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Job title	**PhD - The role of cyanobacteria in carbonate precipitation**
Ref	**2019-01-CYANOBACTERIA**
Date de mise en ligne souhaitée	1 February 2019
Job type (PhD, Post-doc, Engineer)	PhD
Contract duration (months)	36 months
Qualifications (Master degree, PhD…)	Master's degree
Job hours (full time/ part time)	Full time
Employer	UBFC – Université de Franche-Comté
Host Laboratory	Biogéosciences
URL Host Laboratory	UMR 6282
Address Host Laboratory	6 bd Gabriel, 21000, Dijon
Job description	**Scientific context:** Microbially-induced mineralization (often called 'organomineralization') is the process of mineral formation during metabolic activity of living microorganisms. Organomineralization is a major structural and ecological player in the modern and in the past ecosystems and considered as one of the main natural processes controlling CO_2 concentrations in the atmosphere due to carbonate (bio)precipitation, which geological record is referred as microbialites. Several processes are associated with the buildup of microbialites including sediment trapping, binding, and/or *in situ* minerals precipitation, which can vary in space and time with the metabolic activity of the microorganisms and the properties of their exopolymeric substances. Microbialites are found throughout the geological record and considered important biosignatures of life during the early Earth history. The oldest examples of fossil microbialites in the geological record are about 3.5 billion years old. These carbonate buildups may also proof instrumental in the search for extraterrestrial life. Many microorganisms participate in organomineral formation: cyanobacteria, anoxygenic phototrophs, sulfate-reducing bacteria, methanogenic archaea and heterotrophic ureolitic bacteria. Among them, cyanobacteria are the dominant primary producers

abundant in modern microbial mats and thus) are key participants in formation of modern microbialites.

A large variety of mechanisms have been proposed to explain calcium carbonate ($CaCO_3$) – the main mineral component of microbialites – precipitation by bacteria. These mechanisms have been identified and reviewed by Dupraz et al. (2009). The current paradigm is that in microbial mats and microbialites, microbially-induced precipitation of minerals is the most important mechanism. Two factors play a role in this: the first is a change in alkalinity that results from the metabolic reactions of the entire microbial community (as outlined above, cyanobacteria play a predominant role in this). The potential to change the local alkalinity, either favoring precipitation or dissolution, is referred to as the alkalinity engine. Metabolisms change with the time of the day, and both light and dark conditions need to be studied. The second factor is the quantity and biochemical propriety of the exopolymeric substance (EPS) produced by microorganisms. Microbial cell surface and EPS, which carry a net negative electric charge and have the capacity to bind metal ions including Ca^{2+}, initially inhibiting precipitation. Upon alteration (including degradation) of EPS, Ca^{2+} is released and can precipitate as carbonate. Alternatively, the EPS-bound Ca can precipitate on the organic matrix. EPS properties are the result of its production and consumption and, consequently, change constantly. It should be noted that small organic acids – low molecular weight organic compounds (LMWOC; e.g., lactate, acetate) – play a similar role as what is outlined above for EPS. As an example of this process, Dupraz et al. (2004) observed calcium carbonate precipitation on EPS by cyanobacteria.

In sum, the precipitation and growth of organominerals is a complex process that is controlled by three main factors: (1) environmental physicochemical conditions; (2) metabolic activity of microorganisms inducing local geochemical changes; (3) production and consumption of extracellular organic matter (including LMWOC and EPS) by bacteria. The interaction of these three factors is critical for organomineralization processes.

Thesis description:

The objective of this thesis is characterizing and understanding the role of organic matter (EPS and LMWOC) produced by cyanobacteria during carbonate precipitation. For that, cyanobacterial strains with different morphology, growth rate and quantity and quality of EPS production will be investigated.

We propose using a several strains of cyanobacteria with both coccoid and filamentous morphologies. In order to test various biochemical and geochemical analytical methods, we will start by using two well-studied strains of cyanobacteria, *Synechococcus* sp. and *Synechocystis* sp.. In the next phase of the thesis research, other strains of cyanobacteria isolated from the natural environment (i.e., microbial mats and microbialites) will be studied in the context of carbonate precipitation.

Initially, for comparison, the conditions during precipitation experiments will be strictly identical. Any differences between the experiments (kinetic of precipitation, morphology and mineralogy of precipitate, spatial distribution of precipitated crystals) will be strongly related to the quantity and composition of produced EPS, morphology or grows condition of different cyanobacteria strains. Furthermore, properties of EPS and carbonate minerals isolated from the natural environment will be compared with the laboratory observations.

The thesis is structured around seven approaches:

1. Isolation and cultivation of cyanobacteria;
2. Fieldwork on microbial mats and microbialites;

	3. Experiments of carbonate precipitation in flow cells using cyanobacterial cultures; 4. Biochemical and geochemical characterization of EPS and LMWOC (including metal binding potential, sugar content, functional groups, molecular masse distribution) to determine the potential roles in CaCO3 precipitation; 5. Investigation of the effect of culture conditions (e.g., light regime, nutrients) on EPS and LMWOC quality and quantity and assessment of the carbonate precipitation potential; 6. Microscopic and spectroscopic analyses of the precipitate and the cyanobacterial biofilm properties (composition, metagenomic, mineralogy, morphology); 7. Comparison of carbonate morphology and mineralogy in laboratory experiments and in natural system (continental and/or marine environments). The results will be used to relate the specific cyanobacterial morphology and the properties of cyanobacterial EPS to calcium carbonate precipitation and to create conceptual models describing mechanisms of organomineralization in modern and ancient microbialites systems.
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Candidate profile	*Scientific competencies:* The potential candidate should have experience in: • Microbiological techniques: isolation and cultivation of microbes, preferentially cyanobacteria, work using sterile conditions; • Chemical, biochemical, geochemical analysis specifically as these relate to microbial metabolisms and extracellular organic molecules; • Microscopy and spectroscopy: microscopy (light required; SEM, CSLM, AF desirable) and spectroscopy (UV/VIS, required; NMR, FT-IR spectroscopy, and/or XRF spectrometry desirable). Extensive experience in the laboratory work is prerequisite. Experience in fieldwork is preferred. A fundamental understanding in geology (i.e., mineralogy, stratigraphy, geochemistry) is required. Specific experience in research of bio- and organomineralization is welcome. *Linguistic competencies:* Excellent written and oral command of English is required Command of French is a desired skill
Keywords	Geomicrobiology, organomineralization, cyanobacteria, carbonate precipitation, organic matter (EPS), microscopic and spectroscopic analyses.
Application deadline	1 April, 2019
Starting Job	1 September, 2019

Application *Depending on the type of position*	**PhD Position** Please send the following documents (all in one PDF file) by e-mail to job-application@ubfc.fr: 1) For EU candidates: Copy of your national ID card or of your passport page where your photo is printed. For non-EU candidates: Copy of your passport page where your photo is printed. 2) Curriculum Vitae (1 page). 3) Letter of motivation relatively to the position (1 page). 4) Copy of your Master degree and/or Engineer degree if already available. 5) Copy of your final marks and ranks. 6) Coordinates of reference persons (maximum 3, at least your master thesis supervisor): Title, Name, organization, e-mail. If you have questions regarding the application, please contact the supervisors.