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From Magnetotactic Bacteria to Magnetofossils: an experimental approach.

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Magnetofossils are the fossil remains of Magnetotactic Bacteria (MTB) and they are of considerable interest as magnetic proxy to infer environmental conditions and the microbial evolution throughout the Earth's history. MTB are widespread in lacustrine and marine deposits, where they generally live in the oxic-anoxic transition zone.

MTB synthesize intracellular chains of nearly uniform, ferrimagnetic particles that generally consist of magnetite (Fe_3O_4). These magnetite chains generate a magnetic dipole, which is large enough to interact with the Earth's magnetic field and can, therefore, be used as compass by the MTB to find their favorable habitats. The chain configuration stabilized by an organic filament structure is the unambiguous trait of MTB.

The unambigeous detection of MTB in geological systems is difficult, as with the decay of celluar matter the magnetite chains fall apart and the single particles lose then their organic sheaths. Thus far little is known about the fate of the magnetite particles during the celular decay and the formation of magnetofossils

In an experimental study we analyzed the thermally-induced decay of magnetite chains of cultured *Magnetospirillum gryphiswaldense* by means of ferromagnetic resonnance (FMR) spectroscopy in order to simulate the MTB fossilization. FMR spectroscopy is a powerful tool to detect anisotropy properties of ferrimagnetic particles and their arrangement. The anisotropy parameter A and the effective splitting factor g_{eff} are key spectral parameters to distinguish isolated magnetite particles from those arranged in chains. Intact MTB yield highly anisotropic FMR spectra with generally A-values markedly below 1 and g_{eff} less than 2.

At room temperature the spectral parameters for *M. gryphiswaldense* are A =0.3 and g_{eff} = 1.91. Upon heating up to 300 ˚C we observe a gradual change of the anisotropic to a nearly isotropic spectrum as indicated by an increase in A from 0.3 to 0.9 and $g_{eff} > 2$. This indicates the breakdown of the magnetic chain arrangement due to the decomposition of cellular matter.

With further heating a sharp signal with $g = 2$ evolves that can be attributed to a radical stemmed from decomposed organic matter. While the radical becomes more pronounced the magnetic signal weakens. After the heat treatment the FMR spectrum at room temperature consists of the radical, only. The disappearance of the FMR signal is most likely due to the oxidation of magnetite by organic matter and the formation of an antiferromagnetic Fe-phase most likely hematite.

In summary, the thermal decomposition of the cellular matter stabilizing the magnetite chains is a progressive process that is completed at a temperature of about 300 ˚C. Further heat treatment leads to the reaction of the organic matter with the magnetite particles and the formation of antiferromagnetic hematite.