



## Biogeochemical signatures of the anaerobic oxidation of methane in a south alpine lake (Lake Lugano)

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A significant fraction of the methane flux in anoxic marine sediments is consumed by a consortium of methanotrophic archaea and sulphate reducing bacteria. In contrast, methane oxidation in lakes is usually mediated by aerobic, methanotrophic bacteria at the oxycline, while only a few studies found indications for anaerobic oxidation of methane (AOM) in lacustrine systems. In the present study, we combined biogeochemical, lipid biomarker and stable carbon isotope analyses to investigate potential modes of methanotrophy in the water column of the northern basin of Lake Lugano. This basin features a meromictic mixing behaviour with a permanent anoxic hypolimnion (90 – 286 m water depth). Here, biogenic methane ( $\delta^{13}\text{C} = -70\text{‰}$ ) diffuses from sediments into the anoxic water column leading to bottom water methane concentrations of about  $50 \mu\text{M}$ . However, methane decreased exponentially with a maximum concentration gradient of  $8.6 \times 10^{-6} \mu\text{mol cm}^{-4}$  to concentrations  $< 5 \mu\text{M}$  at 200 m water depth (i.e. 100 m below the oxycline). This was furthermore associated to a progressive enrichment of 20‰ in the  $^{13}\text{C}$ -content of the residual methane. In contrast, the methane gradient at the oxycline was almost one order of magnitude lower. These data already provide strong indications for a dominant, anaerobic mode of methane oxidation in the anoxic water column of Lake Lugano. This was further substantiated by the dominance of monoenoic fatty acids in the anoxic hypolimnion with  $\delta^{13}\text{C}$ -values as low as  $-94\text{‰}$  (C16:1 $\omega$ 6c) providing evidence for an incorporation of methane derived carbon. Surprisingly, no compounds typically associated to anaerobic methanotrophic archaea (e.g. archaeol) could be detected pointing to an anaerobic mode of methane oxidation solely mediated by bacteria. However, the identity of the terminal electron acceptor for AOM in Lake Lugano needs further evaluation. In contrast to the hypolimnion, increasing contents of  $\delta^{13}\text{C}$ -depleted fatty acids such C16:1 $\omega$ 8c with values as low as  $-65\text{‰}$  point to a type I aerobic methanotrophic bacterium.