

Microbial Alteration of Mineral Substrates
Experimental and Fossil Microbe-Mineral Surface Interactions

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Extended Abstract

The thesis comprises five principle research chapters presented as articles (chapters 2-6) detailing both experimental and field studies on microbial interaction with mineral surfaces. Chapters 2, 3, 4 are articles that detail the results and conclusions of the experimental work on fungal behavior and involvement in mineral alteration and “diagenesis” of natural mineral substrates. Chapter 5 presents a special field study case on permineralized fossil bacterial forms that were found associated closely with Banded Iron Formations (BIF), and because of its significance within the topic of the work it is presented as a chapter and as an article in press. Chapter 6 presents a case study on probable fossil fungal interaction and digenesis of Neoproterozoic stromatolitic carbonates as an example of ancient fungal interactions and their products. Each chapter has its abstract and introduction as well its final conclusions.

Chapter 2. Reports on the results and conclusions of experimental study involving interaction of fungi with natural carbonates (dolomites and limestones thin-sections) and seawater substrates that emphasized the biomineralization of Ca and magnesium oxalates produced through the free, unselective and un-controlled in vitro fungal growth that could develop on any suitable surfaces and causes important mineralogical, petrographic alterations of the substrates. The identity of biomineralized authigenic minerals was detailed through Raman and XRD techniques, and their crystal morphology, their relationship with both the substrates and fungal hyphae were described. The findings also described the substrate alteration in terms of petrography and mineralogy. This chapter represents a preliminary study into the fungal interaction with mineral substrates.

Chapter 3. Here, the study continues to experiment with carbonate substrates. It involves more rigorous and detailed study of the inherent results on the alteration of carbonate substrates brought about by interacting fungi. Hence, the chapter gives a geological “diagenetic” view and evaluation of the substrate alteration resulting from the interaction. The chapter establishes by matter of morphology and sedimentological-petrographic resemblance that those “micro-alterations” are in fact of diagenetic character. For this reason, several alterations of the substrates are described with sedimentological terminology such as: micritization, cementation, replacement, open-space filling, grain-grain-bridging and zonation structures.

Chapter 4. In this chapter we investigated through experimental study the specific in vitro patterns of fungi-mineral surface interactions in response to different mineral chemistry, topography and geometry and their associated bio-diagenetic products, and focusing on their modes of colonization, degradation and bioleaching. For this purpose minerals such as manganite, bauxite, malachite, chromite, plagioclase, biotite and muscovite were used. The results were presented in terms of tunneling, bioleaching and bioweathering. But, the most significant results were found by investigating the colonization patterns, which suggest that certain fungi are able to recognize thigmotropically mineral geometry and topography, which also put in evidence maybe for the first time, a possible “Metalophagus” behavior by fungi towards solid minerals.

Chapter 5. This is a special case study of microbial-mineral surface interaction. The objectives of this chapter were to study and demonstrate through FE-SEM, SEM-EDX and FE-AES imaging and analysis that possible ancient forms of Dissimilatory Iron Reducing Bacteria (DIRB), found on specular hematite from BIFs selectively adhered to the mineral surfaces in what appears to be crystallographically-oriented coccoidal and chain growth patterns that appear to display appendages similar to microbial nanowires. These forms are also well preserved in magnetite, further suggesting the possibility that previously active Fe(III)-reducing bacteria were fossilized as a consequence of their chemoheterotrophic activity.

Chapter 6. We presented here a field study of the Neoproterozoic of South Gabon that revealed numerous permineralized fungal relicts: sporangia, sporangiophores, columellae, zygosporangia, suspensors, dichotomous hyphae and spores in the upper part of shallowing-upward evaporitic peritidal sequences. The chapter provides a detailed evaluation of the fungal role in an attempt to understand the mechanisms involved in the paleoweathering/diagenesis of a Neoproterozoic carbonate substrate. Our observations compared to *in vitro* experiments allow definition of an eogenetic sequence driven by fungal invasion and colonization of a Neoproterozoic substrate.

Chapter 7. Summarizes the perspectives of future research work, and global conclusions.