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PALEOBIOMARKERS AND DEFINING EXOBIOLOGY EXPERIMENTS FOR FUTURE MARS EXPERIMENTS

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Mars is a cold, dry planet with an oxidizing surface bombarded by ultraviolet and ionizing radiation making prospects for an extant Mars biota bleak. Yet, it is suggested that early earth and early Mars were similar enough that life may have evolved on Mars. If life did evolve on Mars, what evidence for its existence might we find, that is, what constitutes a Martian paleobiomarker, and how can we distinguish such a marker from abiotically produced substances? The topics studied to answer this question include carbon and nitrogen cycling, as well as the stability and relative abundance of their intermediates in microbially dominated ecosystems. The microbially dominated ecosystems studied are the cryptoendolithic microbial community living within sandstone rocks, endoevaporite microbial community living inside salt crystals, and the microbial mat communities living beneath perennially ice-covered lakes and hypersaline ponds. The nitrogen cycle of these communities ranges from the simple, where only assimilation occurs (e.g., cryptoendoliths and endoevaporites) to the more complex where a complete cycle occurs (e.g., microbial mats). The carbon cycle of these communities appears to be complete that is, carbon fixation and remineralization through respiration occur.

The nitrogen cycle of the cryptoendolithic community, composed primarily of a lichen, inhabiting the Antarctic dry valleys, is incomplete. Biological nitrogen fixation, denitrification and nitrification do not occur in nature within this community. All of the fixed nitrogen is supplied exogenously. This is much like the nitrogen cycle of the endoevaporitic microbial community inhabiting a natural mixed crust of halite and gypsum. The endoevaporite community consists primarily of a cyanobacterium tentatively identified as a member of the genus *Synechococcus* Nägeli 1849. *In situ* measurements demonstrate that this community fixes nitrogen in nature, but neither nitrification nor denitrification was detected. The microbial community inhabiting these ecosystems perform the least number of transformations of nitrogen of any ecosystem reported to date, and therefore may represent the simplest nitrogen cycle in nature. Both of these communities, however, fix carbon photoautotrophically.

In contrast, benthic microbial mats carry out complete nitrogen and carbon cycles in nature. The mat inhabiting Lake Hoare, a perennially ice-covered lake in Taylor Valley, Antarctica exhibits an incomplete nitrogen cycle during the austral summer (no N_2-fixation), and a complete nitrogen cycle during spring before melt water runs into the lake. These data suggest that the demand for nitrogen is being met by input from meltwater and sediment entering the lake. Denitrification occurs only within anaerobic sediments, whereas nitrification only occurs in the aerobic portions of the sediment and mat. In the microbial mats inhabiting a hypersaline pond, the nitrogen cycle appears to always be complete. The pattern of nitrogen and carbon fixation and denitrification varies diurnally. Data suggests that this phenomenon is due to diurnal changes in nutrient limitation.

These studies allow us to define experiments and put limits on the types and kinds of compounds that may be utilized as Martian paleobiomarkers. In addition, they provide a data base for ecological data interpretation enabling us to distinguish abiotic from biotic processes.