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Glacial-interglacial variations of microbial communities in permafrost and lake deposits in the Siberian Arctic

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The Artic regions are expected to be very sensitive to the currently observed climate change. When permafrost is thawing, the stored carbon becomes available again for microbial degradation, forming a potential source for the generation of carbon dioxide and methane with their positive feedback effect on the climate warming. For the prediction of future climate evolution it is, therefore, important to improve our knowledge about the microbial-driven greenhouse gas dynamics in the Siberian Arctic and their response to glacial-interglacial changes in the past.

Sample material was drilled on Kurungnahk Island (Russian-German LENA expedition) located in the southern part of the Lena delta and in lake El'gygytgyn (ICDP-project) in the eastern part of Siberia. The Kurungnahk samples comprise Late Pleistocene to Holocene deposits, whereas the lake El'gygytgyn samples cover Middle to Late Pleistocene sediments. Samples were investigated applying a combined biogeochemical and microbiological approach.

The methane profile of the Kurungnahk core reveals highest methane contents in the warm and wet Holocene and Late Pleistocene (LP) deposits and correlates largly to the organic carbon (TOC) contents. Archaeol concentrations, being a biomarker for past methanogenic archaea, are also high during the warm and wet Holocene and LP intervals and low during the cold and dry LP periods. This indicates that part of the methane might be produced and trapped in the past. However, biomarkers for living microorganisms (bacteria and archaea) and microbial activity measurements of methanogens point, especially, for the Holocene to a viable archaeal community, indicating a possible in-situ methane production. Furthermore, warm/wet-cold/dry climate cycles are recorded in the archaeal diversity as revealed by genetic fingerprint analysis.

Although the overlying lake water buffers the temperature effect on the lake sediments, which never became permafrost, the bacterial and archaeal biomarker profiles from lake El'gygytgyn deposits reveal also a glacial-interglacial variability. A reason for this seems to be higher TOC contents during the interglacials forming the carbon and energy source for the indigenous microbial communities. Algae blooms during the interglacials are indicated by the biogenic silica profile. The variety of methanogenic archaea is higher during the interglacials and methane production experiments reveal a high potential for methane production during these periods. Thus, overall the data indicate production and subsequent release of methane from the lake during interglacial periods. However, occasionally higher biomarker contents for methanogens accompanied by significant methane production potentials during glacial periods suggest that lakes might also produce and release methane during glacial periods.