EMD Gas Hydrates Committee Report

April 29, 2013

Art Johnson, P.G., Chairman, Hydrate Energy International, Kenner, Louisiana
Vice-Chairs:
TBA, (Vice-Chair: Industry)
TBA, (Vice-Chair: Government)

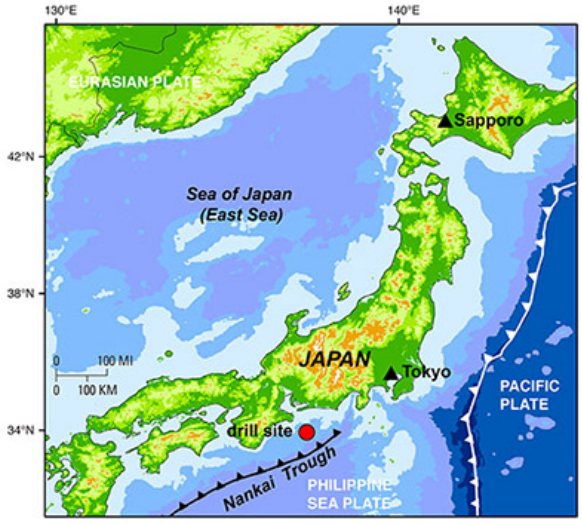
Committee Activities

We are deeply saddened by the death of Gas Hydrate Committee Vice-Chair Ashley Rose Gould on February 14. Her research on gas hydrate geophysics was of a very high caliber and her work on behalf of EMD was of great value. Her talents and her warm, outgoing personality will be greatly missed.

Gas hydrate activity related to energy resource development is occurring primarily outside of North America. As such, there is a specific need for Advisory Group members who will contribute to the committee's work by reviewing reports, organizing sessions at AAPG conventions, and contributing to the EMD Web Portal. Three individuals have joined the Advisory Committee this year, Bryant Mook of Brenham Oil (Houston), Vinay K. Sahay of MEPL-India, and Tim Collett of USGS. Tim was the first chairman of the Gas Hydrate Committee. Vinay has prepared a detailed overview of India's gas hydrate program and it is included in this report. The committee is encouraged that a gas hydrate poster was presented at the September 2012 ICE in Singapore.

Japanese Gas Hydrate Production Test

On March 12, 2013 the Japanese Ministry of Economy, Trade and Industry (METI) announced the commencement of the first offshore gas hydrate production test. The test was conducted in the Nankai Area off the coasts of Atsumi and Shima peninsulas in water depths of approximately 1,000 meters.



Production was initiated through depressurization of hydrate-bearing turbidite sands located 300 meters beneath the seafloor. Sustained natural gas production was established with a drillstem test at a rate of 0.7 MMcf/day. The test continued until March 18, at which point there was both a malfunction of the pump used for depressurization and a simultaneous increase in sand production. A total of 4 million cubic feet of gas was recovered in total, an amount higher than had been predicted. Initial analysis of the test indicates that the dissociation front reached the monitoring wells located 20 meters from the test well.

Abandonment of the site will be completed by August 31, 2013. The brief test was not designed to yield commercial production rates; however the results will be used to implement the next phase of the MH21 program, which will include commercial development. That phase is scheduled for Fiscal Years 2016-2018.

The Nankai test was conducted with the deep sea drillship "Chikyu". Produced gas was either vented or flared, depending on flow rates and weather conditions.

In preparation for the production test, a part of the production well (AT1-P) and two temperature monitoring boreholes (AT1-MC/MT1) were drilled in February and March, 2012. During drilling operations, intensive geophysical logging was conducted. In addition, a dedicated borehole in the same area was drilled to recover pressure cores. This was undertaken to obtain detailed data regarding the geology, geomechanics, geochemistry, microbiology, and petrophysics of the hydrate-bearing sediments.

United States Gas Hydrate Program

The U.S. Department of Energy's Methane Hydrate Program continues to pursue several important areas of gas hydrate research and characterization despite severe budget constraints. The selected projects are designed to increase the understanding of gas hydrates in the context of future energy supply and changing climates. USGS personnel continue to their involvement in resource evaluation, including consultation with assessment programs being conducted outside of the United States.

