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Anaerobic Oxidation of Methane in Sediments of a high Alpine Lake

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Owing mainly to anthropogenic production, atmospheric methane concentrations have doubled from 850 ppb to approximately 1750 ppb over the last 150 years. A significant proportion of the methane emitted to the atmosphere is of natural origin (30%); however, this number is not well constraint and recent publications hint to lakes as an overlooked source of methane emissions. In ocean sediments anaerobic oxidation of methane (AOM), beside gas hydrate formation, generally hinders its release from the seafloor, since methane is almost quantitatively converted to bicarbonate. Whereas the process of AOM has been shown in marine sediments and seep areas and the key organisms have been identified almost nothing is known from lake sediments.We have used organic geochemical and molecular tools to evaluate AOM in sediments of Lago di Cadagno (Ticino/Switzerland). A 30 cm sediment core was taken at around 15 m water depth. A clear sulfate/methane transition zone was seen at approximately 7 cm with a one to one relationship between both. Hydrogen sulfide did also increase from almost zero to 600 μM above 12 cm sediment depth. The carbon isotopic composition of methane ranged from -70 $\perthousand$ VPDB at the sediment bottom to the uppermost 7 cm where a strong increase of ^{13}C values up to -40 $\perthousand$ VPDB was observed. This hints to a strong methane oxidation in the top sediment layers.

Archaeal 16S rRNA gene analysis resulted in 6 different phylogenetic groups. Sequences affiliated with the known groups of anaerobic methanotrophs (ANME 1-3) could not be retrieved, however, a group of sequences distantly related with ANME-2 was detected. This group also includes sequences from freshwater archaea which form aggregates with bacteria and couple AOM to nitrate reduction. Initial in situ analysis with highly specific probes showed the presence of this archaeal group in sediments of

Lago di Cadagno. The cells form aggregates ($<$1 x 10^6 aggregates cm^{-3}) apparently without having any bacterial partner.

Our research clearly shows that AOM is not only restricted to marine settings but occurs also in lacustrine sediments where it hinders the methane to be transported into the water column and further to the atmosphere.