EXTRATERRESTRIAL LIFE

ENDANGERED

Other explanations now appear more likely than Martian bacteria

Eighteen months after David S. McKay and his colleagues at the National Aeronautics and Space Administration Johnson Space Center raised eyebrows with their claim that a potato-shaped meteorite, dubbed ALH84001, contained microscopic fossils of ancient life from Mars, the team has made few converts. "There was a very quick division into a few groups that believed it and many more that didn't," recalls Allan H. Treiman of the Lunar and Planetary Institute in Houston. Since then, Treiman says, "I haven't seen anybody change their mind."

While McKay's team has spent much of the intervening months searching for bacteria on Earth that at least proves that the creatures they hypothesize are not impossible, its critics have published dozens of new observations they believe make that theory increasingly improbable, compared with nonbiological explanations for the meteorite's puzzling features.

One such conundrum is the proximity of iron sulfides, tiny crystals of magnetite (a form of iron oxide) and carbonate rosettes in which Martian bugs supposedly thrived. The carbonate is partially dissolved around the minerals—strange, because sulfides and magnetite form together only at high pH, whereas carbonate dissolves at low pH. But there are bacteria on Earth, McKay's team points out, that excrete both sulfides and long chains of magnetite crystals; perhaps similar microbes lived in weak acid that dissolved the carbonate, they suggest.

An analysis conducted last year by Harry Y. McSween of the University of Tennessee at Knoxville and his colleagues, however, found that the sulfides in ALH84001 are too rich in sulfur 34, a heavy isotope of the element, to have been produced by microbes like any seen on Earth. Moreover, no one has yet reported finding telltale chains of a dozen or more magnetite particles. And McSween and others have observed magnetite crystals growing directly out of other minerals—a sure sign that at least some of them formed through simple chemical means.

Recently Adrian J. Brearley of the Institute of Meteoritics at the University of New Mexico sketched out what those means may have been. The carbonate rosettes contain magnesium-rich cores surrounded by iron-rich rinds in which magnetite and the other purported signs of life are concentrated. A strong blow to ALH84001 (it is known to have suffered at least two) could have rapidly heated much of the rock to more than 550 degrees Celsius—hot enough to cause the iron-rich carbonate to degenerate into magnetite but not so hot as to disrupt the magnesium-rich cores, which are stable up to much higher temperatures. When the iron condensed into crystals, Brearley theorizes, it would have released carbon dioxide enriched in heavy oxygen isotopes and left magnetite particles trapped inside voids.

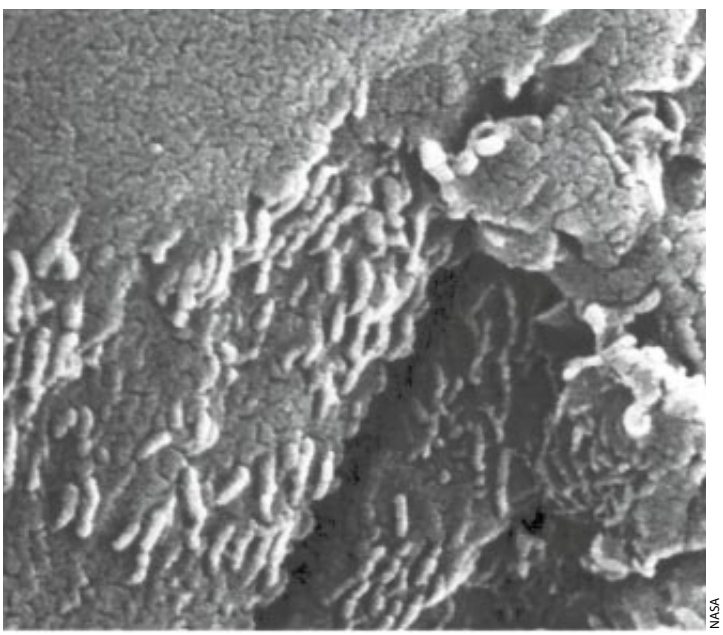
All those consequences have been seen inside ALH84001. "Adrian's idea is quite good," McKay admits. He, Brearley and others are now banging on carbonates in the lab to see whether all the predicted effects do indeed occur.