Ignik Sikumi Gas Hydrate Exchange Trial

The results of the Ignik Sikumi Gas Hydrate Exchange Trial were released in late 2012, including a presentation at the Arctic Technology Conference. The test was carried out from February 15 to April 10, 2012 in Prudhoe Bay Field, Alaska. The project team injected a mixture of carbon dioxide (CO2) and nitrogen into hydrate-bearing sand, and demonstrated that this mixture could promote the production of natural gas. This test was the first ever field trial of a methane hydrate production methodology whereby CO2 was exchanged in situ with the methane molecules resulting in methane gas and CO2 hydrate.


After measurement and compositional analysis, gas from the Ignik Sikumi test was flared

During the test, 210 mcf of a N2/CO2 gas mixture was pumped into the methane hydrate-bearing formation. The injected gas was 23% CO2 and 77% CO2. The recovered gas was 2% CO2, 16% N2, and 82% CH4, demonstrating that significant exchange had taken place within the reservoir of carbon dioxide for methane. Although not a technology for near-term production of methane from hydrate deposits, the test provides a path for carbon sequestration in the future. As such, ConocoPhillips is to be commended for advancing gas hydrate science. All data developed in the test was released in March, 2013.

The Prudhoe Bay production test, delayed by a number of issues, remains under review by the partners. The Gulf of Mexico Joint Industry Project (JIP) has concluded. The pressure-core system and laboratory equipment developed for the JIP was used for the Japanese program.

Gas Hydrate in India

An LWD drilling program is under review for offshore India in 2014, with site selection finalized in April, 2013. This program is focused on reservoir delineation and resource assessment, and is targeting hydrate-bearing sands. Two legs are planned, with the first dedicated to LWD logging. The previous gas hydrate field program (2006) targeted seismic BSRs (bottom simulating reflectors) and recovered significant amounts of gas hydrate, but in fine-grained sediments having low permeability.

A detailed overview of the India gas hydrate program has been prepared by Advisory Committee member Vinay Sahay and is included at the end of this report.

Gas Hydrate in China

China commenced exploratory gas hydrate drilling and coring in Spring, 2013. Results and other details of the program have not yet been released.

Gas Hydrate in South Korea

After two successful drilling programs (2006 and 2010), South Korea is planning a gas hydrate production test for 2014.

Meetings

The EMD Coal, Hydrates, and Geothermal poster session at the 2013 ACE in Pittsburgh will include 8 posters on diverse aspects of gas hydrate geology, geophysics, and petroleum systems. The posters include results from the Gulf of Mexico, Alaska, and several areas outside of North America. The 2013 URTeC meeting in August includes a Theme of "Other Unconventional Reservoirs" and a number of abstracts have been submitted for oral and poster presentations.

Special Report

By: **Vinay Sahay**
Advisory Committee Member

Gas Hydrate Developments in India

Gas hydrates are crystalline solids consisting of 99.9% methane and water. One volume of gas hydrates releases 164 volumes of methane gas and 0.8 volume of fresh water at standard temperature and pressure (STP). Gas hydrates are not stable at standard temperature and pressure (STP). They exist at higher pressure and lower temperature at a depth range which favour such conditions.

Government of India formulated a National Gas Hydrate Programme (NGHP) in 1997 for exploration and development of gas hydrates resources of the country. The National Gas Hydrate Program (NGHP) was launched by the Ministry of Petroleum & Natural Gas, India and is technically coordinated by Directorate General of Hydrocarbons (DGH). The NGHP is a consortium of National E&P companies (Oil and Natural Gas Ltd., Gas Authority of India Ltd.) and National Research Institutions (National Institute of Oceanography, National Geophysical Research Institute and National Institute of Ocean Technology). DGH, on behalf of the NGHP, has signed Memoranda of Understanding in the field of Gas Hydrates with Japan Oil, Gas, Metal Corporation JOGMEC, Gas Hydrate R&D Organization (GHDO) of the Korea Institute of Geology, Mining and Materials (KIGAM) and the US Department of Energy (USDOE) another MOU with the US Geological Survey (USGS) is in the pipeline. DGH has been closely associated with the USGS, USDOE and JOGMEC scientists who have helped the NGHP scientists to gain a lot in terms of knowledge, understanding and experience.

