Methylotrophic methanogenesis fuels cryptic methane cycling in surface sediment of Aarhus Bay, Denmark

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Methane concentrations are generally very low in marine surface sediments and indicate net CH_4 oxidation and methane flux out of the sediment. Yet, methanogenic archaea are present in those sediments, suggesting a potential for methanogenesis. An isotope dilution method based on sediment bag incubation and spiking with ^{13}C-CH_4 was used to quantify CH_4 turnover rates in surface sediment from Aarhus Bay, Denmark. Highest CH_4 production and oxidation rates (>200 pmol cm^{-3} d^{-1}) were repetitively found in the top 0-2 cm, below which rates dropped below 100 pmol cm^{-3} d^{-1} (2-16 cm), leading to a cryptic cycling of CH_4. Parallel ^{14}C-labelling experiments revealed that methanogenesis from the hyrogenotrophic pathway was below 20 pmol cm^{-3} d^{-1} throughout the surface sediment, and that there was no apparent contribution from the acetoclastic pathway. Moreover, in sediment slurry incuabtions with excess substrates (hydrogen, acetate, and trimethylamine) addition, dramatic increase of CH_4 was only detected in those serum bottles amended with trimethylamine, indicating highest potential of methanogenesis from the methylotrophic pathway. Our results show the existence of enhanced methanogenic activity and a dynamic recycling of CH_4 at low concentration in sulfate-rich marine surface sediment, where methanogenesis was dominated by the methylotrophic pathway.