PLANETARY SCIENCE

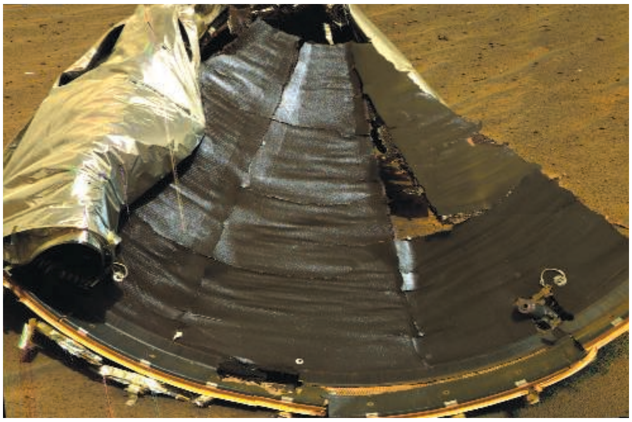
Biologically Reversible Exploration

International policies for protection of Mars and other planets from biological contamination need to be maintained and strengthened.

Christopher P. McKay

The international Committee on Space Research (COSPAR) has established a "planetary protection" policy that involves not contaminating other worlds in a way that would jeopardize the conduct of future scientific investigations. As a signatory to the 1967 Outer Space Treaty, the United States is required by article IX to avoid "harmful contamination" of the other worlds of the Solar System. However, further revisions to the policy are needed.

The two Viking landers that arrived on Mars in 1976 were heat-sterilized to comply with planetary protection. After Viking, COSPAR determined that given the inhospitable conditions on Mars, sterilization was no longer required unless the spacecraft specifically intended to search for life as one of its scientific goals. Thus, the Pathfinder spacecraft and the two Mars Exploration Rovers (Spirit and Opportunity) arrived at Mars with an estimated bioburden exceeding many hundreds of thousands of bacteria (*1*) (see photo).



The heat shield from the Mars Exploration Rover Opportunity photographed in February 2005. Debris on Mars could shield microorganisms from UV light.

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In 2003, COSPAR revised its planetary protection policy for Mars from a probabilistic approach to one that was based on the mission objectives and target (*2*). It includes the notion of "special regions," regions in which biocontamination from Earth might grow and thus require special protection. Any spacecraft components that enter such a special region have to be heat-sterilized. The subsurface ice that was the target for the arm on the Phoenix lander is a special region, and the arm was therefore heat-sterilized and placed within a biobarrier bag before launch to Mars in 2007. Pieces of the rest of the Phoenix lander, which were undoubtedly contaminated, are visible on the surface of Mars.

Any hitchhiking organisms exposed to the martian environment are killed in minutes by the ultraviolet radiation from the Sun (*3*). Bacteria shielded inside the spacecraft would not be killed but would remain dormant because of the dry conditions. Over hundreds of thousands of years, they would be killed by galactic cosmic radiation (*4*).

In 2006, when the U.S. National Research Council emphasized the importance of special regions on Mars (*5*), it also recommended that National Aeronautics and Space Administration (NASA) work with COSPAR and other organizations to convene an international workshop that would focus on "ethical implications and the responsibility to explore Mars in a manner that minimizes the harmful impacts of those activities on potential indigenous biospheres." This would include discussion of whether revisions to current planetary protection policies are needed and how to involve the public in discussions about related ethical issues. This was the first official suggestion that consideration should be given to any indigenous life on Mars even if it is microbial (*6*). This workshop is planned for 2009.

What do we do if we find life on Mars? It is possible that martian life is on the same tree of life as Earth life because of the exchange of meteorites between the two planets (*7*, *8*). Alternatively, it may be that life on Mars represents a second genesis—an independent origin of life (*9*). Contamination by even one Earth bacterium may be a serious issue of environmental ethics. Furthermore, if we find evidence of a second genesis, then this may open discussions of warming Mars to help that alien life to flourish (*10*, *11*). Scientists and policy-makers who consider this choice will have to deal with any contamination left on Mars by previous explorers, so that it does not flourish instead.

Sterilization of robotic spacecraft, while no longer policy, is at least possible. With human exploration, sterilization is not an option. Nor is it realistic to imagine that a human base could be so carefully engineered that it would release no microorganisms into the environment.

The spacecraft that have landed on Mars have all been surface missions. Contaminants will remain local and static and can be removed without requiring an effort vastly larger than the missions that carried the contamination. Even at the crash sites, debris from Earth extends no more than a few meters into the surface. Reversing the contamination involves recovering the spacecraft parts and exposing any contaminated dirt to the sterilizing ultraviolet (UV) sunlight. However, if, for example, robotic or human explorers drill to investigate a subsurface aquifer, biologically reversible exploration would require rigorous sterilization of any components that go down the drill hole. Similarly, if human explorers establish bases inside caves (*12*), the naturally sterilizing effect of the surface UV would be lost, and contamination would be persistent.

We should not do anything now that would close off options for the future. I propose that COSPAR, in its upcoming discussions, set a policy that all Mars exploration be biologically reversible and that this policy extend to human exploration as well.

Space Sciences, NASA-Ames Research Center, Moffett Field, CA 94035, USA; christopher.mckay@nasa.gov

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