Reconnaissance surveys carried out by DGH in the East Coast and Andaman Deepwater areas in 1997 deciphered the most promising areas for Gas Hydrates. The surveys have indicated the presence of several Gas Hydrate leads/ prospects. As per the road map the NGHP has set itself a deadline of mid 2015 as the time to commence commercial production of gas from gas hydrates. **The figure 1** is the gas hydrate thickness map of the Indian shelf with identified prospective/ promising gas hydrate bearing regions.

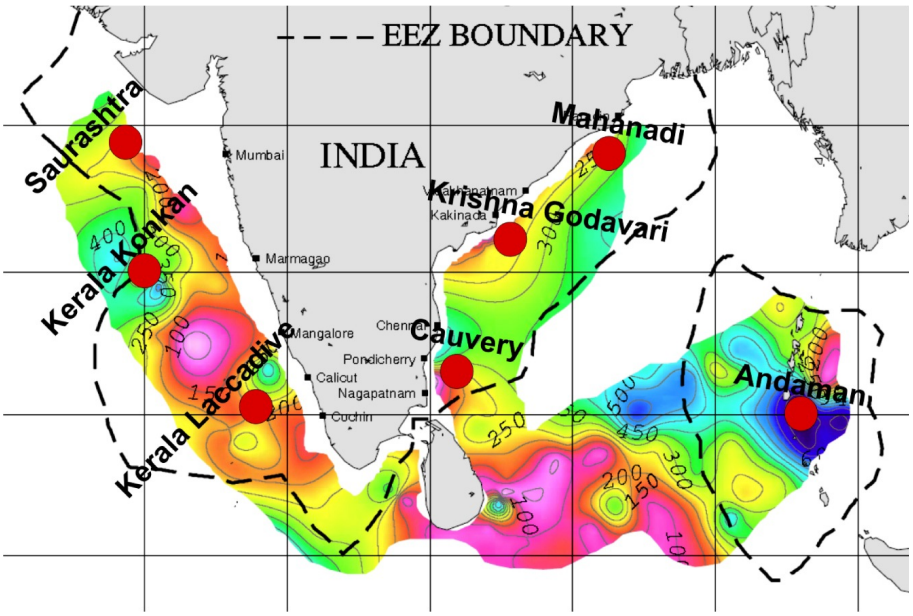


Figure 1. Gas hydrate thickness map along the Indian shelf with the EEZ boundary. The prospective zones (Krishna Godavari, Mahanadi and Andaman Basins) and less explored but potential zones (Kerala Konkan, Saurashtra, Kerala Laccadive and Cauvery) of gas hydrates are superimposed on the map (Sain et al. 2012).

Results of the National Gas Hydrate Program:

The important results of the NGHP can be summarized as following:

- By analyzing multi channel seismic data, the bottom simulator reflector (BSRs) had been identified in Krishna Godavari, Mahanadi and Andaman basins in the eastern Indian margin and in Saurashtra and Kerala Konkan basins in the western Indian margin **(Figure 2)**.
- Delineated the most prospective gas hydrates zones in the Krishna Godavari, Mahanadi and Andaman Basins.
- Proxies for gas hydrates have been recognized in the Kerala Konkan and Saurashtra Basins.
- The Kerala Laccadive and Cauvery basins have also been found prospective for gas hydrates by studying into various physical properties.
- Approximately 1900 trillion cubic meter of methane has been prognosticated within the exclusive economic zone of India.
- The drilling and coring during the NGHP expedition 01 have validated the ground truth in Miocene to Pleistocene/Recent sediments where gas hydrates were predicted from the surface seismic data in the eastern Indian margin.
- The NGHP Expedition 01 drilled holes at 21 sites (one site in the Kerala- Konkan basin, 15 sites in the Krishna-Godavari basin, four sites in the Mahanadi basin, and one site in the Andaman

deep offshore areas), penetrated more than 9,250 m of sedimentary section, and recovered 494 cores encompassing 2,850 m of sediment from 21 holes.

