

Gas Hydrates as an Unconventional Resource: Asian Perspective*

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General Comments

Gas hydrate is a crystalline solid consisting of gas molecules, usually methane, each surrounded by a cage of water molecules and looks like water ice. They form under relatively high pressure and low temperatures as seen in many of the oceanic sediments and permafrost regions.

Unlike conventional petroleum, gas hydrates are solid crystalline materials. They commonly form where there are no pre-existing geological traps. Hydrate deposits typically may be found within upper one kilometer of marine clastic sediments worldwide, with their thicknesses determined by water depth, seafloor temperature, and geothermal gradient.

Countries with gas hydrate research and development programs are Japan, Korea, India, and China, all with resource needs.

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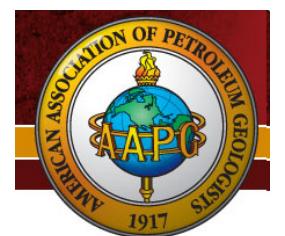


Gas Hydrates As An Unconventional Resource: Asian Perspective

Manoj K Prabhakar

16 March 2012

GTW on “Unconventional Hydrocarbon Plays in Asia” by American Association of Petroleum Geologists (AAPG)



Objectives

- To introduce the technical aspects Gas Hydrates
- To discuss potential technologies to exploit Gas Hydrates and potential issues
- To specifically focus on Gas Hydrate potential & current R&D status in Asia

Outline

- **Gas Hydrates**
 - Introduction
 - Types
 - Identification
- **Resource Potential & Impacts**
- **Asian Status**
- **Looking Ahead**

Gas Hydrate - What is it?

Gas hydrate is a crystalline solid consisting of gas molecules, usually methane, each surrounded by a cage of water molecules and looks like water ice.



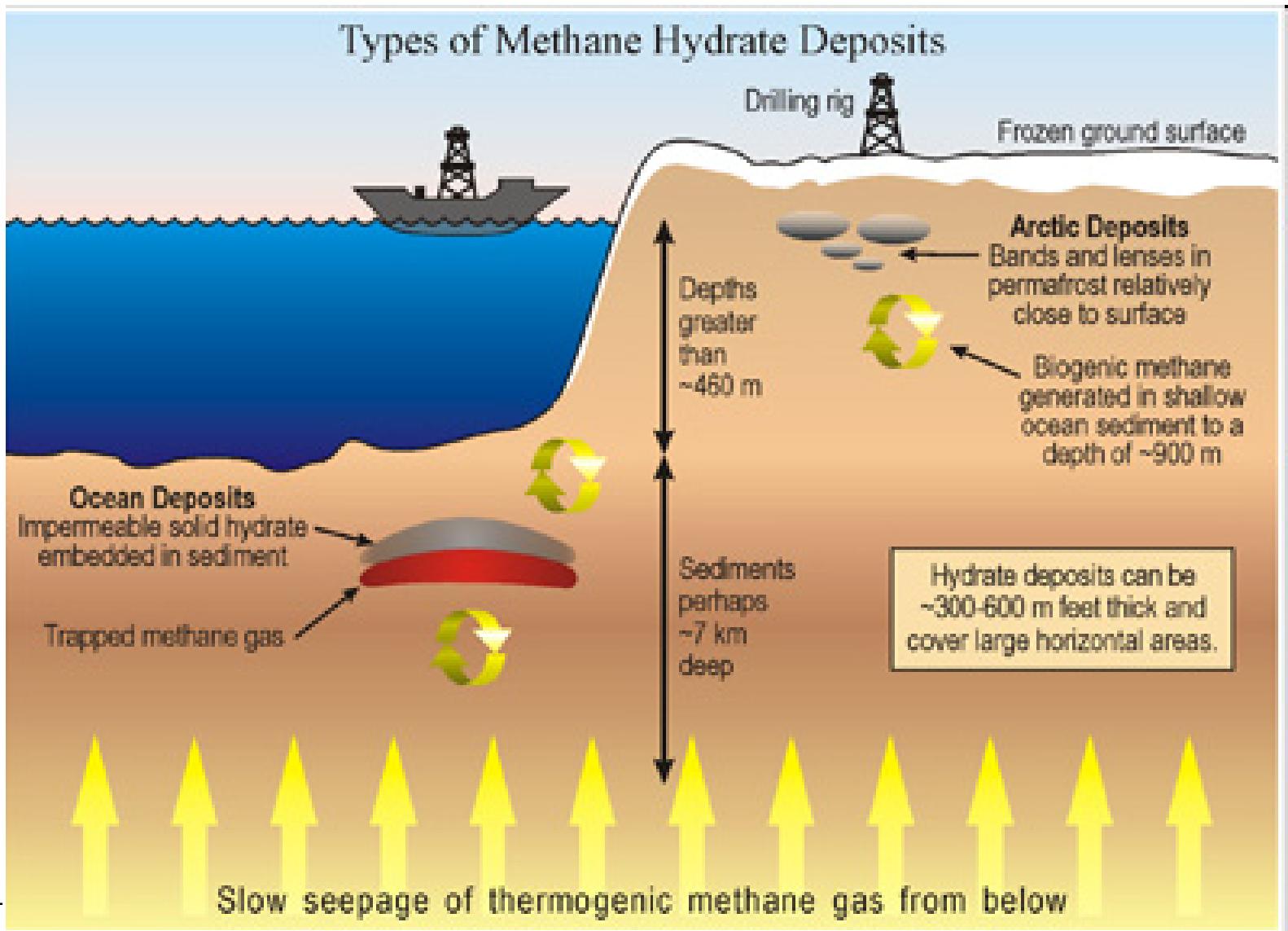
They form under relatively high pressure and low temperatures as seen in many of the oceanic sediments and permafrost regions.

Ref: DOE

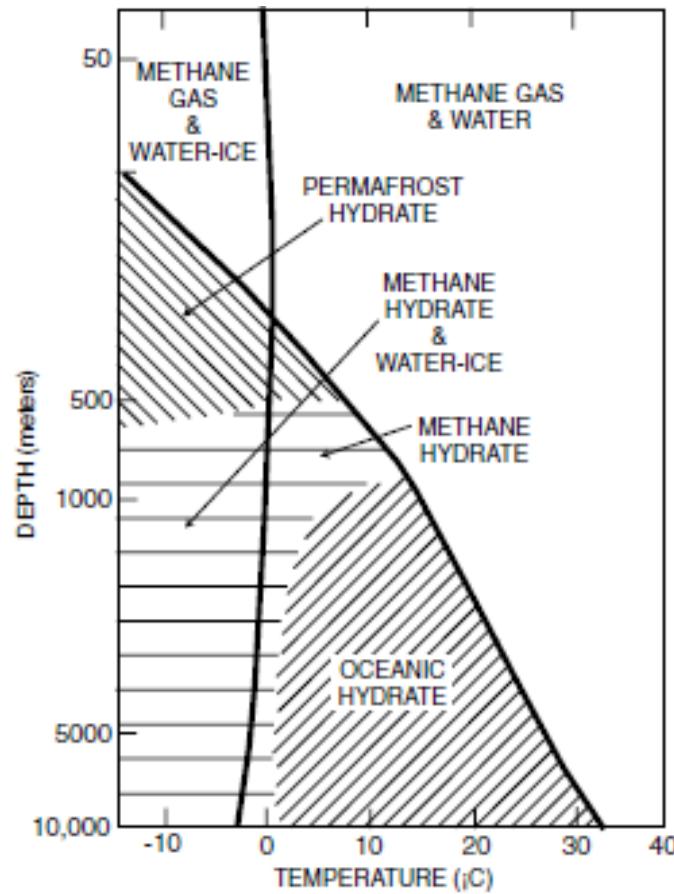
Gas Hydrate - Types

- **Permafrost:** Restricted ar^aal potential for development. Presence depends on particular geological structure and reservoir conditions, existing gas concentrations and supply of water.
e.g.: North slope of Alaska, Mackenzie Delta of Canadian Arctic
- **Oceanic:** Mainly in continental slopes below about 800m water depth (max. 4km) with enough gas flux. It is also associated with gas deposits below BSR (Bottom Simulating Reflector).
e.g.: Nankai area of SE continental shelf of Japan,

