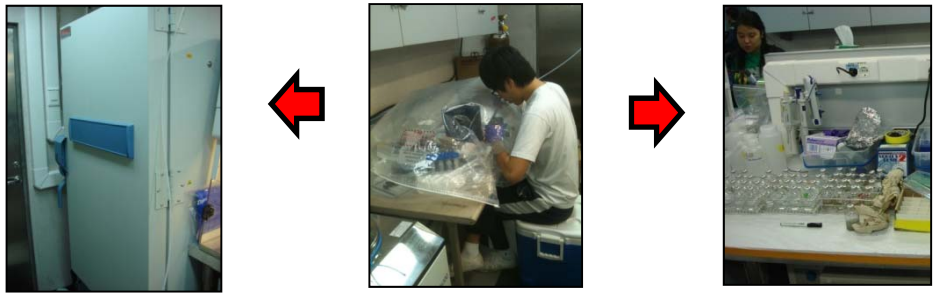
Gas hydrate production test using GHOBS
(built by Dr. J.Y. Lee of KIGAM)

* GHOBS: Gas Hydrate Ocean Simulator System
: built by Dr. J.Y. Lee of KIGAM

Gas Hydrate R&D in 2010

- UBGH2 Microbiological Analyses
  - Workscopes
    : analysis of origin of organic matter and methane,
    : analysis of lipid biomarker related with methane,
    : analysis of microorganisms community structure & functional diversity,
    : isolation and characterization of novel micororganisms,
    : sub-sampling for post-cruise analysis.

  => to determine the origin of methane and organic matter,
  => to understand the role of microorganisms during the methane cycle.



Freeze

ATP extraction

^{35}S injection extraction

Gas Hydrate R&D in 2010

- Development & production studies
  - have been performed using 1D m-scale system.

1D m-scale gas hydrate system for production study

Gas Hydrate R&D from 2011 up to now

- UBGH2 post-cruise analyses
  - were conducted in 2011 mainly by KIGAM.
- Assessment of in-place gas hydrate resource in the Ulleung Basin
  - was performed in 2011 (using seismic and UBGH data).
- Reservoir characterization for selecting the potential production testing site
  - has been performed since 2011.
- UBGH2 Expedition Report (665 pages with digital Appendix)
  - was published in 2012.
- 200 km^2 3D seismic data
  - were acquired in 2012 at proposed production testing site.
- Researches on production technologies
  - have been conducted by simulation and experimental studies.
  - have been performed using KIPED (3D m-scale gas hydrate system) since last May.

Gas Hydrate R&D from 2011 up to now

- Production test (primarily planned to be performed in 2015)
  - has been postponed

- Environmental impact researches for production test.
  - has been conducted to ensure safe production test since 2012.
  - include
    : assessment of environmental risks,
    : examination on domestic environmental laws related to production test,
    : collection of basic oceanographic information,
    : baseline survey,
    : monitoring survey.

Gas Hydrate R&D in the Future

- Technologies for production
  - have been and also will be developed.
- Preparation for production test
  - simulation and experimental studies,
  - characterization of gas hydrate reservoir.
- Baseline surveys and monitoring surveys for production test
  - Baseline survey will be conducted until production test,
  - Monitoring system will be developed,
  - Monitoring survey will be performed before, during and after production test.
- Production test
  - will be performed in next phase.
  - However, schedule for production test is not decided yet.

