Biosignatures in evaporites: Implications for the geological exploration of Mars.

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How do microorganisms survive extremely dry conditions? Are they still an important influence on geology in such environments? Do they produce wide scale signatures in evaporite deposits? With these questions in mind we launched our research activity in Death Valley, a site which offers not only some of the driest and hottest conditions on Earth but also a wide variety of different types of evaporite deposits covering a wide span of geological time. Here, we report our initial results from an investigation of the evaporite crust from the Badwater Basin and its resident endolithic microbial community as it exists in the topmost 5-8 cm, where visible layering is present. These layers are (top down) light grey, orange-brown, blue-green, pink-red, olive green, and dark grey. Corresponding to evaporite minerals at the top and then to microbial layers dominated by diatoms, cyanobacteria, purple bacteria, green bacteria, and sulfate reducers, respectively, each 0.3-0.6 cm thick. The layers were examined by environmental scanning electron microscopy (ESEM) coupled with energy dispersive x-ray spectroscopy (EDS) in order to learn of the inter-relationships among cells, minerals and the aqueous phase. This was supported by X-ray powder diffraction analysis of separated laeyers. The microbial community was seen to have a profound effect on mineral texture and on metal partitioning. The cells were enveloped in a briny layer of water, held in place by the extensive spongy mass of exopolymers they produced. The minerals in their immediate vicinity were highly pitted and "corroded" in sharp contrast to the smooth faces and angular outlines of crystals from the unoccupied zone. Certain elements (Si, Mg, K, Cl, Fe, Mn,) were present at significantly higher levels in the cells as compared to the mineral; a reflection of their physiological requirements. X-ray powder diffraction and ESEM-EDS showed a microstratigraphic layering of minerals within the microbial community with a top to bottom progression of anhydrite-bassanite-strontianite-calcite. Strontianite and calcite were only found in association with the cells and their polymers, usually as a pericellular deposit, implying a biogenic origin. The presence of elevated Sr in the microbial layer was supported by ICP-AES, which also showed high Fe levels in the microbe-dominated layers compared to mineral-dominated ones. The presence of extensive exoploymer around the cells allows the retention of a vital layer of water, even under very dry conditions. This water is also essential for the promotion of mineral weathering and diagenetic alterations. Thus the cells have both a direct and an indirect effect on mineralogy in the Badwater Basin. Future studies will centre on whether this impact is significant enough to leave a large scale biological imprint on the environment which may be detected by remote sensing. Thus we present important groundwork necessary for understanding biosignatures that may be used to assess a life imprint on former evaporite basins on Mars.