WATER RETENTION OF EXTREMOPHILES AND MARTIAN SOIL SIMULANTS UNDER CLOSE TO MARTIAN ENVIRONMENTAL CONDITIONS. J. Jänchen1, A. Bauermeister2, N. Feyh3, J.-P. deVer4,
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Introduction: Recent results and observations of Mars missions regarding the detailed mineralogy and the occurrence of water on the surface of Mars especially in the equatorial regions [1-4] and their implications for the conditions on early Mars have again stimulated the discussion about the development of life on Mars. Latest knowledge about extremophiles on Earth and results of new complex models on the development of the Martian atmosphere [5] improves the basis of this debate. An important issue in this research is the interaction of moisture of the Martian atmosphere with soil components and possibly existing organisms of the planet’s surface. Therefore, we quantitatively examined the water vapor interaction and water-bearing properties of simulated Martian soil components and selected extremophiles in a broader expansion of surface temperature and pressure. The aim thus is to contribute to an improved understanding of exobiological aspects on Mars.

Experimental: Samples selected. Two mineral mixtures representing the early and the late Martian surface (P-MRS, Phyllosilicatic Martian Regolith Simulant and S-MRS, Sulfatic Martian Regolith Simulant) as well as montmorillonite (Stx-1) as a single component, also typical for the early period on Mars, have been selected based on OMEGA results [2-4].

Three different organisms (extremophiles) of the phylogenetic tree of the terrestrial life have been selected for our study: Deinococcus geothermalis, Nostoc commune, and Xanthoria elegans. D. geothermalis, an extremely radiation- and desiccation-resistant bacterium capable of forming biofilms, was cultivated in organic medium (R2A broth) with 5% (wt.) of the Martian soil simulants (see below). The soil particles and bacteria (c. 5x10^10/g soil) were sedimented by centrifugation, the supernatant removed, and the resulting pellet used for the experiment.

N. commune (cyanobacteria) serves as an example of a highly desiccation resistant organism, already present on the primitive Earth 3.5 billion years ago. Naturally occurring biofilms have been collected in the German national park “Unteres Odertal” and stored dry. In terrestrial environments N. commune forms large biofilms by excreting viscous extracellular polysaccharides (EPS) protecting the organisms [6].

The lichen, X. elegans, is an evolved symbiotic and euakaryotic extremophile from polar and alpine regions. It survived space exposure and is able to photosynthesize under simulated Martian conditions [7-9]. The lichen has a gelatinous and mucilage matrix with similar characteristics of EPS and contains a cocktail of secondary metabolites enabling both of the symbionts (algae and fungi) to be resistant to UV- and space radiation, desiccation and freezing.

Methods. The dehydration properties (thermogravimetry, TG, differential thermogravimetry, DTG, and differential thermoanalysis, DTG) were measured on a Netzsch STA 409 apparatus with a heating rate of 10 K/min to 673 K. Prior to the TG experiments bacteria-samples were preconditioned at controlled atmosphere (six days over silica gel in a desiccator, RH=30%). The sorption isotherms were measured gravimetrically from 257-313 K with a McBain quartz spring balance equipped with MKS Baratron pressure sensors covering a range of 10^-5-10^3 mbar. Before each sorption experiment, about 100 mg sample was degassed at 293 K over night (N. commune, X. elegans) or at 383 K (montmorillonite) and p<10^-5 mbar for several hours.

Results and discussion: Figure 1 gives information about the total water content of the late (S-MRS) and the early (P-MRS) Mars regolith simulant. As can be seen S-MRS shows one main step of water release at 130-160 °C due to the dehydration of gypsum. A second modest step can be observed at 300°C related to the dehydroxylation of goethite. The total mass loss (water) amounts to about 5 wt% whereas P-MRS loses more than twice the amount of S-MRS as a result of the hydration/dehydroxylation of its water-bearing components montmorillonite, kaolinite and hydromagnesite. Figure 2 shows the situation for the mixture of D. geothermaliis/P-MRS compared with the pure soil mixture. Some delay of the dehydration of the mixture between 100-300°C seems to occur due to the presence of the biofilm (about 0.06 g bacterial/g soil).

Figures 3-5 give information about the reversibly bound water of N. commune, X. elegans, and nontronite. This water can be taken up by the materials or is released due to rising or diminishing relative humidity of the atmosphere in a broader temperature interval.
This water (roughly 0.2 g/g at RH=80% for all) is related to the RT vacuum dried organisms or modestly at 383 K vacuum dried montmorillonite.

At the first glance the hydration isotherms appear the same for all three materials. However, a closer look reveals significant differences regarding the reversibility of the hydration/dehydration process. *N. commune* shows a fairly big difference between the hydration- and dehydration branch for all three temperatures measured. This is not the case for *X. elegans*. The hydration/dehydration process is nicely reversible (except for the low temperature) and much faster than for *N. commune*. It takes less than 20 min for equilibrating of the water uptake from one to the next point in the lichen-isotherm but more than 400 min. for the same step of the biofilm protected cyanobacteria. So *N. commune* shows, beside this kinetic phenomenon, a water storage ability not marked for *X. elegans*. The hysteresis of montmorillonite is of different kind and related to structure changes [10].

**Conclusion:** By knowing the water vapor pressure or local humidity of the planet’s atmosphere the water content of soil components and possibly occurring extremophiles can be determined. These data can support the modelling of the atmosphere/surface interaction and show the influence on the water inventory of the upper layer of the Martian surface.


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**Figure 1.** TG (solid lines) and DTA (dotted lines) of S-MRS (top curve) and P-MRS.

**Figure 2.** TG (solid lines) and DTG (dashed lines) green *D. geothermalis*/P-MRS, red P-MRS, blue pure *D. geothermalis*.

**Figure 3.** Water sorption isotherms of *N. commune* at temperatures between 257 and 293 K.

**Figure 4.** Water sorption isotherms of *X. elegans* at temperatures between 257 and 293 K.

**Figure 5.** Water sorption isotherms of montmorillonite at temperatures between 257 and 313 K.