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Features

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Testing the Evidence for Life on Mars:
NASA and NSF Fund New Studies of Martian Meteorite

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NASA and the National Science Foundation (NSF) have awarded grants to test the evidence that fossil life has been discovered in martian meteorite ALH84001. **PSR Discoveries** has covered the debate about the evidence in a series of articles and will continue to do so.

The projects, funded after close scrutiny by other scientists, are listed below. They are organized by type of investigation and arranged alphabetically in each section. Many of the studies actually address topics across subject areas, but we list them under the topic that constitutes the major portion of the research being done.

Measurements of Organic Compounds

The nature of organic compounds is important in evaluating whether life existed on Mars. The presence of organic compounds alone does not prove that life existed, as such chemicals can form by nonbiological processes, too. One of the chief research problems will be to test for contamination of the samples, on both Mars and Earth.

Amino Acids and Other Organic Compounds in Antarctic Meteorites and Ice (NASA grant)

Investigators: Jeffrey L. Bada, Luann Becker, and Gene D. McDonald
Organizations: University of California San Diego, University of Hawaii Manoa, Cornell University

An Investigation of Carbon Isotope Abundances in ALH84001 (NSF grant)

Investigator: Greg H. Rau
Organization: University of California Santa Cruz

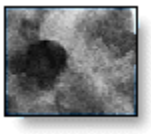
Carbon Characterization, Element Abundances and X-ray Near Edge Structure Measurements on ALH84001 (NASA grant)

Investigators: George J. Flynn and Lindsay P. Keller
Organizations: State University of New York Plattsburgh, MVA Inc.

The Search for Unique Biomarkers in the Martian (SNC) Meteorites ALH84001 and EETA79001 (NASA grant)

Investiator: Richard N. Zare
Organization: Stanford University

Studies of Possible Biomarkers



Biomarkers are minerals or other substances whose presence indicate that organisms were living in a rock. Many of the investigations focus on the nature of the mineral magnetite in ALH84001, in comparison to magnetite produced by bacteria on Earth.

Deciphering Sulfur Isotopic Systematics as a Potential Biomarker in ALH84001 (NASA grant)

Investigators: Charles K. Shearer and James J. Papike
Organization: University of New Mexico

High Resolution Examination of the Intact "Microfossil" - Mineral Interface of ALH84001 for Evidence of Physical and Mineralogical Changes Consistent with Microbial Activity (NSF grant)

Investigators: William W. Barker and Jillian F. Banfield
Organization: University of Wisconsin Madison

Iron-Oxide and-Sulfide Mineral Particles as Biomarkers (NSF grant)

Investigators: Richard B. Frankel, Dennis A. Bazylinski, Bruce M. Moskowitz, and Peter R. Buseck
Organization: Cal Poly State University San Luis Obispo, California

Microstructural Studies Bearing on the Origin of Carbonates and Associated Minerals in Martian Meteorite ALH84001 (NASA grant)

Investigator: Adrian J. Brearley
Organization: University of New Mexico

Oxide and Sulfide Mineral Indicators of Past Biological Activity (NASA grant)

Investigator: Peter P. Buseck
Organization: Arizona State University

The Isotopic Composition of Iron: A Chemical Fingerprint for Ancient Life (NASA grant)

Investigators: Brian L. Beard, Kenneth H. Nealson, and Clark M. Johnson
Organizations: University of Wisconsin Madison and University of Wisconsin Milwaukee

The Isotopic Composition of Iron: A Chemical Fingerprint for Biologic Activity (NSF grant)

Investigators: Brian L. Beard and Clark M. Johnson
Organization: University of Wisconsin Madison

The possible fossils in ALH84001 are associated with carbonate minerals. There is a raging debate about how the carbonates formed, with some scientists claiming that the carbonates formed at low temperatures, hence consistent with life, while others argue that the carbonates formed at high temperatures (more than 700 ^{o}C), incompatible with life. The numerous investigations in this area are designed to determine the temperature and mode for formation of the carbonate minerals in ALH84001.

