ANALYSIS OF PHOTOSYNTHETIC ACTIVITY OF CYANOBACTERIA INHABITING HALITE EVAPORITES OF THE ATACAMA DESERT, CHILE.

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Introduction: The Atacama Desert is the driest place on Earth, with a surface that has been minimally disturbed by natural erosion for millions of years [1], [2] . These conditions have been maintained for some 150 million years making it also the world's oldest continuously arid desert [1] .

Regions within the hyperarid core of the Atacama were, until recently, considered the dry limit of photosynthetic activity and primary production [3] . Unexpectedly, an endolithic community (i.e. microorganisms colonizing the interior of rocks) was discovered in ancient playa deposits in the hyperarid core of the Atacama [4] , (Fig. 1). This endolithic community resides inside halite crusts shaped in the form of nodules, with cyanobacteria and associated heterotrophic bacteria scattered within pore spaces [4] , [5] .

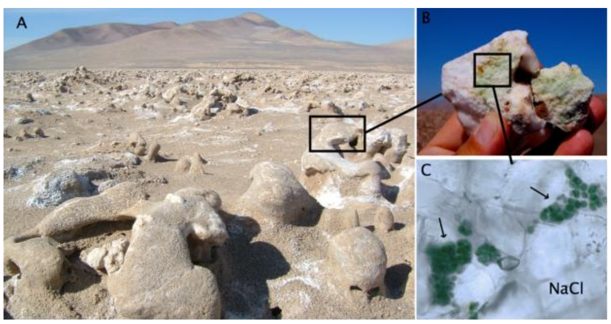

Figure 1: Life at the dry limit, halophilic cyanobacteria in Salar near Yungay. A. Salar surface with pinnacles. B. Fractured pinnacle showing pigmented cyanobacteria colonies. C. Light micrograph showing the unicellular nature of the cyanobacteria and their association with the halite crystals.

How they do so is only partially understood. One possible strategy is to take advantage of the deliquescent properties of the salt habitat, which provide liquid water even at relative humidity (RH) as low as 75% [6] . The goal of this project was to test this hypothesis by measuring the photosynthetic activity of the halite cyanobacteria under different RH conditions.

Materials and methods: An imaging PAM (Pulse-amplitude-modulated) fluorometer was used for these studies. Variable fluorometry is a non-invasive technique that utilizes changes in the fluorescence yield of chlorophyll a (Chl a) to obtain information on the status of photosystem II (PSII) reaction centers[7] , [8] . Photosystem II studies were done on the halite nodules that had been exposed to moisture (RH>75%). Green areas of the halite nodules with observable chlorophyll as well as the other none green areas were studied. The halite with visible cyanobacteria were suspended and incubated in air tight boxes with water that provided humidity inside the box. This was left and observed for several weeks. The Photosystem II activity was checked daily using the imaging PAM. A short saturating light pulse was applied to determine the maximum fluorescence (Fm, dark adapted, Fm' light adapted), resulting from the reduction of all reaction centers. The fluorescence yields were used to calculate a variety of photosynthetic coefficients, including the maximum quantum yield (Fm-Fo/Fm), which provides information about the potential quantum efficiency of PSII [9], [10].

Results: The Photosystem II was active in samples exposed to moisture conditions (RH>75%) at least 3 weeks (Fig 2).

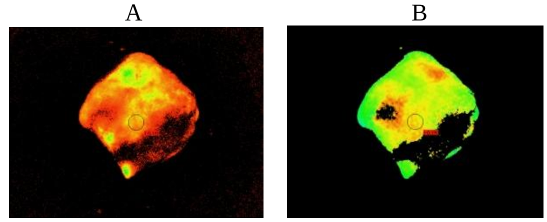

Figure 2: Photosystem II activity of halite inhabiting cyanobacteria showing A) fluorescence B) Maximal PS II quantum yield, Fv/Fm, which was determined after dark adaptation. It is calculated according to the equation: Fv/Fm = (Fm - Fo)/Fm . After dark adaptation normally all PS II reaction centers are open (F = Fo) and non-photochemical energy dissipation is minimal (qN = NPQ = 0) and maximal fluorescence yield, Fm, is reached during a Saturation Pulse. In this state the fluorescence increase induced by a Saturation Pulse (variable fluorescence, Fv) as well as the PS II quantum yield (ΔF/Fm = Fv/Fm) are maximal. The Fv/Fm image was measured in conjunction with an Fo, Fm-determination

The activity of Photosystem II was heterogeneously distributed in the halite and, approximately 75% of the colonies were not active under moist conditions, despite they displayed high fluorescence from the presence of chlorophyll (Fig 3).

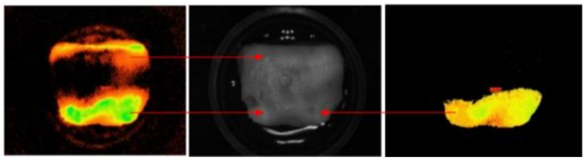

Fig 3: Heterogeneous distribution of the Photosystem activity within the nodules. Halite sample (*center*). Fluorescence image showing a heterogeneous distribution of chlorophyll (*left*). Maximal PS II quantum yield, Fv/Fm, determined after dark adaptation (*right*).

PS II activity was not always observed in areas containing high abundance of chlorophyll and occasionally it was observed in brown regions of the nodules with no observable chlorophyll (Fig. 4).

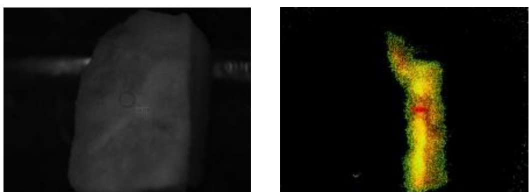

Fig 4: *Left*. Brown area of a halite nodule (as seen in IR image) *Right*. Maximal PS II quantum yield distribution in the same sample.

Discussion and Conclusion:

We established that the Photosystem II of the halite cyanobacteria is active upon exposure to high RH by means of PAM fluorescence. So far this is the only known example of a microbial ecosystesustained by mineral deliquescence. These results expand the water activity envelope of life in our planet, and could have important implications in the search for life on Mars

Aknowlegdement:

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