Preservation and Detection of Lipid Biomarkers within Martian Sulfates

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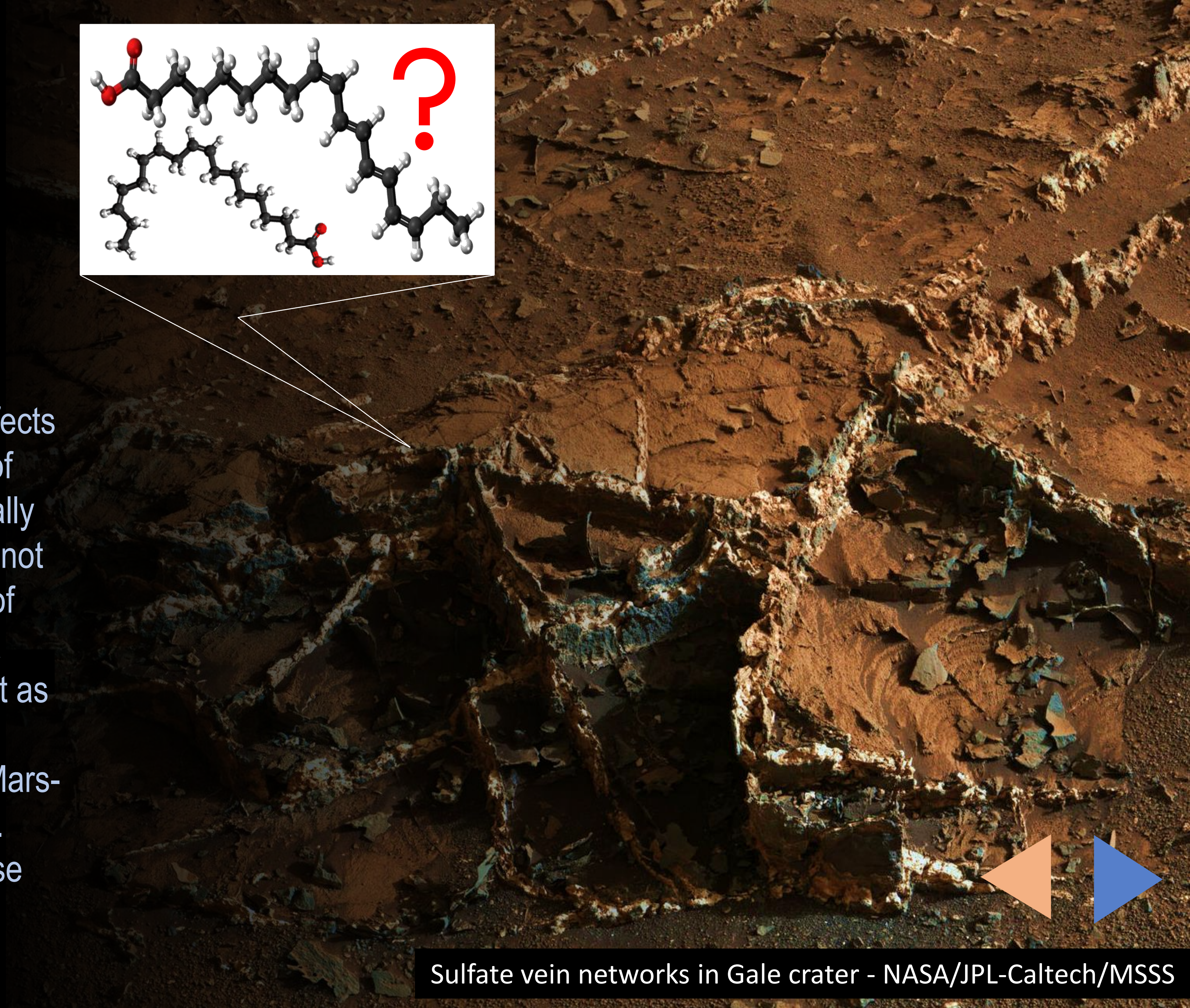
THE BIG QUESTION

