Paleoenvironmental Implications of Archean Magnetotaxis

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Lin et al. [1] demonstrated recently that genes controlling magnetosome formation in magnetotactic bacteria (MTB) from *Nitrospirae* and *Proteobacteria* diverged most likely in mid-Archean time, well before the Great Oxygenation Event (GOE). The conserved magnetosome gene cluster, and their preserved ordering on the chromosmes, yield the same phylogeny as do the nucleic acids, making lateral gene trans-fer unlikely. This cluster controls rock-magnetic properties of the magnetosomes, implying natural selection specifically for magnetotaxis. That implies that the Archean magnetic field was ~ 6 μT or greater; in weaker fields the magnetostatic orientation energy falls below the background thermal energy and magnetotaxis is not favored evolutionarily. To the first order our genetic results on the MTB constrain the geodynamo to be active almost continuously since Archean time, with low-field gaps of no longer than ~ 100 Myr, a result that is independent, but consistent with, paleomagnetic constraints. Given the recent recognition that Earth's inner core nucleated rather late in Earth History, alternative mech-anisms for driving an uninterrupted geodynamo are needed.

As the MTB use the geomagnetic field to navigate across redox gradients in every environment in which they have been found, their presence before the GOE is telling us *something* about the Archean environment. We note that an Archean origin for magnetosome biomineralization and magnetotaxis is compatible with at least three possible microenvironments, ranging from a sub-glacial peroxide system, to the ferric-ferrous zone of Walker's "Inverted Biosphere", to protective measures against harmful UV radiation. Magnetotaxis would have allowed early MTB to survive the harsh conditions on the Archean Earth and may have allowed them to diversify and colonize extensive shallow-water environments long before the GOE. The evolution of MTB therefore provides an unusual biological constraint on the history of Earth's magnetic dynamo.

[1]. W. Lin, G.A. Paterson, Q. Zhu, Y. Wang, J. Kopylov, Y. Li, R. Knight, D.A. Bazylinski, R. Zhu, J.L. Kirschvink & Y. Pan, Origin of microbial biomineralization and magneto-taxis during the Archean, *In review*.