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Evaluating the preservation potential of iron-oxidizing bacteria during experimental diagenesis

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Over the last years, there has been accumulation of geochemical and isotopic proofs in favor of the contribution of microorganisms to the deposition of Precambrian banded-iron formations (BIF) [1]. While structural and morphological microbial fossils have been detected in up to 3.333 Ga-old rocks [2], this evidence is missing for the Precambrian BIF. The major problem encountered in the search for morphological microbial fossils comes from the small size of the microbial remains and from the fact that abiotic processes can produce similar structures. Most of the Precambrian BIF have been submitted to diagenesis/metamorphism, which highly decrease the chances of preserving any microbial structures. The aim of this study was to determine the pressure/temperature conditions within which iron-oxidizing bacteria can be recognizable after undergoing experimental diagenesis. A combination of spectroscopic and microscopic techniques was evaluated to unequivocally identify the material after simulated diagenesis.

We selected as microbial model environmental iron-oxidizing mats sampled in a former mine (Segen Gottes Mine, Black Forest, Germany), which contained twisted organic extracellular polymer structures encrusted to different extent with Fe(III) minerals. These twisted ribbon structures are similar to the ones produced by the Gallionella strains, which were proposed to be used as a biosignature for Fe-oxidizing metabolism [3]. Samples were filled into gold capsules and incubated at different pressure/temperature conditions in a hydrothermal autoclave to simulate diagenesis. We used confocal-laser scanning microscopy (CLSM), scanning-electron microscopy (SEM), Raman micro-spectroscopy (RMS) and Scanning transmission X-ray microscopy (STXM) to characterize the samples and evaluate the preservation potential of the organic-mineral structures.

The results of our experiments show that the microbial twisted structures can be preserved at moderate pressure and temperature conditions typical of the high-grade diagenesis. CLSM allows the unambiguous recognition of the fluorescently-labeled organic twisted structures encrusted in iron minerals. As already shown previously, SEM is an essential tool for the high-resolution imaging of microbial structures. RMS and STXM are significant instruments to provide chemical information on the potential morphological microbial structures. The correlative use of the above mentioned techniques is required to unambiguously identify the biological origin of the microfossils.

References

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