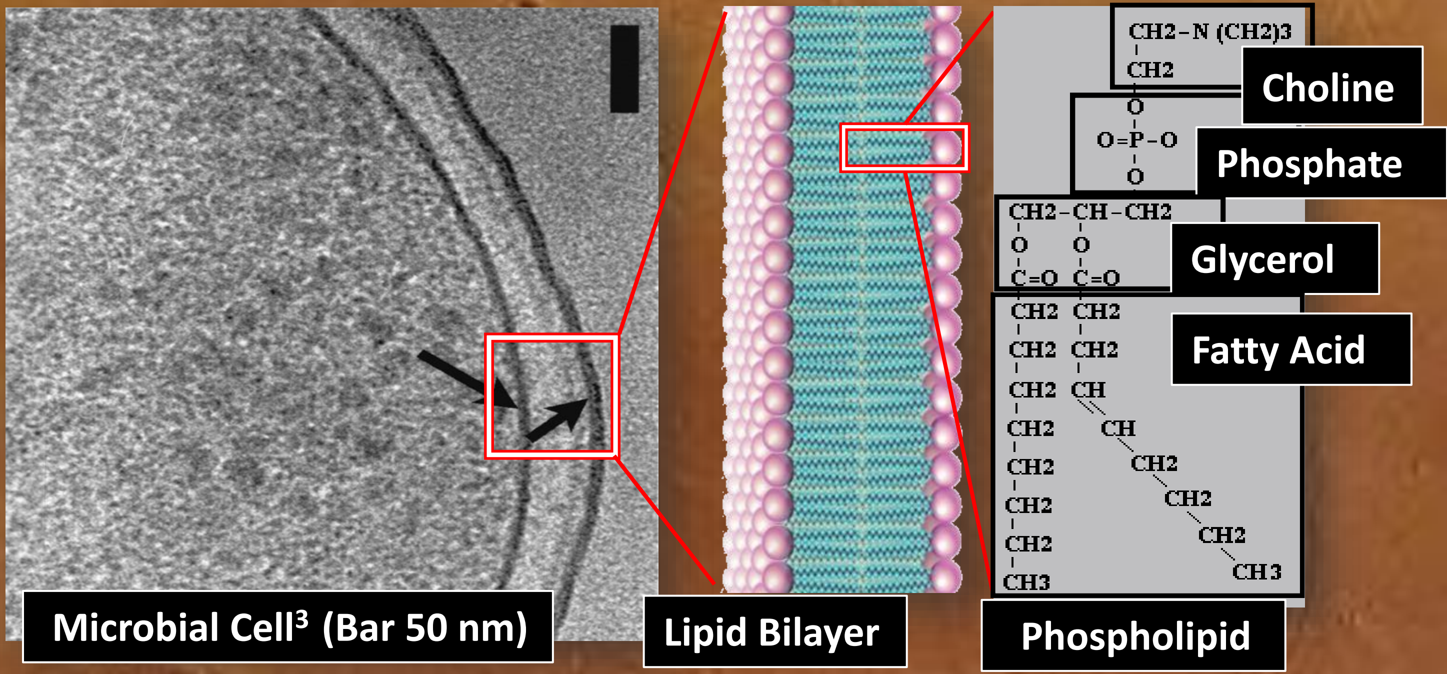
Currently, the beneficial or deleterious effects of sulfate chemistry on the preservation of organic matter, especially under biologically destructive modern martian conditions is not well constrained. Given the prominence of sulfates on the surface of Mars, this work explores whether sulfate minerals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