Gas Hydrate - Types



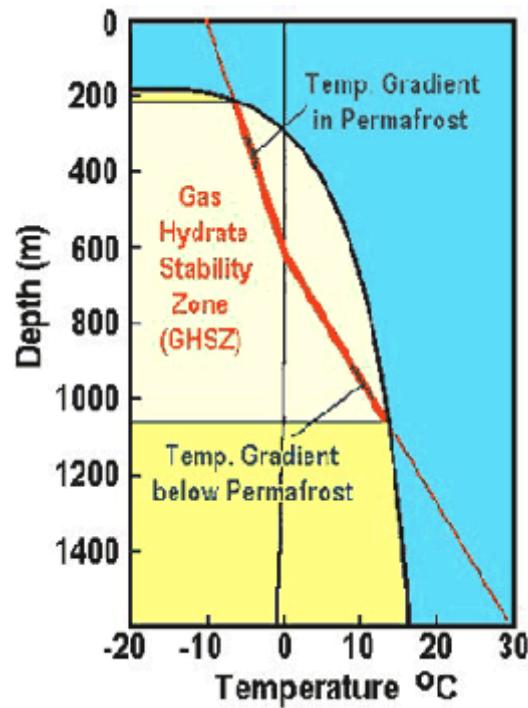
Gas Hydrate - How does it form?



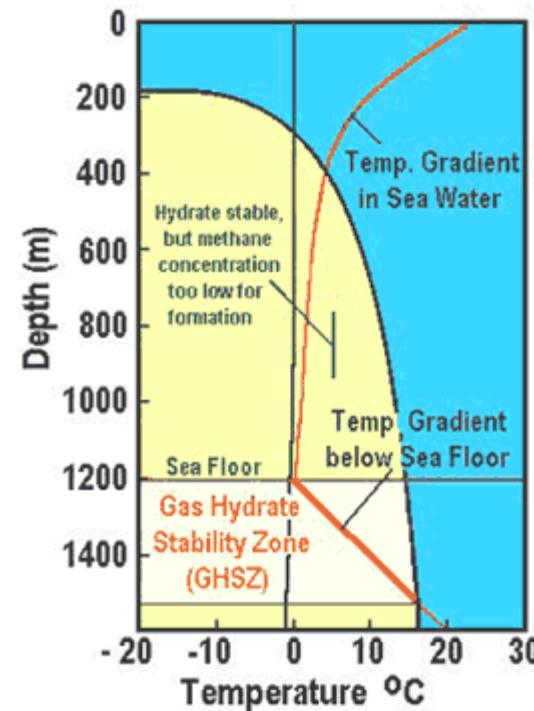
- Adequate supply of Water and Methane
- Suitable Temperature and Pressure
- Geochemical conditions
- Other controls such as Sediment Types and Textures

Diagrammatic methane hydrate pressure – temperature phase diagram (after Max et al., 2006)

Gas Hydrate - How does it form?

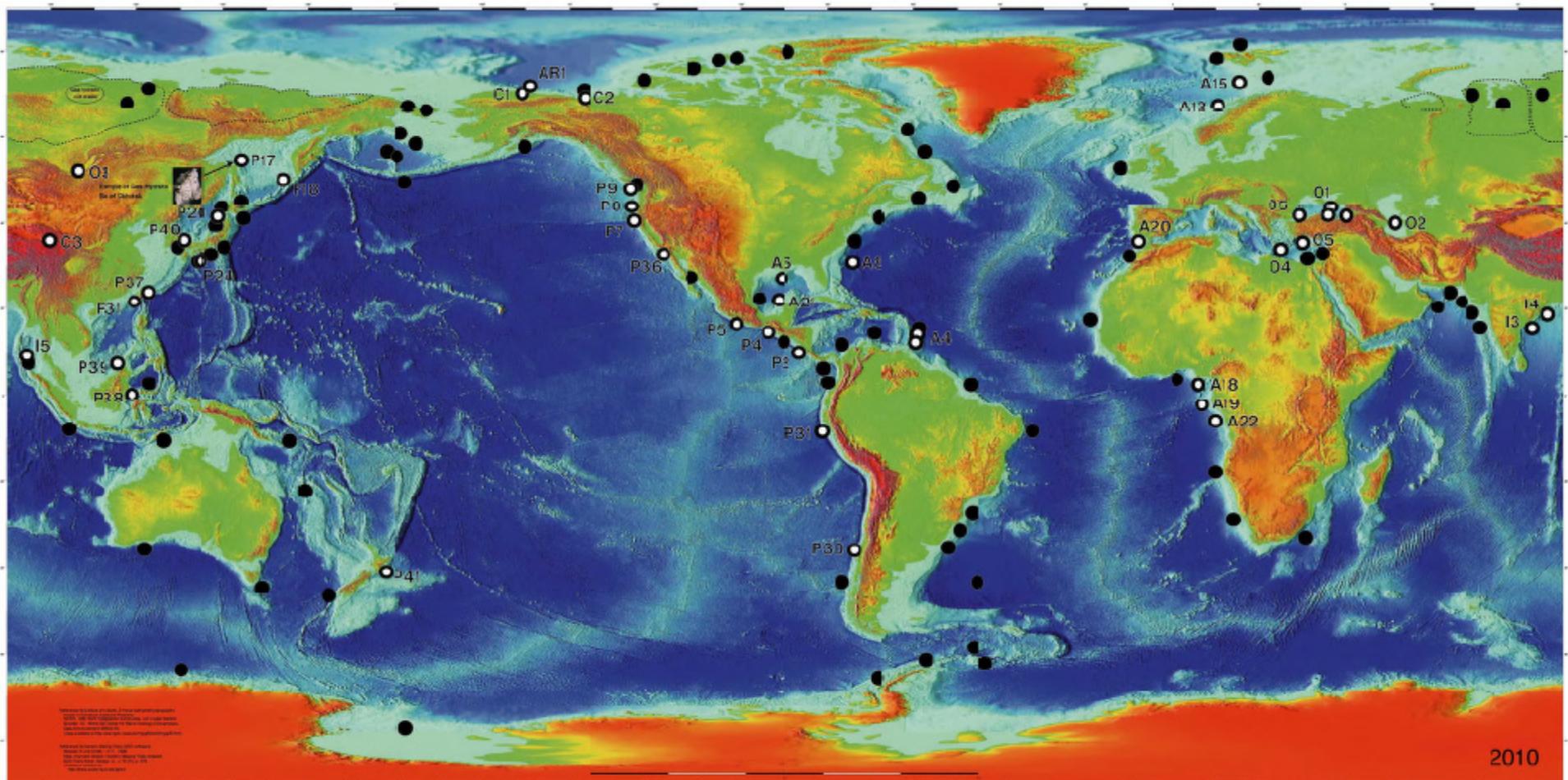


Specific Hydrate Stability
for Arctic **Permafrost**



Typical occurrence of the gas hydrate stability zone on **deep-water continental margins**. A water depth of 1200 meters is assumed.

