Biogeochemical fingerprints in biogenic magnetite nanoparticles

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It has recently been suggested that bacteria played a vital role in the deposition of the oldest banded iron formations (BIFs) [1]. Magnetite ($Fe(II)Fe(III)_2O_4$), a common constituent of these ancient marine sedimentary rock formations, is biomineralized through the activity of iron-metabolizing bacteria (i.e. Fe(II)-oxidizers and Fe(III)-reducers), and magnetotactic bacteria. However, magnetite can also be precipitated abiotically.

The ability to distinguish between these types of biotically- and inorganically-formed magnetite remains highly challenging, especially for fossilized material subjected to diagenetic alteration over billions of years. Yet, the ability to recognize these differences is key to intrepreting these earliest signs of life on Earth and and to better constrain the identity of the relevant biogeochemical processes involved in magnetite formation.

A recent study by Amor et al. [2] demonstrated that magnetite, produced by magnetotactic bacteria, is 100-fold purer compared to inorganically precipitated magnetite. The Sr/Ca ratio is proposed as an especially promising biosignature. Nonetheless, unambigious biosignatures remain to be identified for magnetite from Fe(III)-reducing bacteria. The latter produce a thousand-fold more magnetite compared to magnetotatctic bacteria by mass, hence, they are likely to have played the dominant role in biogenic magnetite precipitation during the Archean.

Here, we investigate biogeochemical fingerprints within biogenic magnetite nanoparticles (biomagnetite) produced by dissimilatory Fe(III) reduction of ferrihydrite by *Shewanella oneidensis* MR-1. The specific pattern of trace element incorporation into biomagnetite is compared with abiotic magnetite, along with a detailed morphological and physical properties characterization of the magnetite nanocrystals. Our results contribute to the scarce fingerprint repertoir for unambigious biomagnetite indentification in ancient environments.

[1] Dodd et al. (2017) Nature 543, 60 - 64.

[2] Amor et al. (2015) PNAS 112, 1699 - 1703.