EPSC Abstracts
Vol. 7 EPSC2012-533 2012
European Planetary Science Congress 2012

Spectroscopy studies of bioinduced carbonates and the search for life on Mars

A. Blanco (1), V. Orofino (1), M. D'Elia (1), S. Fonti (1), A. Mastandrea (2), A. Guido (2), F. Russo (2), F. Tosti (2)
(1) Department of Mathematics and Physics, University of Salento C. P. 193, 73100 - Lecce, Italy
(armando.blanco@unisalento.it, Fax: +390832297505), (2) Department of Earth Science, University of Calabria, Cosenza, Italy

Abstract

A number of evidences, as the past presence of water, a denser atmosphere and a mild climate on early Mars, suggest that environmental conditions favourable to the emergence of life must have been present on that planet in the first hundred million years, or even more recently. If life actually existed on Mars, biomarkers may still be present there.
In previous laboratory works we have investigated the infrared spectral modifications induced by thermal processing on different carbonate samples, in form of fresh shells and fossils of different ages, whose biotic origin is easily recognisable. The goal was to develop a method able to discriminate biotic samples from their abiotic counterparts.
In this work we show that our method can be successfully applied also to microbialites, i.e. bio-induced carbonates deposits, and particularly to stromatolites, the laminated fabric of microbialites, some of which counted among the oldest traces of biological activity known on Earth. This result is of valuable importance since such carbonates are linked to primitive living organisms which can be considered as good analogues for putative Martian life forms.

1. Introduction

Recent findings are demonstrating that carbonates can be more widespread on Mars than previously thought.
Calcium carbonate minerals ($CaCO_3$) are quite interesting to study because they can be produced by abiotic processes or by biologically induced or controlled mineralization [1]. Many living organisms on Earth, prokaryotes and eukaryotes, are able to biomineralize calcite or aragonite and actually the most primitive terrestrial evidence of life are biomineralized carbonates [2]. On the other hand it is well known that carbonates are also produced by purely chemical precipitation according to different processes which are completely independent of the presence of life.
Several samples of microbial carbonates were investigated (see Figure 1). They represent the product of microbial activity in different environments from the Precambrian to the recent age. The samples are composed mainly of calcite and/or aragonite and show different growth fabrics.

2. Sample description

In this paper we analyzed microbial carbonates that developed, in time, in various palaeoecological conditions (Fig. 1).

