of temperatures around the melting temperature may evolve, preferably at sloped at ice covered higher latitudes and at sub-surface depths below an isolation absorbing solid cm-dm thick snow/ice cover in course of the heating "solid state greenhouse effect" (Möhlmann D., submitted at Icarus). The possible surface-morphological, chemical and biological relevance of this liquid martian bulk water is yet unexplored.

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External Energy and Nutrient Sources for Martian Subsurface Life

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Environments of modern Mars prohibit liquid water existence in surface layer of soil because of extremely low atmospheric pressure. On the other hand large amount of water ice is present in surface layer. Our laboratory modeling has demonstrated that terrestrial nonextremophile microorganisms can reproduce even under extremely low atmospheric pressure (0.01–0.1 mbar). Necessary conditions for metabolism and reproduction are the sublimation of ground ice through a thin upper layer of soil and short episodes of warm temperatures in the vapor diffusion layer. On the other hand mm-size layer of martian soil is able to protect hypothetical martian microorganisms against harmful UV radiation. We consider possible energy sources and nutrients for microorganisms in subsurface layers such as products of atmospheric photochemical processes, radiolysis of water ice by cosmic rays, radionuclides decay, accretion of interplanetary and interstellar dust particles and comet impacts. We make a conclusion that subsurface life may exist on Mars and martian-like exoplanets.

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Isothermal Microcalorimetry: a Novel Tool for Non-Disruptive Analysis of Microbial Heat Production in Subsurface Ecosystems

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One fundamental issue in astrobiology and in the search of traces for life in extreme ecosystems on Earth or outer space is the possibility to detect signs of microbial activities. The drawback with many of the current tools is that they are disruptive since they often demand some kind of extraction (e.g. DNA, metabolites, fossil signatures), which often limitate our possibilities to evaluate past or instant in situ activities. The objective in this study has been to explore whether isothermal microcalorimetry, which is able to measure cellular heat production, could provide a more direct proof of cellular activity in a oligotrophic environment. In this context, isothermal microcalorimetry could represent an interesting tool for the astrobiological research field to overcome some of these obstacles. Isothermal calorimetry has been used since Lavoisier and Laplace built and used the first isothermal calorimeter in 1782–83. Currently, isothermal microcalorimeters are common and measure heat flow rates in the micro or nanowatt range. With a sensitivity of 20 to 200 nW, an isothermal microcalorimeter can detect the metabolic heat produced by a small amounts of microorganisms. Since a typical single bacterial cell produces ~2 pW, only 10^4 to 10^5 bacteria are required for a detectable signal. Therefore isothermal micro and nanocalorimeters are highly sensitive tools capable of detecting even minor traces of microbial activities in extreme environments. This tool has for far mainly been used for soil sciences or biomedical studies, however, we anticipate that isothermal microcalorimetry could provide valuable complementary information to other analytical studies, in particular to molecular tools in different types of ecosystems, including extreme ecosystems with a low biomass and high inorganic surrounding.

In this study we have investigated whether microcalorimetry can be used to detect microbial activity in two different karst ecosystems, which are often characterized by low amounts of organic matter. In these dark life ecosystems, bacteria are capable to metabolize different types of organic and inorganic substrates in such oligotrophic environment. The main problem with studying such systems is to prove in situ cellular activities. Therefore we investigated whether heat production (a proxy for overall metabolism) can be measured from such environments using microcalorimetry. In both caves, traces of microbial activity were measured using a TAM48 (Waters/TA) isothermal microcalorimeter. Briefly, samples were introduced in a calorimetric vessel and added with an appropriate amount of medium. Finally they were sealed and introduced in the calorimeters. The heat production rate was then monitored until signal returned to baseline. Using these data we were able to estimate the number of active bacteria in various samples and the overall response of the bacterial community to the addition of various substrates. Such results undoubtedly demonstrate that isothermal microcalorimetry can be a useful tool for the detection of very low bacterial activities.

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Raman Spectra of Biomarkers and Carbonates Obtained under Low Temperature—High Altitude Conditions Using a Miniaturised Portable Raman Spectrometer

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