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Population structure of magnetotactic bacteria forming intracellular polyphosphates in the water column of Lake Pavin, a freshwater ferruginous environment

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Phosphorus (P) is essential to life but a limiting nutrient in many ecosystems. Understanding the role of microorganisms in P cycling, especially the processes of P uptake and storage, is a major environmental issue. Only few models with a high capability to sequester P are known, mostly in marine environments. We thus need to improve our knowledge about other model of sequestration and especially in freshwater environments.

Freshwater magnetotactic bacteria (MTB) affiliated to the *Magnetococcaceae* family have been identified within the water column of Lake Pavin in France [3]. Similarly, to the marine sulfoxidizers *Thiomargarita* and *Beggiatoa* [1, 2], they accumulate intracellular polyphosphates (PolyP) to a uniquely high extent, up to 90% of their cell volume. However, the MTB cocci inhabiting the water column of Lake Pavin harbor the specific capability to store P as PolyP below the oxygen detection limit ($pO_2 < 0.1\%$). Preliminary results tend to indicate that these MTB cocci represent the major population of MTB located right under the oxic-anoxic interface, in a zone of strong chemical and redox gradients. These gradients allow the study of the impacts of varying chemical conditions on the structuration of MTB populations and on the PolyP sequestration capability of MTB cocci.

We combined a variety of methods to identify the different MTB populations as a function of the water column depth and characterize their potential biogeochemical niches.

We used a new sampling system, an online pumping system, that allowed us to reach a better spatial (vertical) resolution [4], down to 20 cm. This sampling system was coupled to the measure of the physicochemical parameters of the water column (e.g. pO_2, pH, redox, conductivity, FDOM, turbidity). We were therefore able to better estimate the impact of the chemical parameters on the MTB. We then sampled the water to measure the geochemical parameters using ICP-OES and to characterize MTB via optical and electron microscopy. Optical microscopy permitted the identification of the main populations of MTB and their concentrations, while electron microscopy allowed the characterization of the different magnetosome organisation and PolyP accumulation capability. We evidenced the stratification of the two main populations of MTB sequestrating two distinct sets of elements (PolyP and counterions, or amorphous calcium carbonates, respectively) and inhabiting different niches whose specific geochemical parameters were identifies using multivariate statistics.

Different environmental conditions, such as the concentration of dissolved sulfate, are correlated to the MTB cocci abundance. Moreover, the proportion of MTB cocci accumulating PolyP is negatively correlated to the concentration of dissolved sulfur. These results bring into light the potential link between the sulfur metabolism of these bacteria and their capability to sequestrate P as PolyP. Moreover, our reccurent observations of intracellular sulfur granules suggest that this new bacterial model for P sequestration below the oxygen detection limit are sulfoxidizers,

Genomic analyses will be done in the future to allow further comprehension on molecular mecanisms and PolyP formation.

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