Société Française d'Exobiologie

7 – 10 novembre 2023, Grenoble, France

Investigating traces of life in a Martian context: a micro-to-nanoscale study of microfossils from Rio Tinto

L. MALDANIS[1], D. FERNANDEZ-REMOLAR[2,3], L. LEMELLE[4], M. GUIZAR-SICAIROS[5,6], M. HOLLER[5], F. M. C. da SILVA,[7] V. MAGNIN[1], M. MERMOUX[8], A. SIMIONOVICI[1]

[1] ISTerre, Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, IRD, IFSTTAR, Grenoble, l.maldanis@vu.nl
[2] SKL Lunar and Planetary Sciences, Macau University of Science and Technology, Macau, SAR, China
[3] CNSA Macau Center for Space Exploration and Science, Macau, SAR China
[4] LGL-TPE, ENS de Lyon, Univ. de Lyon, CNRS, 69342 Lyon, France.
[5] Paul Scherrer Institute, Villigen PSI, Switzerland
[6] Institute of Physics, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland
[7] Brazilian Synchrotron Light Laboratory, LNLS, Campinas, SP, Brazil
[8] Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, Grenoble INP, LEPMI, 38000 Grenoble, France

Understanding the nature and preservation of traces of microbial life in extreme environments is crucial for retrieving Earth's past biosphere and to guide the search for life in other planets. Rio Tinto, a hyperacidic Mars analogue, has produced ferric deposits entombing a diversity of fossilized organisms, despite the putative unfavorable chemical conditions.[1,2] Investigating its unique fossil microbiota can shed light into ancient extremophile communities and on the preservation of biosignatures on acidic environments on Earth and potentially Mars. Here we employed an innovative multiscale approach combining the state-of-art synchrotron X-ray nanoimaging methods of Ptychographic X-ray Computed Laminography [3] and Nano-X-Ray Fluorescence [4] to reveal Rio Tinto's microfossils at sub-cellular resolution. The unprecedented views of several different specimens within their geological and geochemical contexts revealed novel intricacies of the microbial communities. Different morphotypes, taxonomic affinities and ecological interactions were identified based on qualitative and quantitative 3D ultrastructural information, while diagenetic processes and metabolic affinities were inferred with complementary chemical information. Our integrated nano-to-microscale analytical approach unveiled previously invisible microbial and mineral interactions, complementing and filling a gap of resolution of conventional methods. Ultimately, this study contributes to the challenge of deciphering the faint chemical and morphological biosignatures that point to life's presence - both on early Earth and distant worlds

Références

[1] Fernández Remolar D, Carrizo D, Harir M, Huang T, Amils R, Schmitt-Kopplin P, et al. Unveiling microbial preservation under hyperacidic and oxidizing conditions in the Oligocene Rio Tinto deposit. Sci Rep 2021;11(1):1–23.

[2] Fernández Remolar D, Knoll AH. Fossilization potential of iron-bearing minerals in acidic environments of Rio Tinto, Spain: Implications for Mars exploration. Icarus. 2008;194(1):72–85.

[3] Holler M, Odstrcil M, Guizar-Sicairos M, Lebugle M, Müller E, Finizio S, et al. Three-dimensional imaging of integrated circuits with macro- to nanoscale zoom. Nat Electron [Internet]. 2019;2(10):464–70.

[4] Lemelle L, Simionovici AS, Schoonjans T, Tucoulou R, Enrico E, Salomé M, et al. Analytical requirements for quantitative X-ray fluorescence nano-imaging of metal traces in solid samples. TrAC - Trends Anal Chem. 2017;91:104–11.