Known locations of Gas Hydrates



Keith A. Kvenvolden and Thomas D. Lorenson

- Gas Hydrate recovered locations
- Gas Hydrate inferred locations

Outline

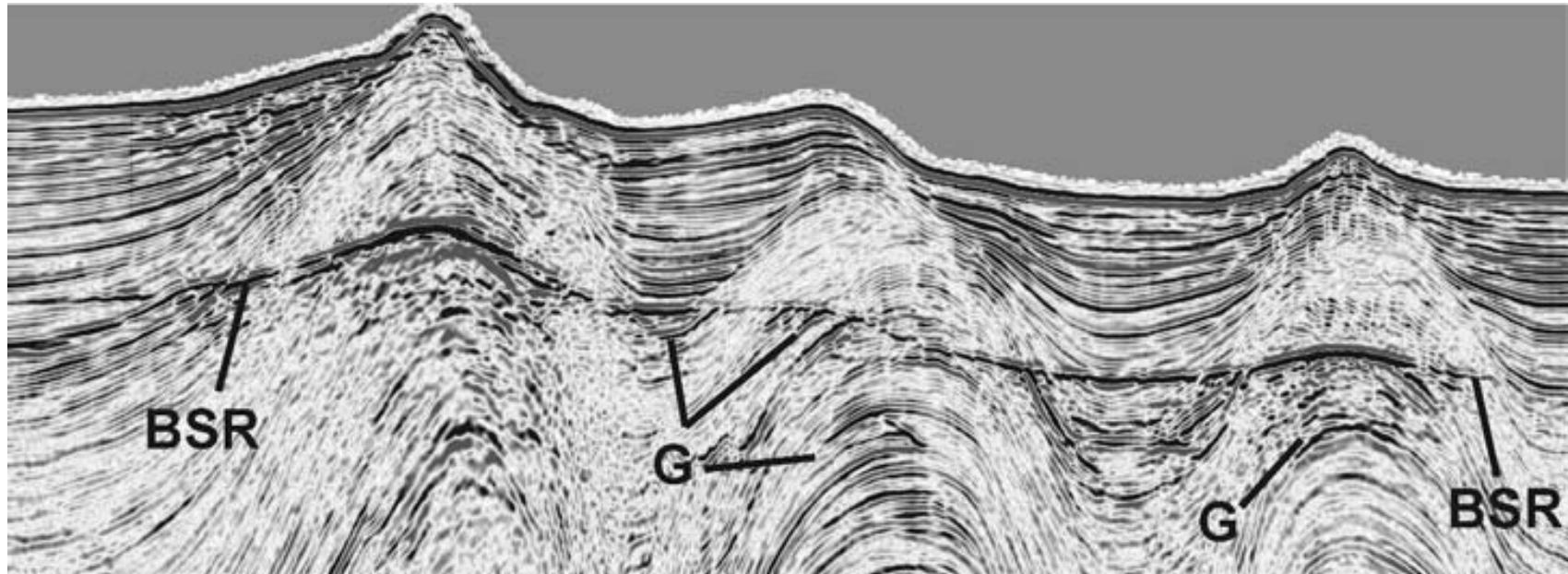
- **Gas Hydrates**
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- Resource Potential & Impacts
- Asian Status
- Future

Methods of Identifying Oceanic Gas Hydrates

- Presence of Bottom Simulating Reflectors (BSR) in seismic data
- Blanking & Accentuation in seismic data
- Seafloor acoustic imagery - gas venting
- Natural Gas analysis - thermogenic gas
- Heat Flow/Vent related seafloor features
- Electromagnetic Methods

All these methods works together -not independently.

Gas Hydrate - How do we locate it?



Reflection seismic lines showing the BSR (Bottom Simulating Reflector- strong reflector cutting across upright active folds that deform strata and the seafloor) from Makassar Straits, Indonesia (Max et al, 2006)

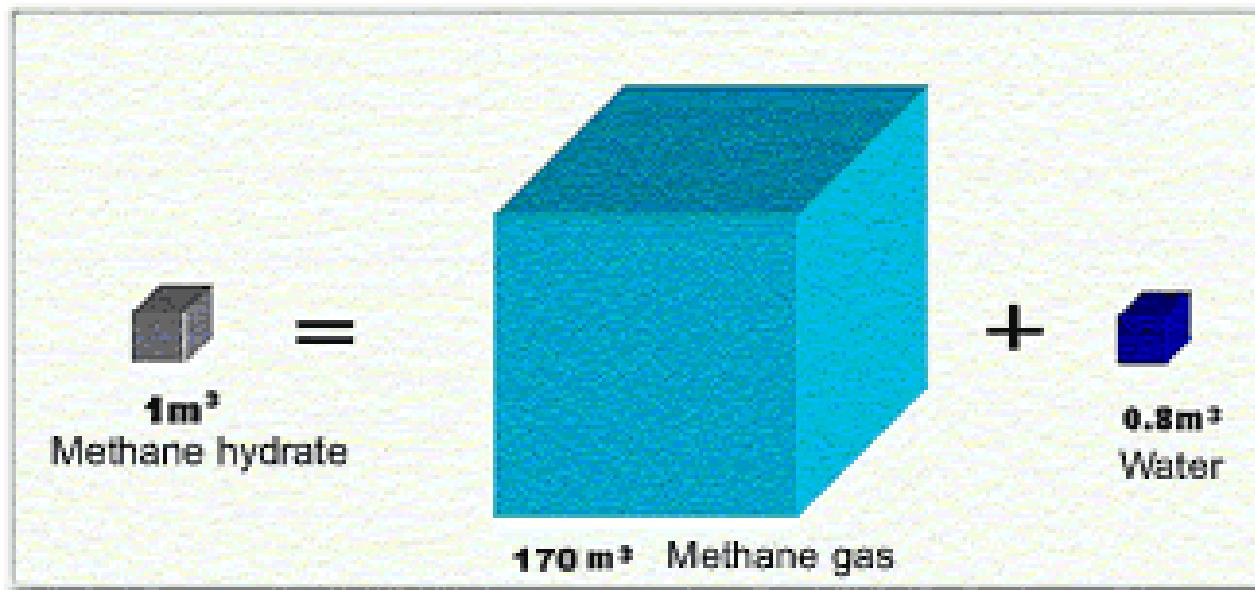
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- Gas Hydrates
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- Resource Potential, Production Methods & Impacts
- Asian Status
- Looking Ahead

Gas Hydrate as a Resource

- Unlike conventional petroleum traps which are either liquid or gas, or a combination, gas hydrates are **solid** crystalline materials
- Conventional deposits are entirely contained within a geologically entrapped reservoir while hydrate deposits commonly form where there are **no pre-existing geological traps**
- Conventional marine deposits may be found in continental shelves & slopes in suitable geological conditions, with no regard for confining pressure and temperature. Hydrate deposits typically may be found within upper one km of sedimentologically and mechanically similar marine clastic sediments world wide, within the local GHSZ, whose thickness is determined by **water depth, seafloor temperature and geothermal gradient.**

