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Biodiversity of methanogenic Archaea in permafrost affected soils of the Lena Delta, Siberia

Introduction

Hydromorphic arctic tundra soils are an important source of the greenhouse gas methane (CH_4). In these environments carbon is accumulated due to reduced decomposition of organic matter. Most of the climate models predict a global warming for the next century which will lead in deeper and longer thaw processes in the active layer of arctic permafrost soils. Consequently a higher emission of methane and carbon dioxide could be expected. The release of CH_4 is a result of strictly anaerobic methanogenic archaea that use simple compounds (e.g. H_2, CO_2, acetate) formed by bacteria during the anaerobic degradation of organic material. There were only a few investigations about the methanogenic community existing in cold terrestrial habitats (e.g. Høj et al., 2005). Here we investigated the methanogenic community structure from three different arctic tundra soils located in the Laptev Sea coast region (Siberia).

Investigation Area

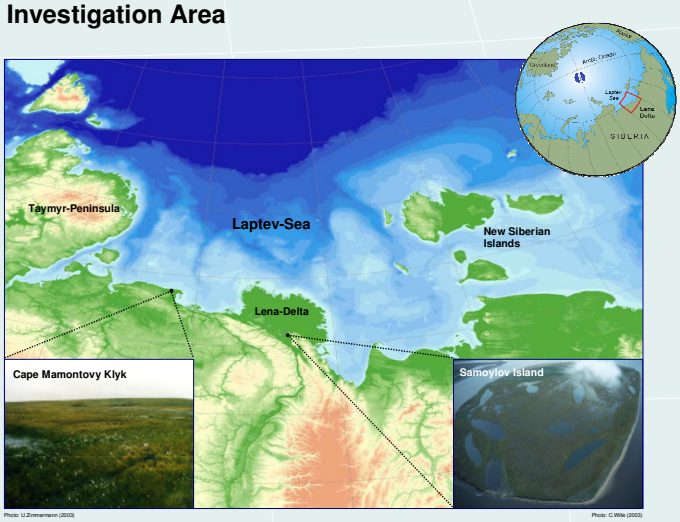
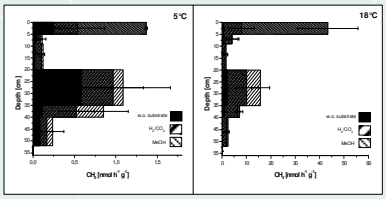


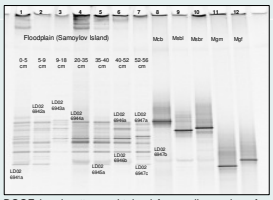
Photo: U.Zimmermann (2003) Photo: C.Wille (2003)

Results

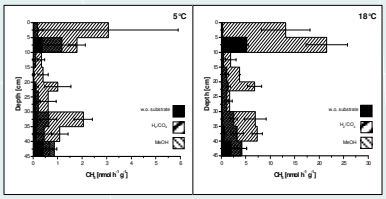
Independent from the chosen temperature or the added substrate the methane production rate reached its maximum in nearly all soil profiles in the upper soil layers. With rising temperature and/or the adding of substrate the methane production rate increase. In all soils we found sequences of *Methanomicrobiales* and *Methanosarcina* but no members of *Methanobacteriales*. In two of the soils we also found sequences belonging to the group of *Methanosaetaceae*.



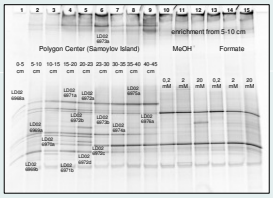
Vertical profiles of CH_4 production rates of a *Typic Aquortel* (floodplain) located on Samoylov Island in dependence of temperature and substrates



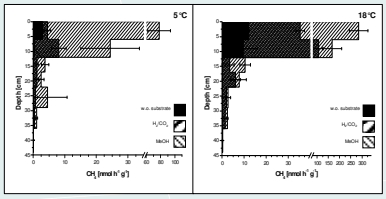
DGGE band patterns obtained from soil samples of a *Typic Aquortel* (floodplain) using a specific primer set (357F-0691R)