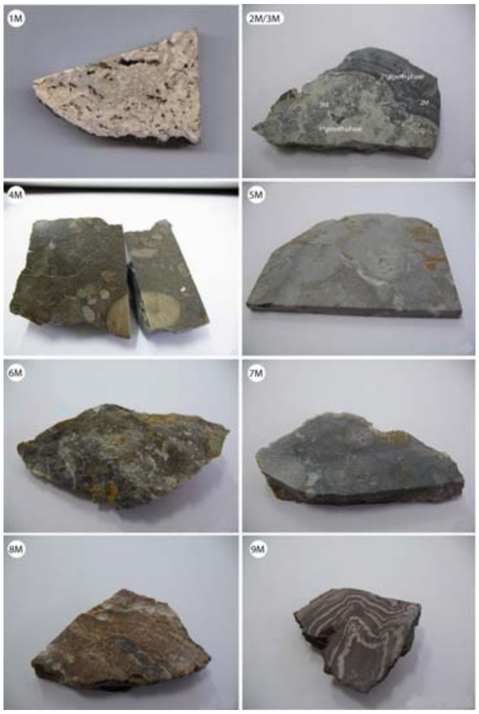

Figure 1. The analysed samples

1M is a relatively young (~ 3,000 years old) sample of stromatolite collected from Lake Thetis, Western Australia. The Lake Thetis stromatolites are roughly laminated stromatolites with columnar elements (bioherms) and are situated within the littoral zone of the southern to south-western shore, forming some kind of microbial "reef platform".
The stromatolitic samples 2M and 3M (see Fig. 1), Upper Jurassic in age (Tithonian, 151-146 Ma) was collected from Thuste Quarries, south of Hanover, Germany. In this area stromatolites developed in stressed environments, probably represented by a lagoonal setting, with alternate deposition of oolitic limestone and evaporites [3].
Four analyzed samples (4M, 5M, 6M, and 7M) are Upper Triassic in age (Upper Carnian, 229-217 Ma) and were collected from the Alpe di Specie section (Prato Piazza, Western Dolomites, Italy). Skeletal organisms (Tubiphytes, skeletal cyanobacteria, sphinctozoan and inozoan sponges, etc.) represent a minor component of the rock (usually less than 40%). On the contrary the composition is dominated by the micritic fraction (about 60%), mainly represented by automicrite, with subordinate amounts of micrite interpreted as detrital (allomicrite). The microbialites or automicrites, which may exhibit both dense microcrystalline (aphanitic) or peloidal microfabric, are sometimes organized in stromatolitic laminae or thrombolitic fabric.
The sample 8M is lower Devonian in age (Lochkovian, 416-411 Ma) and was collected from the Kess-Kess mounds of the Hamar Laghdad Ridge, SE Morocco. In this area microbial activity linked to submarine hydrothermal vents [4] generated spectacular carbonate buildups. The studied stromatolitic facies, decimeter at the mesoscale observations, are made up of millimeter to submillimeter laminations with irregularly alternating wrinkled laminae arranged in columnar structures. The accretionary morphology (very fine wavy-wrinkled laminations), showing antigravity patterns, suggests an organic origin and a syndepositional cementation of this microbialite.
The sample 9M, Precambrian in age (Neoproterozoic, Ediacaran, 600-620 Ma), was collected at the south of Quarzazate (Morocco). These stromatolites developed with domal to columnar morphologies. Javier Alvaro et al. [5] maintain that these stromatolites developed in freshwater (lacustrine) or shallow lagoonal (with a strong freshwater input) depositional settings. At microscale observations they show very fine dark and white laminations that suffered silicification processes. The biogenicity of these structure have been debated for long time and it is still unclear the actual contribution of the bacteria in their formation.

3. Results and Conclusions

Following the procedure described in Orofino et al. [6], we obtained the D index for all the samples under investigation. All of them exhibit a D index significantly smaller then 1, indicative of the biotic origin of the stromatolite/microbialites under analysis.
For this reason, IR spectroscopy, coupled with thermal processing, can be a useful tool for discriminating between carbonates samples of abiotic and biotic origin which can be collected on the Martian surface in the near future.
We are now studying different parts of the same samples having a different D index, trying to correlate the degree of biogenitity to the various kinds of the micrite component.

Acknowledgements

This research has been partially supported by the Italian Space Agency (ASI) and the Italian Ministry of University and Research (MIUR).

References

[1] Mann, S.: Biomineralization: Principle and Concepts in Bioinorganic Materials Chemistry. Oxford University Press, New York, 2001.
[2] Westall, F. et al.: Searching for fossil microbial biofilms on Mars: a case study using a 3.46 billion-year-old example from the Pilbara in Australia. ESA Spec. Pub. 545, 37-40, 2004.
[3] Jahnke, H., Ritzkowski, S.: Die Fazies-Abfolge im Munder mergel der Steinbruche bei Thuste (Ober-Jura, Hilsmulde). Berichte der Naturhistorischen Gesellschaft Hannover, 131, 45-62, 1980.
[4] Joachimski, M.M. et al.: Hydrothermal origin of Devonian conical mounds (Kess-Kess) of Hamar Laghdad Ridge, Anti-Atlas, Morocco: comment and reply. Geology 27, 863– 864, 1999.
[5] Javier Alvaro, J. et al.: Alkaline lake systems with stromatolitic shorelines in the Ediacaran volcanosedimentary Quarzazate Supergroup, Anti-Atlas, Morocco. Precambrian Research 179, 22-36, 2010.
[6] Orofino, V., et al.: Time dependent degradation of biotic carbonates and the search for past life on Mars. Planet. Space Sci. 57, 632–639, 2009.