ARE SULFATES THE VIABLE SUBSTRATES FOR THE LONG-TERM PRESERVATION OF LIPIDS?

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Introduction: The environmental conditions on present-day Mars (mean surface temperature −60°C, atmospheric pressure less than 1% of Earth's, and high levels of solar UV and ionizing radiation) are detrimental for life as we know it; however cumulative evidence suggests that early Noachian Mars (~ 4 Gyr) had a warmer climate with a denser atmosphere [1], capable of supporting surficial liquid water [2] and providing protection from UV and ionizing radiation. The widespread aqueous systems on the surface of early Mars (e.g., saline lakes, evaporative ponds) appear astrobiologically promising [3] and their presence coincides with the time when life emerged on Earth [4]. Therefore, the habitability of martian paleoenvironments is the prime motivation for the search for life on Mars [5].

The presence of evaporite deposits (e.g., chlorides, sulfates, and perchlorates) has been confirmed on the ancient surfaces of Mars (Noachian to Hesperian, 4 to 3.7 billion years old [6,7]). A recent study reported high concentrations of hydrated Mg-sulfate (26–36 wt%) and Ca-sulfate (30–50 wt%) within the Gale crater lacustrine deposits, as identified by the ChemCam laser-induced breakdown spectrometer and other instruments onboard the Curiosity rover [6]. These deposits are thought to have precipitated from the brines, possibly at the beginning of the Hesperian era (~3.7 Gyr), when they evaporated. It is possible that remnants of microbial life present on early Mars could have been preserved within these salts; on Earth, fluid inclusions within crystalline salts have been found to harbour and protect microbial life for a prolonged period, possibly over millions of years [8]. Thus, evaporite sequences provide a compelling target for life detection in which putative biosignatures could be preserved [9].

The residual organic biosignatures (e.g., long-chain hydrocarbons) produced *via* metabolism and reproduction in living systems [10] can be preserved and detected even after significant geological time has passed since it deceased [11]. Among such biosignatures, the fatty acid components of the lipid molecules that constitute cell membranes are deemed less prone to environmental deterioration and are compatible with long-term preservation [12].

Given the prominence of sulfates on the surface of Mars, this work explores whether sulfate minerals can act as viable substrates for the long-term preservation of fatty acids when exposed to Mars-like radiative and atmospheric conditions. This is particularly important because the beneficial or deleterious effects of sulfate chemistry on the preservation of organic matter, especially under biologically destructive modern martian conditions, is not well constrained. The work also aims to determine whether these biosignatures can be explicitly detected by spectroscopic instruments.

Methods: We have isolated microorganisms from the evaporite assemblages of Basque Lakes (BL) (Figure 1), south-central British Columbia, Canada. These lakes are saturated with $MgSO_4$ and considered analogous to early Mars lacustrine environments. The seasonal mean temperature of the valley oscillates from -10°C (January) to 25°C/30°C (July/August) [13].

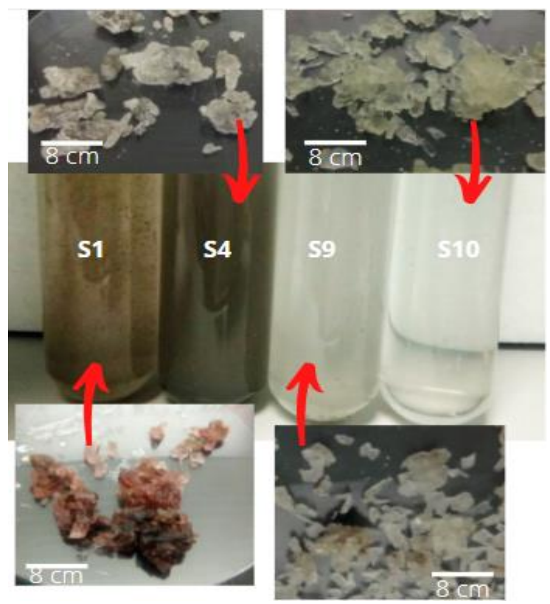

Figure 1. Basque Lake evaporite crystals dissolved in the anaerobic growth medium. S1 is from BL1, S4 is from BL2, S9 and S10 are from BL4.