An Electron Microscopy Survey of Carbonate-Bearing Regions of ALH84001 (NASA grant)

Investigators: Ralph P. Harvey and John P. Bradley
Organization: Case Western Reserve University, MVA Inc.

Collaborative Research: Ion Microprobe Analysis of O and C Isotope Ratios in ALH84001 (NSF grants)

Investigators: John Eiler, Edward M. Stolper, and John W. Valley
Organizations: California Institute of Technology, University of Wisconsin Madison

Experimental Investigations of the Origins of Martian Carbonates (NASA grant)

Investigators: Gary E. Lofgren, Gordon A. McKay, John H. Jones, Friedrich Horz, and Douglas W. Ming
Organization: NASA Johnson Space Center

Isotropic and Experimental Constraints on the Genesis of Carbonates in Martian Meteorite ALH84001 (NASA grant)

Investigators: Laurie A. Leshin, Kevin D. McKeegan, Cecile Engrand, Craig E. Manning, and Ralph P. Harvey
Organizations: University of California Los Angeles, Case Western Reserve University

Paleomagnetic and Rock Magnetic Constraints on the Thermal History of Martian Meteorite ALH84001 (NASA grant)

Investigators: Joseph L. Kirschvink and Hojatollah Vali
Organizations: California Institute of Technology, McGill University

Pathways of Mineral Alteration and Organic Synthesis in Hydrothermal Systems on Mars (NSF grant)

Investigator: Everett L. Shock
Organization: Washington University, St. Louis

Petrologic Studies of Martian Carbonates in ALH84001 (NSF grant)

Investigators: Edward R. D. Scott, Lauren B. Browning, and Shiv K. Sharma
Organization: University of Hawaii Manoa

Stable Isotopic Analysis of Secondary Minerals in ALH84001 (NASA grant)

Investigator: Christopher S. Romanek
Organization: University of Georgia

Investigations of Fossil-like Structures

One of the most dramatic lines of evidence is the existence in ALH84001 of fossil-like objects. It is also one of the most controversial lines of evidence. Studies focus on the nature of very tiny fossils and living bacteria in rocks on Earth, for comparison to those in ALH84001.

Do Nanobacteria Exist? A Microbial Landscape at Nanometer Scale (NASA grant)

Investigators: Todd O. Stevens, Noelle Metting, and James McKinley
Organization: Battelle Pacific Northwest Laboratory

Time of Formation of the Carbonates

The age of the carbonate minerals is important for understanding the evolution of climate on Mars. It is also indirectly related to the issue of fossil life in ALH84001, as some age estimates suggest that the carbonates formed about 3.5 billion years ago, during the time when the climate of Mars is thought to have been wetter and warmer than it is now. However, determining the age of the carbonates may be the most difficult experiment of all those funded.

Comprehensive Microprobe Studies of Stable Isotopes, Noble Gas Isotopes and Trance Elements in Primary and Secondary Minerals in Ancient Martian Meteorites (NASA grant)

Investigators: Grenville Turner, R. Burgess, G. D. Gilmour, Ian C. Lyon, and R. A. Wogelius
Organization: University of Manchester

Radiometric Dating of ALH84001 Carbonates (NASA grant)

Investigators: Laurence E. Nyquist, James Connelly, L.E. Borg, and Donald D. Bogard
Organization: NASA Johnson Space Center, University of Texas Austin

Multidisciplinary Studies

One investigation involving numerous scientists from several institutions encompasses all the categories above, in an integrated, multidisciplinary project.

An Evaluation of Biogenicity in ALH84001 (NASA grant)

Investigators: David F. Blake, David P. Summers, Stephen J. Mojzsis, Jack D. Farmer, David Des Marais, Sherwood Chang, and Allan H. Treiman
Organizations: NASA Ames Research Center, Scripps Institute of Oceanography, Lunar and Planetary Institute