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Baikal mud volcanoes: thermal features of dynamic gas hydrate systems

J. Poort (1), O. Khlystov (2), H. Shoji (3), S. Nishio (4), M. Kida (3), N. Granin (2), L. Naudts (1), M. De Batist (1)

(1) Renard Centre of Marine Geology, Ghent University, Belgium, (2) Limnological Institute, Irkutsk, Russia, (3) Kitami Institute of Technology, Kitami, Japan, (4) Institute of Technology, Shimizu Corporation, Tokyo, Japan (jeffrey_poort@yahoo.com)

In Lake Baikal shallow gas hydrates have already been identified in five mud volcano/seep structures through joint Russian, Japanese and Belgian research. These mud volcano/seep structures are found at different water depths (from 1380 m to as shallow as 440 m) and contain shallow hydrates of both structure I and II. Bottom Seismic Reflections (BSRs), indicative for the presence of deep-seated hydrates, has been observed on nearby seismic profiles. We will report on detailed thermal investigations in association with gravity coring performed over the last three years in the following gas hydrate containing mud volcanoes: “K-2”, “Malenkiy” and “Bolshoy”.

The “K-2” mud volcano is located on the flanks of the Kukuy Canyon at a water depth of 900 m water depth. This oval structure of 60 m in height and 800 m in diameter consists of two separate mud volcanoes corresponding to two culminations. Sediment cores have been retrieved in more than 75 sites (15 contained hydrates), with temperature sensors attached to the corer in 22 occasions. Shallow hydrates were only found in two zones of not more 50-100 m diameter: on the top and between the two culminations. These zones also stand out by anomalous low (30-43 mK/m) and high (90-113 mK/m) thermal gradients in comparison to what is measured outside the mud volcano (60-70 mK/m). Cores with hydrates were directly correlated to low thermal gradient and large non-linearity in the temperature-depth profiles. This can be explained in three ways: (1) heat absorption by hydrate dissociation; (2) topographic effect combined with a dynamic hydrate system; and (3) infiltration of cold lake water, possibly induced by local convection and/or water segregation. The localized occurrence of hydrates within the mud volcanoes and a close relation to thermal anomalies was also

observed in the mud volcanoes “Malenkiy” and “Bolshoy”, located at a water depth of about 1380m. More than 30 gravity cores in both structures indicate zones with shallow hydrates in local depressions and on culminations. Thermal stations show the presence of anomalous thermal gradients, up to 180 mK/m, at short distances of background values.

The mud volcanoes in Lake Baikal do not display a strong activity in terms of acoustic flaring in the water column (almost absent) and large-scale temperature anomalies ($< 1\text{ }^{\circ}\text{C}$). However, they comprise local shallow hydrate systems in close association with anomalous low and high thermal gradients. A dynamic nature of the hydrate system in “K-2” mud volcano has been supported by small shifts of the hydrate occurrence zone within the three year period of investigation.