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A Spectroscopic Method for Identifying Biotic Carbonates in Terrestrial Rocks and Application to Mars

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Abstract

Searching for traces of extinct and/or extant life on Mars is one of the major objectives for remote-sensing and in-situ exploration of the planet. In previous laboratory works [1], [2], [3], 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 (see Table 1). The goal was to discriminate them from their abiotic counterparts.

Table 1: Analyzed carbonate samples ($CaCO_3$, aragonite and calcite) in form of fresh shells and fossils of different ages.

Sample Name	Age (in Myr)
Tellina exigua	Max 1 year old
Cardites antiquata	Max 10 years old
Pecten sp.	Middle Pleistoc. 0.8-0.1
Ostrea sp.	Lower Pleistoc. 1.8-0.8
Arctica islandica	Lower Pleistoc. 1.8-0.8
Myriapora truncata	Lower Pleistoc. 1.8-0.8
Clypeaster	Miocene, 18-20
Haliotis lamellosa	Oligocene, 34-23
Xenophora	Pleistocene, 1.8-0.1
Natica	Pleistocene, 1.8-0.1
Anomia	Oligocene, 34-23
Trochidae sp.1	Oligocene, 34-23
Trochidae sp. 2	Oligocene, 34-23
Potamitidae sp.	Oligocene, 34-23
Ampullinopsis cr. 1	Oligocene, 34-23
Ampullinopsis cr. 2	Oligocene, 34-23
Ampullinopsis cr. 3	Oligocene, 34-23
Cerithium	Oligocene, 34-23
Rudista	Cretaceous, 145-65
Ortoceras	Devonian, 416-359
Fossil stromatolites	Meso-proter. 1.6-1.0 Gyr

In general, it is difficult to identify biotic signatures, especially when the organisms inducing the carbonate precipitation have low fossilization potential (i.e. microbes, bacteria, archaea). Actually a broad variety of microorganisms are implicated in the carbonatogenesis, and their direct characterization is very difficult to be evaluated by traditional methods, both in ancient sedimentary systems and even in recent environments.
In the present work we apply our analysis to problematic carbonate samples - collected from the Calcare di Base (CB) formation, which crops out in the Rossano Basin (Northern Calabria, Italy) and formed in the Late Miocene - in which there are no clear evidences of controlled or induced biomineralization (see Fig. 1). This analysis indicates a very likely biotic origin of the aragonite samples under study, in perfect agreement with the conclusion previously reported by Guido et al. [4], who followed a completely different approach based on a complex set of sedimentary, petrographic, geochemical and biochemical analyses. We show that our method is actually reliable for discriminating between biotic and abiotic carbonates, and therefore it is a powerful tool for the search of life on Mars in the next generation of space missions to the planet.
We are now applying our analysis to different kinds of microbialites (stromatolites, thrombolites and leiolites) in order to test our method with simpler form of calcitic formations more likely to be found on Mars.

Figure 1: Study section (panel A) and general view of the Rossano Basin (panel B) showing the position where six samples have been collected. The black box in B indicates the location shown in A.

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