# THE EFFECTS OF DESICCATION UNDER MARS-LIKE CONDITIONS ON THE SPECTRAL DETECTABILITY OF GYPSUM ASSOCIATED ENDOLITHIC COMMUNITIES

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**Introduction:** Much of the search for evidence of exobiology relies on remote spectroscopic sensing of planetary surfaces for biosignatures of extant or extinct life. For this search, areas that in the past or present have been habitable, as well as detectable molecules indicative of life must be identified. One such habitable environment that may represent the last vestiges for life on Mars is evaporite deposits [1].

On earth such deposits are host to a plethora of extremophilic halophile species that thrive in the high saline yet protective environment that evaporites provide. Evaporites allow for an endolithic biosphere that retains more moisture than the surface environment and provides protection from temperature fluctuations and solar ultraviolet irradiation. These conditions permit this microenvironment to remain habitable even under unfavorable external conditions [2].

The recent discovery of sulphates on the Martian surface has raised the possibility that if life existed on Mars, it may have been associated with these evaporite sulfate deposits, or that traces of endolithic communities may be associated with these deposits [2]. Hydrated sulfate minerals have been detected in the Columbus, Gale and Gusev craters [3,4,5]. As well as possibly being host to endolithic communities, such intracrater evaporite deposits are important to the understanding of early Mars as they may be indicative of hydrothermal activity or paleolakes.

Recent CRISM data from the ~119km diameter Columbus crater (29ºS, 166ºW) has indicated the presence of polyhydrated sulfates and a kaolin group phyllosilicate [3]. One of the polyhydrated sulfates detected was gypsum which occurs as a deposit ringing the lower crater walls. Interbedding of the gypsum and clays was also detected [3,6].

To better understand the habitability of these intracrater evaporate deposits, we are conducting field and laboratory-based investigations of the St. Martin impact structure in Manitoba, Canada, which hosted a post-impact lake and is now characterized by thick (tens of meters) beds of evaporative gypsum/anhydrite [7]. At the St. Martin site, endolithic communities occur in loose gypsum boulders, within intact outcrops, and beneath the soil surface surrounding partially buried gypsum boulders. The endolithic communities are detectable by reflectance spectroscopy only when the host gypsum boulders are broken open to reveal the endolithic communities. However, with respect to the detectability of such communities; the implications of desiccation by Martian atmospheric conditions and degradation by UV exposure are not well understood. With this study we are examining whether such communities are detectable by reflectance spectroscopy after exposure to "Mars-like" conditions for an extended period of time.

**Experimental Procedure:** Samples were collected from gypsum deposit within the Lake St. Martin impact structure in Sept. 2010 from an area of gypsum boulders (at 51° 46.792'N, 98° 37.811'W). All samples were broken off with a rock hammer or scraped with a scoopula into sterile plastic bags and transported to the University of Winnipeg for analysis.

For spectral analysis the most brightly colored fragments of the sample GAB003 were crushed and dry sieved into the following grain sizes; <45, 45-90, 90-250, 250-500, 500-1000, >1000µm. The larger GypPM sample was cut with a diamond tipped rock saw to obtain a fresh cut surface and expose the endoliths.

All samples were placed in an anoxic vacuum chamber being flushed with $CO_2$ with a beaker of Dry-erite desiccant and exposed to a 25W deuterium lamp, and 100 mb pressure for 75 days to simulate Mars surface conditions. Reflectance spectra were collected at days 0, 4, 11, 18, 25, 32, 40 and 75.All reflectance spectra were measured at the University of Winnipeg's Planetary Spectrophotometer Facility (PSF) using an ASD Field Spec Pro HR spectrometer (0.35-2.5 µm) with a 100 watt QTH light source with a viewing geometry of i=30º and e= 0º; 200 spectra were collected and averaged to improve SNR.

**Results:** The spectra of the endolith samples is primarily dominated by characteristic features of gypsum. However, the presence of the endolithic community was apparent by a decrease in absolute reflectance below 800nm and a prominent feature at ~670nm, as well as weaker features at shorter wavelengths. With exposure to the UV, anoxia, low pressure and dessicatory conditions, there was little change in the spectra of the samples. All of the major spectral features seen in the day 0 spectra remained dominant even after 75 days of incubation. Any large changes in the spectra were associated with the dehydration of the gypsum to anhydrite with the weakening of the distinctive water (O-H) features at 1400 and 1900nm. The features below 800nm which are associated with the endolithic communities (chlorophyll and other pigments) also remained present after 75 days. However they became slightly weaker, with a decrease in band depth and intensity. This pattern was seen both in the whole rock samples (Figure 1) as well as the crushed samples (Figure 2), but the decrease in band depth was more significant in the crushed rock samples where the endolithic community is more exposed to the chamber environment.

