ARPHA Conference Abstracts 6: e106753
doi: 10.3897/aca.6.e106753

Conference Abstract

Microbial pyrite formation: mineral morphology and precipitation kinetics

Muammar Mansor[‡], Hrvoje Višić[‡], Eric Runge[§], Jeremiah Shuster[‡], Stefan Fischer[‡], Andreas Kappler[‡], Jan-Peter Duda[§]

‡ University of Tuebingen, Tuebingen, Germany
§ University of Göttingen, Göttingen, Germany

Corresponding author: Muammar Mansor (muammar.muammar-bin-mansor@uni-tuebingen.de)

Received: 22 May 2023 | Published: 12 Oct 2023

Citation: Mansor M, Višić H, Runge E, Shuster J, Fischer S, Kappler A, Duda J-P (2023) Microbial pyrite formation: mineral morphology and precipitation kinetics. ARPHA Conference Abstracts 6: e106753. https://doi.org/10.3897/aca.6.e106753

Abstract

Pyrite (FeS_2) is a mineral of wide interest due to its importance in the biogeochemical cycling of Fe and S, which is tied to those of carbon and other trace metals and nutrients. The mineral itself has potential applications as biosignatures, for environmental remediation and as semiconductors. Despite being a common authigenic mineral in sedimentary environments, most laboratory-based experiments have failed to form pyrite in microbial cultures at ambient temperatures. To fill this knowledge gap, we have employed cultivation-based approaches, using different combinations of microorganisms (Fe(III)- and S^0-reducers; S^0-disproportionaters) and initial Fe and S sources to identify the conditions that are optimal for pyrite formation. Scanning electron microscopy (SEM), Raman spectroscopy and X-ray diffraction (XRD) demonstrate that pyrite is not formed within ~3 years at circumneutral pH when oxidants (e.g., Fe(III) minerals, elemental sulfur, S^0) are exhausted. In contrast, pyrite is formed within months when S^0 and Fe(III) minerals are both present. The precipitation timescale is consistent with those expected in sedimentary environments Mansor and Fantle 2019), albeit some natural pyrite framboids are expected to form even faster Rickard 2019). The pyrite crystals formed in our experiments are in the low micrometer range, with either a spherical or euhedral morphology depending on the initial crystallinity of the supplied Fe(III) minerals. Framboids are not formed in our system, perhaps due to the relatively slow precipitation kinetics. Time-based sampling indicates mackinawite (FeS) as the first product, with rare (and minor) detection of greigite (Fe_3S_4) and vivianite [$Fe_3(PO_4)_2.8H_2O$]. We hypothesize that pyrite formation and growth proceed mainly from transformation of precursor minerals, with potential contributions via dissolution-precipitation and/or particle attachment pathways. Our preliminary study is the first step in optimizing a system for microbial pyrite formation, with the intention of investigating the properties and the reactivity of the mineral with implications for biosignatures, environmental remediation and industrial applications.

Keywords

pyrite, Fe(III) minerals, elemental sulfur, scanning electron microscopy, Raman, biosignatures

Presenting author

Muammar Mansor

Presented at

ISEB-ISSM 2023

Conflicts of interest

The authors have declared that no competing interests exist.

References

- Mansor M, Fantle M (2019) A novel framework for interpreting pyrite-based Fe isotope records of the past. Geochimica et Cosmochimica Acta 253: 39-62. https://doi.org/10.1016/j.gca.2019.03.017
- Rickard D (2019) How long does it take a pyrite framboid to form? Earth and Planetary Science Letters 513: 64-68. https://doi.org/10.1016/j.epsl.2019.02.019