Response of the Methane Cycle to Climate Changes in the Past and Present

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El'gygytgyn Drilling Project

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Introduction

Arctic permafrost environments play an important role within the global methane cycle. Thawing of permafrost and the associated release of the climate relevant trace gas due to an increased microbial turnover of organic carbon and from ancient methane reservoirs represent a potential risk to global warming. For the prediction of a future development of the permafrost environment and its contribution to the global atmospheric carbon budget, it is important to understand in which way this system reacted to environmental changes in the past.

Study Site

The El'gygytgyn lake region, Northeast Siberia, represents an ideal model system for studying the response of the methane cycle to climate change. It is supposed to be unglaciated since the time of a meteorite impact 3.6 Ma ago and since that time the permafrost went through four major climate-induced stages during the last 300,000 years. These changes in climate caused chemical and physical variations in sedimentary column and thus, we expect changes in the composition of key microrganisms being implicated in methane cycle. Drilling was conducted in November 2008 since it was rescheduled. Samples are being transfered to Germany by now.

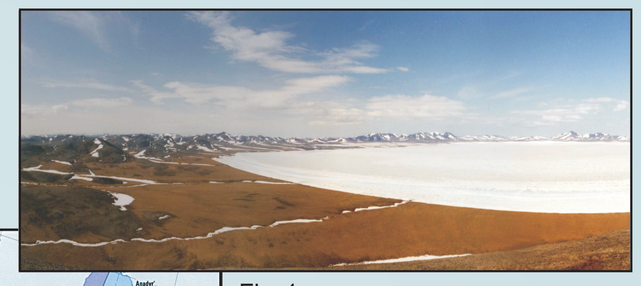


Fig. 1
El'gygytgyn Lake (67°30'N, 172°05'E) in Northeast Siberia (Foto: S. Quart, University of Cologne)

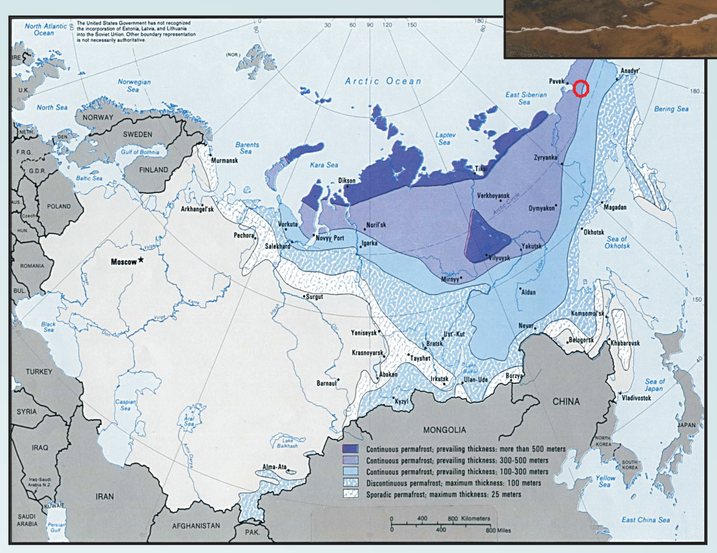


Fig. 2
Distribution and thickness of Eurasian permafrost. The red circle indicates the drilling site at the El'gygytgyn Lake in northeast Siberia (modified after Perry-Casteneda Map Collection, University of Texas).

Scientific Concept

Our studies will be conducted on combining microbial biomarker analyses and rRNA gene analyses in a high stratigraphic resolution. Sediment horizons with and without elevated methane concentrations will be investigated in order to assess spatial dynamics of the methanogenic and methanotrophic communities.These spatial dynamics refer to vertical variations in different core depths influenced by changing environmental conditions in the past.

Genotypic Biomarker

Soil sample → DNA - extraction → PCR

PCR → Methanotrophic primer, Methanogenic primer

Methanotrophic primer → DGGE/ Clone library

Methanogenic primer → DGGE/ Clone library

DGGE/ Clone library → Sequences

Sequences → Phylogenetic tree

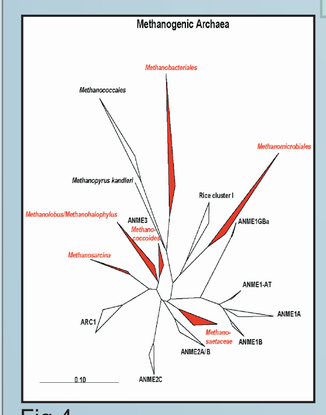


Fig.4
Phylogenetic tree (based on 16S rRNA gene analysis) of methanogenic Archaea from Artic sites

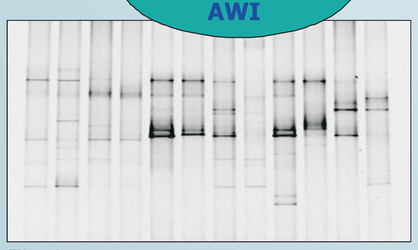


Fig. 3
DGGE - Fingerprint (16S rRNA gene fragments)

Geology AWI

Microbiology AWI

Biogeo-Geochemistry GFZ

CH_4 Cycle in permafrost

Dating, Grain size, ‚Paleo' biomarkers, ‚Viable' biomarkers, Community structure, CH_4 concentration, Microbial activity, C/N/S

Phenotypic Biomarker

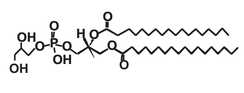
Soil sample → Drying/ Milling → Extraction (Bligh Dyer) → Extract (+ int. Standard) → Column-separation

Column-separation → Phospholipids (PLs), Triglycerids (GDGT), Glycolipids, Free fatty acids

Triglycerids (GDGT) → MPLC

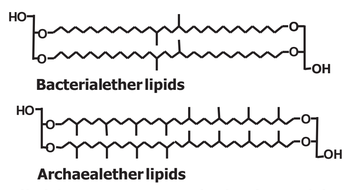
MPLC → Aliphatic hydrocarbons, Aromatic hydrocarbons, NSO - compounds

Life Markers



Phospholipid esters are only stable in intact cells.

Markers for past microbial biomass



Ether lipids cores are relatively stable outside intact cells.

In the horizons of interest the structure of the microbial communities will be characterised by clone libraries and DGGE-fingerprints with focus on methanogenic and methanotrophic communities to obtain detailed information on their taxonomy.

The extraction of microbial biomarkers from environmental samples is quantitative and correlates with the cellular biomass of the sample. Furthermore signals of viable and fossil markers can be distinguished.

Outlook

The obtained data will be interpreted in context of the results on inorganic properties in permafrost deposits of the El'gygytgyn lake region and paleoclimate reconstructions in this area provided by cooperation partners of the ICDP project "Scientific Drilling at El'gygytgyn Crater Lake".

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