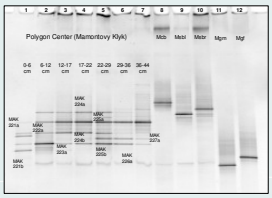
Vertical profiles of CH_4 production rates of a *Typic Historthel* (polygon centre) located on Samoylov Island in dependence of temperature and substrates



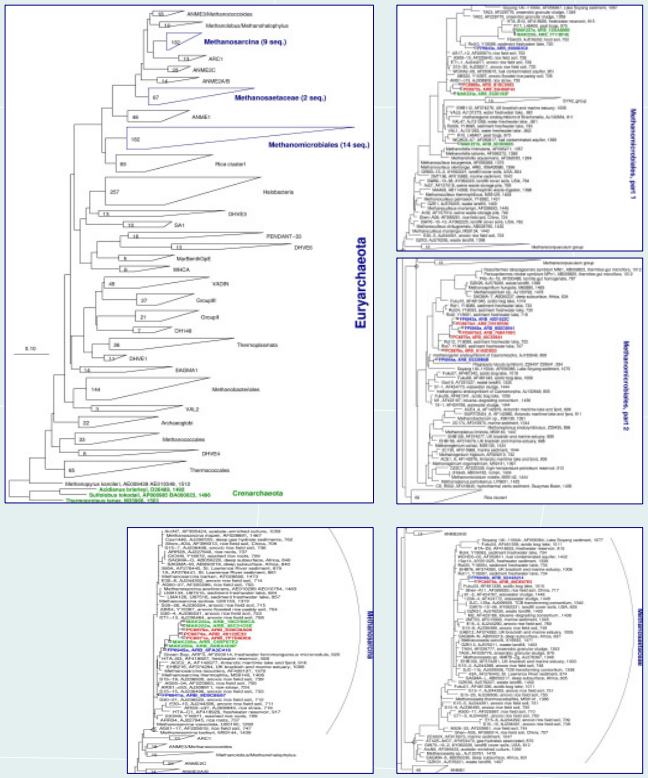
DGGE band patterns obtained from soil samples of a *Typic Historthel* (polygon centre) using a specific primer set (357F-0691R)



Vertical profiles of CH_4 production rates of a *Typic Aquiturbel* (polygon centre) located at Cape Mamontovy Klyk in dependence of temperature and substrates



DGGE band patterns obtained from soil samples of a *Typic Aquiturbel* (polygon centre) using a specific primer set (357F-0691R)



Phylogenetic relationships of 16S rDNA sequences retrieved by DGGE from three arctic tundra soils. The sequences obtained in this study are coloured. FP – Floodplain Samoylov Island, PC - Polygon Centre Samoylov Island, MAK – Polygon Centre Cape Mamontovy Klyk. The scale bar represents 0.1 changes per nucleotide.

Conclusions

In all three investigated permafrost soils methanogens could be detected by activity tests and molecular methods. Sequences of *Methanosaetaceae* indicating the presence of methanogens that use acetate as the only carbon and energy source. Most of the described *Methanomicrobiales* use mainly H_2/CO_2 or formate for methanogenesis and growth while the genus *Methanosarcina* can use a wide variety of substrates. With increasing depth the decrease of DNA bands in DGGE patterns could be explained by the decrease of temperature and/or the availibility of substrate. Those bands could represent psychrotolerant or psychrophilic methanogenic archaea that are well adapted to these low temperature conditions near the permafrost table. This is supported by the results of the activity tests that show a distinct CH_4 production at a temperature of 5°C.

References

Høj et al. (2005) Archaeal communities in High Arctic wetlands at Spitsbergen, Norway (78°N) as characterized by 16S rRNA gene fingerprinting. *FEMS Microbiology Ecology* 53, 89-101

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