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First Lipid Biomarker evidence for aerobic methane oxidation in the water column of Lake Untersee (East Antarctica).

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Lake Untersee is a perennially ice-covered freshwater lake (6.2 km long, 4.2 km wide, max. 169 m water depth) located in the Gruber Mountains of central Queen Maud Land, East Antarctica. Lake Untersee receives water only from glacier runoff (Anuchin Glacier) and has no outflow. Comparatively high evaporation rates lead to high sulphate concentrations in surface waters (ca. 1.5 mM). Most of Lake Untersee's water column is supersaturated with respect to oxygen and characterised by very low rates of primary production. However, Lake Untersee also features a 100 m deep trough at its southern tip, with anoxic bottom waters containing high amounts of biogenic methane (up to 22 mM) and sulphide (up to 2 mM). In a previous study in Lake Untersee (Wand et al., Limnol. Oceanogr. 51, 2006), high rates of sulphate reduction and anaerobic oxidation of methane (AOM) were observed at 84 m water depth, just a few meters below the oxycline (80 m water depth) A negative shift in the stable carbon isotope composition (δ^{13}C) of suspended particulate organic carbon (SPOC) from -30‰ to -45‰ in a constrained water layer (84 – 86 m water depth) provides further indication for methane consumption at this depth. To gain further insights into methane cycling in Lake Untersee, we analysed the lipid biomarker composition and stable carbon isotope signatures from SPOC samples collected during the 1995 sampling campaign. Against our initial expectation, we could not detect any isoprenoidal lipid compounds typical for *Archaea* involved in the sulphate-dependent mode of AOM (e.g. the dialkyl-glycerol-diethers 'archaeol' or '*sn2*-hydroxyarchaeol'). However, we were able to detect substantial amounts of two specific steorids (4α-methyl steroid and 4,4-dimethyl steroid) and one hopanoid (diplopterol). These compounds displayed very low δ^{13}C-values (as low as -68%¸) and were, again, confined to water depths between 84 – 86 m. The biomarker composition and isotopic signatures are consistent with an origin from aerobic methanotrophic bacteria, possibly *Methylococcus sp*. As a consequence, aerobic (MOx), rather than anaerobic methanotrophy most likely accounts for the low δ^{13}C-values found for POC at 84 – 86 m water depth and is responsible for a significant fraction of methane consumption. These results have important implications for our understanding of the spatial stratification of biogeochemical processes in lacustrine water columns. At Lake Untersee, aerobic methanotrophs are apparently active at oxygen concentrations below the detection limit of normal O_2-sensors (<50 nM). Furthermore, MOx, sulphate reduction and AOM may occur over extremely confined vertical distances in the stratified water column.