Life on Mars?
A Dilemma Case Study in Planetary Geology*

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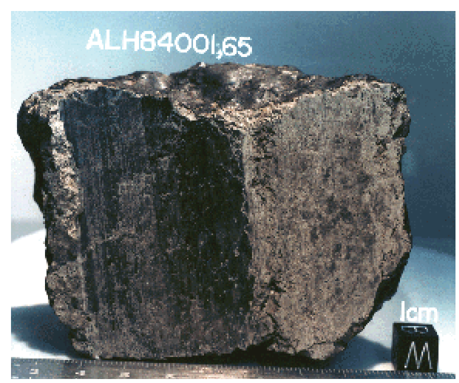
Michael King let his mind wander as he waited for the meeting to begin. Although still young, he had earned a reputation as a competent planetary geologist through years of hard work at the U.S. Geological Survey. He attributed his success in part to an excellent education which stressed the validity of the scientific method. He fully understood the need to proceed cautiously whenever the announcement of a new discovery was contemplated. That was why he was both astonished and dismayed when NASA Senior Scientist David Collins called with the news that the "Life on Mars" investigation would be revealed at an upcoming press conference. As part of the investigative team, Michael felt that such an announcement was premature. He did not want to risk his reputation and career by rushing to make a public disclosure before the work was validated. He tried to imagine the public and professional reactions if the first report of life on another planet was ultimately proven false. The repercussions would be far worse than the simple disappointment many felt when the Viking Lander soil experiments produced negative indications of life 20 years ago.

Michael stopped musing and turned his attention to the meeting. David was trying to explain the situation. "We are here because word has leaked that we have discovered evidence of life on Mars. If we let this get out of control, we could have a public relations nightmare. A news blackout will do more harm than good. So, we are going public tomorrow at 1:00 p.m. with a televised press conference." Michael wished he could find an argument against a well-orchestrated press release as the best method of rumor control. He could not, so he kept quiet.



Peter Kraft, a geochemist with the Johnson Space Center (JSC) and the lead author, spoke next. "Let's review the project. We received a sample of an SNC (shergottite, nakhlite, chassigny) class meteorite, ALH84001, for analysis two years ago from LPI (Lunar and Planetary Institute). Microscopic and chemical analysis of the sample led us to conclude that there was biologic activity on early Mars. Four lines of evidence were developed in support of our hypothesis: 1) the meteorite and the calcium carbonate it contains came from Mars, 2) the mineralogy and chemistry of the carbonate globules are compatible with biologic origin, 3) the meteorite contains organic material from Mars, and 4) there are micro-fossils within the globules. Any of these data have alternate interpretations but, taken collectively, they are indicative of ancient Martian life."

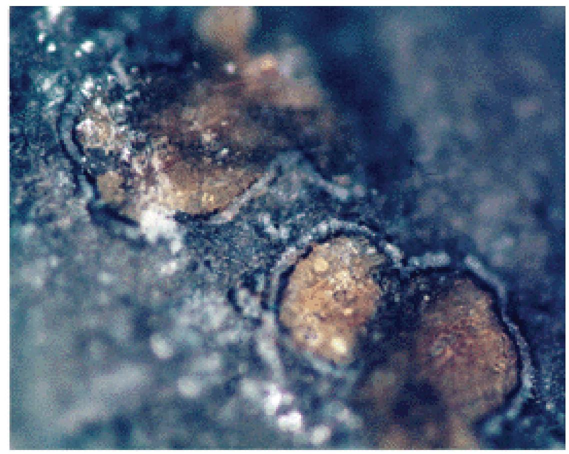
* This case study is fiction. The scenario is the creation of the authors. Yet, the study deals with the historical announcement on August 7, 1996, by NASA (National Aeronautics and Space Administration) of the possible discovery of ancient life in a Martian meteortie. Accordingly, the science is authentic and the important background material and references are factual. Portions of the original NASA press conference aired by the CNN television news channel were extracted and used as source material to enhance the sense of authentic human interaction in this unusual situation. However, the characterizations are only loosely based on the actual scientists and not meant to parody any real individuals. Also note that while this is an examination of some of the reasons for the controversies surrounding the evidence of the discovery and the method of public disclosure, there is no intention to "find fault" or present an opinion pro or con. Judgement in this and similar cases is in the domain of the scientific community. Instead, this work is an attempt to portray, from a skeptic's perspective, the multitude of ethical and procedural dilemmas that professional scientists encounter. Every effort was made to present the scientific considerations concisely and accurately. Any errors should be attributed to author Bruce Allen and not the original investigators.

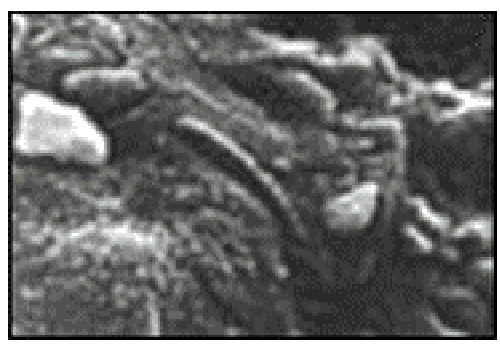
Kenneth Holland, also a geochemist with JSC, picked up where Peter left off. "I've prepared a brief history of the meteorite…. Mars began solidifying 4.5 billion years ago. The meteorite's parent rock formed at that time according to rubidium-strontium radiometric dating. Early in Martian history, the surface was considerably warmer and wetter than it is now. Approximately 3.6 billion years ago calcium carbonate globules precipitated from chemical solutions flowing through preexisting fractures within the parent rock. At the same time a micro-biota was present and became entrained in the carbonate. Moving ahead to about 16 million years ago, an asteroid-sized object impacted Mars and ejected ALH84001 from the surface. It traveled through space exposed to cosmic rays until it landed in Antarctica 13,000 years ago. In 1984 it was recovered by a joint NASA/NSF (National Science Foundation) /Smithsonian team and classified as a diogenite. Nine years later it was recognized as a Martian meteorite. Then, as Peter said, we received a sample in 1994."