The biological theory also leaned heavily on the discovery by Richard N. Zare, a co-author of McKay, that the meteorite holds in its rosettes an unusual mix of both very light and very heavy varieties of organic compounds known as polycyclic aromatic hydrocarbons, or PAHs. The PAHs, Zare proposed, could have come from decomposed corpses of Martian germs.

The mix could also have come from inorganic chemical reactions that are known to create a few heavy PAHs from a batch of lighter ones, argued Edward Anders of the University of Chicago in late 1996. Although the process moves slowly at low temperatures, magnetite can act as a catalyst, accelerating the conversion. Zare has conceded that the PAHs could have formed in this way. If they did, it might help explain results reported in March by Thomas Stephan and his colleagues at the University of Münster. Stephan found that PAHs are present all throughout the meteorite and, if anything, are scarcer in the rosettes than elsewhere.

Proof, if it exists, of Martian life thus seems to stand now on one remaining leg: the alleged microfossils themselves. Many of the awe-inspiring herds of egg- and rod-shaped features have turned out under closer examination to be bits of clay or ridges of mineral. McKay grants that "the wormy features that we believe are fossils are not very common." In fact, although many scientists have examined fragments of the meteorite at high magnification, only one other group has released images of structures that McKay believes are microfossils. Nevertheless, he says, "There is no question in our minds that there is evidence for life in ALH84001."

How can they be so



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NOT EVIDENCE OF MARTIAN LIFE, concedes the scientist who found these tiny structures inside ALH84001. Such forms are probably clay or mineral deposits.

sure? Unreleased electron micrographs offer "very strong evidence that will convince any biologist that there was life in that meteorite," McKay says, provocatively, but he refuses to elaborate until the analysis is peer-reviewed. Yet he also confides that the first chemical study of the microfossils, not yet published, shows that the structures are not composed of organic material but rather of iron oxides (such as magnetite) and other minerals. That does not disprove McKay's hypothesis, because ancient microfossils on Earth also lack organic chemicals. But it may aid skeptics' arguments that the "fossils" are merely unusual mineral formations.

Even if new pictures convince everyone that something once lived in ALH-84001, however, there now seems little hope of a scientific consensus that the life was Martian. Two studies published in January revealed that the meteorite is rife with contamination from homegrown organic material. A. J. Timothy Jull of the University of Arizona looked inside the meteorite for carbon 14, a variety that is common on this planet but nowhere else (so far as we know). He found plenty: all but a trace of the organic molecules from his samples clearly comes from Earth. Jull is uncertain whether the tiny remainder that came from Mars is organic or not.

Jeffrey L. Bada of the Scripps Institution of Oceanography in La Jolla, Calif., looked for a different biological signature—amino acids. "PAHs are not good biomarkers: they are everywhere, constituting, by some estimates, up to a few percent of the total carbon in the universe," Bada points out.

Bada's analysis dismayed McKay, even though it revealed that the rock does indeed contain amino acids—for they were the same amino acids, present in nearly the same proportions, as those in the Antarctic ice in which ALH84001 lay for 13,000 years. "We agree with Jull and Bada that there is a fair amount of contamination in this meteorite," McKay allows. "It will make it harder to prove that any life we find is Martian."

Bada, among others, doubts that is even possible. "This meteorite just has too complex a history to tell us whether life ever existed on Mars," he says. "To answer that question, we're going to have to go to the planet and either analyze the rocks there more thoroughly than Viking did or bring samples back."

—W. Wayt Gibbs in San Francisco

BIOLOGY

CLOCK SETTING

Lighting up your knees may reset your circadian rhythms

Organisms from bread molds to bread makers rely on biological clocks that respond to light cues that help them synchronize their activities to the rising and setting of the sun. In humans, this circadian clock controls a variety of physiological processes, including daily rhythms in body temperature, hormone production and sleep itself. Now Scott S. Campbell and Patricia J. Murphy of Cornell University Medical College in White Plains, N.Y., report in *Science* that they can reset the master circadian clock in humans by shining a light not in the subjects' eyes but on the backs of their knees.

"The results are incredibly provocative," says Steve Kay of the Scripps Research Institute in La Jolla, Calif. "And very surprising," he adds, because previous studies in humans suggested that the light signals that entrain the body's