FOSSIL ENDOLITHIC CYANOBACTERIA IN EVAPORITES: IMPLICATIONS FOR THE ASTROBIOLOGICAL EXPLORATION. N. Stivaletta[1], R. Barbieri[1], L. Marinangeli[2], G.G. Ori[2] and M. Bosco[3] [1]Dipartimento di Scienze della Terra, Università di Bologna, P.zza Porta San Donato 1, 40126, Italy, stivaletta@geomin.unibo.it, [2] International Research School of Planetary Science, Università di Pescara, [3] DiSTA, Area Microbiologia, Università di Bologna

Introduction: The search for Terrestrial analogues of Martian environments focuses on certain conditions in which physical and chemical parameters exceed those commonly experienced in Earth-like ambient conditions. These environmental conditions approach the known limits to terrestrial life [1]. Arid and saline environments are thought to be good terrestrial analogues of Martian environments that host or may have hosted life. Evaporite deposits are indicators of bodies of water and this has implications for astrobiology. Evaporites allow to test the preservation potential of biologically induced structures because of the rapid sealing provided by precipitating minerals. Moreover, they allow an evaluation of the fossilization conditions for specific groups of extremophiles, such as moderate and extreme halophiles. The surface of Mars has harsh conditions, therefore life, if ever it existed on its surface, might have withdrawn into more protected environments [2]. On Earth, endolithic microorganisms in hot and cold deserts are an example of how life has withdrawn into protected zones. These microniches provide protection from dessication, rapid temperature variation, UV radiation flux, and, in turn, they allow a sufficient light penetration for photosyntethic processes [3]. In this study we document morphologies interpreted as the product of endolithic cyanobacterial colonies and microbial-derived biosedimentary structures from modern spring mounds developed in Chott el Jerid, a complex of arid and saline environments of southern Tunisia. These mounds are morphologically distinct from eolian landforms, such as dunes, and are characterized by sands and salt precipitation (especially gypsum) that form superficial crusts [4]. The microbial-derived, mineralized (subfossil) morphologies are preserved in these gypsum crusts.

Methods: We have investigated the superficial crusts that occur on top of two spring mounds, along the south-eastern border of the Chott el Jerid. Samples of millimetric, brown to green gypsum layers, were collected at the surface and just below the surface of the gypsum crusts (Figure 1). Thin and polished sections, and fresh cuts were studied with reflected-light microscopy and scanning electron microscopes equipped with EDS analyzer for determining the elemental composition of minerals. X-ray diffractometer allowed the mineral recognition. Microbial communities from mats of a modern saltern have also been microbiologically investigated for morphological and taxonomic comparisons.

Result and Discussion: SEM and light microscope investigations allowed to detect the presence of structures interpreted as cyanobacterial colonies in the gypsum crusts. Coccoid morphologies (spherical and oval shape ranging from 2 to 5 microns in diameter) are preserved in the green layers, just below the surface. The green layers consist of quartzose sand cemented by gypsum. Colonies and isolated cells are commonly embedded in extracellular products. Bacterial colonies occur on the surface of quartz grains and in the interstial spaces, according to a cryptoendolithic mode life, where they create the biofilm for binding the quartz grains together. EDS analyses have revealed that the green layer largely consists of organic carbon- rich compounds and are also characterized by abundance of Ca and S as a consequence of mineral (sulphate) precipitation. Cyanobacterial cells appear preserved in different ways. Some of them present a deflated apperance, and are characterized by a collapsed central area (Figure 2), whereas others appear inflated (Figure 3) with examples of preserved cell division processes (Figure 4). Features such as size, shape, colonial organization, location, production of extracellular substance, collapsed cells and the preservation of organic carbon support the biogenicity of these morphologies and their interpretation as endolithic cyanobacteria. Different degrees of mineralization (i.e. fossilization) of the organic material are based on the following evidences: 1) the different cells preservation, inflated and collapsed cells (cell lysis), is attributed to early mineralization; 2) the mix of mineral and organic compounds is attributed to processes of partial permineralization of the organic matter; 3) the local fractured appearance of the extracellular products is attributed to processes of mineralization of the biological material [5]. Ongoing investigations of the processes of early degradation of microbial communities sampled from modern salterns in northern Italy allow direct comparisons with cells and colonies from evaporite deposits of the Chott el Jerid.

The endolithic microbial communities of Chott el Jerid are an example of how microbes can be preserved, and then recognized, in extremely arid and saline environment. Because evaporites may be preserved over geologic times where surface hydrological cycles are absent, such as on Mars, their ability of preserving different traces of life, make them of special interest for astrobiology [1]. A proper identification and interpretation of these microbial fossils can therefore help for identifying signatures of biological activity on Mars surface.

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Figure 1- Fresh cut through the gypsum crust from a spring mound, Chott el Jerid. The green layer (arrow) contains endolithic cyanobacterial colonies.

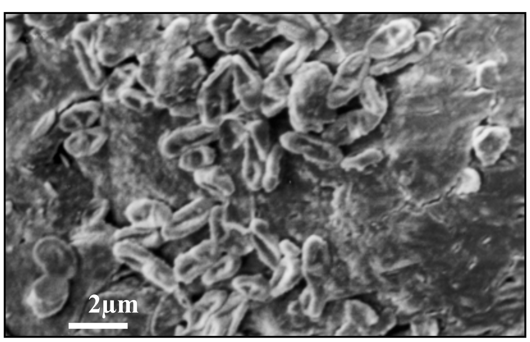

Figure 2- The green layer of the gypsum crust showed in Fig. 1. Collapsed cells due to lysis processes.

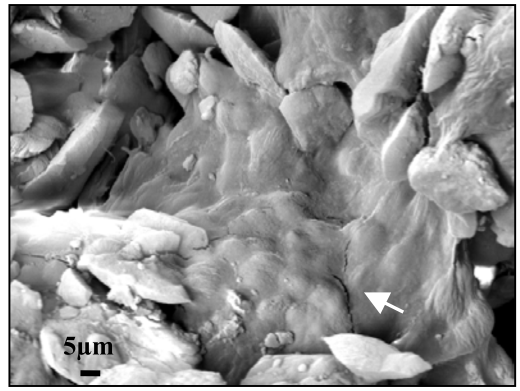

Figure 3 – The green layer of the gypsum crust showed in Fig.1. Inflated cells embedded in the extracellular substance, (white arrow indicates a local surface fracture).

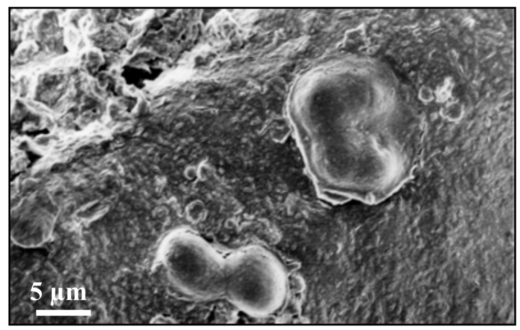

Figure 4- The green layer of the gypsum crust showed in Fig.1. Example of cell division preserved in a mineralized bacterial colony.