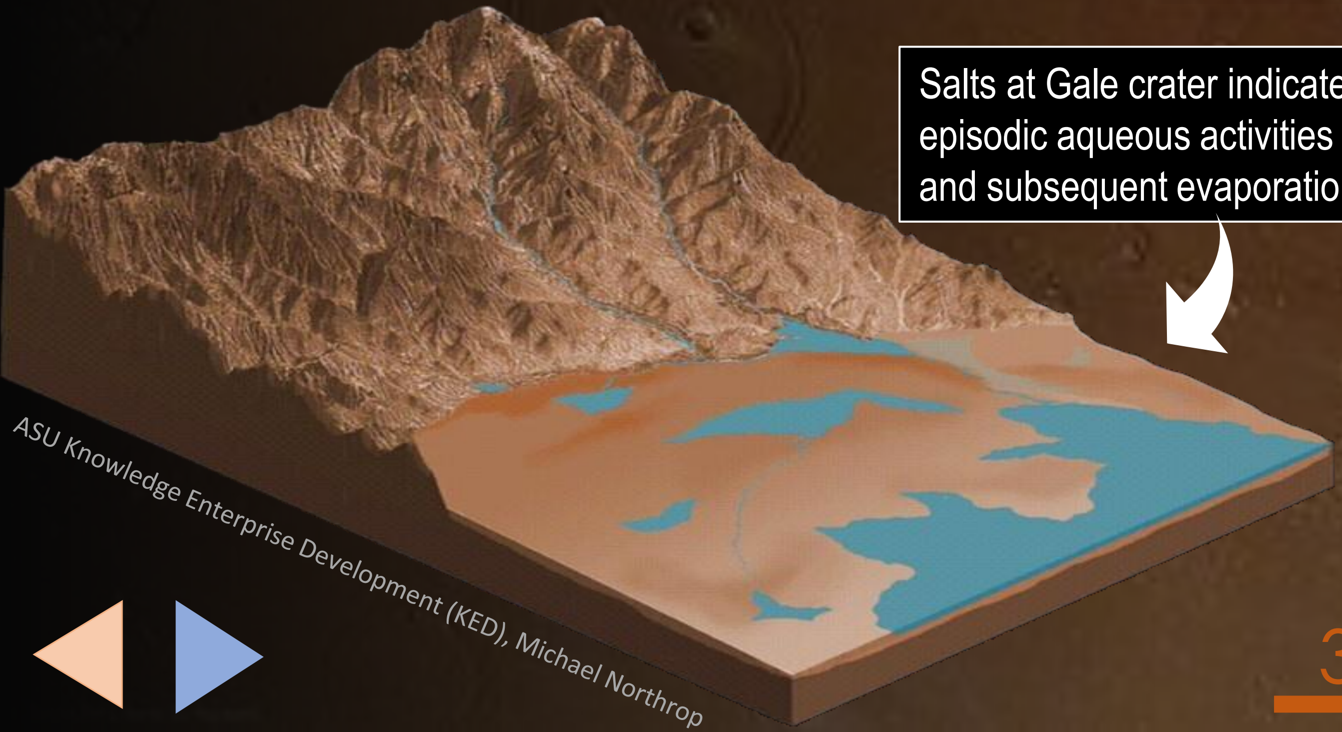


Sulfate vein networks in Gale crater - NASA/JPL-Caltech/MSSS

LIPID BIOMARKERS

While cellular degeneration is a rapid process following cell death, the lipid molecules that constitute cell membranes can be preserved over geological timescales[2]. These provide molecular clues (biosignatures) to the prior existence of microorganisms. Importantly, each group of microorganisms leaves behind a distinct lipid “fingerprint” that is relatively resistant to harsh environmental conditions.





Salts at Gale crater indicate episodic aqueous activities and subsequent evaporation[4]

MARTIAN SULFATES

Calcium and magnesium sulfate enrichments have been observed in the Hesperian (~ 3.3–3.7 Ga) sedimentary rocks of Gale crater[4], which indicate the previous presence of widespread liquid water on Mars. On Earth, fluid inclusions within such salts have been found to harbour and protect microbial life for a prolonged period, possibly over millions of years[5]. Thus, evaporite sequences are deemed compelling targets for life detection attempts, as putative biosignatures could be preserved in them[6].

