Daria Morozova

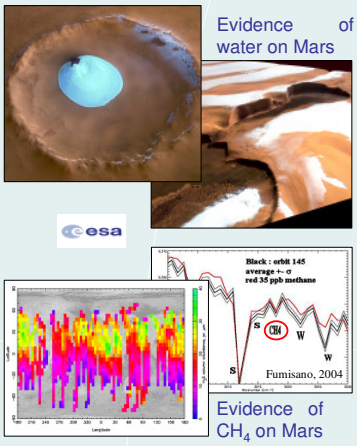
Forschungsstelle Potsdam
Telegrafenberg A 43
14473 Potsdam

dmorozova@awi-potsdam.de

Daria Morozova and Dirk Wagner (WA 1554/1-2)

Response of methanogens from Siberian permafrost to extreme conditions of terrestrial and extraterrestrial permafrost

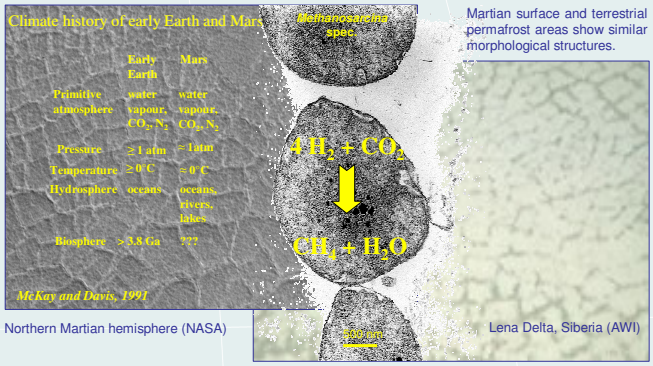
Introduction



Evidence of water on Mars

Evidence of CH_4 on Mars

Since ESA mission Mars Express determined water on Mars, fundamental requirement for life, and presence of CH_4 in the Martian atmosphere, which could be originated only from active volcanism or from biological sources, it is obviously that microbial life could still exist on Mars, for example in form of subsurface lithoautotrophic ecosystems, which are also exist in permafrost regions on Earth. In the scope of a DFG project we use methanogenic archaea from Siberian permafrost as a model for comparative system studies regarding the resistance of methanogens to different extreme conditions.



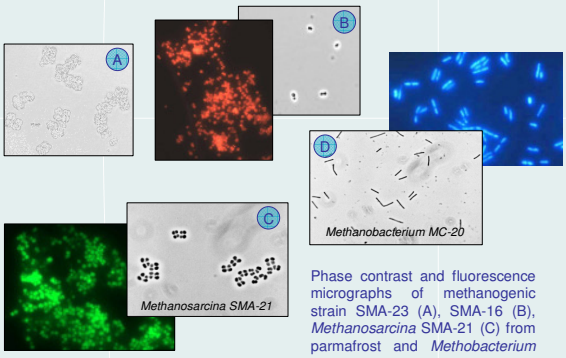
Northern Martian hemisphere (NASA)

Martian surface and terrestrial permafrost areas show similar morphological structures.

Lena Delta, Siberia (AWI)

Methanogenic Archaea

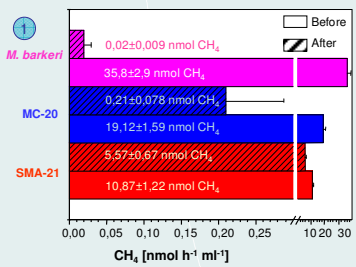
Methanogenic archaea were isolated from permafrost soils of the Lena Delta (Siberia). The study site represents a typical low-centred ice-wedge polygon. The organisms were grown on bicarbonate-buffered, oxygen-free OCM culture medium under an atmosphere of H_2/CO_2 (80:20, v:v) or N_2/CO_2 (80:20, v:v) with methanol at 10°C and 28°C.



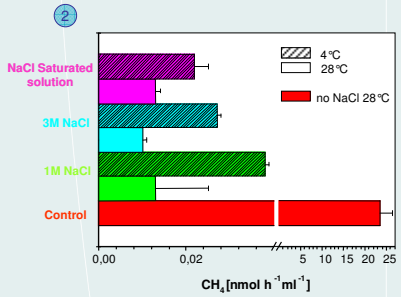
Phase contrast and fluorescence micrographs of methanogenic strain SMA-23 (A), SMA-16 (B), *Methanosarcina* SMA-21 (C) from parmafrost and *Methobacterium* MC-20 (D) from non-permafrost habitats.

Methanogenesis under Extreme Conditions

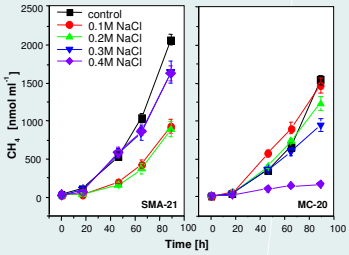
Studies of stress resistance of methanogenic archaea from Siberian permafrost in pure cultures as well as in their natural environments revealed a high survival potential of methanogens against freezing at – 80°C (1) (5.57 nmol CH_4 h^{-1} g^{-1}), high salinity (2) (3) (0.02 – 17.98 nmol CH_4 h^{-1} ml^{-1}), desiccation (4) (5.24 nmol CH_4 h^{-1} ml^{-1}) and high doses of UV-C irradiation (5) (0.8 – 5.86 nmol CH_4 h^{-1} g^{-1}/ml^{-1}). Moreover, our results indicated that methnogenic archaea from Siberian permafrost are more resistant compared to the methanogens from other habitats and thus are better adapted to the extreme environmental conditions of terrestrial or extraterrestrial permafrost.



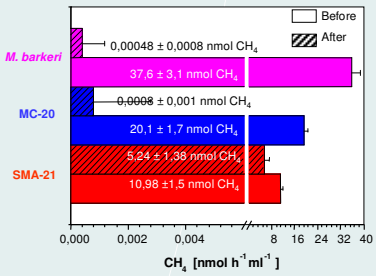
Methanogenesis of methanogenic archaea from permafrost and non-permafrost habitats before and after freezing at – 80°C



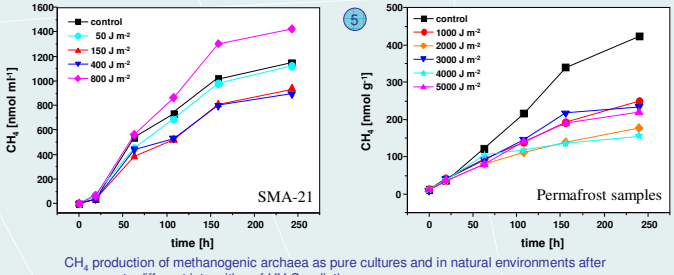
CH_4 production rates of permafrost strain under high salinity and different temperatures



Differences of CH_4 production of permafrost and non-permafrost isolates under different salinities



Methanogenesis of permafrost and non-permafrost isolates before and after exposure to 3 weeks of desiccation



CH_4 production of methanogenic archaea as pure cultures and in natural environments after exposure to different intensities of UV-C radiation

Conclusion

The presented results show that methanogenic archaea from permafrost environments are highly resistant to different stress conditions comparably to methanogens from non-permafrost habitats. Permafrost isolates could be suitable *keystone organisms* for further studies about adaptation strategies and long-term survival in extreme environments. Investigation of the survival potential of these high specialized organisms can provide a unique insight to explore the putative life on the extraterrestrial planets.

Alfred-Wegener-Institut
für Polar- und Meeresforschung
in der Helmholtz-Gemeinschaft

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