The 2013 World Congress on
Advances in Structural Engineering and Mechanics (ASEM13)
Jeju, Korea, September 8-12, 2013

The Seafloor deformation and well bore stability monitoring during gas production in unconsolidated reservoirs

*Joo Yong Lee, Jong-Hwa Chun and Se Joon Kim

Petroleum & Marine Research Division, KIGAM, Daejeon 305-350, Korea
jyl@kigam.re.kr

ABSTRACT

The production of hydrocarbon from unconsolidated reservoir sometimes induces additional compactions of the reservoir. Gas hydrate, one of the unconventional carbon resources, usually occurs in unconsolidated deposits, from seafloor to ~300mbsf in deep sea environments. Consequently, controlling and monitoring seafloor deformation and well bore stability during production is crucial for safe and efficient gas production from gas hydrate deposits. The seafloor deformation monitoring system and well bore stability monitoring system of three marine gas hydrate reservoirs, the Ulleung Basin in Korea, the Gulf of Mexico in USA, and the Nankai Trough in Japan have been explored and compared to enhance the system planned at the gas hydrate reservoir in the Ulleung Basin, East Sea, Korea. The observing program in the Gulf of Mexico has been established to understand sea-floor stability relations and model hazardous geologic conditions. Hydrophones and positioning devices are used in the water column and three component accelerometers are placed on the seafloor. Data are transmitted through fiber optic to the platform and telemetered to shore. In Nankai Trough, the observation program focuses on short time geologic events induced from gas hydrate dissociation and P/T changes. Two monitoring wells are placed to observe P/T conditions and cable type accelerometers are placed on the seafloor. In the Ulleung Basin, pressure transducers and deepwater digital tiltmeters will be placed for seafloor deformation monitoring. Pressure transducers and distributed temperature sensors are planned to be installed along boreholes. Geophysical monitoring could be adopted for well bore stability monitoring during production.

1. INTRODUCTION

The production of hydrocarbon from unconsolidated reservoir sometimes induces additional compactions of the reservoir. Gas hydrate, one of the unconventional carbon resources, usually occurs in unconsolidated deposits, from seafloor to ~300mbsf in deep sea environments. Consequently, controlling and monitoring seafloor deformation and well bore stability during production is crucial for safe and efficient gas production from gas hydrate deposits.
Boswell et al. (2012) categorized the geohazard into two groups; “naturally-occurring”

geohazards that are related to geologic processes and “industrial” geohazards that are directly triggered by human activities (Fig. 1). Naturally-occurring geohazards are mainly associated with submarine landslides and slope instability induced from dissociation of that gas hydrate by natural causes such as such as pressure changes due to sea-level changes or temperature changes due to climate change (Bowell et al. 2012). The gas hydrate dissociation releases free gas, induces excess pore pressure, and cause slope instabilities. Industrial geohazards are mostly associated with oil and gas production activities. If seafloor infrastructures are installed on shallow hydrates deposits, the installation can induce hydrate dissociations, weaken sediment integrity, and damage the infrastructures (Bowell et al. 2012). Drilling through gas hydrate deposits and gas production from gas hydrate deposits can also trigger gas hydrate dissociations, inducing deteriorate sediment integrity.

