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Biogeochemical cycles of methane in Lake Baikal

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Geophysical studies revealed that at the bottom of Lake Baikal in places of BSR pinch low hills were formed due to destruction of hydrate layer and methane seep into water column (Batist et al, 2002, Rensbergen et al., 2002). Geological testing of these regions allowed to prove that those hills were mud volcanoes on the slopes of which in the first 200 cm layers there were found methane hydrates. Studies on methane concentrations in water column and bottom sediments of Lake Baikal testify to the fact that methane seeps from the lake bottom. Methane concentrations above the volcano "Malenki" in waters of Southern Baikal reached 1.3 μl/l. It was 0.8 μl/l above one of the faults in the northwest off the Selenga delta (Kukuisky Canyon). In shallow waters above methane flames detected by echosounding, methane concentrations made up 2.3 μl/l. Moreover, the river flow affected significantly the formation of methane fields in water column. The influence of river flow on methane concentrations was observed for long distances: in the avandelta of the Selenga River – up to 15 km, and in Barguzin Bay – up to 5 km. Methane concentrations in waters of the Selenga and Barguzin Rivers reached 5-20 μl/l.

Vertical distribution of methane in deep areas of the lake was of the same type during all the seasons studied (March and August 2003 and June 2004). In surface layers of water column methane concentrations made up 0.2-0.3 μl/l and reduced sharply up to 0.05 μl/l at the depth of about 200 m. In the lower part of the fault, methane concentrations fell to 0.01-0.02 μl/l. Vertical distribution of methane in deep areas of Lake Baikal appeared to be surprisingly similar to that in waters of the Central Atlantic excluding the upper 200m zone of Lake Baikal where methane concentrations were

2-4 times higher than those in oceanic waters.

Judging by profiles of methane distribution in background regions of all the lake basins, methane was actively utilized by microorganisms in Lake Baikal. It was also proved by laboratory experiments: Baikal water containing microorganisms sampled at different depths was able to oxidize large amounts of methane. Molecular and biological studies showed the presence of methanotrophic bacteria in both aerobic zone of sediments (up to the depth of 5 cm) and in water column. Among studied sequences prevailed methanotrophic bacteria of type I, which were more similar to representatives of the genus *Methylobacter*.

According to vertical profiles on intensity of oxidation and concentrations of methane in bottom sediments, its oxidation is likely to occur under anaerobic conditions. This process is possible only in the zones with increased concentration of sulfate, which is formed in areas of buried brackish lakes, which existed at the early stage of Baikal formation (Lomonosov, 1974, Dzyuba et al., 2001). Seeps of such water take place in areas of near-surface deposition of methane hydrates. Sulfate concentrations in some layers reach 1 g/l of pore waters and more. Analyses of bacteria DNA from different layers of sediments containing hydrates show the presence of sequences, which are similar in structure to archaebacteria of the kingdom Crenarchaeota. This sequence occupies an intermediate position on the phylogenetic tree between true methanogenes and methanogenes, which are able to oxidize methane under anaerobic conditions (ANME-1 è ANME-2).

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