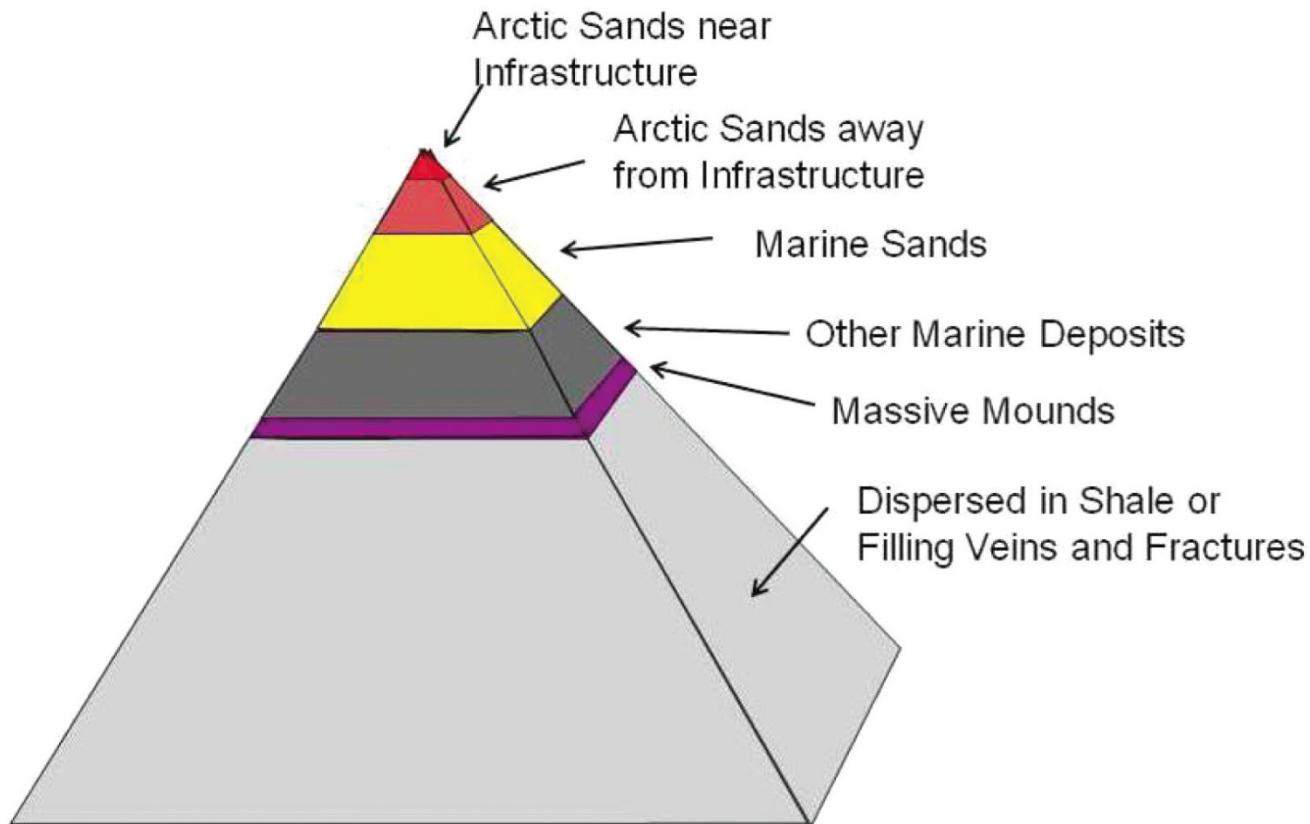
Gas Hydrate as a Resource



Gas-Water Ratio in Gas Hydrates

Ref: BOEMRE

Gas Hydrate as a Resource

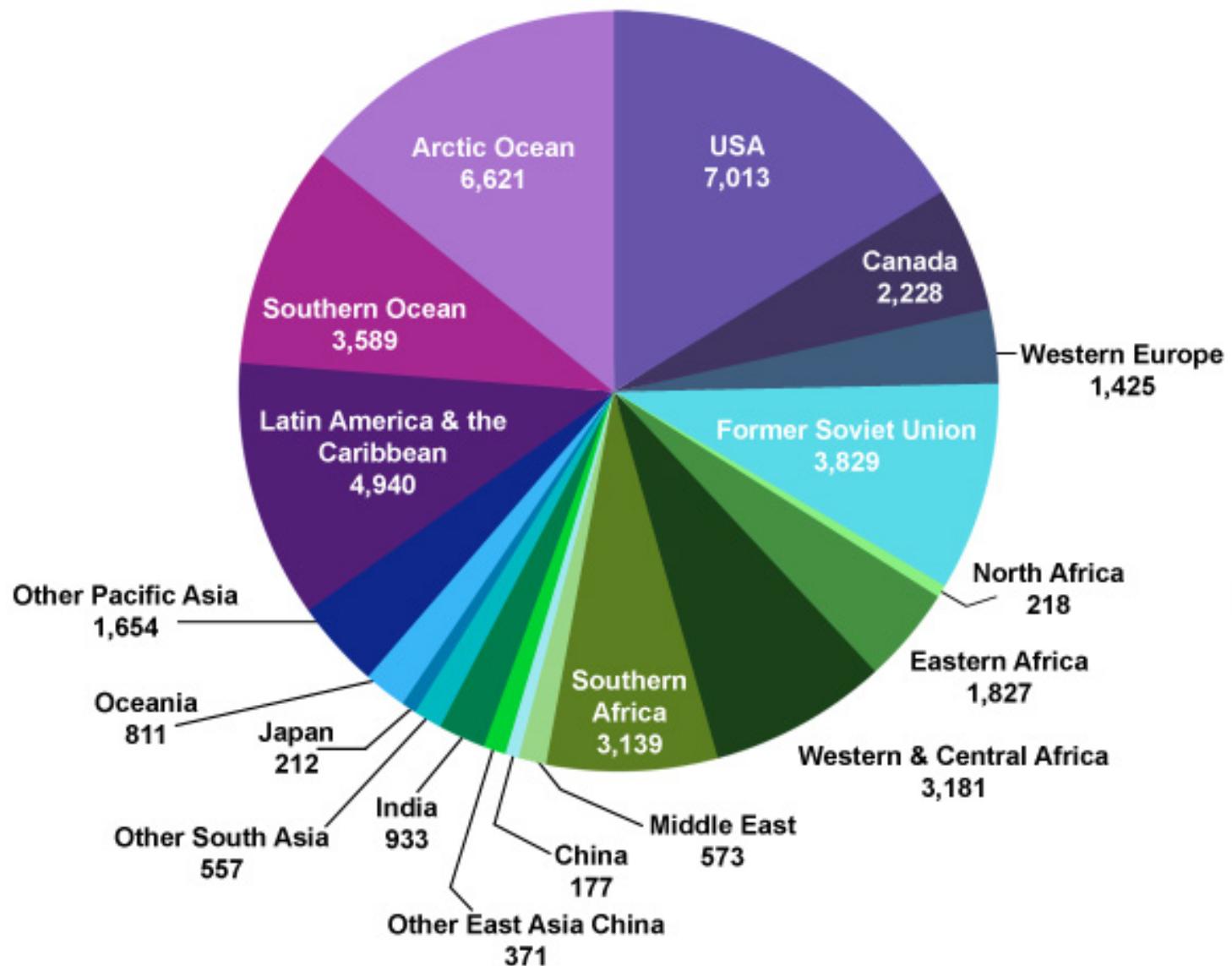


Gas Hydrate Resource Pyramid
(Boswell & Collett, 2006)

