Molecular structure evolution of biogenic and abiotic organics during experimental diagenesis: clues for decoding the organic fossil record

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The early Life fossil record is based upon a limited number of controversial graphitic microfossils. These controversies directly result from (i) potential late contamination, (ii) the possibility that abiotic structures can mimic microfossils, and, most importantly, (iii) the poorly quantified degradation of the fossil record. The original (bio)chemical signatures of biogenic organic molecules fossilized within sedimentary rocks are indeed inevitably altered during fossilization and burial. Yet, although well known, the impact of these processes on organic biochemical signatures remains quantitatively poorly constrained. Experimental investigations thus appear crucially needed.

Here, we report 'fossilization' experiments that we performed on *Gloebacter Violaceus* cyanobacteria and abiotic organics synthesized from a N_2-CO gaseous mixture using low-pressure plasma discharge experiments. These biogenic and abiotic organics, which exhibit quite similar molecular structures, have been experimentally submitted to well-controlled conditions that mimic those of diagenetic and metamorphic settings (250-500°C, 1-250-500 bars) for different durations (1 to 100 days). Solid residues of all experiment have been characterized using synchrotron-based XANES spectroscopy which has provided key information on carbon and nitrogen speciation.

Results indicate that significant aromatization and defunctionalization have affected the molecular structure of *Gloebacter Violaceus* cyanobacteria. Surprisingly, although the abiotic organics used for the present experiments originally exhibit a XANES signature quite similar to the one of *Gloebacter Violaceus* cyanobacteria, the evolution of their molecular structure with increasing time and temperature is qualitatively and quantitatively very different. The implications of such differential evolution will be discussed in the context of the search for the earliest traces of life. In any case, although experimental simulations may not perfectly mimic natural diagenesis, the present study provides key insights on the fate of natural organic matter and the evolution of its spectroscopic signatures during burial.