Magnetite in bacteria: A FMR study

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Under controlled conditions, most of the known magnetotactic bacteria (MTB) precipitate intercellular magnetite crystals within membrane-bound organelles (magnetosomes). The magnetite crystals have an array of physical properties such as size and shape that fall within a narrow distribution. The magnetic properties of cultivated and wild magnetotactic bacteria have been studied in detail by classical rock magnetic methods. Recently ferromagnetic resonance (FMR) spectroscopy has been introduced as an additional tool to assess size and shape distribution in order to identify MTB. We used a pure culture of *Magnetospirillum gryphiswaldense* to analyse FMR effects of magnetite in MTB between 293 and 77K.

Under the TEM the MTB revealed chains of near-equidimensional magnetite crystals of about 50 nm in size which is characteristic for single-domain nanoparticles. For the FMR measurements the MTB were freeze-dried and fixed with paraffin in a glass tube.

At 293 K, the FMR measurement (ν = 9.5 GHz) revealed an asymmetric spectrum with a line width of 187mT and a g-value of 1.885 (Figure 1). Considering the magnetite in the MTB as a “chain of spheres” the absorption spectrum is dominated by shape anisotropy. No angular dependence of the spectrum was found, which indicates a random distribution of the magnetite chains in the sample. At 77K a different FMR signal with a line width of 198 mT and g = 2.24 was observed. This temperature is below the Verwey transition (Tv = 120 K) where magnetite undergoes a crystallographic transition from cubic to monoclinic symmetry. Based on literature data, it can be postulated that the FMR spectrum at 77K is dominated by magnetocrystalline anisotropy. Considering the spectral development with temperature, the change from a shape-dominated to a magnetocrystalline-dominated anisotropy in the MTB at T < 110 K can be postulated (Figure 1).

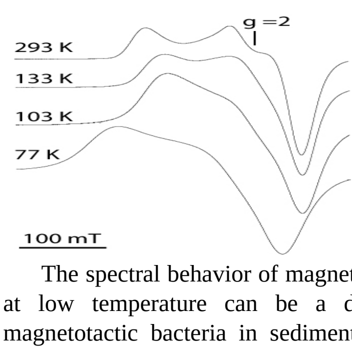

Figure 1: FMR spectra at 293, 133, 103, and 77K.

The spectral behavior of magnetite nanoparticles in chains at low temperature can be a diagnostic tool to detect magnetotactic bacteria in sediments and soils or magnetite arrays in geological environments indicative of bacterial origin.

Extreme oligotrophy in subsurface sediments of the South Pacific Gyre: Evidence from low oxygen fluxes

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To study subsurface microbial life at its energy limits, we investigated benthic microbial oxygen consumption as a key parameter for organic matter oxidation during an IODP site survey to the South Pacific Gyre in December 2006. The scientific goal of the expedition with the R/V Roger Revelle was to understand the nature of subseafloor sedimentary life in the most ultra-oligotrophic oceanic region on Earth. Here, primary production, particle fluxes and sedimentation are extraordinarily low. We investigated benthic microbial respiration rates by measuring oxygen concentrations in sediments on different spatial scales ex situ (in piston, gravity and multi- cores), and in situ (using a benthic lander equipped with an incubation chamber, a microelectrode profiler, and an optode profiler). Along a transect from 24° to 46°S and 165° to 117° W, cores at 10 of 11 sites were oxygenated for their entire lengths (as much as 8m below seafloor), at concentrations >150µM O_2. This represents the deepest oxygen penetration ever measured in marine sediments. All profiles showed a similar pattern of a rapid decrease in oxygen concentrations from ~220 µM to ~170µM within the first 50cm, which can be explained by oxidation of sedimented organic matter. In the deeper zones, only a very small gradient of ~6µM m-1 was present, indicating extremely low oxygen fluxes and consequently low respiration rates.

We conclude, that the South Pacific Gyre represents the most oxidized and energy-limited marine benthic habitat on earth, with respiration rates at least 3 orders of magnitude lower than previously analyzed marine sediments.