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Size distributions of nanoparticles from magnetotactic bacteria as signatures of biologically controlled mineralization

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Abstract

This paper addresses the problem of magnetite nanoparticle size distributions in magnetotactic bacteria. The methods described in the paper can be used to determine the origin of natural magnetite nanoparticle samples. We analyzed 36 histograms related to bacterial, inorganic, and biomimetic nanoparticle sizes. Using statistical software we concluded that the size of the nanoparticles in cultured magnetotactic bacteria follows an extreme value distribution. Magnetite in uncultured samples can be treated as a two-component mixture containing extreme value and/or log-normally distributed nanoparticles. Analysis of the time-dependent formation of bacterial magnetite revealed that the magnetite size distribution transforms from the initial log-normal (young bacterial culture) through normal-like toward the extreme value distribution (evolved culture). It seems that at a certain moment during bacterial magnetite formation, the bacterial system starts to behave as a closed system. The closing of the system must be followed by another unknown process, because restriction of the nutrient supply into magnetosomes is insufficient for the generation of the extreme value distribution. Based on our analysis, approximately 50% of the magnetite particles in the martian meteorite ALH 84001 follow an extreme value distribution.

Keywords: Biomineralization, magnetite, magnetotactic bacteria, meteorite ALH 84001, extreme value