Bullet-shaped magnetosomes: Magnetic properties and possible routes of biomineralization

PÓSFAI, M.[1], KOVÁCS, A.[2], LEFÈVRE, C. T.[3] AND DUNIN-BORKOWSKI, R. E.[2]

[1]Dept. of Earth and Environmental Sci., Univ. of Pannonia, Veszprém, Hungary; mihaly.posfai@gmail.com

[2]Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons and Peter Grünberg Institute, Forschungszentrum Jülich, Germany; a.kovacs@fz-juelich.de, rdb@fz-juelich.de

[3]CEA/CNRS/Aix/Marseille Université, Laboratoire de Bioénergétique Cellulaire, Saint Paul lez Durance, France; lefevrechristopher@hotmail.com

The morphologies of the magnetosomes produced by magnetotactic bacteria (MTB) show an intriguing correlation with the phylogenetic affiliation of their host strains. Magnetite magnetosomes with the most peculiar, bullet-like shapes occur in MTB that belong to the Deltaproteobacteria and Nitrospira. Since the biomineralization of crystals bound by high-energy surfaces requires additional energy, bullet-shaped magnetosomes should provide the cell with some evolutionary advantage. An increased efficiency of magnetotaxis would appear to be the most obvious benefit of having elongated magnetosomes. We used off-axis electron holography in the transmission electron microscope to study the magnetic properties of bullet-shaped magnetosomes from three bacterial strains that each produce magnetite particles with different crystallographic axes of elongation, including [100], [110] and [111]. Our results show that the magnetic induction is confined to be parallel to the elongation axis of each particle, irrespective of the crystallographic direction that is parallel to its elongation direction. On the other hand, in disordered chains where crystals occur side by side, with their long axes parallel to each other, magnetostatic interactions between adjacent particles result in some of the bullet-shaped magnetosomes being magnetized perpendicular to their directions of elongation. Thus, if the particles are in chains, then particle shape and elongation axis do not seem to matter much magnetically, since the magnetic interactions between the magnetosomes will determine the direction of the magnetic field. Therefore, the evolutionary driving force behind the development of bullet-shaped magnetosomes is probably something other than the optimization of magnetotaxis. While the nucleation and initial growth of bullet-shaped magnetosomes may be under genetic control, the further growth of their elongated, pointed sections might be determined by environmental factors.