Abstracts for the Distinguished Lecture Program of the European Association of Geochemistry

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Abstract 1

Iron biomineralization by neutrophilic anaerobic Fe-oxidizing bacteria: a nanoscale perspective

Iron-oxidizing bacteria can induce the formation of iron minerals by their metabolic activity and by forming nucleation surfaces. This process has diverse implications such as the trapping of inorganic pollutants in soils and rivers or possibly the formation of huge sedimentary iron deposits the Precambrian Earth called Banded Iron formations. The first discovery of bacteria able to oxidize Fe(II) under anoxic and neutrophilic conditions was made only less than 20 years ago. Hence, much remains to be understood on detailed Fe-biomineralization processes. For example among Fe-oxidizing bacteria that can be cultured, some localize mineral precipitation outside the cells while others get encrusted by Fe-mineral formation and we do not know what makes the difference between these strains. Here, I will present results from a combined use of cryo-transmission electron microscopy and synchrotron-based x-ray spectromicroscopy on laboratory cultures of diverse Fe-oxidizing bacteria. With such analyses, it is possible to follow the evolution of Fe redox in these cultures, detect Fe redox heterogeneities at the ~40 nm scale, as well as characterize and image organic molecules associated with these minerals. As a result, it allows to uniquely discussing Fe-oxidation processes mediated by bacteria.

Abstract 2

Combination of transmission electron microscopy and synchrotron-based x-ray microscopy for the study of geomicrobiological samples.

Geomicrobiology studies interactions between microorganisms and minerals. Working at the nanoscale on such systems is not just a methodological challenge and the use of new fancy tools. Here, I will show how we can combine Scanning Transmission X-ray Microscopy (STXM) and Transmission Electron Microscopy (TEM) to perform high spatial and energy resolution near-edge x-ray absorption fine structure (NEXAFS) and high resolution imaging on diverse samples of geomicrobiological interest. I will consider diverse samples including naturally and experimentally biomineralized bacteria, and bioweathered silicates. Spectroscopy was performed at the C K-edge, Al K-edge, Ca L2,3-edge, Fe L3-edge, and N K-edge offering the possibility to characterize diverse biochemical compounds, unique bacterial spectroscopic signatures, and iron oxidation state at microorganism-mineral interfaces. Combination of TEM and STXM provides remarkably clear chemical state-specific images of fossilized microorganisms and microorganism-mineral interfaces at the nanometer scale. This allows finding yet unreported chemical and mineralogical

heterogeneities at the submicrometer-scale in ancient and recent rocks, and also reveals in experimental samples a more complex picture of a given process than that observed at a rougher scale. By reviewing studies performed on Archean stromatolites, modern Fe-oxidizing bacteria, fossils preserved in metamorphic rocks or pathological calcifications, I will show how the methodology presented here should be helpful in assessing the importance of microorganisms in the evolution of Earth's surface chemistry and in identifying them in early Earth and planetary materials

Abstract 3

Biomineralogical study of stromatolites at the nanoscale

Stromatolites are layered sedimentary structures initiated from a limited surface and forming a variety of morphologies. They are often composed of calcium carbonates and found throughout the geological record back to 3.5 Ga. While they have often been considered as one of the oldest traces of life on Earth, the relative impact of abiotic and biological processes involved in the formation of modern stromatolites is yet poorly known. We believe that a detailed study of mineralogical processes occurring in modern stromatolites would dramatically improve our understanding of ancient samples. In this talk, I will present some of our recent work on Archean stromatolites (from the Tumbiana Formation, Australia, 2.7 Gyr) and modern stromatolites from hyperalkaline lakes. I will discuss the origin of laminations in lake stromatolites; I will show how the combination of microscopy and spectroscopy techniques, including transmission electron microscopy and synchrotron-based x-ray microscopy allow evidencing diverse pools of organic matter in modern and ancient stromatolites. Finally, I will show a preliminary study of the crystallographic texture of minerals in modern stromatolites. Alltogether, this information will help discussing existing models for the formation of stromatolites and the way we interpret the geological record.