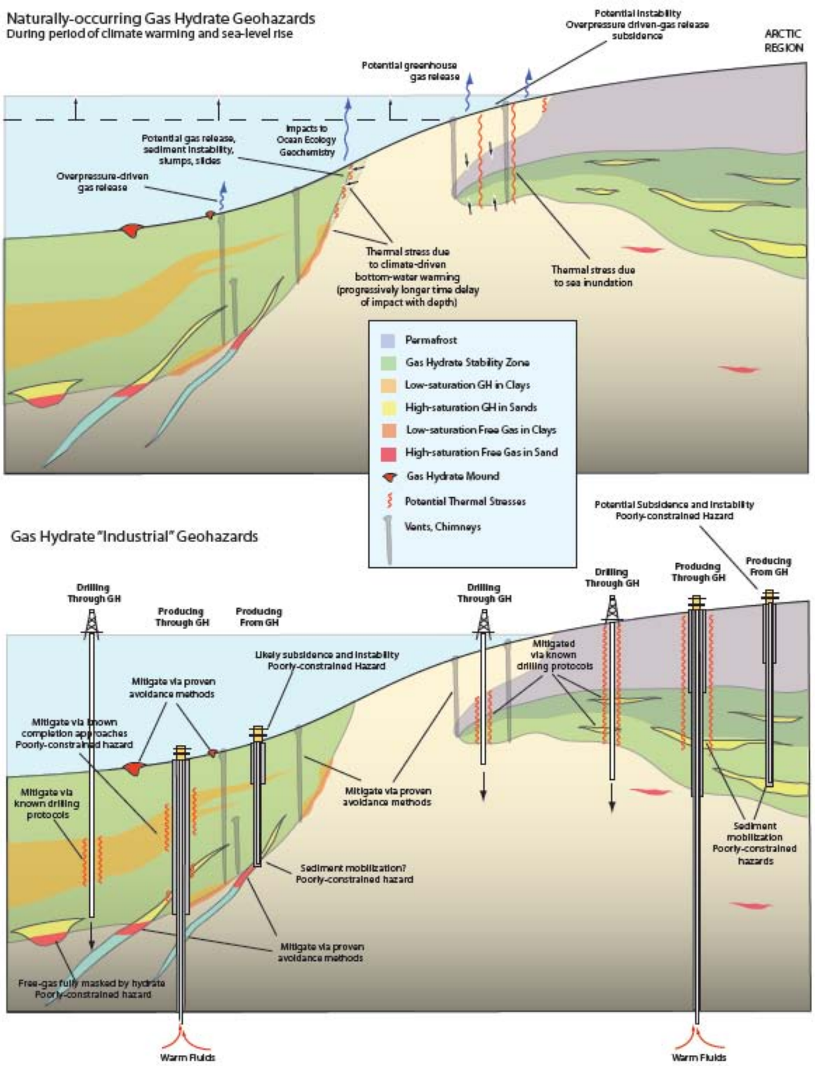


Fig. 1 Schematic diagram of “naturally-occuring” and “industrial” gas hydrate geohazards (Boswell et al. 2012)

2. SEAFLOOR MONITORING SYSTEMS FOR MONITORING GEOHAZARDS

The Gulf of Mexico Gas Hydrates Research Consortium (GOM-HRC) was organized to establish sea-floor observatory (SFO) to monitor the hydrate deposits of the northern Gulf of Mexico (Woolsey et al. 2009). SFO has been equipped with variety of sensors that enables monitoring steady state physical, chemical and thermal conditions. The seafloor monitoring system, employed as part of SFO is the Sea Floor Probe (SFP), which is a multiuse tool to effectively deploy sensors into the shallow subsea-floor. The SFP include a; Penetrometer, 10m Gravity Coring System, Pore Fluid Array, and Thermister Geophysical Line Array (Woolsey et al. 2009).

