Extremophiles, early Earth biosphere and exobiology

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Many studies of extremophiles focus on prokaryotic organisms (Archaea and Bacteria). However, several groups of eukaryotes also thrive in severe environments although their diversity is much less known. Eucaryotes have been present on Earth for at least 2.7 billion years and their role in the generally prokaryote-dominated extreme environments has not been investigated in details. We propose to study cyanobacteria and primitive protists living in extreme physico-chemical conditions similar to conditions on early Earth and possibly beyond (Mars, Europa). This multidisciplinary project includes laboratory and field investigations, in collaboration with Dr. Wilmotte (University of Liège, Chemistry Dept., Belgium) and Dr. Fernández Remolar (Centro de Astrobiologia, Spain).

Early Earth environments were extreme in various physical and chemical aspects, such as UV radiation and low oxygen concentration. Extremophiles from Antarctica are exposed to intense UV radiation and cold temperatures, conditions analog to those on Mars and Europa. Microorganisms from the Rio Tinto, Spain are adapted to extremely acidic and iron-rich waters, and preserved in hematite deposits reminiscent of those of Terra Meridiani, Mars. Molecular phylogeny studies in these environments have revealed a large diversity of prokaryotes and protists. Cultures of some of these organisms are available to us for artificial taphonomy experiments. Microorganisms from these environments producing decay-resistant tests or sheaths (potentially preserved in the fossil record) will be studied using a combination of microscopy and microchemistry. The morphology and ultrastructure of their walls or sheaths will be determined with combined microscopy (light, SEM, TEM). Analyses of the chemical composition and identification of biopolymers and biomarkers (pigments and lipids) will be carried out using Fourier-Transform infrared (FTIR), micro-Raman spectroscopy, Laser Pyrolysis GC/MS, elemental analysis (EDEX). In parallel, microfossils preserved in microbial mats from Antarctica, hematite deposits from the Rio Tinto, and Precambrian shales and cherts will be studied with a similar approach to investigate the processes of biosignatures preservation (fossil morphologies, biomarkers) in extreme environments. This research will contribute to the building of a comparative database for the identification of fossil microorganisms in Precambrian sediments from Earth and possibly in extraterrestrial samples (*in situ* or returned).

Our multidisciplinary approach will improve the understanding of extremophiles biology and paleobiology, and the role of extreme environments in the biosphere evolution on Earth and possibly beyond.