# STRUCTURE, COMPOSITION, AND MAGNETIC PROPERTIES OF MINERALS IN MAGNETOTACTIC BACTERIA

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Magnetotactic bacteria form chains of nanometer-scale, magnetic iron oxides or sulfides (magnetite and greigite, respectively) inside their cells. The bacterium uses the chains of magnetic minerals as an internal compass for orienting itself in its aquatic environment, following geomagnetic field lines in order to reach an optimal position in a chemically non-uniform medium (water or sediment) (BAZYLINSKI & MOSKOWITZ, 1997). In order to assess the impact of magnetotactic bacteria on sediment and rock magnetism, it is necessary to characterize mineral species within contemporary bacteria and to compare them with magnetic minerals in geological specimens. Since magnetotactic bacteria produce single-domain magnetic crystals that have specific morphologies and sizes, such crystals could have practical applications in fields such as medicine or magnetic recording; it is thus important to obtain a better knowledge of biological control over crystal growth. Nanometer-scale magnetite crystals from the geological environment have also been interpreted as "magnetofossils" signatures of former life. The most notable among the reports of biogenic magnetite are studies that claim to have identified relics of former life on Mars in the form of "prismatic" magnetite crystals in Martian meteorite ALH84001 (MCKAY *et al.*, 1996). However, it is difficult to distinguish with confidence the biogenic or inorganic origins of these minerals. A knowledge of the magnetic microstructures of biogenic iron minerals is also important for a better understanding of their paleomagnetic contributions.

We studied the sizes, morphologies, microstructures and compositions of magnetite from several morphological types of magnetotactic bacteria, from both cultured and "wild" strains, collected from lakes and streams in Hungary. The widespread occurrence of magnetotactic species indicates that they are significant contributors to the magnetic mineral content of freshwater sediments. We also studied iron sulfides from a marine organism that was earlier described as a "multicellular magnetotactic prokaryote" (MMP) (DELONG *et al.*, 1996). Our goals were to better understand the process of biologically-controlled mineralization of iron oxides and sulfides, and to define criteria that could be used to distinguish bacterial from inorganically formed minerals in geological specimens.

Our transmission electron microscope (TEM) observations showed that ferrimagnetic greigite in magnetotactic bacteria forms from nonmagnetic mackinawite (tetragonal FeS) and possibly cubic FeS. Greigite crystals typically contain defects and show uneven, blotchy contrast in TEM images. In contrast, we found no precursor mineral for magnetite from magnetotactic bacteria. We also used electron holography in the TEM to study magnetic domain structures, magnetocrystalline and shape anisotropies, and magnetostatic interactions between oriented, nano-scale magnetic particles.

Crystal size distributions (CSDs) convey information about the growth histories of crystal populations (EBERL *et al.*, 1998). We found that magnetite from magnetotactic bacteria typically produces asymmetric, negatively-skewed CSDs, whereas greigite from the MMP has a Gaussian CSD. Since inorganically-formed crystals commonly have lognormal distributions, the statistical analysis of crystal sizes provides a tool for identifying biogenic iron minerals in both terrestrial and extraterrestrial geological specimens.

**References**

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