THREE FACES OF MARTIAN DUST: DUST FOR COVER, DUST TO BREATHE, AND DUST EVERYWHERE J.A. Spry[1], J.D. Rummel[1], M.S. Race[1] and C.A. Conley[2], [1]SETI Institute, 189 N Bernardo Ave, Mountain View, CA94043 [2]NASA Headquarters, 300E St SW, Washington, DC20546

Introduction: In the human exploration of Mars, it is not expected for the endeavor to take place using completely sealed systems [1]. This means that interchange between the martian environment and the terran-like environments that the astronauts bring with them would be an inevitability. From a planetary protection perspective, the impact of atmospheric dust in this situation is threefold:

First, dust particles have the potential to cover Earth microbes, possibly for a long, long time, protecting them against UV irradiation [2].

Second, there is the possibility for dust with unknown toxicity to be inhaled or ingested by the crew, with similarly unknown potential for acute and chronic effects on their health status.

Third, the dust is everywhere and, similarly to Apollo [3] will represent a challenge for habitation exploration systems and act as a carrier (in and out) of microbial life, both Terran and Extraterrestrial (should there be any).

Planetary Protection as an Issue for Human Exploration: The international consensus goals for planetary protection in the Outer Space Treaty (to which all spacefaring nations are signatories) are expressed as: *"The conduct of scientific investigations of possible extraterrestrial life forms, precursors, and remnants must not be jeopardized. In addition, the Earth must be protected from the potential hazard posed by extraterrestrial matter carried by a spacecraft returning from another planet or other extraterrestrial sources"* [4].

While detailed approaches, implementations and requirements to achieve this are mature for robotic missions [5], only high-level guidelines are available for how planetary protection might be implemented on crewed missions. More information is needed before the following dust-related factors can be addressed in a planetary protection risk assessment, and adequate mitigations be identified and deployed.

Dust as a Shield: Several studies have concluded that the UVC fluence rates at the surface of Mars would rapidly kill unshielded microorganisms, even UV-resistant spores, reducing the exposed bioburden by several orders of magnitude on timescales ranging from minutes to hours [e.g., 6]. This finding holds true even on the undersides of spacecraft, but under protective layers of dust, spores could reamin almost indefinitely, waiting for conditions to change that would allow them to replicate. This could be due to dust deposition onto spacecraft hardware, or onto the martain surface where contaminant organisms had been released from a spacecraft hardware element or crewmember.

Dust to Breathe and Ingest: On the issue of astronaut health, it has to be considered what the impact of a ~500 day exposure to martian material would be. Based on the properties of dust we have seen displayed during robotic explorations [7] and the chemistry of the dust, some ingestion of perchlorates by astronauts would seem to be an extremely likely scenario. Goiter, caused by iodine depletion, is the most well-known ailment on Earth that might result from exposure to a perchlorate-rich environement like Mars. As well as swelling in the thyroid, it can also be responsible for fatigue, weight gain and depression in sufferers, with severe cases resulting in serious mental health problems, brain damage and death. As well as perchlorate, chemical constituents such as hexavalent chromium (or any other toxic trace contaminant) that may be present in the martian environment could cause illness that may be indistinguishable based on present information from effects of exposure to a martian organism. More data is needed about the chemical composition of martian dust.

Dust as an Environmental Constant:

For the Apollo crews dust was a significant contributor to equipment failures, even after stays of only a couple of days. [3] While the martian dust may not be as aggressive as lunar dust, there is still the threat of performance degradation over the time of a 500-day mission, affecting not only the exploration activity, but also the elevation of cross-contamination risk.

Dust can also be the vehicle for movement of microorganisms across the planet. A preliminary lab study by Mancinelli [8] indicated that microorganisms would be shielded by lofted dust. However, sufficient protection may only occur on relatively large lofted grains (~3-45 μm), rather than on the smaller grains (<~3 μm) that comprise large dust storms on Mars. Larger grains are not typically transported far from their source regions, so that locally-lifted particles may be the most important contribution to forward contamination. However, quantitation of these parameters (size and bioload of contaminated dusts) is needed before quantitative assessment of planetary protection risk can be made.

Conclusion: With current planning for human exploration of Mars goes a two-way contamination threat. First, there is the threat of dust contaminated by terrestrial organisms being released and dispersed in the martian environment. This threatens our ability to determine whether Mars has (or ever had) its own biosphere, and potentially compromises our ability to exploit Mars' natural resources, should they become contaminated. Next is the threat that astronauts, affected by the Mars environment, might be unable to ascertain whether their ailment is simply due to exposure to chemical irritants or due to exposure to an environmentally-encountered martian organism.

Mitigation of these threats comprises a multi-part solution. First, a significantly enhanced knowledge of the martian environment and its effects, particularly the dust environment, its chemistry and habitability is required. Second, a more complete understanding of the release, processes and fate affecting terrestrial biota introduced into the martian dust environment is required. Third, the performance requirements for the systems and operations of the mission architecture is needed to appropriately control the ingress and egress threat of martian and terrestrial material, respectively.

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