Arctic Sands and Marine Sands are used for resource estimation

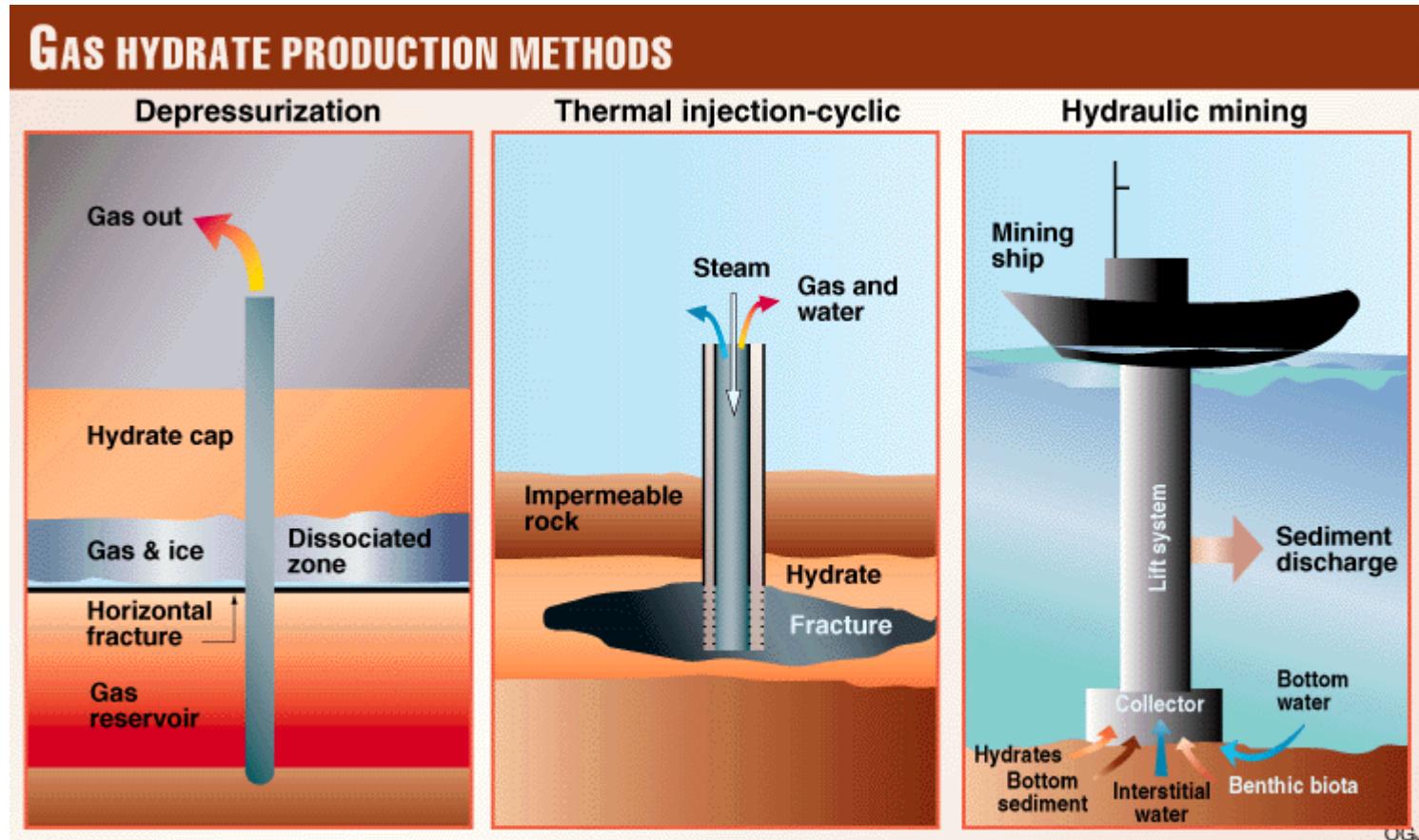
Calculated Gas In-Place in Hydrate-Bearing Sands

Total Median = 43,311 tcf



Johnson, 2011

Gas Hydrate – Production Methods



Ref: OGJ (Collett and Kuuskraa, May 11, 1998)

Gas Hydrate - Impacts

- Resource Potential – Enormous, if able to tap it
- Geohazards – Submarine slope failures, drilling, etc.
- Climate Change issues - Release of Methane into atmosphere

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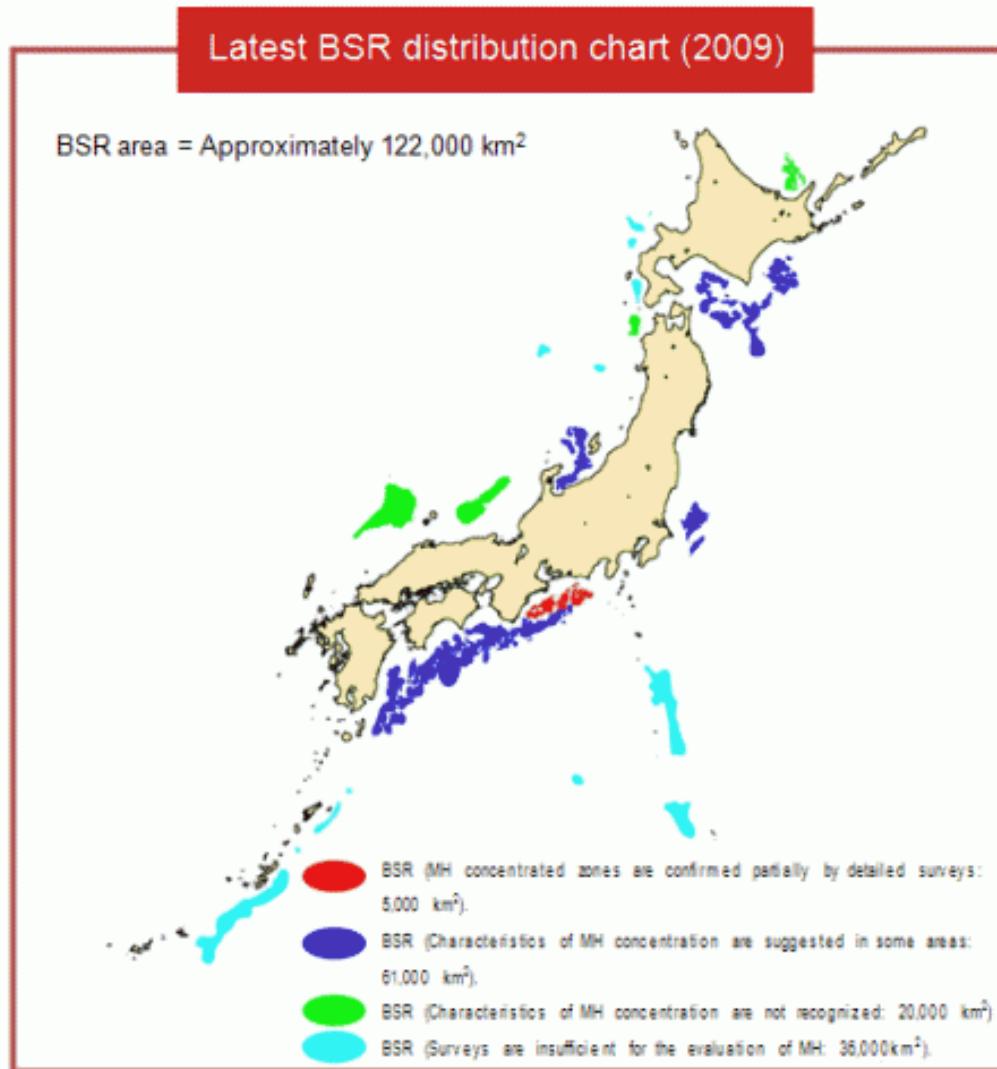
Asia Status

- Major Countries in Asia with Gas Hydrate R&D programs are: Japan, Korea, India, China
- All of them are resource scarce countries....!!!

