Methane sources and sinks in Lake Kivu

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Abstract

Unique worldwide, Lake Kivu has an enormous amount of dissolved CH_4 and CO_2 in its deep waters. A recent study reported that methane concentrations have increased by 15% in the last 30 years and such an accumulation could lead to a limnologic explosion by the end of the century. This study therefore investigated recent methane production and oxidation in Lake Kivu. Our results show that aerobic methane oxidation is the major pathway preventing methane to escape into the atmosphere and is performed by methane oxidizers closely related to type X gammaproteobacterial. On the contrary, anaerobic methane oxidation, carried out by a novel type of Archaea related to ANME ab, appeared to be of minor importance. Analyses of $^{14}C_{CH4}$ reveal that below 250 m methane is produced by 44% acetotrophic methanogenesis and by 56 % via reduction of magmatic CO_2. Above 250 m, this reduction does not occur and may indicate that magmatic CO_2 and H_2 strictly enter the deep part of the lake. Since the measurements in the 1970s, $^{14}C_{CH4}$ and $\delta^{13}C_{CH4}$ changes indicate that methane produced from organic material has increased. Since the 1960s, higher organic carbon accumulation and the sudden onset of carbonates in sediment are explained by amplified inflows of subaquatic springs following hydrological changes. Higher subaquatic inflows, also confirmed by the alteration of double diffusive layers, caused an intensified upwelling, releasing more nutrients in the epilimnion. Higher primary production, and thus organic matter sedimentation, have led to the observed methane increase.

Keywords: African lakes/ carbon cycling / methanotroph / methane oxidation / reduction of magmatic CO_2 / acetotrophic methanogenesis

Subject category: Geomicrobiology and microbial contributions to geochemical cycles