Bacterial magnetite

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Some kinds of microorganisms can synthesize intracellularly nano-sized and membrane-bound magnetic particles consisting of magnetite or greigite. They are magneto-sensitive and therefore called magnetic bacteria. Magnetic bacteria have morphological and habitat diversity. In contrast, because of its undefined metabolism, pure culture of magnetic bacteria has been hardly achieved. However, pure cultures of oxygen-tolerant or obligate anaerobic magnetic bacteria have brought to develop the gene transfer system and the metabolic investigation. Several finding and suggestive data on the formation of bacterial magnetite have been obtained through the studies using these magnetic isolates. Here, we report about the microbiological, geological aspects on the production of bacterial magnetite.

Introduction

Some kinds of microorganisms can synthesize intracellularly nano-sized and membrane-bound magnetic particles consisting of magnetite or greigite. These bacteria are magneto-sensitive and therefore called magnetic bacteria. Magnetic bacteria have morphological and habitat diversity. The cells with various morphologies such as coccoid, short or long rod, vibrioid and spirillum, have been found from sediments in diverse aquatic environments, e.g. marine, river, pond and estuary. In contrast, because of its undefined metabolism, pure culture of magnetic bacteria has been hardly achieved. However, successful isolations of oxygen-tolerant or obligate anaerobic magnetic bacteria in pure culture have brought to develop the gene transfer system and their metabolic and phylogenetic investigations. Several findings and suggestive data on the formation of bacterial magnetite have been obtained through the studies using these magnetic isolates. We report here about the microbiological and geological aspects with regard to the production of bacterial magnetite.

Oxygen-tolerant magnetic bacteria

Regarding suitable purpose of magnetotaxsis a hypothesis is set that magnetic bacteria use intracellular magnetite as a magnetic compass to know the direction of sediment suitable for their habitats because magnetic bacteria are microaerophiles. Ecological investigations on the relationship between swimming direction of magnetic bacteria and latitude on earth suggest to be supported this hypothesis by the existences of south-, north-, and both-directions-seeking magnetotactic bacteria on northern and southern hemispheres and equator respectively. Magnetotaxsis has been explained as an oxygen-evading (aerophobic) behavior. However, our isolated magnetic spirilla, Magnetospirillum spp. strains AMB-1 and MGT-1 are oxygen-tolerant magnetic bacteria capable of growing aerobically in free gaseous exchange with an air atmosphere. Additionally, they are facultative anaerobic denitrifier. In anaerobic respiration, nitrate serves as terminal electron acceptor. The bacterial magnetite was produced in anaerobic or microaerobic conditions. Although they did not synthesize intracellular magnetite crystals in aerobic conditions, approximately 10-50 fold amount of iron was accumulated into non-magnetic cells grown aerobically in comparing with that of Escherichia coli or marine alga. When non-magnetic cells were employed as inoculum in the anaerobic growth medium, the grown cells were magnetic and production of bacterial magnetite recovered. These results indicated that magnetotaxsis as an aerophobic behavior can not be conformed to our isolated magnetic spirilla.

Obligate anaerobic magnetic bacterium

RS-1 is a sulfate-reducing magnetic anaerobe isolated from sulfide-rich freshwater sediment. Recent phylogenetic analysis shows this bacterium is a new species of genus Desulfovibrio. The metabolism in anaerobic respiration is different from other purely cultured magnetic bacteria. This isolate illustrates the wider metabolic diversity of magnetic bacteria and suggests the presence of a novel mechanism of magnetite biomineralization. Single-domain-sized magnetite particles can be synthesized in the cells. RS-1 is also capable of exracellular precipitation of magnetic iron sulphides. This fact indicates that a single species of sulfate-reducing bacteria can contribute to iron biomineralization and sedimentary magnetization using oxygen (magnetite) as well as sulphur (iron sulphides). Additionally, RS-1 is capable of producing intracellular magnetite using ferrous iron in the anaerobic fermentation process. These results suggest that the presence of RS-1 can explain reasonings on the existences of past life on Mars suggestible in Martian meteorite ALH84001 and biological activity in deep-spheres such as oil stratum and deep marine sediments and that oxidation of ferrous iron plays an important role the formation of bacterial magnetite.