Asia Status- Japan

- Started Hydrate program in 90's to asses its resource potential by MITI.
- Started MH21 (Research Consortium for Methane Hydrate Resources in Japan), which aims to establish technology platform for commercial gas production from hydrates by 2018.
 - First phase was between 2001- 2008. Completed resource assessment of GHs in Japanese waters, developed a hydrate reservoir simulator and field verified gas production techniques.
 - Gas-in Place in 4600km² area of eastern Nankai trough=40 Tcf
 - Tested the low-cost depressurisation (via water lifting) method successfully at Mallik gas hydrate well.

Asia Status-Japan



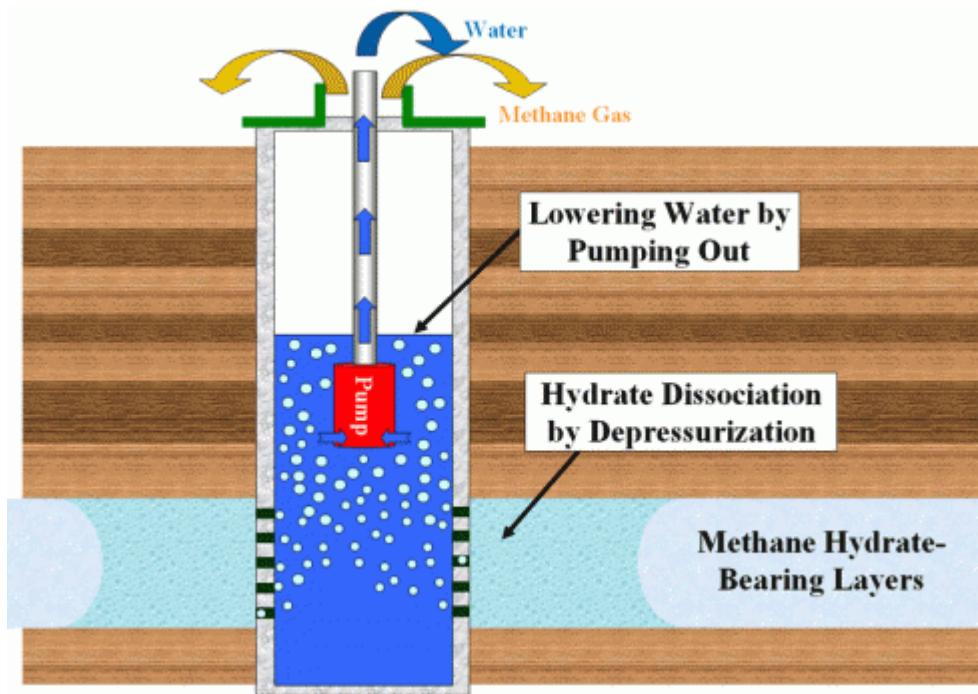
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Asia Status-Japan

- Second phase began April 2009 and will extend to 2015. In phase 2, team planned to complete two offshore production tests, carry out resource assessment other than Nankai Trough, study environmental impact of field development
 - First drill in March 2012

Asia Status-Japan

Conceptual design for methane production by depressurisation



Ref: MH21

Asia Status- South Korea

- Initiated by Ministry of Commerce, Industry & Energy (MOCIE) along with industry players (KNOC, KOGAS, etc) and government research organisations (KU,KIGAM, etc)
- Started Korea Gas Hydrate R&D organisation with an aim of beginning the commercial production in 2015.
- Conducted a number of surveys in Ulleung Basin and drilled a few gas hydrate wells. Identified gas hydrate structures of thickness ~130m in Ulleung Basin (one of the thickest recording in the world).

Asia Status- South Korea



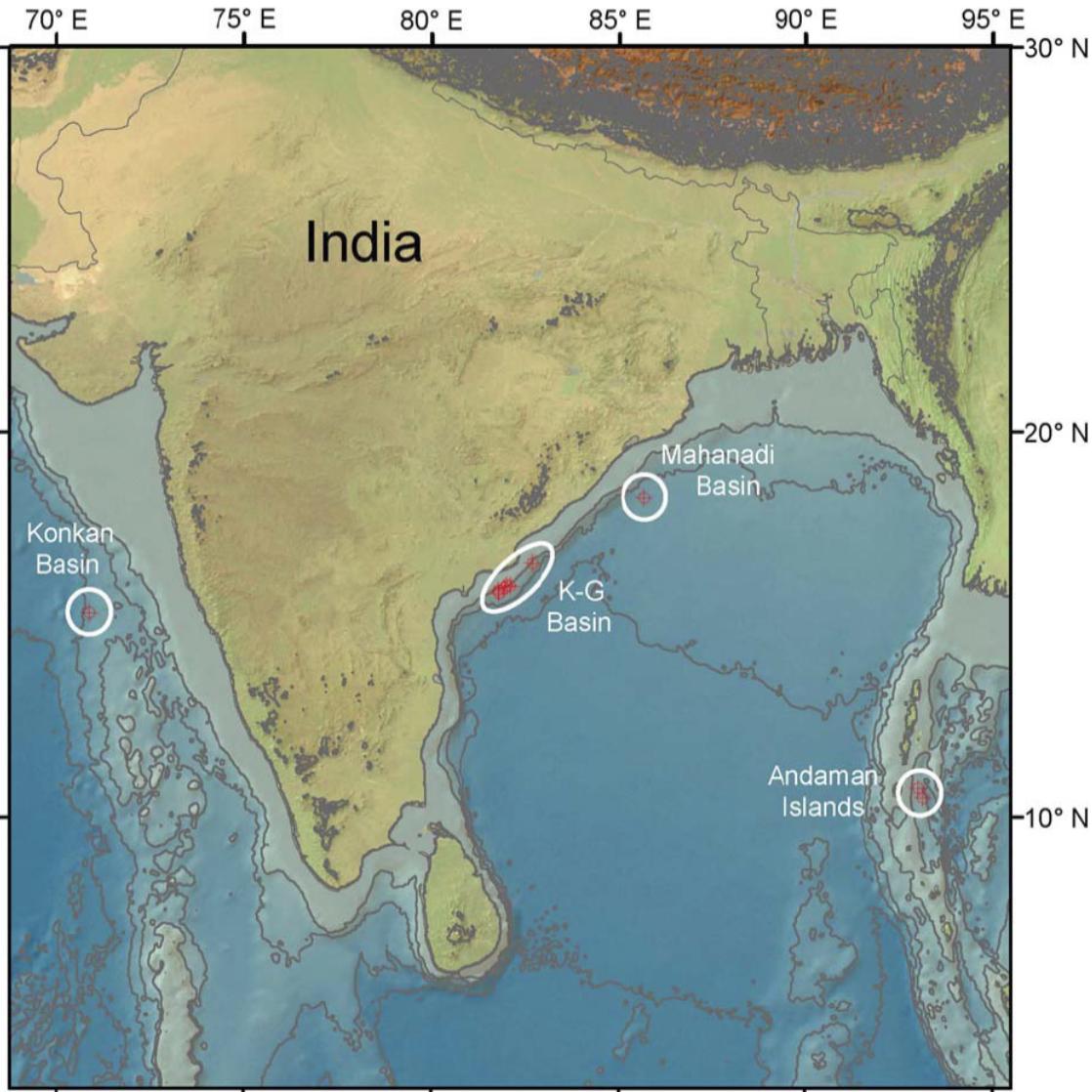
- **UBGH1 Expedition-2007:** Ulleung Basin hydrate-bearing reservoirs are at 150m below seabed in 1800-2100m water depths
- **UBGH2 Expedition-2010:** Ulleung Basin hydrate-bearing reservoirs are at 230-360m below seabed in 910-2160m water depths

