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Liquid water and brines in the upper surface of Mars

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Abstract

Liquid water cannot stably exist at present p- and T-conditions on the surface of Mars, but there are different forms of pure liquid water, which can evolve below the surface in the layers with regolith and ice. This is due to freezing point depressions by different physical processes, by solutions, and by local subsurface melting.
Undercooled liquid interfacial water must evolve in course of adsorption and freezing of atmospheric water in the porous regolith. The interface ice surface - mineral (grain) surface is thermodynamically not stable in case of attracting interfacial forces (as van der Waals forces, e.g.), which cause an "attractive" tension acting upon the ice. As describable by a generalized Clapeyron-equation, a pressure driven freezing point depression must establish, and liquid interfacial water can evolve also under thermodynamic conditions as on Mars. Another freezing point depression of liquid water can in course of the surface tension of water evolve in capillaries and pores. These freezing point depressions can be expected to cause an, at least temporary, presence of undercooled pure liquid interfacial water in the upper regolith of Mars. This interfacial water is to be characterized by nanometer-scales. Nevertheless, the amount of interfacial water can reach macroscopic values in the range of up to several 10 b.w.% in wet soil (on Earth and Mars). The processes, which can cause the presence of undercooled pure liquid interfacial water are described in detail. This formation of layers of undercooled liquid interfacial water can happen also by covering particles (and microbes), cf. Figure 1.
The importance of the described above "physical" freezing point depressions can remarkably increase if soluble salts are present, which will go into solution when undercooled pure liquid interfacial water will be present (in course of processes as described above, e.g.). Brines of sulfates and perchlorates are known to have at appropriate concentration eutectic temperatures down to a few degree above 200 K These brines will be liquid at higher temperatures, what indicates that the known presence of salts, as sulfates and perchlorates e.g. on Mars can, at least temporarily, be followed by the formation of liquid brines. In this case not "only" interfacial but bulk liquids can be present on Mars today. Another type of bulk water could temporarily evolve in the subsurface of translucent ice on Mars in course of the heating by the "solid state greenhouse effect" in ice. The processes, which can cause the presence of bulk liquids in the surface of Mars are discussed in detail.
Possible also recently relevant, and at least temporary physical (rheological, e.g.), chemical (brines, photochemical, e.g.) and eventually also biological (support of metabolic processes) consequences of the presence of liquids in the surface of Mars are discussed.

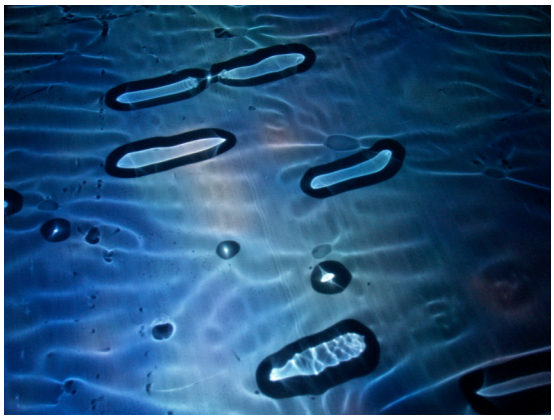

Figure 1: Illustration of grains/microbes mantled by liquid interfacial water (Image credit Helmut Eigenmann).