Michael interjected. "Remember that ALH84001 is three times older than any other SNC. That makes it very unusual and casts some doubt on its origin."

"Look, Mike, we've been over this before. Most meteoriticists agree that it is from Mars and so do most members of this team. So, put it to rest." Kenneth did not like to be challenged.

Claudia Morgan from Lockheed-Martin took this opportunity to speak. "ALH84001 is an igneous rock. Its most interesting features are those carbonate globules that Ken mentioned. Transmission electron microscopy (TEM) reveals the black color around the rims is due to a high concentration of magnetite crystals. We consider the magnetite to be biogenic based on three criteria: 1) distinctive shapes, 2) chemical composition, and 3) environment of deposition. The cuboid and teardrop shapes of the magnetite crystals are consistent with magnetofossils produced by terrestrial bacteria. The same is true of the chemical composition, which is very pure. Furthermore, the isotopic compositions of the globules suggest they were formed in a low temperature, aqueous environment. The simplest explanation for these features is that they are by-products of Martian life." Claudia's presentation was cogent and concise, but Michael had more doubts.





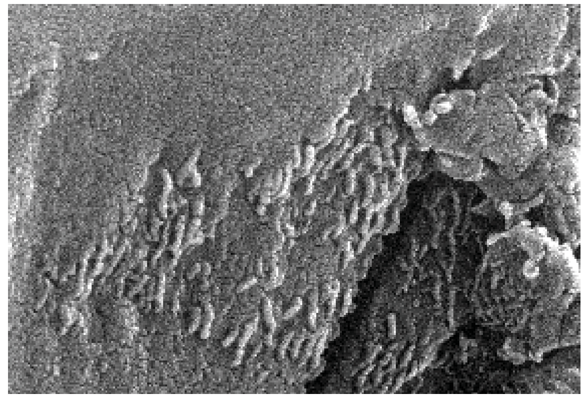
"Claudia, you know, the minerals are anhydrous and often found in environments hot enough to fry any bacteria. And what about the magnetite? Terrestrial bacteria are thought to navigate with it in Earth s magnetic field, but Mars has no magnetic field! So, why is it there?"

Peter interrupted before Claudia could answer. "Mike, this meeting is not a debate. It is simply a review in preparation for tomorrow. So, let's move on. All right?"

Peter signaled that Brian Murphy from UCLA was next. "I found PAH's (polycyclic aromatic hydrocarbons) that correlate with the position of the globules, but I admit they can be found in organic combustion products ranging from soot to burned steak. However, the observed mass spectrum is much simpler than typical for a meteorite. That suggests simple organic decay instead of combustion. Moreover, the concentration of PAH's increases with depth from the fusion crust.

Any terrestrial contamination would have produced a surficial concentration." Michael knew that frictional heating from high speed entry into the Earth's atmosphere would burn off volatiles in the outer layers of the rock. On the other hand, he did not value PAH's as a biomarker because they are found virtually everywhere.

Then Kenneth reviewed the scanning electron microscope (SEM) photos for the group. "The cylindrical forms in the globules could be dried-up clay, but they strongly resemble in both size and shape the microphotos of terrestrial nanobacteria. Segmentation present in some examples suggests cellular structures."



Michael could not let those last remarks pass without comment. "There is no evidence of cellular walls and the existence of segmentation is doubtful. Besides that, there are no confirming biochemical signatures of life: no DNA, no protein, not even a trace of an amino acid! Even worse, these things are 10 times smaller than anything previously recognized as life. To conclude these structures are micro-fossils is unjustified."

"I don't agree, Michael," retorted Ken. "I've been in touch with an excellent mineralogist that says he has found fossil bacteria of the same scale as ours in copper deposits in Chile. So, let's leave that issue for the biologists to sort out."

The discussions continued for some time. When they were finally over, Michael was still left with a feeling that the issues were unresolved and would continue to be unresolved until further evidence was gathered. He still was not sure what he should do personally. Should he risk his career by backing the project publicly or resign from the team? Either way, for the right decision, the rewards could be enormous. For the wrong decision, the penalties to his career could be devastating. Suddenly, it all became clear to him. There was only one way to preserve his personal and professional integrity, but it meant he would not get much sleep that night.

Questions

1. How do we know that ALH84001 is a meteorite?
2. Why do we think it originated on Mars?
3. How was the parent rock of ALH84001 determined to be 4.5 billion years old?
4. What evidence indicates it became a meteor 16 million years ago?
5. What mechanism could have propelled it into Outer Space?
6. How do we know it landed in Antarctica 13,000 years ago?
7. Why do we think the carbonate globules are 3.6 billion years old?
8. Why do we think their deposition occurred in a low temperature environment?
9. Why do we think the globules contain organic material?
10. Why do we think the organic material is Martian and not terrestrial contamination?
11. Why do we think that certain minerals in the meteorite are biogenic?
12. What physical characteristics of magnetite makes it useful to some forms of terrestrial life?
13. What common characteristic of the globules, the organics, and the minerals suggest life?
14. How do we know the globules contain tiny cylindrical structures?
15. Are the cylinders large enough to have been alive?
16. Why do we think the cylinders are microfossils?

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