

Pyrite formation in pure cultures of sulfate-reducing bacteria

A. DUVERGER^{1,2}, J. MIOT¹, V. BUSIGNY²

¹Institut de Minéralogie, Physique des Matériaux et Cosmochimie, Sorbonne Université, Muséum National d'Histoire Naturelle, CNRS UMR 7590, IRD 206, Paris, France (arnaud.duverger@mnhn.fr, jmiot@mnhn.fr)

²Laboratoire de Géochimie des Isotopes Stables, Institut de Physique du Globe de Paris, Sorbonne Paris Cité, Université Paris Diderot, UMR CNRS 7154, Paris, France (busigny@ipgp.fr)

Pyrite (FeS₂) is the most abundant metal sulfide at Earth's surface and is ubiquitous in modern and ancient sediments. As sulfide production is mainly driven by sulfate-reducing microorganisms, it is assumed that pyrite found in the past sediment record is biogenic and could be used as a biosignature. However, most of the studies of sulfate-reducing bacteria in pure cultures report the formation of metastable iron sulfides such as mackinawite (FeS) or greigite (Fe₃S₄), instead of pyrite. Hence, we lack an understanding of the role played by sulfate-reducing bacteria in sedimentary pyrite formation.

Here, we present results from pure cultures of *Desulfovibrio desulfuricans* in the presence of different sources of iron (dissolved Fe²⁺ or amorphous Fe^{III}-phosphate nanoparticles). We monitored iron and sulfur speciation, as well as phosphate and organic acid concentrations over one month. Moreover, we characterized the minerals produced in the cultures down to the atomic scale, using a multi-analytical approach including X-ray diffraction, Fe K-edge X-ray Absorption Spectroscopy, Scanning and Transmission Electron Microscopy and Scanning Transmission X-ray Microscopy at C K-edge and Fe L_{2,3}-edges.

As reported in the literature, a rapid precipitation of amorphous iron sulfide occurred in the cultures. But noteworthy, biogenic sulfide reduced Fe^{III}-phosphate leading to the formation of vivianite (Fe^{II}₃(PO₄)₂·8H₂O) in addition to iron sulfides. We identified conditions upon which amorphous FeS evolved into well-crystallized mackinawite then greigite and finally pyrite. We will discuss the mechanisms of pyrite formation and implications for the search of biosignatures.