



PhD position: “Modeling the morphological evolution of mineral surface upon (bio)alteration: Implications for the concept of biosignatures” (M/F)

Location: ISTerre, Grenoble, France

PhD advisors: Damien Daval (ISTerre, Grenoble) and Philippe Ackerer (ITES, Strasbourg)

Contract duration: 36 months

Expected starting date: 1 September 2024

Gross salary: 2135 €, according to the CNRS salary scale

Funding: ERC Mobidic

Description

The Institute of Earth Sciences (ISTerre, UMR 5275) is looking for a creative, qualified and motivated individual to lead an interdisciplinary thesis project at the interface of Earth sciences, microbiology and physical chemistry.

Defining the imprints left by microorganisms on the surface of altered minerals upon bioalteration appears to be a prerequisite for the search of life in the geological record on Earth and beyond. Nowadays, the description of the changes in mineral surface morphology associated to microbially-mediated mineral dissolution is limited to the misleading concept of etching features resembling “in size, shape and distribution” to bacteria. In the present PhD project, we propose to revisit this concept by adopting an independent theoretical modeling perspective. Building upon our current numerical developments, we suggest simulating the morphological evolution of a mineral surface based on a stochastic approach whereby atom detachment is scaled to the probability of breaking the bonds that connect it to the surface. Distinct morphological patterns may be anticipated when biomolecules are involved. To test this hypothesis, the work will consist in (i) developing atomic-scale kinetic Monte Carlo codes to simulate the hydrolysis of various mineral structures; (ii) running sensitivity tests to explore the impact of various reactants; and (iii) defining invariant descriptors that can relate the outputs of the simulations to the input parameters. Comparisons with existing observations of mineral surfaces reacted experimentally will be eventually conducted to pave the way to the definition of biosignatures of mineral alteration with a theoretically-informed basis, of interest for astrobiology and/or the detection of life on Earth in extreme environments.

Working context

The work will be conducted in the framework of the ERC project Mobidic (2021-2026; see <https://cordis.europa.eu/project/id/101001275>).

The thesis will be jointly supervised by Damien Daval (ISTerre, Grenoble) and Philippe Ackerer (Institut Terre et Environnement de Strasbourg) and developed in collaboration with Karim Benzerara (Institut de Minéralogie, de Physique des Matériaux et de Cosmochimie (IMPMC), Paris). The thesis work will be carried out mainly within the Geochemistry team of

ISTerre in Grenoble, with regular stays envisaged in Strasbourg (several weeks / year), financially supported by the project.

ISTerre is a Unité Mixte de Recherche de l'Université Grenoble Alpes, CNRS, USMB, IRD and Université Gustave Eiffel, located 1381 rue de la Piscine 38400 Saint-Martin d'Hères and on the scientific campus of Bourget du Lac.

It is part of the Observatoire des Sciences de l'Univers de Grenoble (OSUG) and of Pôle de recherche PAGE of the University of Grenoble Alpes (UGA). It has a staff of about 300 people and an average annual budget of €7 million.

It is organized around 9 research teams and services, the scientific objective being the physical and chemical study of the planet Earth, particularly by focusing on the couplings between observations of natural objects, experimentation and modeling of the associated complex processes. ISTerre also provides solid Earth observation missions, hosts and maintains national parks of geophysical instruments, and a data center.

The selected student will enjoy a large degree of academic freedom, will lead numerical developments and collaborate on fluid-mineral-(microorganisms) experiments, will collaborate to the multi-scale characterization of altered mineral roughness through the use of vertical scanning interferometry, atomic force microscopy, and confocal microscopy.

Several regular stays at ITES, Strasbourg, will be financially supported by the project.

Additional information

Candidates must have a master degree and/or an engineering degree with knowledge in numerical methods (stochastic modeling, finite element method), statistics, and/or chemical kinetics and thermodynamics. Good oral and written communication skills in English are also required. Good computer skills (simulation and/or statistical software, office automation) are desirable.

Applications should include a CV and a cover letter, as well as the contact information of at least two referees in the academic field. They should be posted by responding to the relevant vacancy on <https://emploi.cnrs.fr/Offres.aspx>.

Applications will be considered until the position is filled. The desired start date for the thesis is the beginning of September 2024.