Phyllosilicates and chlorides in evaporitic setting as key targets in the search for life on Mars

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The evaporites-bearing and phyllosilicates-rich material have been widely identified on the southern highlands of Mars, mostly within Noachian-aged terrains. These deposits offer a paleo-environmental record of their formation and subsequent modification. Understanding their history is crucial for the investigation of liquid surface water and the past geochemical environment on the Mars surface, as well as for the search for potential habitable environments and biosignatures.

Phyllosilicate-bearing materials are characterized by their light-toned appearance, polygonal fractures, and late Noachian-early Hesperian formation age. They are the major products of chemical weathering of mafic silicate minerals. Generally a stratigraphic relation between various kinds of phyllosilicates has been detected, in which Fe/Mg-phyllosilicates form the bulk of the deposit and the upper superficial part has been altered into Al-phyllosilicates. This stratigraphical relation indicates a major change in the local chemical environment. The formation of Fe/Mg-phyllosilicates is believed to be linked to abundance presence of liquid water, which prevailed during early Mars in neutral to alkaline environments whereas alteration towards Al-phyllosilicates is the result of a top-down leaching process due to limited surface runoff. 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 [1].

The main evaporite minerals detected on the highlands of Mars are chlorides and sulfates. 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. Their formation has been interpreted as precipitation in brines as result of water accumulation in ponds [2]. The deposits rich in evaporites are found in proximity to phyllosilicate-bearing materials 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 salt-rich upper 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 [3] and biosignatures found in sedimentary evaporitic layers in dry Rio Tinto [4]. Analogue studies in the Atacama desert show that even highly saline environments may offer temporary habitable conditions to certain types of bacteria [5].

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 evaporites, may be prime locations for search for potential habitable environments and biosignatures.

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