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Formation of single-domain magnetite by a thermophilic bacterium

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ABSTRACT

Magnetite is a common product of bacterial iron reduction and may serve as a potential physical indicator of biological activity in geological settings. Here we report the formation of single-domain magnetite under laboratory conditions by a thermophilic fermentative bacterial strain TOR-39 that was isolated from the deep subsurface. Time-course analyses were performed at 65 °C to study the effect of bacterial activity on solution chemistry and magnetite formation during the growth of TOR-39. Run products were examined by transmission electron microscopy. Magnetite particles formed exclusively outside of bacterial cells and exhibited octahedral shapes having relatively equal length and width ($<15\%$ difference). Tiny magnetite particles (<12 nm) nucleated between 10 and 11 h of incubation and increased to average lengths of 55.4 ± 26.8 nm after 24 h of incubation. Between 24 h and 22 d of incubation, magnetite particles maintained average lengths of 56.2 ± 24.8 nm. Based on size constraints, greater than 85% of the particles observed fell within the magnetic single domain. Little to no magnetite was detected in abiotic controls at 65 or 95 °C, or in TOR-39 cultures whose activity was suppressed. Unlike mesophilic iron-reducing bacteria (e.g., GS-15), TOR-39 produced crystals having shapes and sizes similar to some particles produced intracellularly by magnetotactic bacteria. Thus the single-domain magnetite produced by thermophiles such as TOR-39 may represent a heretofore unrecognized biological contribution to natural remanent magnetization in sedimentary basins and other geothermal environments.