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THE ACIDOPHILIC IRON-SULFUR BACTERIUM ACIDITHIOBACILLUS FERROOXIDANS AS A MODEL ORGANISM FOR A PUTATIVE MARTIAN ECOSYSTEM

Abstract

In the last decades our knowledge about the environmental conditions on Mars, especially about its geochemistry, has increased substantially. Large regions of the Martian surface are covered with sulfate- and ferric oxide-rich deposits. These sediments indicate the possible existence of aqueous, acidic environments on early Mars. Acidophilic iron-sulfur bacteria striving in such habitats on Earth, e.g. Rio Tinto, could have been part of a potential extinct Martian ecosystem or might even exist today in protected subsurface niches. Acidithiobacillus ferrooxidans was chosen as a model organism to study the ability of such bacteria to survive or even grow under Martian conditions. A subsurface environment was assumed as the most likely habitat in these experiments, because it has a higher probability for liquid water, can provide different sources of energy for lithotrophic metabolism, and afford protection from the harsh surface physical conditions. A. ferrooxidans can use many different electron donors and acceptors, so that it can adapt easily to changing environmental conditions. Growth tests were performed on two different Mars regolith simulants without additional nutrients and under different atmospheric compositions (air, N2/CO2, H2/CO2). The bacteria can grow on both Mars regolith simulants without extra nutrients, by using the Fe(II) dissolved from the minerals (aerobic) or the Fe(III) bound to the minerals by attaching to the particles (anaerobic). A. ferrooxidans able to withstand low temperature (-80C) at least for several weeks without any cryoprotectant. It was found that resistance to desiccation strongly depends on the mode of drying. Biofilms can tolerate longer periods of desiccation than planktonic cells dried without any added protectants, and drying under anaerobic conditions is more favourable to survival than drying in the presence of oxygen. Although A. ferrooxidans was found to be sensitive to UV-C radiation ample shielding is provided already by shallow layers of dust (especially containing Fe3+) or by upper cell layers in a biofilm. Comparing the average ionizing radiation dose on Mars with the tolerance of A. ferrooxidans, a population of these bacteria could remain viable in the shallow subsurface of Mars for long time periods. In sufficient depths, organisms would be protected from surface radiation and could persist even longer, if maintenance metabolism and repair are possible intermittently. Thus, from a geochemical perspective, these chemolithoautotrophic bacteria are relevant candidates for a hypothetical underground Martian food chain based on its metabolic capacities.