Korea Gas Hydrate R&D Program

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Sung-Rock Lee (Gas Hydrate R&D Organization)
What is gas hydrate?

- Gas hydrate is an ice-like solid substance composed of water and natural gas.
- It is formed under high pressure and low temperature condition.

Gas hydrate structure

Cavity formed by hydrogen-bonded water molecules

Combustion of gas hydrate recovered from the Ulleung Basin, East Sea of Korea (UBGH1 scientists, 2007)
Where is gas hydrate found?

- Gas hydrate occurs worldwide in deep-water and polar sediment.
Why is it important to study gas hydrate?

- Gas hydrate contains a great volume of methane (2 times more than fossil energy). Thus, it is very important as a future energy resource.

- Gas hydrate research is also important for:
  - conventional gas exploration & development,
  - natural gas storage & transport,
  - greenhouse gas storage,
  - global climate change
1st stage (1996 – 1999)
- Gas hydrate research was launched in 1996.

- Gas hydrate potential and deposition area was determined by regional surveys and studies.
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 km² multi-beam echo-sounder data

Budget

- 50% from the Ministry of Commerce and Economy (MOCIE, now MKE)
- 50% from the Koreas Gas Cooperation (KOGAS)
Piston corer & cold sample storage of R/V TAMHAE II
Gas hydrate survey using RV TAMHAE II  (IGT: 2085 t, Length: 64.4 m, Breath: 15 m)
now upgraded (ca. 9 mil. US$)
**Geological-geochemical analysis**

- performed using piston cores

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

  => to identify geological-geochemical indicator

    : soupy layer
    
    : gas expansion crack, etc.

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

- performed using geophysical data

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

BSR in the East Sea (Ryu et al., 2009)
Chimney showing pull-up structure & high velocity in the Ulleung Basin (Ryu et al., 2009)
Study for development of production technology

- performed through experimental and simulation studies

=> to determine thermodynamic & kinetic characteristics of gas hydrate
National R&D Program

- 10-year national program.
- Has been performed by KIGAM, KNOC & KOGAS since 2005.
- Has been managed by “Gas Hydrate R&D Organization (GHDO)”.
- Has been funded through Ministry of Knowledge Economy (MKE).
- Research: performed by KIGAM & KOGAS
- Data acquisition (seismic & drilling): operated by KNOC
Geological-geochemical analysis

- performed using core data.
  - 61 piston & 3 PROD cores
- also performed through water and gas analysis.
  => to determine methane flux & origin of gas hydrate
  => to identify geological-geochemical indicator
    - gas expansion crack,
    - authigenic carbonate, etc.

Gas hydrate recovered using piston corer (KIGAM, 2007)
Methane anomaly (μmol/l)

Hole plug of UBGH1
Abnormal seafloor

Time (Depth)

Methane sensor
Water sampling

USBL-guided sled operation
Geophysical data acquisition, processing & interpretation

- Data collected by using R/V Tamhae-2
  - 6,600 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 indicator

=> to select UBGH2 sites

=> to estimate gas hydrate resources
Combustion of gas hydrate recovered from UBGH1 (UBGH1 scientists, 2007)

CT-scan of pressure core recovered from UBGH1 (left) & CT-image (right)
1st gas hydrate drilling expedition (UBGH1)

- 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
=> to evaluate the in-place gas hydrate resources in the Uelling Basin

- LWD: 5 sites
- Coring: 3 sites, 5 holes
- WL: 1 site
Site selection for the 2nd gas hydrate drilling expedition (UBGH2)

- performed in 2009

- data used for selection of UBGH2 sites
  - mainly:
    - 2D seismic data acquired in 2005
    - 3D seismic data acquired in 2006 and 2008
    - UBGH1 data obtained in 2007
  - additionally:
    - 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 RV TAMHAE II
Development & production studies

- 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
2nd gas hydrate drilling expedition (UBGH2)

- was performed as a part of Korean National Gas Hydrate Program
  - from July 7 to August 30 (84 days)
  - using D/V Fugro Synergy

  => for site selection for test production in the Ulleung Basin
  => for resource assessment in the Ulleung Basin

- LWD: 13 sites

- Coring: 10 sites, 18 holes

- WL/VSP: 2 sites
National GH R&D Program

- **UBGH2**
  - managed by
    : GHDO
  - operated by
    : KNOC (Korea National Oil Corporation)
  - onboard logging and core data analyzed by
    : KIGAM
    : HYU (Hanyang University)
    : KOGAS (Korea Gas Corporation)
    : KORDI (Korea Ocean Research Development Institute)
    : KAIST (Korea Advanced Institute of Science & Technology)
    : USGS (U.S. Geological Survey)
    : GSC (Geological Survey of Canada)
    : OSU (Oregon State University)
  - data collected and technically supported by
    : Fugro, Schlumberger, Geotek
UBGH2 LWD
- Workscopes
  : log data QC
  : log data interpretation
  : site selection for WL
  : preparation of coring & borehole plans

Real-time monitoring of LWD data

 Equipments in LWD operation unit

LWD tool
UBGH2 WL/VSP
- Workscopes
  - log data QC
  - log data interpretation
  - log data correlation with LWD & core data

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

Air-gun for VSP (150 inch³ G.I gun)
UBGH2 ROV Operation
- Workscopes
  : seafloor morphology observation
  : dissolved methane sensing
  : seafloor sediment sampling
  : push coring & analysis

FCV3000-ROV

ROV operation unit
UBGH2 Sedimentological Analysis
- Workscopes
  - MSCL-IR / XCT image analysis
  - MSCL-CIS scanning
  - Core description
  - Smear slide observation
  - Sub-sampling for post-cruise analysis

