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Morphology of nanomagnetite crystals: Implications for formation conditions

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ABSTRACT

A series of controlled abiotic syntheses of magnetite nanocrystals were carried out to explore the possibility of using morphological criteria, crystal size distributions, and shape ratio as tools for identifying nanocrystals that would be specifically produced by magnetotactic bacteria. High-quality magnetite crystals synthesized with various controlled total iron concentrations were shown to have cubo-octahedral shapes and sizes varying from 4 to 24 nm. The mean particle size of the population was found to be 10.5 ± 0.7 nm and no significant effect of the total iron concentration on the particle size was observed. Systematical analyses of size and morphology also allowed for the determination of crystal size and shape ratio distributions. Crystal sizes were observed to follow log-normal distributions. Shape factors are bounded by one, with maxima between 0.80 to 1.00. Their distributions are asymmetric, with a cut off toward the high values. Crystal morphologies and shape factors appear not to be a powerful diagnostic tool for the differentiation of abiotic vs. biotic particles. However, crystal size distributions of abiotic crystals are significantly different from those of biotic populations. Indeed, opposite asymmetry of the size distributions from biogenic and non biogenic crystals was observed, with cut off toward larger sizes for biogenic nanocrystals and with cut off toward smaller sizes for abiogenic nanocrystals. This therefore constitutes a potential diagnostic tool for deciphering magnetite origin.