

## Variety of near-surface gas hydrates at the southern Baikal basin

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Natural gas hydrate exists in the bottom sediment of Lake Baikal. Near-surface gas hydrate was first discovered at the Malenky mud volcano at the southern Baikal basin in 2000. In the framework of Multi-phase Gas Hydrate Project (MHP, 2009-2017), our international collaboration between Japan, Russia, and Belgium, has revealed distribution of near-surface gas hydrates at the southern Baikal basin, and found eight new places (Krasnyi Yar 1-3, Kedr, Mamay, PosolBank2, Kedr2, and Solzan). The total number of places where near-surface gas hydrates were found is 14 in the southern Baikal basin, and we report the characteristics of gas hydrates retrieved from these sites.

Gas hydrate crystals were quickly collected onboard and stored in liquid nitrogen. Samples of hydrate-bound gas were obtained onboard and stored in 5-mL vials. We obtained the powder X-ray diffraction (PXRD) patterns of the crystals and measured molecular and stable isotope compositions of the gas vials.

PXRD results showed that almost all samples belonged to the crystallographic structure I; however, some samples retrieved at Kedr and Kedr2 where massive and granular crystals were recovered in the last cruises (MHP-15 and 16) belonged to the crystallographic structure II.

According to the  $C_1/C_2 - C_1d^{13}C$  diagram (Bernard *et al.*, 1976), the  $d^{13}C$ -dD diagram for  $C_1$  (Whiticar, 1999), and the  $C_1d^{13}C - C_2d^{13}C$  diagram (Milkov, 2005), the gas characteristics show the following information:

1) Hydrate-bound hydrocarbons at the Krasnyi Yar 1-3, PosolBank2, and Solzan are mainly microbial origin, those at the Kedr and Kedr2 mud volcanoes are thermogenic origin, and those at the Mamay are in the field of mixed-gas between microbial and thermogenic.

2)  $C_1dD$  of the hydrate-bound gas at the Krasnyi Yar 1-3, PosolBank2, and Solzan distributed around -300 permil, and those at the Kedr and Kedr2 were around -270 permil due to the effect of thermogenic methane.

3)  $C_2d^{13}C$  of the hydrate-bound gas at the PosolBank2 was around -30 permil, and that at the Solzan was around -70 permil, indicating the effect of microbial  $C_2$ . The latter  $C_2d^{13}C$  at the Solzan is the lowest value of hydrate-bound  $C_2$  in the world.

4)  $C_2d^{13}C$  of the hydrate-bound gas at the Kedr and Kedr2 mud volcanoes showed that  $C_2d^{13}C$  of the structure II was around 10 permil lower than that of the structure I, suggesting that the structure I dissociated and formed the structure II according to an isotopic fractionation.

### References

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