Redesign of the Winogradsky's column as an experimental chamber for evaluating the effect of Martian atmosphere on the ecology of a hypersaline microcommunity

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Introduction

Aiming to contribute to the search for life on Mars for the next robotic missions, this project's objective is to progressively simulate a realistic Mars-like atmosphere inside an adaption from the concept of Winogradsky's column with a microcommunity that may have existed on Mars. In its past, theories suggest that Mars had rivers and oceans and that meteorites impacts could have maintained an active hydrothermal system for millions of years. During water's evaporation and freezing, a hypersaline microbiome could have developed in the ever saltier craters.

Methodology

From the literature, the design of a Winogradsky's column was adapted to fit mild radiation and atmospheric simulations. The hypersaline sediment was collected by hand coring at Lagoa Vermelha at Araruama (Rio de Janeiro, Brazil). Two groups of three columns were exposed to Earth's atmosphere (sealed) and pure CO_2 (flux) for two months (Fig. 1). Then, columns were disassembled and analyzed in distinct heights for shifts in biological, mineralogical and elemental distributions.

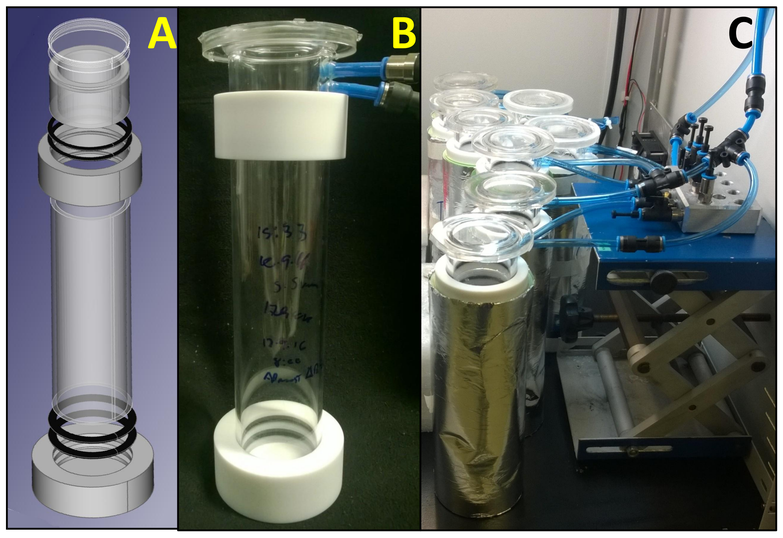

Figure 1: (A) CAD design of the column, showing its major components' assembly;

(B) Picture of a fully assembled column;

(C) Picture of the experimental setup, with three columns under pure CO_2 flux and three other sealed with earth's atmosphere.

Preliminary Results and Discussion

In the first day of the simulation, the columns under pure CO_2 had to be placed under a continuous flux instead of being sealed due to increasing low pressure build up (enough to rip the thin UV polymer window), probably due to CO_2 consumption by cyanobacteria. After two months under these conditions, the columns sealed with Earth's atmosphere showed a dense pink colored mass covering the surface of the microbial mat. It is likely that purple sulfur bacteria dominated the cyanobacteria stratum when the environment went anoxic. However, the columns under CO_2 flux displayed a thin white surface layer followed by a thin pink colored layer, which could be a sign that all the CO_2 being "consumed" was actually being bio or abiotically precipitated.

Analysis using XRD and FTIR weren't able to distinguish calcite from dolomite, nor did indicated major differences between the two column groups. Likewise, Micro-XRF mapping of the profile of the first 10mm showed no significant differences, though the most superficial Ca layer in the sealed condition seemed more dense. Through SEM, the thin white layer morphology and composition was analyzed in greater detail through EDS, indicating to be composed mainly of carbonates (Fig. 2 and 3).

