PLANETARY SCIENCE RESEARCH PSRD Discoveries
about PSRD | archive | search | subscribe | glossary | comments

Features posted October 18, 1996

Rules for Identifying Ancient Life

Written by G. Jeffrey Taylor
Hawai'i Institute of Geophysics and Planetology, University of Hawaii

J. William Schopf (University of California, Los Angeles) has spent many years examining ancient rocks on Earth to identify the oldest fossils. This work is painstaking and frought with difficulty and potential errors. The worse mistake is to identify an ancient fossil, only to find out later that you were fooled by a nonbiologic mineral grain that looked like a fossil, but was not. This work has led to a set of criteria, or rules, that must be met for establishing credible evidence for past life in geologic samples.

We outline those rules here, adapted slightly. These criteria were published by Dr. Schopf in *The Proterozoic Biosphere* (J. W. Schopf and C. Klein, editors, Cambridge University Press, New York, 1992), pp. 25-39. We also offer an assessment of the evidence for life on Mars, based on remarks made by Dr. Schopf during the press conference at NASA Headquarters (August 7, 1996) and on additional comments by other scientists since then. In spite of considering opinions expressed by others, **PSR Discoveries** is solely responsible for the assessments below. We will update these assessments as new evidence accumulates.

As Dr. Schopf noted, "The burden of proof is on those who claim that [the fossils and other evidence] are biological." He also quoted Carl Sagan: "Extraordinary claims require extraordinary evidence." These thoughts have been taken into account in our assessment.

Rules

The suspected fossils must occur in rocks of known provenance.

This means in the case of ALH 84001 that the meteorite is from Mars, and the supposed fossils were formed there, not on Earth.

Assessment: There is a very high probability, at least 90%, that the meteorite came from Mars. The carbonate globules, which is where the evidence for life is found, almost certainly formed before arrival on Earth. Some distinctive patterns in the mineral grains are offset by little faults that must have formed before the meteorite arrived in Antarctica. The carbonate ages are not well established, but are at least a billion years, much older than the time the meteorite fell, about 13,000 years ago. Overall score: Criterion satisfied.

The fossils must be indigenous to the rock.

For the Earth this is very important in establishing the antiquity of the life forms. For example, younger microorganisms might take up residence in a very ancient rock, leading an unsuspecting investigator to believe that the organisms were older than they actually are. For the Martian meteorite, we do not need to worry about contamination by younger life. ANY life on Mars would be an exciting discovery, no matter what its age. Eventually, of course, we would need to establish when life began, but at this stage, just finding it is sufficient. The investigators have also ruled out possible contamination of the meteorite on Earth by noting that the carbonate globules must have formed on Mars or in space. They also showed that concentrations of organic compounds are greater inside the rock than on the surface. If there were contaminants, their abundances would be greater on the surface, not in the interior.

Assessment: Contamination is not a problem and there is no worry about the age of the microorganisms. Overall score: Criterion satisfied.

Fossils must have formed at the same time as the enclosing rock.

For ALH 84001, this means at the same time as the carbonate globules, not the entire rock. The rock originally formed in a magma, slowing accumulating and growing crystals, a setting clearly unsuitable for life.

Assessment: The organic compounds (PAHs), microscopic minerals, and fossil-like structures are clearly associated with the carbonate globules. However, we do not know if all these features formed at the same time. Overall score: Jury still out.

Environment of formation must be suitable for life.

Terrestrial organisms do not survive at high temperatures, so the rock in which they are found must have been formed at a low temperature, perhaps around 100 degrees Celsius or less. For ALH 84001, this means the carbonates must have formed at low temperatures.

Assessment: The jury is still out on the temperature of formation of the carbonates. The NASA-Stanford team cites evidence from the abundances of oxygen isotopes that suggests that the temperature was 0 to 80 degrees Celsius, certainly suitable for life. On the other hand, Ralph Harvey and Harry McSween, in a paper published in the journal *Nature* (4 July,1996), suggest on the basis of the elemental compositions of the carbonates that the temperature was far higher, perhaps up to 700 degrees Celsius, clearly unsuitable for life! Additional tests are clearly needed, and until they are done, the low-temperature origin of the carbonates cannot be accepted as established. Overall score: Jury still out.

Be of assured biological origin.

All of the above set the stage for the study of microfossils and associated deposits. One must observe certain essential features: (1) Clear-cut biomarkers (diagnostic minerals, isotopic compositions, organic chemicals). (2) Some fossils must have identifiable cellular structures, such as internal cavities and cell walls. (3) We ought to see evidence for life cycles, such as cell division. (4) There needs to be evidence that the fossils were made from organic material.

Assessment: There certainly are some features taken by the researchers as good biomarkers. These include the presence of PAHs and the small grains of magnetite and iron sulfide. However, other investigators have offered alternative explanations not involving biology for the presence of these features. For example, PAHs are found in other meteorites that have no evidence for biological activity. These alternatives need to be assessed in detail before we can take the biomarkers offered by the NASA team as convincing. As for the features of the suspected fossils, they have not yet been examined in sufficient detail to show cellular structures, life cycles, or the presence of organic material. As dramatic as the images of the fossil-like stuctures are, they are not yet credible fossils. Overall assessment: Jury still out.

HOME

[About PSRD | Archive | Search | Subscribe]

[Glossary | General Resources | Comments | Top of page]

---

psrd@higp.hawaii.edu
main URL is http://www.psrd.hawaii.edu/