- Twelve holes were logged with logging-while-drilling tools at 10 sites, and an additional 13 holes were wireline-logged.
- Discovered 120 m thick massive gas hydrates in 64% porous fractured shale in Krishna Godavari basin. This is one of the richest gas hydrate accumulations discovered up to now in the world.
- Discovered the thickest (~340 m) disseminated gas hydrates (4.4% saturation) in volcanic ash in Andaman basin area. This is one of the thickest and deepest gas hydrate occurrence.
- The gas hydrate bearing volcanic ash layer, in Andaman basin, is present as deep as 600m below the sea floor. Smectite is the dominant clay mineral with presence of illite and chlorite.
- Presence of gas hydrate deposits in sand reservoirs in Mahanadi basin.
- Provided information on type and nature of host rocks of gas hydrates.
- The recovered gas hydrates has been documented as pore- filling grains, disseminated grains or fracture filling grains in clay sediments.
- The presence of fractures, pores in sediments and coarse grain sediments controls the occurrence of gas hydrates.
- The methane in recovered gas hydrates in NGHP expedition 01 is predominantly microbial in origin. Evidences have been also found for thermal origin of a portion of methane of gas hydrates from Andaman and Mahanadi basins.

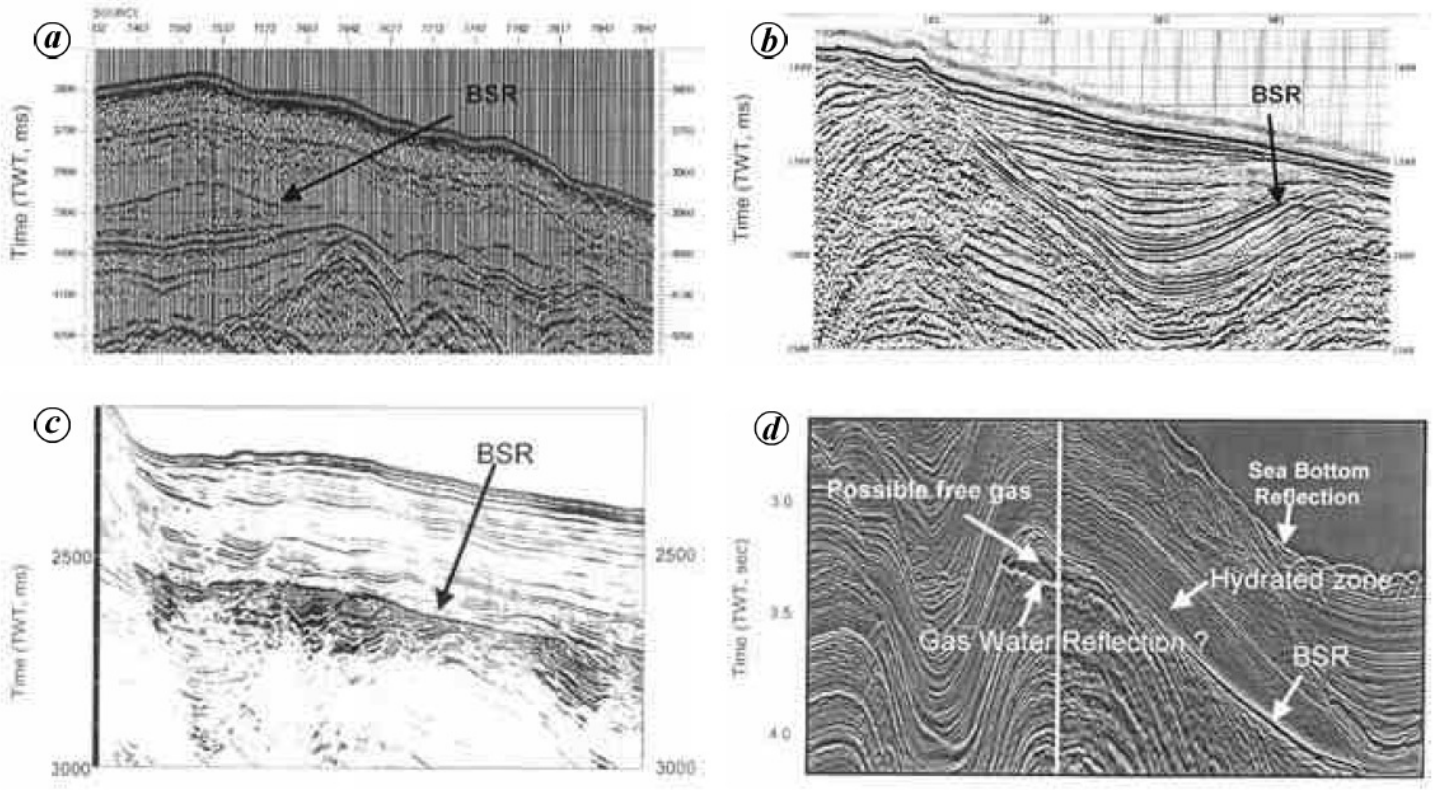


Figure 2. Examples of BSRs in (*a*) Goa offshore, (*b*) KG offshore, (*c*) Mahanadi offshore and (*d*) Andaman Sea (Source: Ramana et al. 2006).

