Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 152

Magnetite and Greigite from Magnetotactic Bacteria and from Sedimentary Rocks: Size Distributions and Microstructures

Balazs Arato (aratob@vehok.vein.hu)[1], **Krisztina Cziner** (czinerk@freemail.hu), **Mihaly Posfai** (posfaim@almos.vein.hu), **Emoke Marton**[3] & **Peter Marton**[4]

[1] Department of Earth and Environmental Sciences, University of Veszprem, Veszprem, POB 158, Hungary
[2] Paleomagnetic Laboratory, Eotvos Lorand Geophysical Institute, Budapest, Homonna u. 1., Hungary
[3] Department of Geophysics, Eotvos Lorand University, Budapest, Ludovika ter 1., Hungary

Magnetotactic bacteria produce intracellular ferrimagnetic minerals, magnetite and greigite. Strain- or species-specific morphologies and narrow size distributions are characteristic of such bacterial crystals. Since different growth mechanisms are known to produce distinct crystal size distributions (CSDs) (Eberl et al., 1998), studying the CSDs of magnetite and greigite from magnetotactic bacteria can shed light on the mechanism of biologically controlled crystal growth. A comparison of CSDs of crystals from sedimentary rocks with those of crystals from bacteria can be useful for identifying the biogenic or non-biogenic origin of magnetic minerals in rocks. We used analytical transmission electron microscopy (ATEM) to study both magnetite and greigite crystals from magnetotactic bacteria, and the CSDs of iron sulfides from Miocene rocks from the Pannonian basin.

Magnetite inclusions were studied in two magnetotactic species, a helicoid bacterium (designated MH-1) and a diplococcus (designated MDC-1) that were collected from Hungarian streams, rivers and ponds; these two morphological types seem to be widespread in the studied freshwater environments. The CSDs of magnetite crystals show distinct asymmetry with sharp cut-offs towards larger sizes, consistently with observations by Meldrum et al. (1993) and Devouard et al. (1998) on other magnetotactic species. The maxima of the CSDs occur between 55-70 and 80-90nm for MH-1 and MDC-1, respectively. The shapes of the CSDs match those model results of Eberl et al. (1998) that result from Ostwald ripening. A remarkable feature of both CSDs is that they have a small peak at 30-35nm. Since crystal agglomeration is known to produce multimodal CSDs (Eberl et al., 1998), it is possible that both agglomeration and Ostwald ripening played a role in shaping the CSDs of bacterial magnetite. Several crystals may nucleate within the same magnetosome vesicle; some agglomerate and produce twinned crystals. Then smaller nuclei dissolve and only one crystal will grow to the species-specific size.

We studied magnetite from the deeper layers of sediments in the same aquatic environments from which magnetite-bearing bacteria were obtained. However, we failed to find magnetite in chain configuration or with CSDs similar to those observed in bacteria. Magnetite occurs in some studied sediments but may be of detrital origin, indicating that the small bacterial crystals may not be preserved under reducing conditions that prevail in the sediments.

The CSD of greigite magnetosomes was studied in cells of a multicellular magnetotactic prokaryote (MMP) that were collected at Salt Pond, Woods Hole, MA and Sweet Springs Nature Preserve, Morro Bay, CA (as described in Pósfai et al., 1998). In contrast to bacterial magnetite, the CSD of greigite is almost perfectly symmetric, bell-shaped. The shape factor (elongation) distribution does not have a clear maximum, indicating that neither the shapes, nor the sizes of the crystals are controlled by the bacterium to the extent as is typical of bacterial magnetite.

Electron diffraction and ATEM results confirmed the presence of greigite in two rock samples that were selected because in these rocks greigite was found by bulk magnetic measurements to be the likely carrier of remanence. In a marl specimen from Laki, Poland, greigite crystals occur in clusters on the surfaces of clay minerals. They show uneven contrast in the TEM (which is a typical feature of bacterial greigite, Pósfai et al., 1998), and a CSD that is very similar to that obtained from crystals from the MMP. In contrast, the other marl specimen (from Mihalovce, Slovakia) contains large clusters of greigite and pyrite crystals that show a distinctly different, asymmetric CSD, with a "tail" extending to micron-sized crystals. Both the peak value (400nm) and the shape of the CSD is similar to those described from pyrite framboids (Wilkin et al., 1998). Based on the CSDs and typical TEM contrast features, it is likely that greigite in the Laki specimen formed intracellularly, whereas iron sulfides in the Mihalovce specimen are the products of biologically-induced mineralization.

Devouard B, Posfai M, Hua X, Bazylinski DA, Frankel RB & Buseck PR, *Amer. Mineral.*, **83**, 1387-1399, (1998).

Eberl DD, Drits VA & Srodon J, *Amer. J. Sci.*, **298**, 499-533, (1998).

Meldrum FC, Mann S, Heywood BR, Frankel RB & Bazylinski DA, *Proc. R. Soc. Lond. B*, **251**, 231-236, (1993).

Posfai M, Buseck PR, Bazylinski DA & Frankel RB, *Science*, **280**, 880-883, (1998).

Wilkin RT, Barnes HL & Brantley SL, *Geochim. Cosmochim. Acta*, **60**, 3897-3912, (1996).