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New Evidence Strengthens Claims of Ancient Life on Mars
Study of Martian Meteorite Reveals Magnetic Fossils

Researchers have found magnetic material in a 4.5-billion-year-old Martian meteorite that could only have been produced by bacteria. This new data strongly supports the primitive life on Mars hypothesis of David McKay and co-authors in 1996.

"There are no known reports of any inorganic process that could produce such magnetites," said Kathie Thomas-Keprta, an astrobiologist at NASA's Johnson Space Center and the lead researcher on the study. The Martian magnetites are identical to those found in a bacteria strain on Earth called MV-1. "This group of magnetite deeply embedded in the Mars meteorite is so similar to the ones produced by the Earth bacteria that they cannot be told apart by any known measurement," said David McKay, a geologist at JSC and a co-author on the paper. "We considered that perhaps earth bacteria or earth magnetite had gotten into the Mars meteorite," McKay continued, "but extensive examination and testing by both our team and many other investigators eliminated that possibility."

Scientists generally agree that ALH84001 is a member of the group of 16 meteorites found on Earth that originated on Mars. The potato-sized igneous rock is the oldest of them – about 4.5 billion years. It lay in Antarctic ice for more than 13,000 years. But the biogenic-type magnetite crystals are embedded in 3.9-billion-year-old carbonates within ALH84001. Previous work by co-author Chris Romanek, of the Savannah River Ecology Laboratory has shown that these carbonates formed on Mars; thus the magnetite crystals must also have formed on Mars.

Using electron microscopy, team members examined the Martian magnetites still embedded in the carbonate and also removed about 600 crystals and examined the individual particles to determine their chemical composition and crystal geometry. "These crystals are so tiny, ranging from 10 to 200 nanometers, that nearly a billion of them would fit on the head of a pin," said Thomas-Keprta.

The authors found that about a quarter of the Martian magnetites from ALH84001 are identical to magnetites produced on Earth by the magnetotactic bacteria strain MV-1, which has been extensively studied by co-author Dennis Bazylinski, a geobiologist and microbiologist at Iowa State University who has developed many ways of culturing these difficult to grow microorganisms. No one has found terrestrial inorganic magnetites, produced either naturally or in the laboratory, that mimic all the properties displayed by biogenic magnetites. "There is currently no known inorganic chemical means of producing these magnetite crystals with their unique morphologies," he said.

Magnetite (Fe_3O_4) is produced inorganically on Earth. But the magnetite crystals produced by magnetotactic bacteria are different – they are chemically pure and defect-free. Their size and shape is distinct. Magnetotactic bacteria arrange these magnetite crystals in chains within their cells. These characteristics make the magnetite crystals very efficient compasses, which are essential to the survival behavior of the bacteria by helping them locate sources of food and energy. "Mars is smaller than Earth and it developed faster," co-author Simon Clemett of

Lockheed-Martin at JSC noted. "Consequently, bacteria able to produce tiny magnets could have evolved much earlier on Mars."

"The process of evolution has driven these bacteria to make perfect little bar magnets, which differ strikingly from anything found outside of biology," added, Joe Kirschvink, a geobiologist at Caltech and a co-author of the paper. "In fact, an entire industry devoted to making small magnetic particles for magnetic tapes and computer disk drives has tried and failed for the past 50 years to find a way to make similar particles. A good fossil is something that is difficult to make inorganically, and these magnetosomes are very good fossils."

Mars has long been understood to provide sources of light energy and chemical energy sufficient to support life. Early Mars, the authors note, may have had even more chemical energy produced by active volcanism and hydrothermal activity. Also, when the team asserted in 1996 that Martian meteorite ALH84001 showed signs of life existing on Mars, that planet was not known to have ever had a strong magnetic field. But since then, the Mars Global Surveyor has observed magnetized stripes in the crust of Mars that show a strong magnetic field existed early in the planet's history, about the same time as the carbonate containing the unique magnetites was formed. Surface features also suggest that early Mars had large oceans and lakes. These attributes, coupled with a CO_2-rich atmosphere, provided the necessary environment for the evolution of microbes similar to the fossils found in ALH84001.

A team of 10 researchers collaborated on the four-year study, which was published Feb. 27 in a special Astrobiology issue of the Proceedings of the National Academy of Science. The team, led by Thomas-Keprta of Lockheed Martin at Johnson Space Center, was funded by the NASA Astrobiology Institute. Co-authors of the study are Simon Clemett and Susan Wentworth of Lockheed Martin at the JSC; Dennis Bazylinski of Iowa State University (also funded by the National Science Foundation); Joseph Kirschvink of the California Institute of Technology; David McKay, Everett Gibson and Mary Fae McKay of JSC; and Christopher Romanek of the Savannah River Ecology Laboratory.

For a more technical discussion of this paper please see the following Web site:

http://ares.jsc.nasa.gov/astrobiology/biomarkers/recentnews.html

Full PDF version of the paper: Truncated hex-octahedral magnetite crystals in ALH84001: Presumptive biosignatures.