# The application example of GNSS for natural gas development together with PDCA Management Method

*Yoshiyuki Muramoto[1], Susumu Hayatsu[1], Michiharu Hiyama[1], Daisuke Murai[1], Shoji Kunisue[1]

1. KANTO NATURAL GAS DEVELOPMENT CO., LTD

[Background]
We have been developing the Southern Kanto gas field for many years. This field which contains natural gas dissolved in water is located primarily under Chiba prefecture, and it extends across a wide area of the Kanto region, including Ibaraki, Saitama and Kanagawa prefectures as well as Tokyo Metropolis. This field's recoverable reserves are estimated 368.5 billion cubic meters, making it the largest field of gas dissolved in water in Japan. The gas is dissolved in formation water which is called brine, so it is produced together with brine. Commercial production of natural gas has been conducted in Chiba prefecture since 1931 and has contributed to the growth in the region. Formerly, it was mainly used for industrial gas, but now most common usage is for city gas. On the other hand, land subsidence has been confirmed in Kujukuri area, east of Chiba prefecture. Brine production is considered as one of possible causes of it. Companies producing natural gas in this area including our company have made a land subsidence prevention agreement with the Chiba prefectural government to prevent and control land subsidence. Also, from the technical point of view, we conduct joint study on environmental issues with other gas production companies as a member of "Environmental Technology Research Association for Natural Gas Dissolved in Water".

[Observation of land subsidence]
The Chiba prefectural government has conducted leveling every year. We also have conducted it, but it takes a lot of time to get the survey result because we have to revise the observation data based on the leveling result conducted by local government. On the other hand, GNSS observation which is one of the surface level observation techniques has been prevailed recently. The advantage of GNSS is that continuous observation is possible at the place where it is installed. In Japan, the Geographical Survey Institute has established GEONET (GNSS Earth Observation Network System) throughout the country. We installed GNSS stations in our operating area and analyze these data together with GEONET's since 2013 to get circumstance of land subsidence quickly.

[Application example of GNSS for natural gas production]
We installed GNSS station to monitor the land subsidence in a certain area where natural gas is newly developed. The reason for that is because we need to adjust the brine production rate based on land subsidence. We use GNSS data in "PDCA Management for Land Subsidence Control", one method for controlling land subsidence systematically. This method consists of four elements. "P", Plan, means making of production plan based on the simulation result. "D", Do, means production of natural gas based on the production plan. "C", Check, means observation and evaluation of land subsidence by GNSS and leveling. "A", Act, means update of simulation model. By repeating this method every year, we will improve the way of subsidence management.
In the presentation, we will introduce the application example of GNSS for natural gas development together with PDCA Management Method.

Keywords: GNSS, Natural gas dissolved in water, Southern Kanto gas field