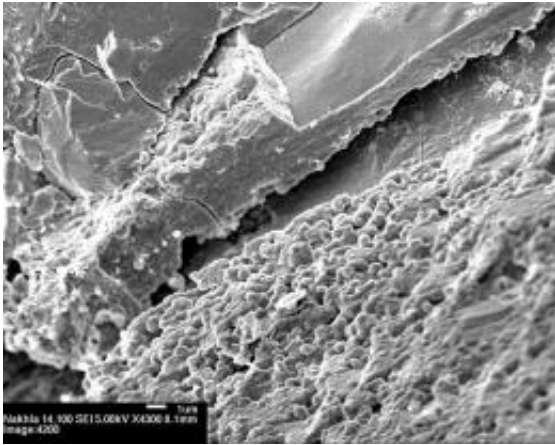


# New Study of Meteorite Provides More Evidence for Ancient Life on Mars

December 17 2009, By Lisa Zyga

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This image of the meteorite, seen through a scanning electron microscope, shows bumps that resemble a fossilized colony of microbacteria. Some of the rounded bumps are preserved at the top of the surface and resemble individual spherical and ovoid-shaped microbes. Image credit: NASA.

(PhysOrg.com) -- In 1996, when scientists examined a meteorite from Mars previously uncovered in Antarctica, they were intrigued by what looked like microscopic fossils of ancient Martian life forms. Now, using new technology that wasn't available 13 years ago, NASA scientists have found further evidence that the materials and structures in the meteorite are likely signs of ancient life, rather than the results of inorganic processes.

## ALH84001 History

Scientists estimate that the [meteorite](#), called Allan Hills 84001 (ALH84001), formed on [Mars](#) about 4.5 billion years ago, making it one of the oldest known objects in the solar system. Because the meteorite contains microscopic carbonate disks that are about 4 billion years old, scientists have previously hypothesized that the meteorite interacted with water that may have existed on Mars at this time.

Much later, about 15 million years ago, a larger meteorite likely struck Mars and ejected ALH84001 into space. After spending most of that time traveling throughout the [solar system](#), the meteorite landed on Earth about 13,000 years ago. Then, in 1984, a team of US scientists discovered it in Antarctica. The meteorite finally made news headlines in 1996, when NASA scientist David McKay and others peered at the rock under a [scanning electron microscope](#) and saw what appeared to be nanoscale fossils of bacteria-like life forms.

## Bacterial or Thermal Origin?

Now, McKay, along with Kathie Thomas-Keprta, Everett Gibson, Simon Clemett, and Susan Wentworth, all of NASA's Johnson Space Center, have revisited the original hypothesis with new observations of the meteorite. The study is published in a recent issue of the journal *Geochimica et Cosmochimica Acta*.

In the new study, the scientists used advanced microscopy techniques to investigate the carbonate disks and, more importantly, the magnetite [nanocrystals](#) within the disks. These embedded magnetites are the apparent fossils that exhibit features similar to contemporary magnetotactic bacteria.

During the past 13 years, different groups of scientists have proposed competing hypotheses to explain the origins of these magnetites. Some of the leading hypotheses are non-biological, suggesting that the magnetites were formed via thermal decomposition of the carbonates in which ALH84001 was struck by other meteorites. Such impacts may have increased the temperature of ALH84001 and caused the carbonates to decompose into magnetites via bond redistribution. In some models, ALH84001 may have experienced this shock by a random meteorite impact while still on Mars, while in other models, thermal decomposition may have occurred due to the impact event that ejected ALH84001 from its home planet.

But whatever event might have triggered a thermal decomposition process, the scientists argue in the current study that very few - if any - of the magnetites embedded in ALH84001 carbonates are a product of thermal decomposition. By analyzing details such as the percentage of magnetite volume in the carbonate disks, the trace amounts of impurities observed in some of the magnetites, and the lack of siderite which some previous models suggested may have decomposed to form magnetite, the scientists concluded that these new observations were inconsistent with the previous inorganic-based thermal decomposition hypotheses.

By showing that it's very unlikely that the magnetite originated from the decomposition of ALH84001's carbonate, the scientists argue that possible biological origins of the magnetite need to be considered more seriously than before.

“For the past 10 years, the leading (and only) viable non-biologic hypothesis for the origin of the nanophase magnetites concentrated in ALH84001 has been thermal or shock decomposition of iron-bearing carbonates, a process known to produce small magnetite crystals,” Thomas-Keprta told *PhysOrg.com*. “Our paper has falsified this non-biologic hypothesis by showing, based on thermodynamics and minor

element chemistry, that this non-biologic hypothesis simply cannot produce the ultrapure magnetites actually present in ALH84001 as a significant population of all magnetites. By falsifying this non-biologic hypothesis, we are left with only the biologic hypothesis to explain the detailed properties of the magnetites in this martian meteorite.”

## **Magnetite Biosignature**

Although they have not yet developed a model for the origin of the magnetite in ALH84001, the researchers’ new observations are consistent with the possibility that the magnetite has an “allochthonous origin,” in which it was exposed to aqueous solutions such as water.

As Thomas-Keprta explained, the magnetite in ALH84001 could have been one of several ferromagnetic minerals produced by magnetotactic bacteria that live in aquatic environments. When these bacteria die and their shells degrade, a chain of magnetite is released into the environment. Without its confining shell, the magnetite chain configuration cannot be maintained, so individual magnetite crystals begin to mix with inorganic particles in the water.

On Earth, magnetotactic bacteria are quite common in aqueous environments, and scientists often find magnetites in surface and subsurface sediments.

“For many years, the presence of the specific kind of nanomagnetite formed by magnetotactic bacteria on Earth have been completely accepted as a biosignature when found in any Earth sediment or rock,” Thomas-Keprta said, noting that these magnetite have very specific properties.

“When we first documented these specific properties in the ALH84001 carbonates, the only alternate non-biologic hypothesis that was

commonly accepted as viable was the thermal decomposition of iron-bearing carbonate,” she said. “Now that we have completely falsified this hypothesis with this latest paper, we are still left with the specific properties of the ALH84001 magnetite that, if found on Earth, would be a robust biosignature indicating production by bacteria.

“We also point to the many discoveries since our original paper showing supporting evidence such as an early strong magnetic field on Mars (necessary for the development of magnetotactic bacteria); the presence of near surface water at many locations on current-day Mars; the presence of possible oceans, major drainage channels, and other features associated with an early wet Mars; and the recent evidence for variable releases of methane into the Martian atmosphere. . . . We do not believe it is too incautious to restate our original hypothesis that such magnetites constitute strong evidence of early life on Mars.”

**More information:** K.L. Thomas-Keprta, S.J. Clemett, D.S. McKay, E.K. Gibson, and S.J. Wentworth. “Origins of magnetite nanocrystals in Martian meteorite ALH84001.” *Geochimica et Cosmochimica Acta*, 73 (2009) 6631-6677.

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Citation: New Study of Meteorite Provides More Evidence for Ancient Life on Mars (2009, December 17) retrieved 19 April 2024 from <https://phys.org/news/2009-12-meteorite-evidence-ancient-life-mars.html>

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