Activity and Diversity of Methanogens and Methanotrophs Under Extreme Environmental Conditions in Permafrost Soils

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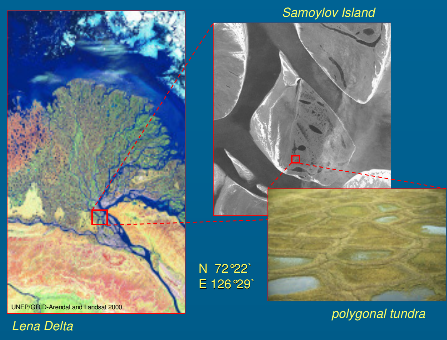
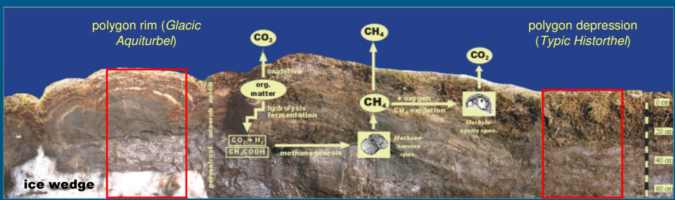
Introduction

Permafrost soils of high-latitude wetlands are an important source of atmospheric methane. More than 14 % of the world`s soil carbon is preserved in permafrost. Microbial life in these habitats, which are completely frozen most time of the year, is influenced by extreme environmental conditions. In order to improve our understanding of the carbon dynamic in permafrost soils, we studied the CH_4 fluxes as well as the function and diversity of the fundamental processes of CH_4 production and CH_4 oxidation in a typical polygonal tundra of the Lena Delta, Siberia.

Study site on Samoylov Island located in the Lena Delta, Siberia.





Cross section of a typical ice-wedge polygon (Lena Delta, Siberia)

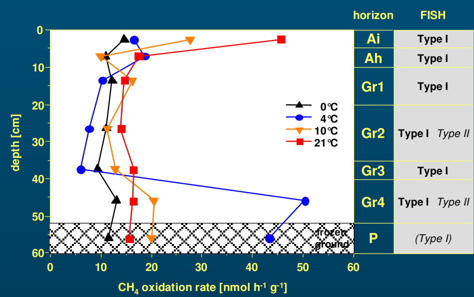
Study Site

The field investigations were carried out on the island Samoylov located in the Lena Delta, Siberia, which represented an area of typical polygonal tundra. The peaty soils of the polygon depression (*Typic Historthel*) are characterized by a water level near the soil surface and the predominantly anaerobic accumulation of organic matter. The drier soil of the polygon rim (*Glacic Aquiturbel*) show a distinctly deeper water level and lower accumulation of organic matter. The average air temperature was -14.7 °C with a min. of -47.8 °C in January and a max. of +18.3 °C in July.

Activity and Diversity

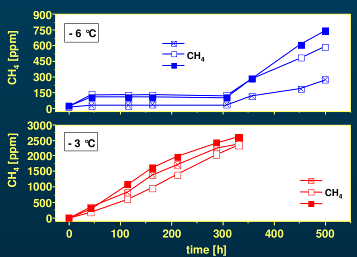
The CH_4 production and oxidation under *in situ* conditions revealed great differences during the vegetation period (1). Even the incubation of soil material at sub-zero temperatures showed a significant CH_4 production (2). Oxidation experiments at temperatures between 0°C and 21°C indicated the highest CH_4 oxidation in the bottom of the active layer at 4 °C (3). DTAF-staining and FISH showed a decrease of total cell counts from the top to the bottom of the active layer and large variation of the microbial community in different horizons (4). Within the constantly cold horizons of the active layer an aggregate formation of archaea could be regularly observed (5).

(3)



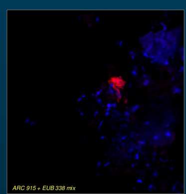
CH_4 oxidation rates at 0, 4, 10 and 21°C and the distribution of Type I and Type II methanotrophs within the active layer of a permafrost soil.

(2)



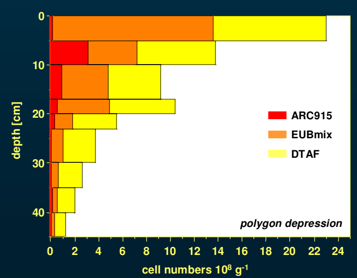
CH_4 production at sub-zero tempera-tures with H_2/CO_2 as a substrate.

(5)



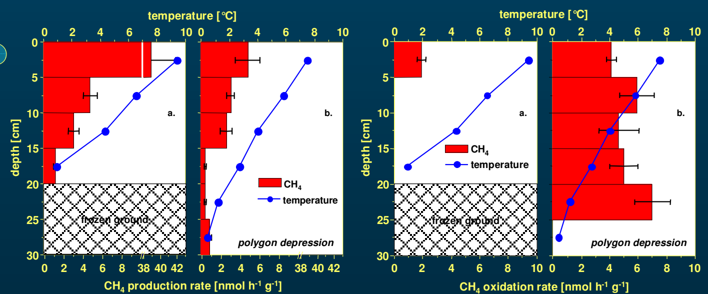
Aggregates of methanogenic archaea in permafrost soils detected by fluorescence *in situ* hybridisation. The aggregate formation could serve as protection against extreme habitat conditions.

(4)



Vertical profile of Archaea, Eubacteria and total cell counts in the active layer detected by FISH and DTAF-staining.

(1)



Vertical profile of CH_4 production and *in situ* temperature. CH_4 production rate and soil temperature determined (a) in July 1999 and (b) in August 1999.

Vertical profile of CH_4 oxidation and *in situ* temperature. CH_4 oxidation rate and soil temperature determined (a) in July 1999 and (b) in August 1999.

Conclusion

The results indicated the existence of a permafrost microbiota, which has well adapted to the extreme environmental conditions. The knowledge of the activity, physiology and ecology of the microbial community is fundamental for understanding trace gas fluxes in the Arctic. In outlook, this approach provides the basis for future environmental studies that deal with the fate of carbon stored in permafrost in the course of climate changes.

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