To determine the mineralogy of BL crystals and the distribution of fluid inclusions, petrological, Electron Microprobe (EMP) and Scanning Electron Microscopy coupled with Energy Dispersive X-Ray (SEM-EDX), and X-ray Diffraction (XRD) analyses have been conducted. We have prepared the enrichment culture

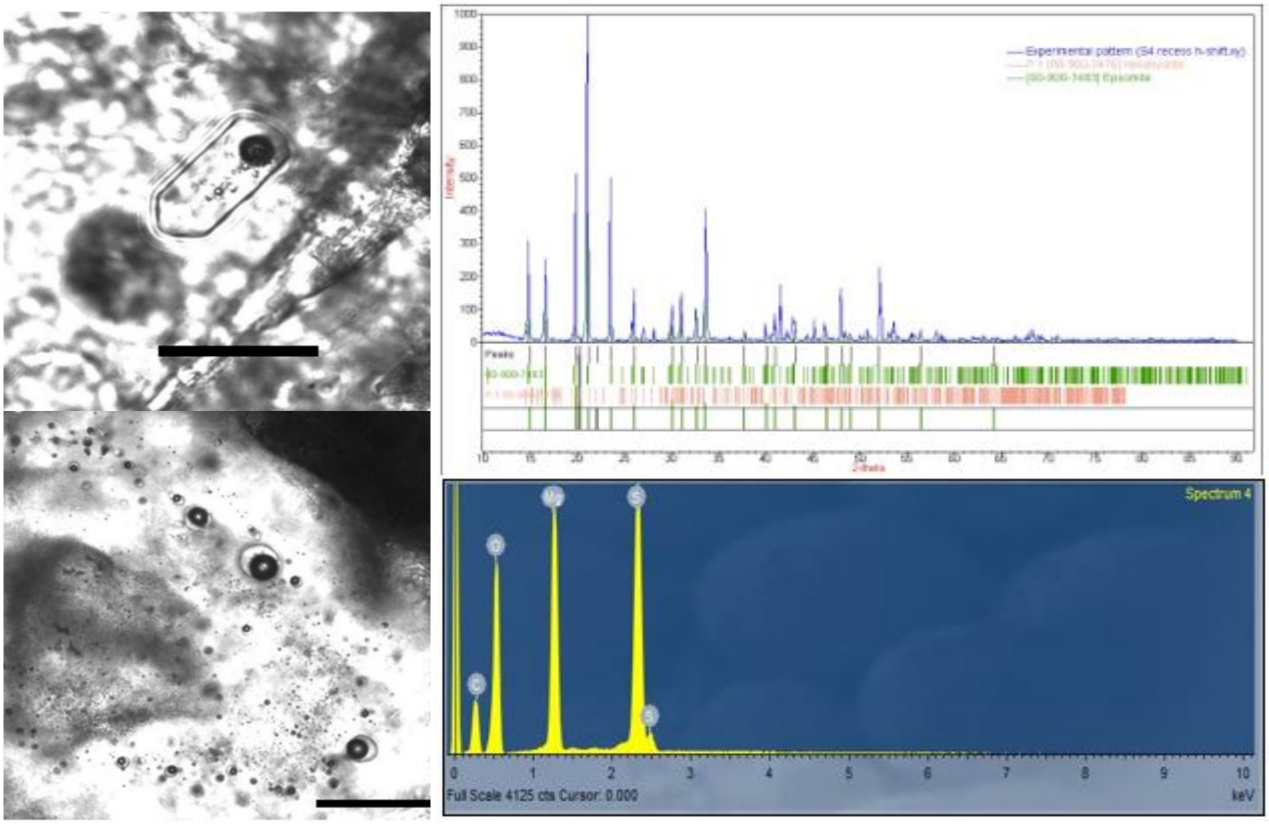

Figure 2. Rounded fluid-inclusions in S4 (left above; bar 60µm); Square shaped fluid-inclusions (left below; 15 µm). SEM-EDX spectra of S4 shows abundance of Mg and S elements (right above). X-ray diffractogram of S4 showing the patters for epsomite crystal faces (right below).

(Figure 1), and pure isolates are being obtained by serial dilution, spread plates, and floating filters.

Results: The elemental compositions of the salt crystals from BL were probed using SEM-EDX and EMPA. The results have shown that all BL crystal samples are enriched in Mg and S with trace amounts of other elements, e.g., Ca, Na, and Si. Also, XRD analysis suggests that samples are predominantly epsomite ($MgSO_4.7H_2O$) with minor amounts of hexahydrite ($MgSO_4.6H_2O$). Also, fluid inclusions (mainly circular and square shaped) have been observed within epsomite crystals (S4; Figure 2), which supports the theory of microbial entombment in BL evaporites. Microbial isolation from BL salt crystals and their characterization is underway.

Future work: BL isolates will be used to assess the microbial survivability and preservation of their lipid signatures in simulated martian sulfates using The Open University's Mars Chamber facility. This will have important implications for understanding the impacts of the simulated martian environment and martian mineralogy on the preservation and detection of lipid biomarkers.

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