Geophysical Research Abstracts
Vol. 21, EGU2019-6142-1, 2019
EGU General Assembly 2019

Sr as marker of primary crystallization: synchrotron radiation micro XRF investigation of modern microbial mats and Triassic loferites

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Debate about sedimentary structures found in intertidal zones of highly evaporative environments such as sabkhas, has commonly been focused on the interpretation of their morphology as purely abiotic or microbial. This is relevant to the study of early signs of Life on Earth, of the resilience of Life in extreme environments and for the search of signs of Life on Mars and exoplanets. Critically, ancient rocks likely underwent multiple diagenetic phases that may have partially overprinted primary features, yet microbially-influenced structures may be stabilized by micrite and micrite itself can be stabilized by organic molecules.

The aim of the present study is to investigate the best chemical tracer that highlights primary (or very early diagenetic) depositional features by utilising Synchrotron Radiation based micro-X Ray Fluorsecence (SR-μXRF) mapping. Here we present the first SR-μXRF investigation of living microbial mats collected in the Dohat Faishakh Sabkha (DF) of Qatar compared with a similar fossil counterpart, the loferite facies from the Late Triassic Dolomia Principale (DP) in the Brenta Dolomites (Italy).

In the modern DF sample we found that As, Br, Fe and Mn were associated with the dark, microbial laminae (organic part), whilst Sr was associated with the “mineral” part, along with Ca and Rb. This pattern has been already observed by SR-μXRF investigation of continental microbial mats.
In the Late Triassic DP laminated facies - commonly interpreted as fossilized cyanobacterial microbial mats that originally thrived in an evaporative environment similar to that of the Qatar sabkha - the laminae consist of dolomite, whose genesis is a matter of debate. However, novel nanostructural investigations of the laminites suggest that some primary structures are preserved and, critically, the SR-μXRF maps revealed that Sr is associated with micrite outlining “microbial laminae”.

It is well known that Sr is immobilized by calcification and totally related to the mineral parts of the mats. By contrast, other elements, such as Br are in the “organic part”, and are preferentially carried away during diagenesis. Sr distribution in the DP is very similar to that in the DF samples, which, coupled with modern growth rates of the mat, hints to the idea that it marks primary carbonate deposition as related to annual cycles in environmental parameters. At the same time, it is interesting to note that all the elements associated with “organics” are not detectable in the Triassic samples.

This finding provides a new tool for both assessing existence of a primary mineral component of a microbial mat in fossil samples and for understanding annual-scale processes that drove the formation of “lofer” facies.