THE IMPORTANCE OF ADSORPTION WATER IN THE UPPER MARTIAN SURFACE.
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Introduction: Mars Odyssey has proven the existence of water in the soil of the upper martian surface (meter depths) at equatorial and mid-latitudes [1], [2]. The water content can regionally reach values up to about 15%. This water is in the form of irreversibly chemisorbed, of partially reversibly structurally bound („crystal“) water [3], or of reversibly bound, liquid-like, and partially unfrozen, adsorption water [4]. This adsorption water can have remarkable influences on the interaction of the uppermost martian surface with the atmosphere, where morning fog indicates the presence of near-surface water. Saturation of water vapor and related adsorption and condensation can be reached during night and morning hours, while desorption dominates during warmer day-time conditions. This atmospheric water vapor interacts by adsorption and desorption with the uppermost parts of the martian surface and also with the surfaces of dust and other particles.

Adsorption water is bound to external and internal surfaces of soil grains and other surface materials, and to atmospheric dust particles, which can act as CCH (cloud condensation nuclei).

<u>Consequence: There is, at least temporarily, adsorption water in and above the upper martian surface also at mid- and low latitudes.</u>

Properties of adsorption water:

Adsorption water is the physisorbed part of sorption water, and it can exist in a liquid-like state at temperatures down to –40° C and less. The terrestrial counterpart is the „unfrozen water“ in permafrost [5]. Soil with unfrozen water has modified physical, chemical and biological properties if compared with dry frozen soil.

<u>Consequence: “Unfrozen” adsorption water in the soil of the upper martian surface behaves liquid-like.</u>

Adsorption water driven surface chemistry:

Liquid-like water can act as a solvent, and it supports transport processes to become effective. Chemical processes, which are triggered by adsorption water, are shown to be effective under martian conditions. These processes are energetically driven by photons. Possibilities for a related photon-driven bio-chemical Martian iron-carbon cycle are discussed. As an example: UV-VIS radiation is expected to be the energy source to generate the highly oxidizing OH^* radicals in the presence of Fe^{3+} and water in the uppermost Martian surface layer. This process is related to $Fe^{3+}_{aq} + H_2O \xrightarrow{h\nu} Fe^{2+}_{aq} + H^+ + OH^\bullet$ (“Photo-Fenton reaction”). It has been shown experimentally that even a few percent of adsorption water are sufficient for this reaction to become effective [4[. Thus, the presence of adsorption water in the upper martian surface may contribute to the high degree of oxidation of martian surface materials. Hydroxyl radicals oxidize organic compounds, and a photo-Fenton-like process may together with adsorption water be responsible for the lack of organics of meteoritic origin in Martian soil.

Similar “mars-analogue” experiments are in progress to investigate if the observed presence of formaldehyde in the martian atmosphere [6] can, at least partially, be explained on the basis of an adsorption water triggered OH-driven oxidation of methane in the upper martian surface.

Methane has been observed in the martian atmosphere too [7].

Consequence: Adsorption water on Mars is able to trigger, to support, and to make possible chemical processes. Photochemical processes seem to be most important for the upper martian surface.

Possible biological consequences:

Where chemistry works, biochemical processes can be expected to become possible too. An example: The Photo-Fenton reaction reduces ferric iron to ferrous iron in the presence of UV and adsorption water. Bacteria exist in terrestrial permafrost, which are, in the presence of photons (VIS), CO_2 and water, able to oxidize ferrous iron into ferric iron [8]. VIS-photons are used under anaerobic conditions for fixation of CO_2 to organic carbon $(CH_2O)_n$. Energy, necessary for life processes, can be derived from this oxidation process.

This photon-driven redox-cycle with a biological sequence is an example of an iron-carbon cycle, as it has been suggested by [9]. Under martian conditions, an analogue Photo-Fenton reaction must proceed in the uppermost surface layer, where all the UV must be absorbed, while the oxidizing biogenic reaction could happen in the layers directly below, which can be reached by scattered VIS only. Liquid-like adsorption water and solar photons are simultaneously available there over a few hours after sunrise, while the liquid-like adsorption water for the cellular metabolism can become available during night and early morning.

It has been shown by experiments that liquid-like adsorption water can trigger chemical processes, which are expected to be of relevance for Mars [4]. Liquid-like adsorption water can be deposited on grain surfaces and surfaces of microbes as well. Adsorption water on cell walls or other external surfaces of organisms can support biological processes by providing a source of liquid-like water. In thermodynamic equilibrium, this source can continuously be "refilled" from the gas phase. This can temporarily allow a "steady" delivery of liquid water.

Eventually, the inward transport of water could be realized by temperature-governed aquaporines, which allow a temperature-controlled water transport into cellular bodies by opening during cools conditions and closing at daytime.

Consequence: To study biological processes, which are driven, supported or become possible by adsorption water, seems to be a current challenge to biophysics and biochemistry, also from the exobiological point of view.

Summary:

Consequences of the diurnally variable presence of adsorption water on physics, chemistry and on hypothetical biological processes at and in the upper martian surface at equatorial and midlatitudes are discussed by describing processes, which are driven by adsorption water.

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