Fully funded PhD at the Laboratoire Magmas et Volcans
(University of Clermont Auvergne, France)

PhD title: Decoding Archean oxygenation through the stromatolite record

Supervision: Nicolas Olivier (LMV, UCA, supervisor), Johanna Marin-Carbonne (UNIL, Switzerland, co-supervisor), Marion Garçon (LMV, UCA, co-supervisor)

We offer a fully funded PhD opportunity at the Laboratoire Magmas et Volcans (LMV) of University of Clermont Auvergne (UCA), France, in collaboration with the University of Lausanne (UNIL), Switzerland. This PhD is funded by the UCA's Graduate Track InVolc program. The successful candidate will conduct interdisciplinary research involving fieldwork, laboratory analyses, and geochemical techniques to explore Earth's biosphere and its interaction with early atmospheric oxygen.

The rise of molecular oxygen (O_2) in the Archean oceans and atmosphere is linked to oxygenic photosynthesis and the expansion of cyanobacteria. These microorganisms shaped Earth's geochemistry, creating local redox conditions that promoted biomineral precipitation. This process led to the formation of microbialites—organosedimentary structures formed by microbial activity and preserved as key evidence of early life. Stromatolites, a type of microbialite, preserve oxidation traces critical for understanding the early biosphere and Earth's oxygenation history. While geochemical evidence points towards "whiffs" of oxygen before the Great Oxygenation Event (GOE, 2.45–2.31 Ga), the timing and nature of this transition remain debated. Redox-sensitive elements and nitrogen isotopic compositions suggest that free oxygen existed in the oceans prior to the GOE. However, most data indicate that Archean stromatolites formed in an anoxic environment, making it challenging to determine redox conditions due to the low concentrations of redox-sensitive elements and post-depositional alterations.

This thesis will provide new insights into Archean ocean redox conditions through the study of stromatolites from the Malmani-Campbellrand carbonate platform (2.64–2.51 billion years old) in South Africa, which predates the GOE. The research will explore the impact of post-depositional alterations on primary geochemical signatures preserved in stromatolites, offering insights into early ocean redox states. The project will include field sedimentological analyses at different sites across the Malmani platform. Mineralogical composition will be assessed using Raman spectroscopy and SEM. Geochemical analyses will focus on sulfur (S) isotope compositions at both bulk and micrometric scales in sulfides and sulfates to track sulfur cycle evolution and identify metabolic signatures in stromatolites. In situ stable iron (Fe) isotopes will be analyzed to assess the redox state during stromatolite deposition. Cerium (Ce) isotopic compositions will be investigated as a proxy for paleo-redox conditions in Archean oceans. Stable and radiogenic Ce isotopes are expected to provide deeper insights into redox states, with recent studies suggesting that stable Ce isotopes offer more precise information than Ce anomalies alone. This work will utilize the La-Ce radiogenic system to ensure that the redox conditions recorded by stable Ce isotopes match the stromatolite ages.

Applicants should send a letter of motivation, CV, academic record and the names of 2 referees to Nicolas Olivier (nicolas.olivier@uca.fr), Marion Garçon (marion.garcon@uca.fr), and Johanna Marin-Carbonne (johanna.marincarbonne@unil.ch). Applications will be considered up until May 20, 2025. The PhD position is set to begin on October 1, 2025.