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Carbon and nitrogen stable isotope measurements and X-ray photoabsorption spectroscopy of microbial-mat-containing gypsum crust in modern saline pan

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A gypsum crust collected from the Sosalt commercial salt work at Trapani (western Sicily, Italy), which was deposited in several years, has a remarkable layered structure with different colors and physical appearance (from the top to the bottom: transparent gypsum, green layer, and granulous layer containing black particles), each color representing a different microbial community. Previous studies suggest that the colored layers consist of different cyanobacterial communities, purple sulfur bacteria and sulfur reducing bacteria, respectively, and that their biochemical processes are intimately connected (e.g. Caumette et al., 1994; Canfield et al., 2004). In this study we performed stable carbon and nitrogen isotope measurements, elemental mapping, and bulk chemical analyses to describe geochemical characteristics of this layered evaporite deposit.

Lower values of δ13C and δ15N in the colored layers compared to the topmost transparent layer indicate active biochemical processes by the bacterial communities, as expected. To further describe the differences between the layers, a synchrotron based micro-X-ray fluorescence (μ-XRF) was used to acquire the spatial distributions of Na, Mg, Sr, S, Cl, and P in the each layer of different color. The elemental mapping combined with chemical speciation of S K-edge X-ray absorption near edge structure (XANES) spectra of the gypsum crust showed that the transparent and the green layers were uniformly filled with gypsum crystals, while a somewhat high concentration of elements other than sulfur were observed in the interparticle realm of the bottom gypsum layer. This indicates an earliest alteration at the bottom layer probably as a result of sulfur reduction by sulfur reducing bacteria inhabiting the interparticle realm. It is noteworthy that no reduced sulfur compounds, except for gypsum, was detected in the sample by μ-XANES analysis, despite the presence of a layer inhabited by sulfur reducing bacteria.

Since gypsum is one of the main components of the evaporites formed during the Messinian salinity crisis (MSC), and that it is widely distributed across the entire Mediterranean area, studies on gypsum may help the comprehensive understanding of the MSC. Information obtained from our study represents a modern analogue in investigating the geochemical characteristics of Messinian gypsum.