Core splitting  MSCL-CIS scanning

Smear slide observation

Sub-sampling

Grain size analysis  SP sample analysis

Packing

Core analysis (UBGH2 scientists, 2010)
UBGH2 Geochemical Analysis
- Workscopes
  - gas hydrate analysis
  - pore water analysis
  - headspace gas analysis
  - void gas analysis
  - bound gas & water analysis
  - sub-sampling for post-cruise analysis
    (trace elements, isotope analysis etc.)
UBGH2 Physical Property Measurement

- Workscopes
  - index property (bulk & grain density, porosity, color spectrometry) measurement
  - geophysical property (resistivity, P-wave velocity, magnetic susceptibility) measurement
  - shear strength measurement
  - thermal conductivity measurement

MSCL-XZ

Resistivity measurement equipment

MAD pycnometer (left) & weighing balance (right)
UBGH2 Pressure Core Analysis

- 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

* GHOBS: Gas Hydrate Ocean Simulator System
  - built by Dr. J.Y. Lee of KIGAM
UBGH2 Microbiological Analysis

- 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 microorganisms
  : 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
Development & production studies

- have been performed using 1D m-scale system.
UBGH2 post-cruise analysis
- will be performed mainly in KIGAM

Assessment of in-place gas hydrate resources in the Ulleung Basin
- will be performed using seismic and UBGH2 data

Site selection for test production and reservoir characterization

Research on field development technology
- well planning, design & operation
- borehole stability

Production test

Development of production method
- will be performed using 3D m-scale gas hydrate system
Core repository and Lab.

- was completed in April 2010.
- all analytical equipments (incl. CT & XRF scanner) are installed.
- floor space: 2,343 m²
- ca. 40,000 m long core can be reposited.
International School for Geoscience Resources (IS-Geo)

- was completed in April 2010.
- 5 conference and lecture rooms, and 51 beds (floor space: 3,163 m²)
- has been used for education and training for domestic and foreign researchers.
INTRODUCTION

KOREA INSTITUTE OF GEOSCIENCE AND MINERAL RESOURCES (KIGAM)

TRAINING COURSE ON

Gas Hydrate Exploration & Development

The International School for Geoscience Resources of KIGAM presents an intensive training course on Gas Hydrate Exploration & Development. The course will take place at the Aes room of International School for Geoscience Resources of KIGAM in Daejeon (Korea) in Nov. 1 to 11, 2010 and will include the following topics:

- **Topic 1. Gas Hydrate R&D in KIGAM** by Dr. Byung-Jae Ryu
  Nov. 1st (Mon.) Gas Hydrate R&D in KIGAM

- **Topic 2. Geophysical Aspects of Gas Hydrate** by Prof. Gwoon Lee
  Nov. 2nd (Tue.) Geophysical Aspects of gas hydrate
  Nov. 3rd (Wed.) Geophysical Aspects II of Gas Hydrate

- **Topic 3. Natural Gas Hydrates** by Dr. Nataliya V. Miltov
  Nov. 4th (Thu.) What is a Natural Gas Hydrate
  Nov. 5th (Fri.) Examples of Natural Gas Hydrate occurrences
  Nov. 6th (Sat.) How much gas occurs in Natural Gas Hydrates

- **Topic 4. Characterization of Hydrate-Beareng Sediments** by Prof. Tae Joo Yun
  Nov. 7th (Sun.) Characterization of HBS – Part I
  Nov. 8th (Mon.) Characterization of HBS – Part II

- **Topic 5. Laboratory Studies of Gas Hydrate** by Drs. Jong-Jin Roh & Joo Yong Lee
  Nov. 9th (Tue.) Geological & geochemical analyses
  Experimental studies for development of gas hydrate production technologies

  Nov. 10th (Wed.) Gas hydrate indicators
  Nov. 11th (Thu.) Equipments for marine gas hydrate survey
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<thead>
<tr>
<th>Date/Time</th>
<th>Program Description</th>
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<tbody>
<tr>
<td>11. 1 (Mon)</td>
<td>Registration</td>
<td>Room Room</td>
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<tr>
<td>14:30-15:00</td>
<td>Topic 1: Geophysical Aspects of Gas Hydrate #1</td>
<td>Room Room</td>
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<tr>
<td>15:00-16:30</td>
<td>Lecture 1: Introduction</td>
<td>Dr. Young Lee (Pusan National University)</td>
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<td>16:30-18:00</td>
<td>Lecture 2: Gas hydrate exploration</td>
<td>Prof. Guang Lin (Ruyang National University)</td>
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<td>19:30-21:00</td>
<td>Lecture 3: Applications of geophysical exploration</td>
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<td>11. 2 (Tue)</td>
<td>Topic 2: Geophysical Aspects of Gas Hydrate #2</td>
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<td>Lecture 1: From the bottom-coring reflector</td>
<td>Prof. Guang Lin (Ruyang National University)</td>
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<td>13:30-15:10</td>
<td>Lecture 3: Case studies</td>
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<td>Topic 3: Natural Gas Hydrates #1 - What is a Natural Gas Hydrate</td>
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<td>11:50-13:30</td>
<td>Lecture 2: Where natural gas hydrates occur</td>
<td>Dr. Alexei V. Milkov (University of Cambridge)</td>
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<td>11. 4 (Thu)</td>
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<td>Dr. Alexei V. Milkov (University of Cambridge)</td>
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<td>11. 6 (Sat)</td>
<td>Topic 6: CNG Development</td>
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* The working language of this course is English.
THANK YOU