Hydrated minerals and evaporites as key targets for a Mars sample return mission. S. Adeli[1], E. Hauber[1], and R. Jaumann[1,2], [1]Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institute for Planetary Science, Berlin, Germany (Solmaz.Adeli@dlr.de), [2]Freie Universität zu Berlin, Institute of Geosciences, Berlin, Germany.

Introduction: The early Mars climate and surface conditions are two major questions still under debate. There is clear morphological evidence of liquid surface water on early Mars, such as: large crater lakes, valley networks, and alluvial fans [e.g., 1, 2]. Moreover, there is widespread evidence of thick layers rich in aqueous minerals, i.e., phyllosilicates, which indicate the abundant presence of liquid water during their formation. It is nevertheless still unclear whether the early Mars climatic conditions were “warm and wet” [3], “cold and wet” [4], or even “cold and icy” [5]. The aqueous minerals and evaporites offer a paleo-environmental record of their formation and subsequent modification. Thus, investigating direct samples from these materials would increase our knowledge about the past geology of Mars as well as its astrobiological potential.

Hydrated minerals: Here we focus on two groups of minerals found widely on Mars, which have the potential of preserving traces of past life; phyllosilicates (clay minerals) and evaporites.

Phyllosilicates: Phyllosilicate-bearing materials are characterized by their light-toned appearance, polygonal fractures, and late Noachian-early Hesperian formation age [6, 7]. They are the major products of chemical weathering of mafic silicate minerals [8]. In several outcrops, a stratigraphic relation between various kind of phyllosilicates has been detected, in which Fe/Mg-phyllosilicates (mainly Fe/Mg-smectite, saponite, nontronite) form the bulk of the deposit and the upper superficial part have been altered into Al-phyllosilicates (kaolinite, montmorillonite, Al-smectite). This stratigraphical relation indicates a major change in the chemical environment of the deposit, since formation of the Fe/Mg-phyllosilicates are believed to be linked to abundance presence of liquid water, which prevailed during early Mars in neutral to alkaline environments [e.g., 7] whereas alteration towards Al-phyllosilicates is the result of a top-down leaching process due to limited surface runoff [e.g., 9].

Phyllosilicates have been hypothesized as a major element in the chemical evolution resulting in the origin of life on Earth, because of their ability to concentrate and catalyze complex organic molecules, and to protect against UV radiation [10]. Smectitic clays have a reactive surface able of absorbing considerable amounts of organic compounds in the mineral structure, and if buried they have a preservation capacity [11]. Therefore, the phyllosilicate-bearing deposits on Mars have been investigated as a potential target for the investigation of past habitable sites.

Evaporite minerals: The main evaporite minerals detected on the highlands of Mars are sulfates and chloride salts. They are mainly found in local depressions and appear within light-toned deposits ranging in width from a few tens of meters to a few kilometers, with polygonal fractures. Their formation has been interpreted as precipitation in brines as result of water accumulation in ponds [12], and the source of water is most likely surface runoff. The deposits rich in evaporites are found in proximity to phyllosilicate-bearing deposits and are overlying them. This stratigraphic relationship indicates that the salts were deposited at a later time, thus by a later water activity. This late-stage water activity may have been the last major local water activity as it is suggested by the presence of the undegraded, uneroded, and unaltered chloride-rich layer.

On Earth, evaporites and salts form in alkaline and/or acidic conditions, and they can preserve traces of life, e.g., salt crystals which can preserve amino acids for 4-40 Ma [13] and biosignatures found in sedimentary evaporitic layers in dry Rio Tinto [14]. Analogue studies in the Atacama desert show that even highly saline environments may offer temporary habitable conditions to certain types of bacteria [15].

Conclusion: The widespread presence of water involved in the deposition of phyllosilicates, in addition to their chemical and molecular structure, make them a potentially favorable environment to host life. Therefore if life has ever developed on Mars, its traces have to be searched within ancient phyllosilicate-rich material. This material, however, must have been well preserved since its formation time (early Mars) until now on the surface or shallow subsurface. Hence, where phyllosilicate-rich materials are covered and preserved by evaporates, may be prime locations for sampling and further lab analysis.

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