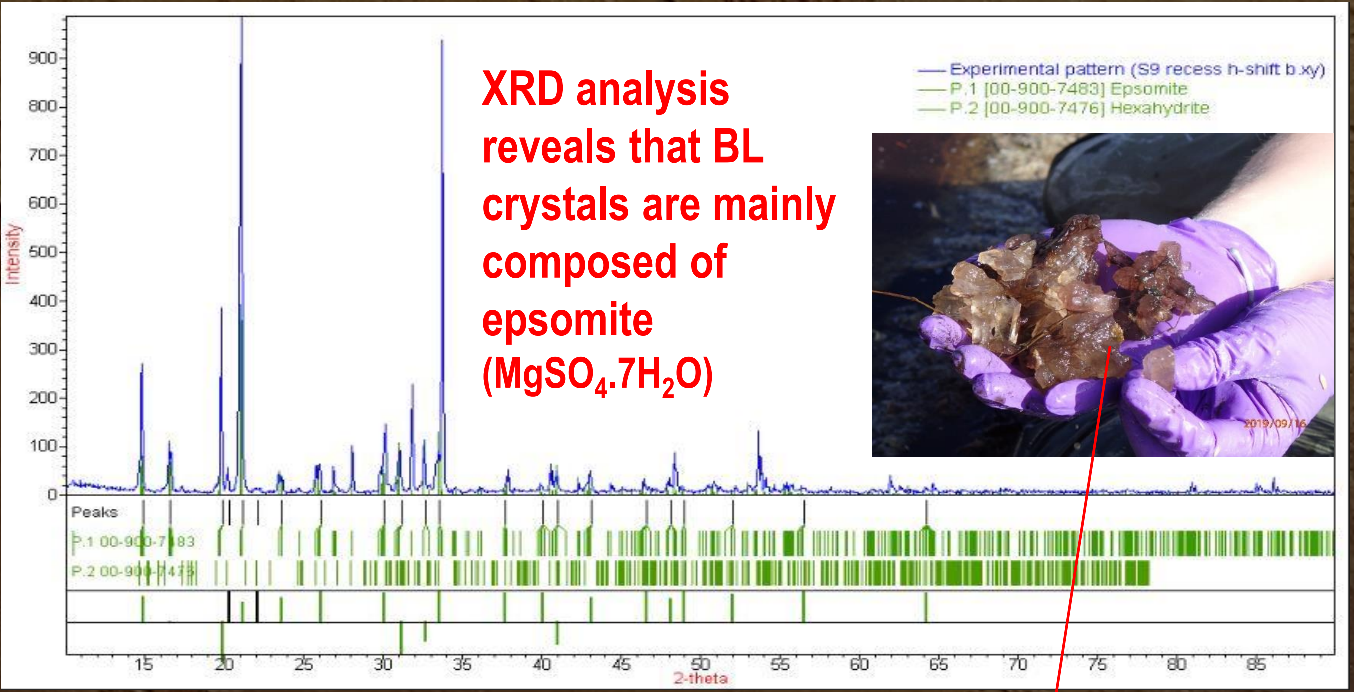
EXPERIMENTAL: DETECTION OF LIPID BIOMARKERS IN MARTIAN SULFATES

a. An experimental fluid with a composition similar to that modelled for Gale crater lake on Mars will be prepared.

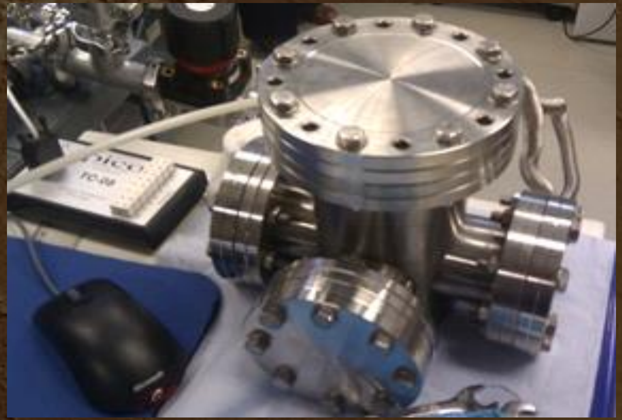
b. Microorganisms from epsomite crystals from a Mars analogue site – Basque Lake (BL) – will be isolated. The crystal compositions were confirmed *via* SEM-EDX, microprobe, and XRD analyses.

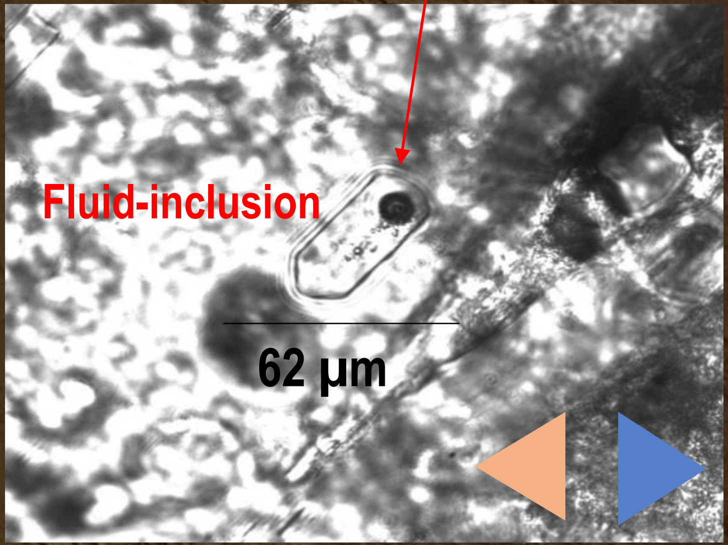
c. Selected BL crystal isolates will be introduced to the experimental Mars brine and the brine will be evaporated under Mars conditions (low atmospheric pressure and a UV radiation source). This will produce artificial sulfate crystals, entombing the microorganisms.

