Lipid Biomarkers as a Record of Life on Mars

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Introduction

Past life on Mars would have generated organic remains in the form of biomarkers that may be preserved in Martian rocks that are accessible in the present day [1]. Of the potential biomarkers that are accumulated, biological lipidsare the most resistant to degradation and thus become concentrated in the rock record [2].

The latest period in Martian geological history that supported widespread surface water was the late Noachian to early Hesperian (3.7 Ga) [3,4], which would have sustained the most evolved and widely distributed Martian life. Acidic, sulphur-rich streams can be used as geochemical analogues for this period in Martian history [5], and the investigation of the preservative qualities of the iron sulphates and iron oxides in these environments can guide future missions to Mars.

This study reports the organic signal of an acidic stream containing acidophilic, iron- and sulphur-reducing organisms.The abundance and diversity of these remains vary across iron-rich deposits of differing mineralogy, including jarosites and goethites. The data is derived from gas chromatography-mass spectrometry (GC-MS) analysis of free fatty acid Bligh-Dyer extracts of the acid stream samples (Figure 1).

Results

Saturated straight-chain fatty acids were found to be the most common general indicators of life, consistent with their recognised abundance in terrestrial organisms [6]. A strong even-over-odd predominance (EOP) was observed, with C_{16} and C_{18} fatty acids being ubiquitous, consistent with the knowledge that they are the most common saturated fatty acids found in terrestrial organisms [6]. Other lipids were found to indicate a more specific form of life, such ascyclopropyl fatty acids certain forms of monounsaturated fatty acids, polycyclic terpenoids and long-chain alcohols. It is possible to infer the fossilised form of these lipids in a Martian environment by observing their diagenetic products as they undergo decarboxylation and defunctionalisation [7].

The acid stream data also indicate a mineralogical control on biomarker preservation. Goethite in acid streams is derived from jarosite decomposition in the presence of humid conditions [8], and is shown to possess the highest concentration of lipids. This shows that lipid biomarkers are retained in iron oxides despite mineralogical transformation from iron sulphates.

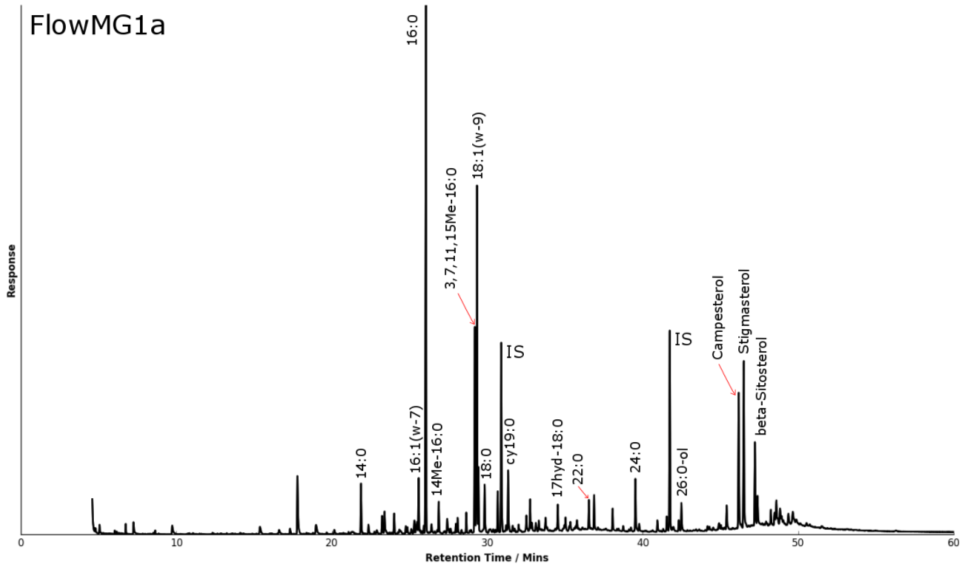

Figure 1:*Chromatogram showing GC-MS data from taken a goethitic layer in the sulphur stream. The figure shows the abundance and diversity of lipids such as saturated and unsaturated fatty acids, long-chain alcohols and polycyclic terpenoids. IS: Internal Standard.*

Conclusions

Acid stream data show that a significant amount of fossilised organic material is preserved in the form of a diverse suite of biological lipids. Several organic markers are identified that allow for the indication of previous life, or specific groups of organisms. The discovery of lipids preserved in goethites that have replaced pre-existing jarosites shows that these fossils can potentially survive mineralogical transformation in Mars rocks, and are concentrated in rocks that suggest persistent aqueous conditions. Thus, it is suggested that iron oxide remnants of sulphur-rich environments are good candidates for future life detection missions on Mars due to their demonstrated preservation potential.

References

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