Figure.5. Massive and disseminated form of gas hydrate recovered from KG offshore during NGHP expedition (Source: Ramana & Ramprasad, 2010)

Challenges in Commercial Production of Gas Hydrates for the India:

At present there is no proven technology world over to produce methane from Gas hydrate on a commercial scale. Apart from this much of the gas hydrate reserves worldwide are found disseminated in sandstone. So whatever research being done on the extraction of gas from hydrates focus on disseminated deposits in sands. However, Indian scenario is different in comparison with those. The reservoir rock of gas hydrate in Krishna Godavari basin is fractured shale, whereas the reservoir rock of gas hydrates in Andaman basin is volcanic ash. The following scientific and technical issues have been identified through compilation and analysis of the NGHP and their results.

- How to dissociate hydrates, containing methane, efficiently to release methane from hydrates and allow its migration towards production wells.
- Which type of production wells will be suitable technically and commercially; either vertical or lateral or horizontal or an integrated horizontal branched well.
- How the integrity and stability of upper part layer of the gas hydrate deposits can be maintained so that the leakage of methane in ocean, and in atmosphere through it, can be avoided during the production.
- Which technique (like depressurization, thermal flooding, or others) will be most appropriate technically as well as commercially to produce methane from hydrates of fractured shale or volcanic ash.
- As one volume of gas hydrates releases 164 volumes of methane gas and 0.8 volume of fresh water, there may be substantial flow of water during the production. How this will be managed.
- Geomechanical issues related with production of gas hydrates in fractured shale and volcanic ash.
- The NGHP should have to plan to work on this and address these issues for successful National Gas Hydrate Program from exploration to commercial production of gas hydrates in India.
- As per road map of DGH the NGHP Expedition 02 would aim at the identification of sites for carrying out pilot production testing. The expedition would aim at identifying sites which would ideally have: 1. Sand dominated gas hydrate occurrence; 2. Reasonably compacted sediments; 3. Occurrence of free gas below the gas hydrate stability zone. However, DGH should have to equally focus on commercial production testing in fractured shale, Krishna Godavari basin as reward to success is comparatively high for the India, because of the thick deposit of gas hydrates. These finding will also have utility in volcanic ash gas hydrates, Andaman basin.

References

Arya, O. P., Manoj Kumar Tewari, M. K., and Singh, B. (2009) Sub-surface characterization of the gas hydrate bearing volcanic ash sediments with wireline logs in Andaman deep waters, India. 2nd SPWLA-India Symposium, November 19-20.

Collett, T., M. Riedel, J. Cochran, R. Boswell, J. Presley, P. Kumar, A. Sathe, A. Sethi, M. Lall, V. Siball, and Natural Gas Hydrate Program (NGHP) Expedition-01 Scientific Party (2008) in Indian National Gas Hydrate Program Expedition 01 Initial Report. Directorate General of Hydrocarbons.

Kuldeep Chandra, Singh, R. P. and Julka A. C. (1998) Gas hydrate potential of Indian offshore area. 2nd Conference and Exposition on Petroleum Geophysics, SPG 98, Chennai, 1998.

Ramana, M. V. and Ramprasad, T. (2010) Gas hydrate occurrence in the Krishna-Godavari offshore basin off the east coast of India. Exploration & Production, 8 (1), 22-28.

Ramana, M. V., Ramprasad, T., Desa, M., Sathe, A. V. and Sethi, A. K. (2006) Gas hydrate-related proxies inferred from multidisciplinary investigations in the India offshore areas. Current Science **91**, 183–189.

Sain, K., Gupta, H., Mazumdar, A., Bhaumik, A.K., Bhoumick, P.K. (2012) Geo-scientific investigations of gas hydrates in India. Proc. Indian Nat. Sci. Acad., 78, No.3, pp. 503-511.

www.dghindia.org