**Discussion:** The spectral features observed in the endolith samples below 800nm are diagnostic of chlorophyll and UV-protectant pigments that are ubiquitous to halophiles and cyanobacteria that thrive within evaporite deposits; the most prominent of these being the 670nm band that is attributed to chlorophyll. These results indicate that this spectral biosignature can persist even after desiccation and exposure to the equivalent of 750 years of UV radiation on the Martian surface (1 lab day = ~1 decade) [8].

These results imply that the biological molecules producing these spectral features have some degree of innate resistance to UV degradation, and/or the environment within the gypsum provides such protection. The results support the role of gypsum as a preservation mechanism whereby the endolithic communities have a layer of gypsum between them and the UV source (whole rock sample), resulting in better preservation of the 670 nm feature, as opposed to direct contact as in the crushed samples. The spectral features are also stronger in the larger grain sized samples (Figure 2), further suggesting that surface area is an additional mechanism affecting preservation of chlorophyll. This provides promising evidence for the preservation of such signatures in evaporite deposits on Mars, should they have been host to endolithic communities in the past or present.

The present Mars Explorations Rovers (MER) Spirit and Opportunity are equipped with Panoramic Cameras (Pancams) which are a multispectral, stereoscopic, panoramic imaging system consisting of two digital cameras. There is a possibility that the differentiation between pure gypsum and endolith-containing gypsum may be made using these filters. The 0.67µm endolith feature have the greatest likelihood of being detected using the L3 filter which has a central wavelength of 0.673 µm (673 nm) and a band pass of 16 nm [9]. However, detectability would still be hampered by the fact that the 670 nm feature is narrow.

The preservation of this spectral signature has other implications for biosignatures in evaporite deposits as it implies that the molecules producing this spectral feature have been preserved. These molecules are organic biological compounds which should be readily detectable by the science payload of the newly launched Mars Science Laboratory (MSL) [1].

**References:** [1] Summons et al (2011) *Astrobiology 11, 2,* 157-181. [2] Stivelleta N. et al (2010) *Geomicrobiology Journal,* 27, 101–110. [3] Wray J. J. et al. (2009) *LPSC XXXX*, abstract #1896 [4] Milliken R. E. (2009) *LPSC XXXX,* abstract #1479. [5] Lane et al. (2004) *Geophys. Res. Lett*., *31*, L19702. [6] Wray J. J. et al. (2010) *Geology, 37,* 1043-1046. [7] Stromberg J. et al. *LPSC XLII* abstract #2170. [8] Cloutis et al, 2008 *Icarus 195,* 140-168. [9] J. F. Bell III et al. (2003) J. *Geophys. Res., 108(E12),* 8063.

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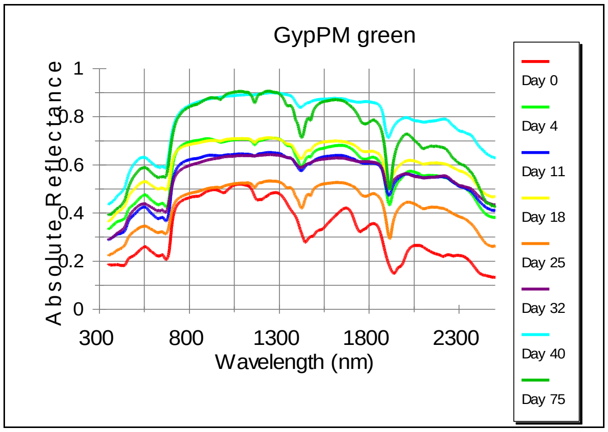

**Figure 1.** Reflectance spectra of the whole rock sample GypPM containing green endolithic communities.

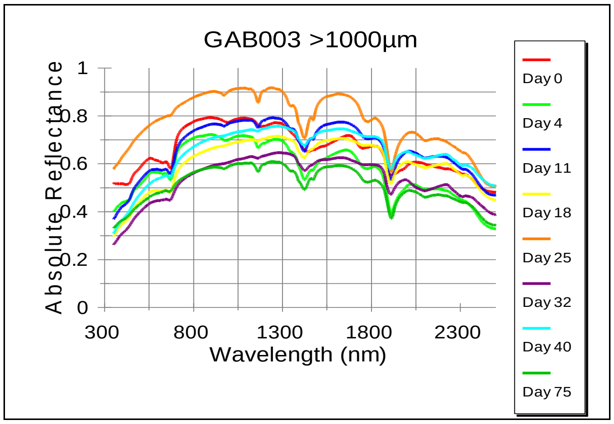

**Figure 2.** Reflectance spectra of the crushed sample GAB003 containing green endolithic communities.