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# Ethical Considerations Regarding the Biological Contamination of Climatically Recurrent Special Regions.

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With the dawn of planetary exploration, the international science community expressed concerns regarding the potential contamination of habitable planetary environments by the introduction of terrestrial organisms on robotic spacecraft. The initial concern was that such contamination would confound our efforts to find unambiguous evidence of life elsewhere in the Solar System, although, more recently, this concern has been expanded to include ethical considerations regarding the need to protect alien biospheres from potentially harmful and irreversible contamination. The international agreements which address this concern include the UN Space Treaty of 1967 and the Planetary Protection Policy of the International Council for Science's Committee on Space Research (COSPAR).

In the context of Mars exploration, COSPAR calls a potentially habitable environment a 'Special Region', which it defines as: "A region within which terrestrial organisms are likely to propagate, or a region which is interpreted to have a high potential for the existence of extant Martian life forms." Specifically included in this definition are regions where liquid water is present or likely to occur and the Martian polar caps.

Over the years, scientists have debated the level of cleanliness required for robotic spacecraft to investigate such environments with the goal of defining international standards that are strict enough to ensure the integrity of life-detection efforts during the period of 'biological exploration', which has been somewhat arbitrarily defined as 50 years from the arrival date of any given mission. More recently, NASA and ESA have adopted a definition of Special Regions as any Martian environment where liquid water is likely to exist within the next 500 years. While this appears to be a more conservative interpretation of the original COSPAR definition, it specifically excludes some environments where there is a high probability of liquid water on timescales greater than 500 years, such as in the Martian polar layered deposits (and other high-latitude, ice-rich environments), at times of high obliquity.

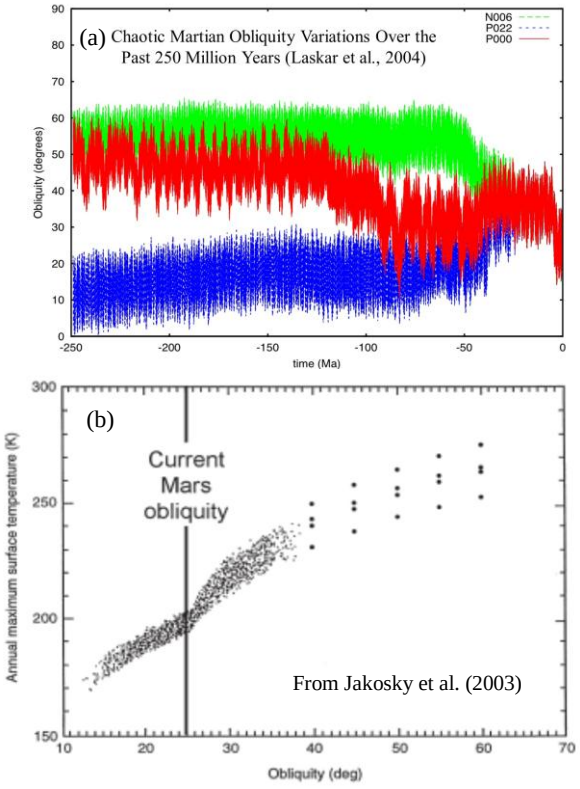


Figure 1. (a) The potential for chaotic variations in Martian obliquity over the past 250 Ma (Laskar et al., 2003). (b) Variation in maximum summertime temperature as a function of obliquity (Jakosky et al., 2003).

Current climate models suggest that, for obliquities > 45°, summertime surface temperatures at polar and near-polar latitudes may approach or exceed the melting point of water for continuous periods of many months (Costard et al., 2001; Jakosky et al., 2003) – conditions that may be repeated annually throughout the maximum obliquity phase of the $10^5$-year obliquity cycle. If so, these ice-rich, high-latitude environments may be considered climatically recurrent Special Regions – and may be among the most potentially habitable environments on Mars for the survival and growth of terrestrial microorganisms.

A significant concern arising from this potential is that, whether by accident or the nominal operation of investigating spacecraft (cleaned to less than Special Region (IVc) standards), we might irreversibly contaminate these sensitive environments. While such contamination may not pose an immediate threat to the integrity of our spacecraft life-detection experiments, its potential impact on the long-term health and ultimate survival of a native Martian biosphere raises significant scientific and ethical concerns, as identified in the NRC report on *Preventing the Forward Contamination 0f Mars* **[4]**.

Precedents for considering the adoption of planetary protection standards that minimize the potential impact of our exploration efforts on a native biosphere include the NRC report on *Preventing the Forward Contamination of Europa,* which noted that "future spacecraft missions to Europa must be subject to procedures designed to prevent its contamination by terrestrial organisms. This is necessary to safeguard the scientific integrity of future studies of Europa's biological potential ***and to protect against potential harm to Europan organisms, if they exist, and is mandated by obligations under the [Outer Space Treaty]***" [5]). Virtually identical concerns were expressed by the NRC Committee on Planetary and Lunar Exploration [6] in its report *A Science Strategy for the Exploration of Europa*.

Because microbial contaminants on spacecraft cleaned to less than IVc standards could introduce terrestrial organisms into polar and other ice-rich environments that current climate models and geologic evidence suggests are likely to become habitable on timescales of $10^5$ – $10^7$ years, PREVCOM argued that the definition of Special Regions should be extended to include such environments, in agreement with the original COSPAR definition.

Our failure to do so could lead to the irreversible biological contamination of Mars and the potential extinction of the very first extraterrestrial biosphere we have attempted to detect. While there are those who believe that the advent of human exploration will make the irreversible biological contamination of Mars inevitable, it is an issue that should be addressed explicitly and in advance -- before the momentum of our robotic exploration activities renders the debate over the protection of such a Martian biosphere moot.


## Acknowledgements

The ethical concerns associated with the biological contamination of climatically recurrent special regions were discussed extensively by the Committee on Preventing the Forward Contamination of Mars [4]. The views expressed here have their origins in that discussion.


## References:


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[6] NRC. 1999. A Science Strategy for the Exploration of Europa. National Academy Press, Washington, D.C.