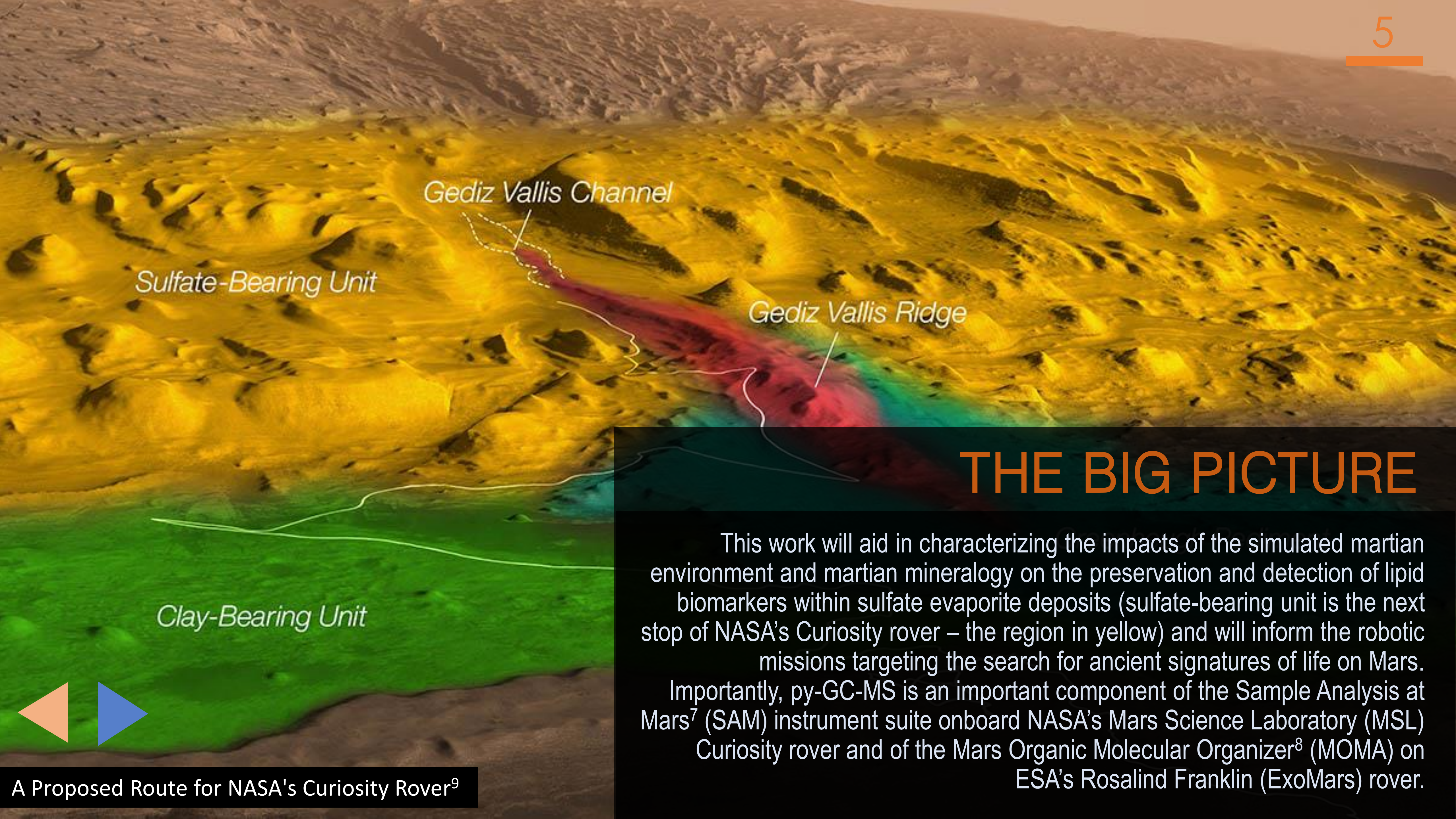
d. The lipids will then be extracted, derivatised and analysed by py-GC-MS to identify the fatty acids present, and compared with a control (entombment under ambient conditions).



The Open University Small Mars Chamber Facility







A Proposed Route for NASA's Curiosity Rover[9]

THE BIG PICTURE

This work will aid in characterizing the impacts of the simulated martian environment and martian mineralogy on the preservation and detection of lipid biomarkers within sulfate evaporite deposits (sulfate-bearing unit is the next stop of NASA's Curiosity rover – the region in yellow) and will inform the robotic missions targeting the search for ancient signatures of life on Mars. Importantly, py-GC-MS is an important component of the Sample Analysis at Mars[7] (SAM) instrument suite onboard NASA's Mars Science Laboratory (MSL) Curiosity rover and of the Mars Organic Molecular Organizer[8] (MOMA) on ESA's Rosalind Franklin (ExoMars) rover.

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