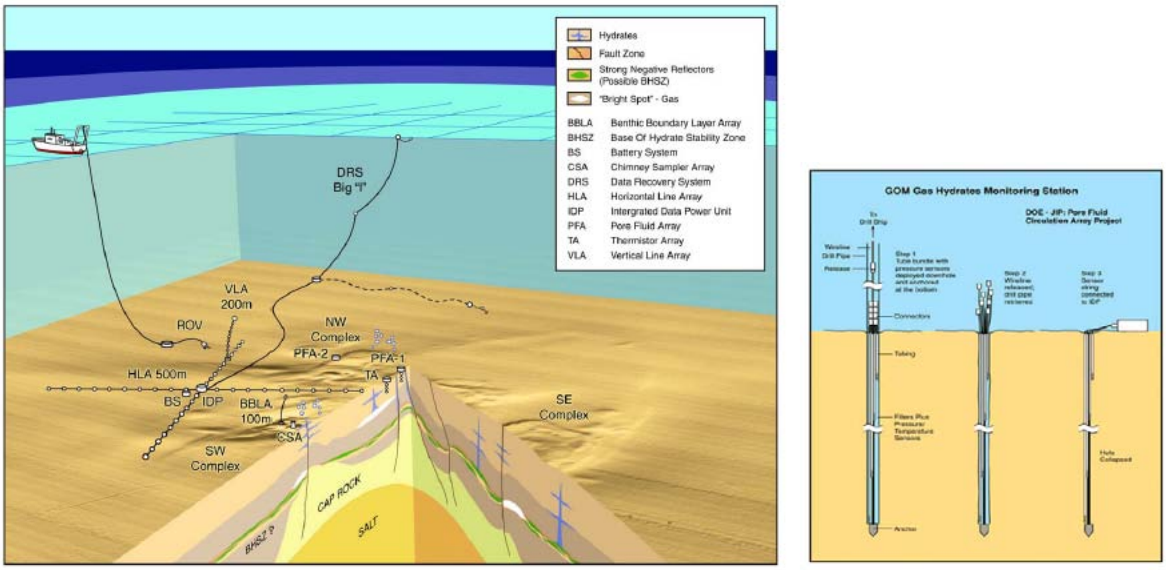
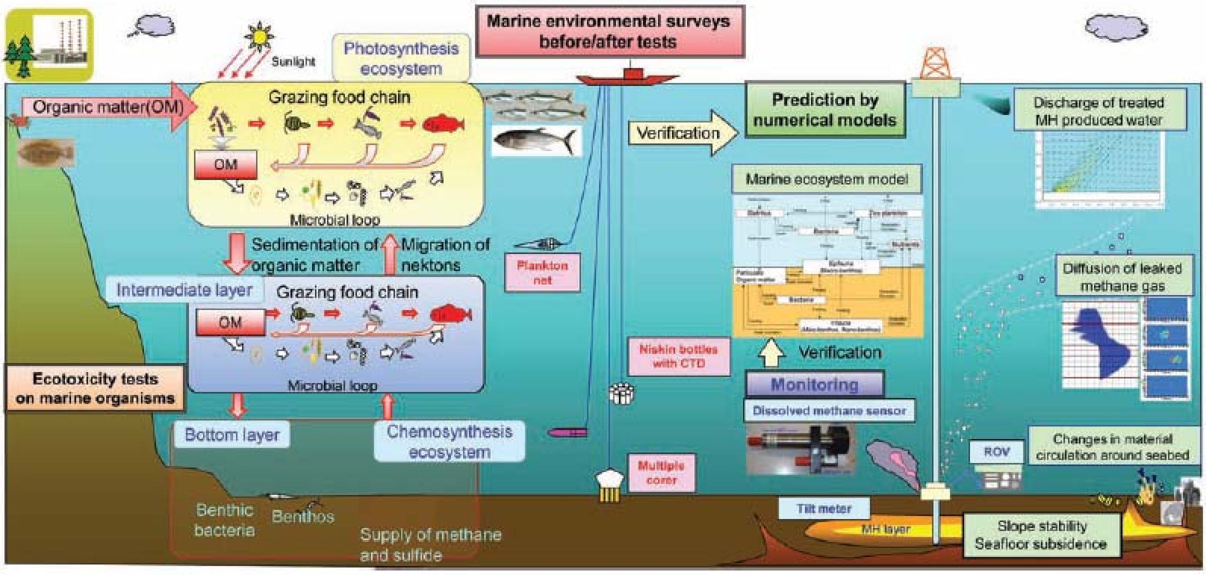
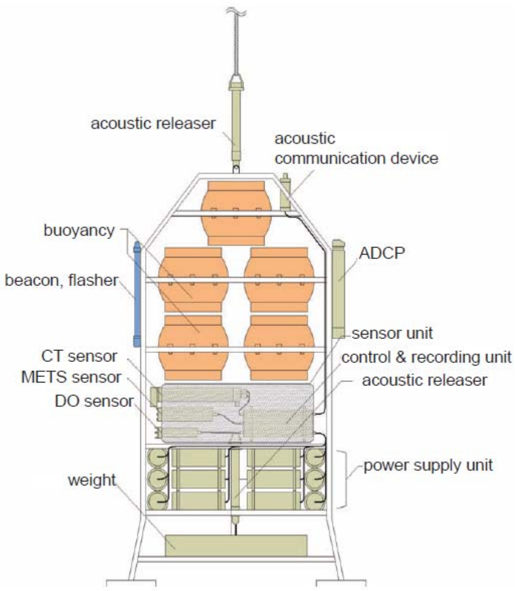


Fig. 2 Monitoring system in the Gulf of Mexico

The Ministry of Economy, Trade and Industry (METI) in Japan established Methane Hydrate R&D Program in 2001. One of the primary research objectives in this program was the development of a system that fully complies with environmental protection (Nagakubo et al. 2011). The seafloor deformation monitoring system particularly focused on methane leakage from the seafloor and seafloor deformation such as subsidence and/or landslide. Methane Leakage Monitoring System (MLMS) mounts a METS Sensor (dissolved methane sensor)' developed by MH21 together with a temperature sensor, salinity sensor, and current meter (Fig. 3, Nagakubo et al. 2011).
Seafloor Deformation Monitoring System (SDMS) mounts tilt meter and pressure sensor to detect seafloor deformation (Fig. 3, Nagakubo et al. 2011).





