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Preservation of microbial structures in modern and ancient fossil assemblages: a microscopy and spectroscopy assessment

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Finding features that are indicative of a past biological activity in rocks has been an important challenge over the last 10 years. Indeed, it has been increasingly shown that what was formerly considered as unambiguous bio-signatures could actually be produced by abiotic processes as well. One way to have a better insight into what might be truly biogenic consists in characterizing as exhaustively as possible the systems of interest at the nm-scale. Moreover, before considering ancient samples that underwent various diagenetic and metamorphic transformations, we need to assess what biological features (ultrastructures as well as chemistry) can be preserved in the first stages of fossilization. In that purpose, we will review studies that we performed both on bacteria fossilized in the laboratory (1) and on modern stromatolites (2) using a combination of nanoscale spectroscopy and microscopy techniques, mostly Transmission Electron Microscopy (TEM) and synchrotron-based X-ray microscopy (STXM). TEM and STXM provide information on the chemical composition for major elements and

on the speciation of elements such as carbon, oxygen, nitrogen, iron etc. at the few nanometers scale. They thus allow doing organic geochemistry at the nm-scale. Those results will be compared with similar analyses performed on 2.7 Ga old stromatolites from Tumbiana (3) and on fossils preserved in high-grade metamorphic rocks from the Alps (4). From that review emerges the idea that some biological features can be preserved in old and/or metamorphosed rocks.

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