Ref: DOE

Asia Status-India

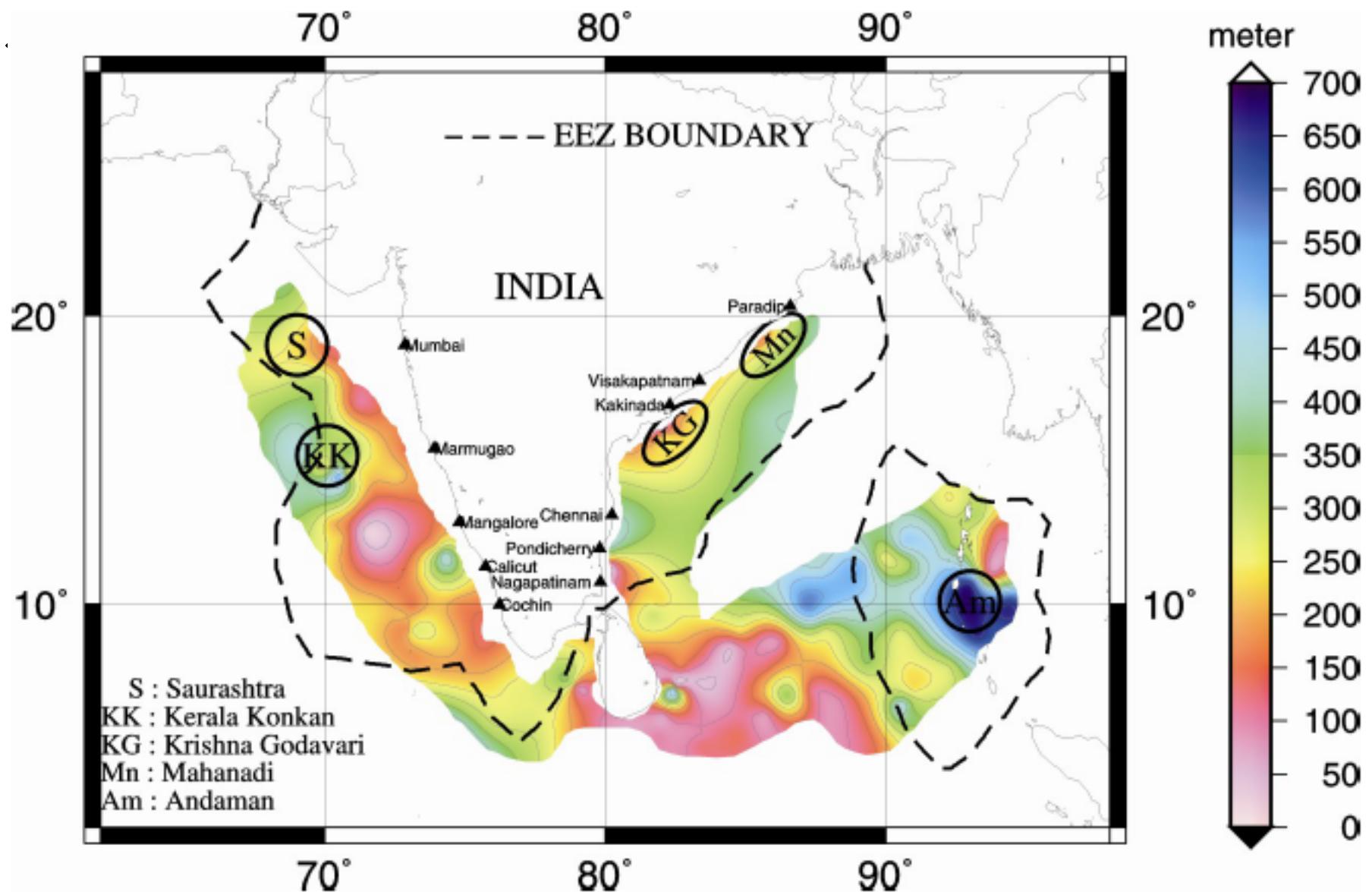
- **National Gas Hydrates Program (NGHP) started in 2006 by Directorate of Hydrocarbons, Govt of India together with a number of research organisations and Industry players.**
- **More than 2800m gas hydrate cores from 39 holes/21 sites. Major basins are from KG Basin, Mahanadi basin, Konkan Basin and Andaman basin.**

Asia Status-India



Ref: DGH, Govt of India

Asia Status-India



Gas Hydrate Stability Thickness Map along Indian Continental Margins (Sain et al., 2010)

Asia Status-India

- Currently focusing on KG Basin, for gas hydrate reservoir delineation and reserve estimation.
- NGHP Expedition 02: Identification of sites for riser drilling and pilot production testing, after completion of ongoing studies on samples and data from NHGP01

Asia Status - China

- In 2007, Expedition GMGS-1 by Guangzhou Marine Geological Survey, China Geological survey and Ministry of Land & Resources recovered gas hydrate samples from Northern South China Sea
- In 2008-2009, Permafrost gas hydrates were recovered from Qilian Mountain in Qinghai Province by Chinese Academy of Geological Sciences, China Geological Survey and others.
- More exploration activities are being planned, particularly on the marine side

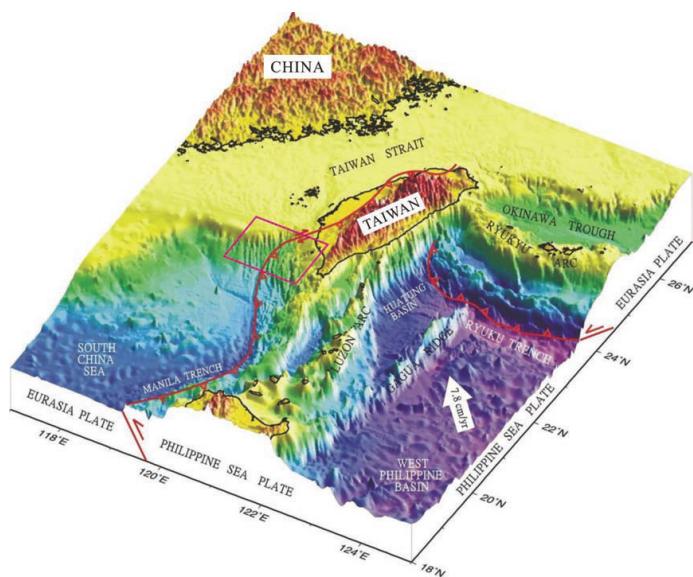
Asia Status-China



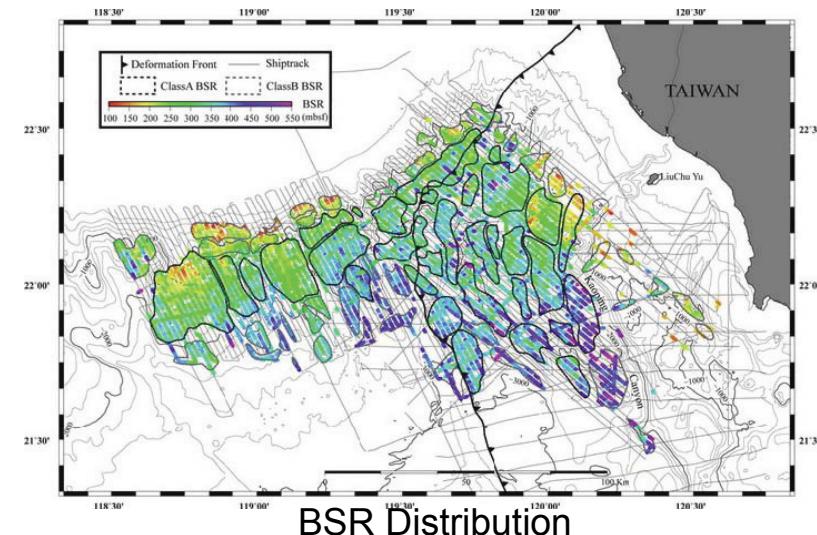
Ref: Zhang et al., 2007, Lu et al., 2010

Asia Status- Taiwan

- Taiwan: Started Gas Hydrate program from 2004 and developed Taiwan Gas hydrate data base. Second phase of the program started in 2008; it aimed to understand the gas hydrate environment in a better way through further studies.