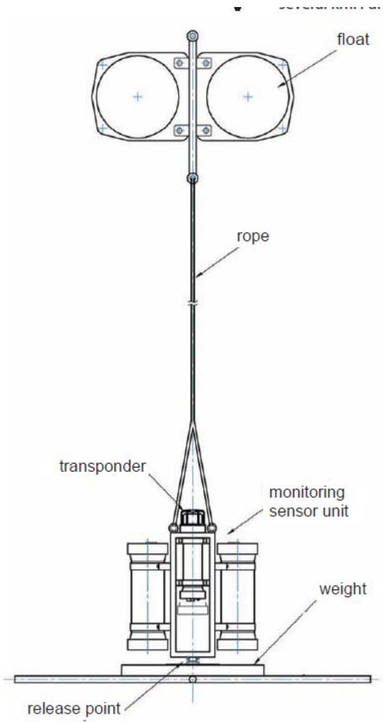


Fig. 3 Monitoring system in Nankai Tough. Top: Whole system, Lower left: MLMS, and Lower right: (SDMS)

In Korea, the Korea Institute for Geoscience and Mineral Resources (KIGAM) plans to develop a seafloor environmental monitoring system for operation during gas hydrate test production to be undertaken in the northern Ulleung Basin. The overall aims of the seafloor monitoring program are to observe changes to the seabed and nearseabed environment which could be attributable to the drilling activities and to test production of subsurface gas hydrates. Seafloor deformation can be characterized by vertical translation and/or tilt of the seabed. High accuracy sensors for measuring pressure are all based on the Paroscientific Digiquartz series of sensors. The most accurate version is the Bottom Pressure recorder (BPR) used on NEPTUNE Canada for the tsunami detection array. These ultra-precise transducers are capable of resolving 10ppb (i.e. 25um in 2500m of water). High precision tilt sensors pre-packaged for oceanographic use include the Deepwater from Applied Geomechanics with an accuracy and precision of 0.002 degrees (Fig. 4).

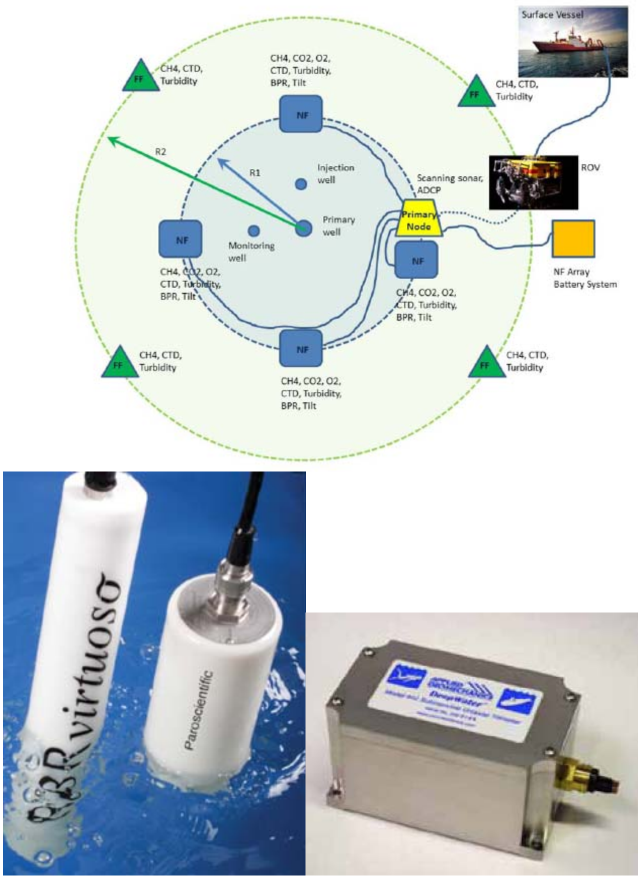


Fig. 4 Monitoring system planned in the Ulleung Basin, East Sea, Korea

REFERENCES

Cadappa, D.C., Sanjayan, J.G. and Setunge, S. (2001), “Complete triaxial stress-strain curves of high-strength concrete,” *J. Mat. Civil Eng., ASCE,* **13**(3), 209-215.

Chern, J.C., Yang, H.J. and Chen, H.W. (1992), “Behavior of steel fiber reinforced concrete in multi axial loading”, *ACI Mat. J.,* **89**(1), 32-40.

Boswell, R., Collett, T., Dallimore, S., and Frye, M. (2012), “Geohazards Ass oci ated wi th Naturally-occ urring Gas Hydrate,” Fire In The Ice, **12** (2), 11-15

Nagakubo, S., Arata, N., Yabe, I., Kobayashi, H., and Yamamoto, K. (2011), “Environmental Impact Assessment Study on Japan‘s Methane Hydrate R&D Program,” Fire In The Ice, **10** (3), 4-11

Woolsey, J. R., McGee, T.M., and Lutken, C. B. (2009), “Support of Gulf of Mexico Hydrate Research Consortium: Activities to Support Establishment of a Sea Floor Monitoring Station Project” Final Report, DOE Award No.: DE-FC26-02NT00041628