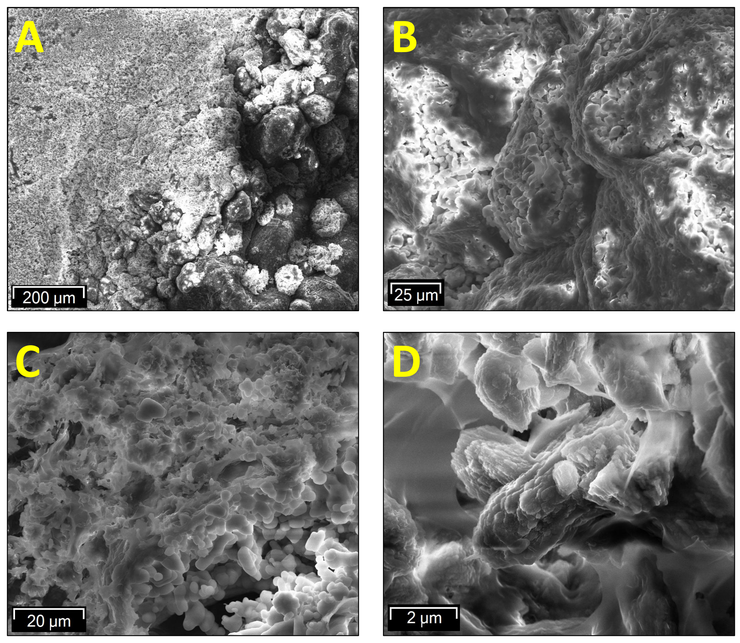

Figure 2: SEM images from the columns:

-Sealed under Earth's atmosphere:
(A) transition between the halite coverage and the pinkish spheroids.
(B) magnification in the spheroids, showing salt crystals deposited inside the spheroids;

-Under continuous CO_2 flux:
(C) surface mainly made of carbonates with halite in a fissure at the lower right corner;
(D) magnification of the carbonate's crystal' habit.

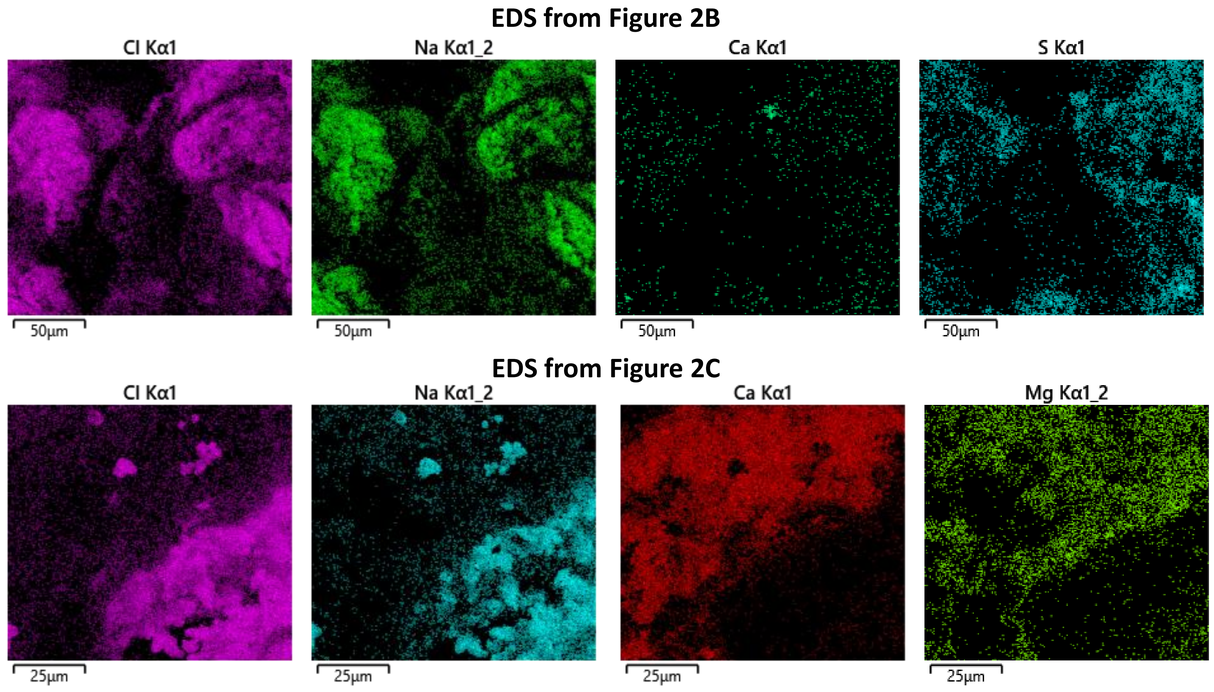

Figure 3: EDS images from: Figure 2B (top row) suggests clusters of halite grown inside an organic matrix with little to no carbonates on site; Figure 2C (lower row) indicate a coverage mainly made of carbonate, probably Mg rich calcite or dolomite, with few halite crystals on the surface, predominating inside fissures.

Conclusions

From this first experiment it was possible to determine which improvements must be done to the adapted Winogradsky's column to allow a more realistic simulation. For example, changing the polymeric window by a rigid quartz one (with a transmittance just as good). Also, further analysis is needed to identify the carbonates precipitated in the white layer, which could be proposed as a biosignature on Mars, if proven to be bioprecipitated dolomite. In the present moment, samples taken in different heights of the column are being 16S sequenced to verify changes in microbial diversity to support the data.

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