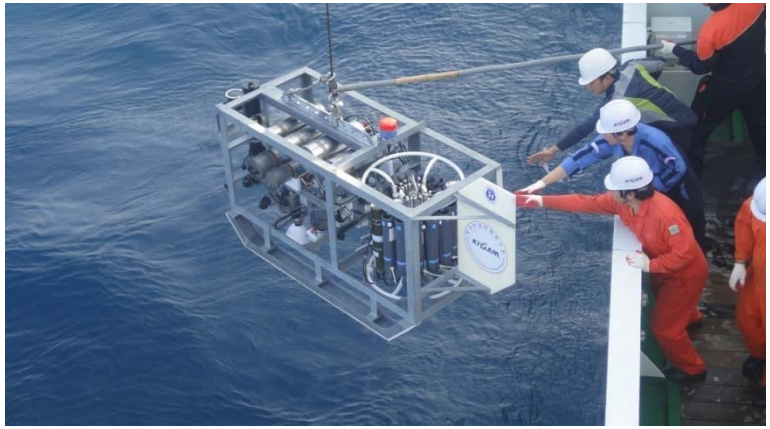
Thank you very much for your attention

感 謝

Gas Hydrate R&D in the Future

- Baseline survey
  - has been conducted using KIGAM Seafloor Observation System (KISOS) and *R/V TAMHAE II* since 2012.
    : to examine the seafloor morphology and development of fault,
    : to collect the basic oceanographic information (temperature, currents, etc.).
  - KISOS has been upgraded.
    : new unified power system (~20 hours observation),
    : new sea laser and light system of video camera (950 -> 5,000 lumens),
    : new pump-type methane senor, and turbidity and current meters.

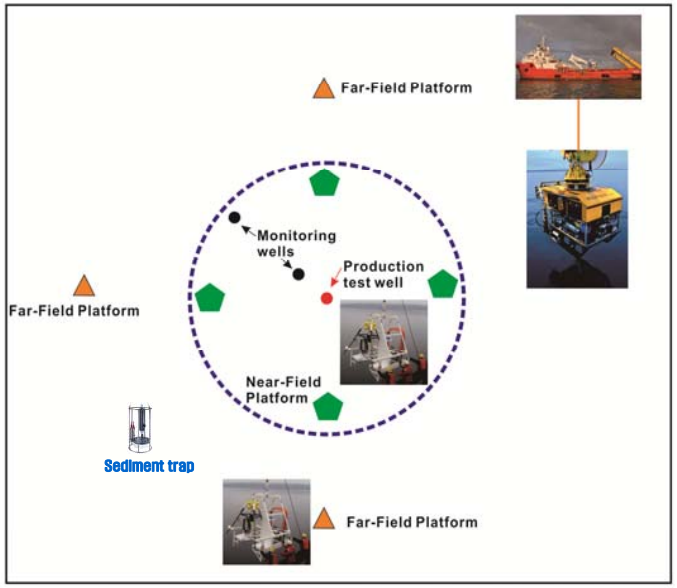
R/V TAMHAE II



KISOS

Gas Hydrate R&D in the Future

- Environmental monitoring surveys
  - will be performed before, during and after the production test . using KIGAM Seafloor Monitoring System (KIMOS), *R/V TAMHAE II*, ROV and support vessel.
    : to monitor the gas leakage and seafloor deformation,
    : to identify the changes in chemical characteristics of bottom water and seafloor turbidity.
  - KIMOS
    : is a self-logging E-monitoring system,
    : consists of near-field arrays and far-field arrays.



Generalized sketch of KIMOS

Gas Hydrate R&D Facilities

R/V TAMHAE II

- was built in Norway in 1996.
- is 2,085 tones big, 64.4 m long and 15 m wide.
- has seismic systems (single-channel, 2D & 3D multi-channel), gravity meter, gradiometer, multi-beam echo-sounder, sonar Chirp, coring equipments, etc.
- Geophysical systems were recently upgraded (ca. 10 million US$).

Seismic data recording system of *R/V TAMHAE II*

Gas Hydrate R&D Facilities

Core center

- was completed in April 2010.
- floor space: 2,343 m^2
- 40,000 m long cores can be reposited.
- All analytical equipments (incl. CT & XRF scanner) are installed.

KIGAM core repository & lab.

X-Ray CT-scanner & dewars
in KIGAM core repository & lab.

Gas Hydrate R&D Facility

Korea In-situ Production Experimental Device (KIPED)

- 3D m-scale gas hydrate experimental device
- was set up in May 2014.
- has been utilized for experimental studies of production.

KIPED and X-ray CT scanner at KIGAM

Education and Training Facility

- International School for Geoscience Resources (IS-Geo)
  - was completed in April 2010.
  - has been used for education and training for domestic and foreign researchers.
  - 5 conference and lecture rooms, and 51 beds (floor space: 3,163 m^2).

KIGAM IS-Geo (birds' eye view)