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Biosygnatures on olivines in search of past life on Mars

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Biosignatures indicate past and present activity of living organisms. Only inorganic biosignatures, e.g. results of interactions between the minerals and the microorganisms in Martian soils could resist harsh environmental conditions on Mars. However, it may be difficult to distinguish the traces of the organism activities from the effects of "natural" chemical and physical processes.
In this study, an acidiophilic, chemoautotrophic, iron-oxidizing bacteria Acidithiobacillus ferrooxidans were incubated with magnesium-iron silicate (olivine) crystals to identify the potential development of biogenic textures on the surface. The Mg-rich olivines were separated from the gabbro rock (Trodos, Cyprus). The isometric crystals were up to 2 mm in size. All the grains were cleaned in ultrasonic bath and fixed on the epoxy stubs. This enabled the observation of the very same surfaces before and after the experiments allowing inspection of natural etch pits and weathering patterns present before inoculation as well as the forms resulting from the experiments. The stubs with the olivines were sterilized with ethanol prior to the experiments.
Bacteria were isolated from old pyrite mine in Klucze near Olkusz (Southern Poland). A liquid media K9 was used through the experiments (Silverman and Ludgren, 1959). The experiments were run in triplicates. Olivine grains were placed in the inoculated medium and incubated for 7 days at 28 C. An abiotic experiment was run as control. Additionally, the experiments in modified (iron deficient) medium were designed to stimulate potential active scavenging for Fe by bacteria-mediated dissolution. In the Fe-deficient medium, the negligible amount of iron was present only to initiate the bacteria growth: the only source of Fe was the olivine grain throughout the experiment. After 7 days of incubation the olivine grains were removed and air-dried. The alterations of the crystals by both, purely inorganic and biologically mediated dissolution were investigated with the use of scanning electron microscopy (SEM) with EDS microanalyzer.
Any alteration of mineral surface resulting from mineral-microbes interaction was considered as a biosignature. In the standard Fe-rich K9 medium, occasional precipitation of the sulfate phase was observed. There is no evidence for the microbial control on this process. Formation of etch pits was observed in both, Fe-rich and Fe-deficient experiments, in the presence and in the absence of bacteria. The dissolution patterns were indistinguishable. Therefore, the experiments resulting in formation of the biofilm will be designed in future.

SILVERMAN M.P., LUNDGREN D.G., 1959. Studies on the chemoautotrophic iron bacterium Ferrobacillus ferrooxidans. An improved medium and a harvesting procedure for securing high cell yields. Journal of Bacteriology, 77(5): 642–647.