GROWTH OF *ACIDITHIOBACILLUS FERROOXIDANS* ON IMPACT-ALTERATED ROCKS AND MINERAL DEPOSITION

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Since the beginning of the Solar System, the young basaltic crusts of the rocky planets were susceptible to large-scale impacts from asteroids and comets. Although becoming less frequent over time, these impacts were responsible for alterations in the target rock, creating breccia, melts and other structural and chemical changes. Hydrothermal and weathering processes were responsible for subsequent modifications of the shocked rocks, leading to the formation of mineral deposits, that can be used by different metabolisms, like pyrite (FeS_2) and melanterite ($FeSO_4 \cdot 7H_2O$), in addition to solubilize other species important for life. Therefore, aqueous environments associated to craters are often cited as important places linked to the development of the life as we know it[1]. Today, past deltaic and lacustrine environments on Mars are being studied for a better understanding of the wet past of the planet and the possibility of the registry of ancient life. The presence of minerals like jarosite in some areas support that some ancient local environments were acidic, with high concentration of soluble iron species, similar to places found on Earth with presence of acidophilic chemolithoautotrophic microorganism[2]. To access the habitability capabilities of aqueous environments associated to craters formed in basaltic crust, traditional and shock-altered basaltic rocks were offered to the growth of the acidophilic chemolithoautotrophic bacterium *Acidithiobacillus ferrooxidans*, capable of oxidizing Fe^{2+} to Fe^{3+} to gain energy. To do so, 100 mg of comminuted samples of Serra Geral (BSG) basalt and basaltic breccia from Vista Alegre (BVA) and Vargeão (BV) craters were added to 20 ml of T&K modified medium (pH = 1.8) without soluble iron. First, the biotic and abiotic cultures were kept at 30°C for a week. Fe^{2+} and Fe^{3+} were quantified by colorimetric methods while the MPN method was used to quantify the organism growth. To evaluate the mineral formed after exposition to the acidic culture medium, Raman and XRD analysis were performed on the solid phase left after the liquid drying .The abiotic cultures showed an Fe^{2+} leaching of 0.756 mM for BSG, a more pristine sample, 0.405 mM for BVA, a rock with less evidence of post-impact alterations and only 0.062 mM for BV, a rock with extensive post-impact hydrothermalism. The biotic cultures showed lower concentrations of Fe^{2+} and higher of Fe^{3+}, demonstrating the biotic oxidation of the iron leached from the rocks. The presence of *A. ferrooxidans* led to a higher total iron leaching (> 0.3 mM, in all three cases). A summary of the iron leaching experiments can be seen in the Table 1.

Table 1. Iron leaching of the basaltic samples.

Sample		Final pH	$[Fe^{2+}]$ (mM)	$[Fe^{3+}]$ (mM)	Total Fe (mM)
BSG	Abiotic	2	0.756	0.347	1.103
	Biotic	2	0.206	1.209	1.415
BVA	Abiotic	2-3	0.405	0.242	0.647
	Biotic	2-3	0.256	0.791	1.047
BV	Abiotic	2	0.062	0.183	0.245
	Biotic	2	0.073	0.481	0.554

In the beginning, all biotic cultures had a cell concentration of 6.9 ± 0.18 $\log_{10}$ MPN. At the end, both BSG and BVA showed no statistically significant changes (7.0 ± 0.17 and 6.7 ± 0.19 $\log_{10}$ MPN, respectively) while BV, that provided the lower amount of Fe^{2+} for the organism, showed a decrease in cell concentration (6.3 ± 0.19 $\log_{10}$ MPN). This apparent absence of change in cell concentration is due to the low total amount of Fe^{2+} available during these experiments. However, in a larger scale, an abiotic acidic leaching of a BSG sample could provide up to 151 mmol of Fe^{2+}/kg of rock, enough to produce more than 1 L of standard culture medium for *A. ferrooxidans* (T&K medium - 120mM of Fe^{2+})[3]. The XRD analysis of the original comminuted rocks and the leached solid phases showed the dissolution of the clay minerals of the rocks in both biotic and abiotic cultures. In the leached solid phases, it was also detected sulfate minerals like gypsum (all cases) and jarosite (all, except BVA). The Raman spectroscopy allowed a detailed analysis of the minerals, and sulfate was detected in all leached samples. Gypsum and Mg-sulfates were detected in all abiotic experiments, while jarosite and other Fe^{3+}-sulfates where detected in the biotic experiments (except biotic BV). A Raman shift for higher values was observed in the major peak of pyroxene in the biotic compared to the abiotic condition. This shift trend may be explained by the iron depletion in pyroxene during the biotic experiments, increasing the proportion of lighter elements in the mineral[4]. This reinforces the observation that the presence of the microorganism led to a higher total iron leaching from this mineral, probably by shifting the solubility equilibrium of Fe^{2+}, by oxidizing it to Fe^{3+}. This way, it was demonstrated that acidic medium is capable of removing iron from the basaltic samples, a process similar to the hydrothermalism that has already affected some of the studied rocks. It was also possible to observe that the *A. ferrooxidans* action provided an even greater iron leaching, by oxidizing Fe^{2+} to Fe^{3+}. Although the oxidation of iron is a natural process in an oxidizing atmosphere like ours (even in acidic solutions), the microorganism action could be perceived by the formation of Fe^{3+}-sulfates, detected by XRD and Raman, and by the possible iron depletion from the pyroxenes, also detected by Raman. Thus, hydrothermal systems in impact structures could provide conditions and create environments to sustain chemolithoautotrophic metabolisms like the one of *A. ferrooxidans*. Therefore, these finds can broaden the astrobiological potential and the prospects of the habitability of hydrothermal systems in craters on basaltic crusts of the Solar System.

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