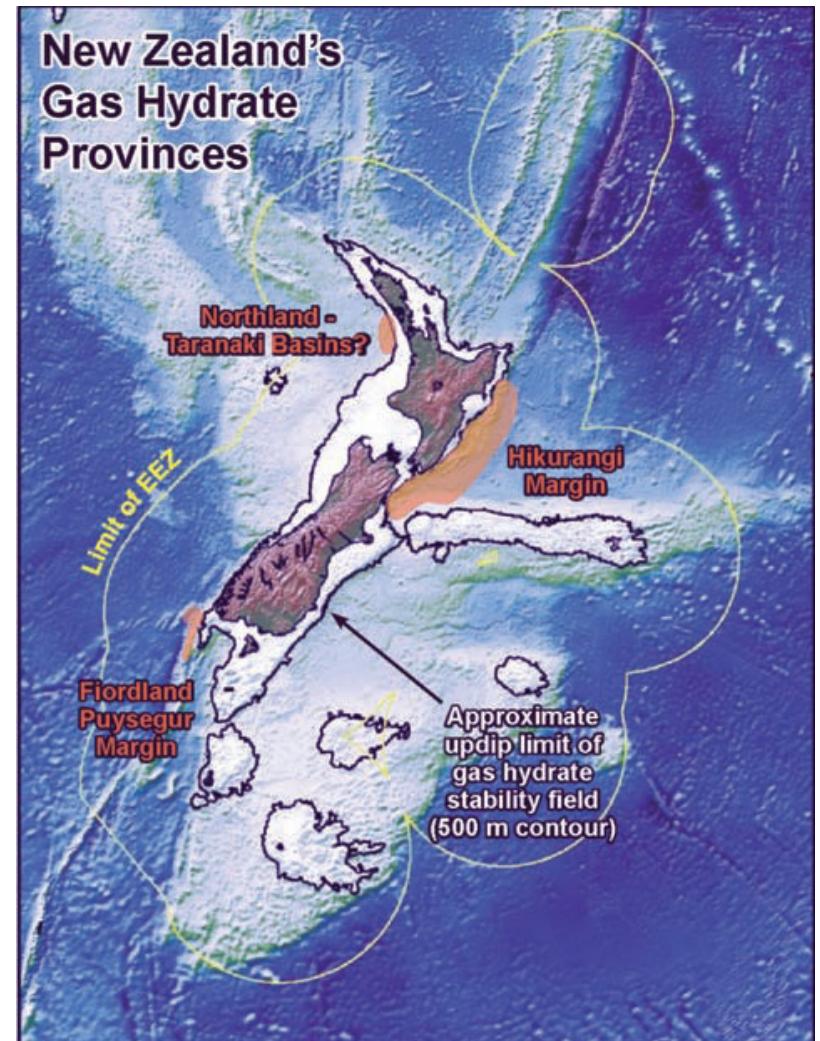
Ref: Wang et al., 2009



BSR Distribution

(Asia) Status – New Zealand

- New Zealand: BSR's were noticed in a number of places with features that promote strong fluid flow. Also noticed gas hydrate veins in cores recovered
- e.g.: Hikurangi Margin



Ref: Pecher et al., 2010

Asia Status- Others

- **Pakistan:** Noted presence of Gas Hydrates in core samples from Makran Ridge
- **Malaysia:** Reported BSRs in Gumusut-Kakap field
- **Indonesia:** Reported BSRs in Makassar Strait & Sunda Strait

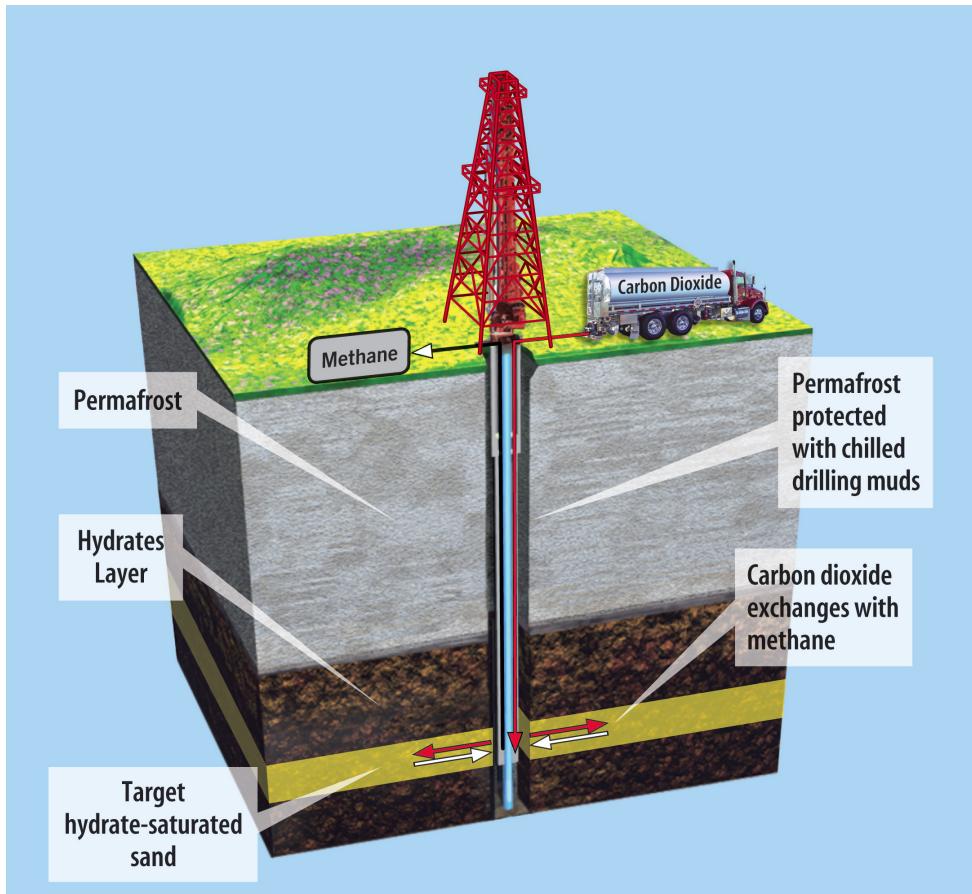
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Updates

- Production test drilling in Nankai Trough – Q1 2012
- Production test drilling in Alaska – Q2 2012
- Coring/Logging/testing of Gas Hydrates at Gulf of Mexico by JIP – Q4 2012

Planned Gas Hydrate Well at Alaska



- DOE sponsored program
- Production trial by ConocoPhillips and Univ. Bergen (Norway)
- Aim to produce methane gas and CO₂ to be sequestered into hydrate molecule
- Testing: does lab-proven exchange mechanism work in field with minimal sand and water production? what rate and exchange efficiency will be demonstrated at field?



Thank you..



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