Meteoritics & Planetary Science 33, 545–546 (1998)

From the Editors

The legacy of Allan Hills 84001

This issue contains nineteen papers on the theme of the Martian meteorites and early Mars. Seven papers concern mineralogy and petrology, six concern cosmogenic and stable isotopes, two concern composition, two are spectroscopic studies and two are essentially biological in nature. Reflecting the outburst of interest generated by the suggestion that ALH 84001 might contain evidence for relic life on Mars, most of the papers concern ALH 84001. Although they all address some aspect of the Martian and terrestrial history of ALH 84001, only three papers directly address the origin of the features attributed by McKay *et al.* to Martian microorganisms. Bradley *et al.*, Scott *et al.* and Sears and Kral separately discuss the origins of the magnetite, carbonate and microfossil-shaped objects in ALH 84001. All three papers argue, for entirely separate reasons, that McKay and his colleagues were mistaken in their conclusions. However, as the recent Lunar and Planetary Science Conference demonstrated, there was no firm consensus yet on the origin of these features and the validity of the claims of McKay *et al.*

The great majority of papers in this issue on ALH 84001 and the other Martian meteorites are silent on the issues raised by McKay and colleagues. Instead, we have some important and original contributions concerning the origin and history of the Martian meteorites, ALH 84001 especially, a review of bacterial survival under Martian conditions and a study of magnetism and soil composition at the Pathfinder site. In short, regardless of the possible biological interpretations of the properties of ALH 84001, we are seeing an important meteorite and a fascinating topic explored at a level of detail that might not otherwise have been employed.

But this series of papers, while important, is obviously not the complete legacy of ALH 84001. In the summer of 1995, it seemed that NASA Ames Research Center at Moffet Field in California was in trouble. There was serious discussion that the facility should cease as a NASA Center and a small nucleus transferred to Stanford University to be run as a university research institute. This would have resulted in the loss of a considerable number of talented and highly trained personnel, and it would have virtually removed NASA from the field of exobiology. With the publication of the ALH 84001 paper in the summer of 1996, press conference and subsequent media hype, all that changed.

Within weeks, well before the scientific community could make any formal response, which typically takes a year or so, NASA announced programs to support research aimed at exploring the validity of the McKay *et al.* claims. Many research groups were to be funded, thereby deferring judgement until they completed the funded studies. This would add another year or so to the time it would take to assemble formal responses. Before this could happen, the idea to establish a new Astrobiology Institute at Ames was announced, and all discussion of closing the NASA Center ceased. For two years the Center was to be funded at $5,000,000 per year, and in the year 2000 the support level was to reach $15,000,000. Exobiology, incorporated into an interdisciplinary astrobiology program, is alive and well at NASA, thriving in a way that was undreamed of before the summer of 1996. And it is not just NASA. Exobiology now has a place in NSF's realm, through both its program to support investigations of ALH 84001 and its program to explore life in extreme environments. Carl Sagan, who struggled for many years to find ways to support exobiology and SETI (Search for Extraterrestrial Intelligence), lived just long enough to see the opening of this saga, but even he would probably not have predicted the size of the windfall.

The present series of papers illustrates another related legacy of the ALH 84001 story which is the presence of biologists in our field. There have always been a few biologically-oriented scientists working on meteorite and planetary topics, but not many. That has now changed, and the rate of change will grow with the funding of the Astrobiology Institute.

The presence of the Morris *et al.* paper in the present series reminds us that the robotic exploration of the solar system is reaching a new levels of excitement and productivity following developments in technology and some inspired leadership by Wes Huntress at NASA headquarters. We are about to embark on a period of sample return that has not been seen since the days of Apollo but, unlike the Apollo rocks, these samples will not be coming from bodies that are unquestionably sterile. The next decade or so will see the return of samples from comets by the Stardust and Deep Space 4/Champollion missions, from an asteroid by the Muses C mission, and from the Sun by the Genesis mission. Most relevant to ALH 84001 are the sample return missions from Mars that will surely be highlights of the next few decades. If nothing else, the ALH 84001 excitement has led to a dry run for these uniquely important, potentially biological, sample return missions.

For the community that is dedicated to sample analysis, the ability to look at samples returned under controlled conditions is arguably the major contribution of the space program, especially that fraction of our community whose data are potentially compromised by terrestrial contamination. We have already seen what excitement and flood of new ideas stemmed from the Apollo rocks, and now it is time for samples from Mars, comets and the asteroids. And experience with meteorites has repeatedly demonstrated that contamination by biologically significant materials is just about the most serious and problematical form of terrestrial contamination.

The ALH84001 controversy has shown that future sample return missions, especially those from Mars, will be handled quite differently from the Apollo samples. We now know that terrestrial organisms can survive and prosper in rocks at depths of several kilometers, temperatures of up to 113 °C, and head-to-toe temperature differentials of 60 °C. Some fraction of the minerals on the surface of the Earth may well have been produced at temperatures below 113 °C by microorganisms extracting energy from reactions involving methane, hydrogen and sulfur. To check for microbial activity in Martian rocks is going to require the development and application of definitive biomarkers using ALH 84001 and terrestrial rocks. It will require genuine interdisciplinary science of the sort that the Astrobiology Program is set up to foster. Petrographic, chemical and isotopic studies will only be possible after suitable sterilization processes have been applied to the samples. The ALH 84001 experience will improve NASA's position with respect to protecting our environment from hazardous extraterrestrial microbes, an issue that will loom larger as sample return get closer.

So the present issue of *Meteoritics & Planetary Science* does not resolve unequivocally, in any formal sense, the correctness of the McKay *et al.* paper. The definitive papers have yet to be written. They will come in time. More importantly, the present series of papers demonstrates that exciting work is being done on a wide number of fronts, that the role for imaginative scientific leadership at NASA headquarters is as important now as it ever has been and, indirectly, that the forces that drive Science are diverse and unexpected.

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