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Organic matter remains in the Kess Kess mounds of the Hamar Laghadad (Anti Atlas, Morocco): record of microbial biomineralization

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Carbonate Mud Mounds are well documented in the geological record, and span from Proterozoic to recent times, in shallow- and deep-water settings. They are a significant expression of the history of Earth's microbial life. The origin of carbonate mud-mounds has long been debated and the discovery of seep- and vent-related ecosystems from different geotectonic settings, associated to authigenic carbonate mounds, allowed the re-interpretation of some mounds as the product of chemosynthetic microbial mediation.

We analyzed the carbonate mounds, informally called "*Kess-Kess*", cropping out in the Hamar Laghdad Ridge, eastern Anti-Atlas, SE Morocco. These mounds are the most spectacularly exposed carbonate buildups of the world and, due to differential erosion, they show their original shapes and the relationships with associated strata.

The origin of these buildups is still under debate and the most consistent hypotheses are related to submarine hydrothermal vents or hydrocarbon seapage in which bacteria and/or archaea plaied a prominent role in the carbonate biomineralization.

To investigate the possible remains of prokaryote metabolic activity we studied the micrite precipitation processes through microfacies and biogeochemical analyses.

The more indicative micrite texture is stromatolitic with very fine wrinkled lamination organized in antigravitative pattern. High resolution SEM observations suggest the presence of widespread trace of organic phantoms.

The geochemical characterization of extracted organic matter was performed through the functional group analyses by FT-IR spectroscopy. The infrared spectra showed bands between 600 and 3000 cm^{-1}. They contain stretching aliphatic bands (υCHali) at 2950, 2925 and 2850 cm^{-1}, and deformation bands of methyl (δCH_3; 1365 cm^{-1}) and both methyl and methylene [$\delta(CH_2 + CH_3)$; 1458 cm^{-1}] groups. The spectra also display the band assigned to carbonyl and/or carboxyl groups (νC=O; 1740 cm^{-1}). The νC-O vibration appears between 1300 and 1100 cm^{-1}. We recorded also the band νC=C probably related to unsatured compounds (alkene and/or carboxylic acids).

The organic matter correlated to the fine laminated micrite is characterized by the presence of stretching C=C vibrations. The lack of bands in the 700-900 cm^{-1} and 3000-3100 cm^{-1}regions permits to exclude that νC=C band belongs to aromatic compounds. We attribute this band to alkene and/or unsatured carboxylic acids that could have been synthesized by bacteria and/or archaea communities, which caused the precipitation of carbonates through their metabolic activities.

We used the A Factor (2930+2860 cm^{-1})/(2930+2860+1630 cm^{-1}) and a C Factor (1710 cm^{-1})/(1710 + 1630 cm^{-1}) in order to quantify changes in abundances of aliphatic and carbonyl/carboxyl groups. These factors can be used in a similar manner to the traditional H/C – O/C elemental ratios or to Rock-Eval pyrolysis parameters, as Hydrogen Index (HI) – Oxygen Index (OI), for the classification of kerogen types and maturation level of organic compounds. In the analyzed samples, the A factor is $\sim$0.70 while the C factor is $\sim$0.63. These parameters indicate a marine origin for the organic compounds and a low thermal evolution. Considering the thermal maturity of the organic compounds, further analyses in Gas Cromatography-Mass Spectrometry could confirm the presence of specific bacterial/archaeal biomarkers. These analyses will clarify the microbial metabolic activities that induced

biomineralization processes in the Kess Kess Mound.