Structural and chemical controls for biomineralization in bacterial biofilm observed in situ in Liquid-Cell Scanning Transmission Electron Microscopy

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Bacterial cells, mostly in the form of biofilm, are largely widespread in soils (up to 10^9 cells per gram of soil) and can be very reactive with their environment. Indeed, the mineral phases created by biomineralization in the biofilm can be highly reactive with environmental pollutants.
However, although in literature, many studies on microbial biomineralization exist, only few of them consider the specific properties of biofilms fine structure. As a result, numerous questions regarding mineralization processes in these structures remain open.
For instance, the chromium mining site of Sukinda Valley, India, generates annually a highly toxic Cr(VI) flux. Given the difficulty for oxidizing Cr(III) originally present in ore, the occurrence of bacteria identified on this site is likely to control the Cr(VI) toxic release, by promoting Mn(II) oxidation into MnO_2, a highly oxidant mineral, able in turn to oxidize Cr(III) into Cr(VI). However, given the biofilms complex nature, the dynamics of Cr(VI) release from these metal-rich systems remain poorly understood.
We propose here to test two hypotheses to better define the Mn and Cr mineralization mechanisms in biofilms: i) biomineralization is strongly impacted by the extracellular polymers types and 3D organization, ii) biomineralization is dependent on the presence of nucleation sites and not only on local oversaturation in microenvironments.
In order to study mineralization in these biofilms, several approaches are used, including Confocal Laser Scanning Microscopy, Scanning Electron Microscopy, Liquid-Cell Scanning Transmission Electron Microscopy (LC-STEM) and Synchrotron techniques.
Here we will present you results obtained thanks to LC-STEM technique. We were able to image in vivo bacteria in a medium containing manganese in STEM and to determine how and where the biomineralization of manganese occurs depending on the type of Extracellular Polymeric Substances secreted by the bacteria and constituting the biofilm. This way, we can begin to understand the impact of the structure of biofilms on biomineralization.