MARS ATMOSPHERIC DUST AS AN INADVERTENT CARRIER OF POTENTIAL MARS MICROORGANISMS BACK TO EARTH ON THE RETURN HUMAN MISSION.

J. S. Levine[1] and A. S. Levine[2]

[1]Department of Applied Science, William and Mary, Williamsburg, VA 23187 (jslevine@wm.edu).

[2]Long Duration Exposure Facility (LDEF) Project Office, NASA Langley Research Center, Hampton, VA 23669 (Retired) (ajlevine18@gmail.com).

Introduction: Mars is a dusty environment. Even the "clear" sky of Mars is never dust-free and the omni-present dust is responsible for the permanent pinkish/reddish color of its atmosphere. In addition, there are localized, regional and global dust storms. Viking Orbiter measurements were used to determine that during a localized dust storm near Solis Planum about 13 million metric tons of dust were lofted into the atmosphere and during a regional dust storm about 430 million metric tons of dust were lofted into the atmosphere [1]. More recently, estimates of the dust lofted into the atmosphere of Mars have also been determined using TES measurements: About 400 million metric tons of dust is globally transported into the atmosphere of Mars each year and the atmospheric dust settling on the surface of Mars produces a dust layer of about 50-100 micrometers [2].

The NASA Engineering and Safety Center (NESC) organized a Workshop on Dust in the Atmosphere of Mars and Its Impact on Human Exploration at the Lunar and Planetary Institute (LPI), Houston, TX., June 13-15, 2017. The findings and recommendations of the Mars Dust Workshop were summarized in a NASA/NESC Report [3] and papers presented at the Workshop appear in the workshop proceedings volume [4]. The Workshop recommendations were based on the three Workshop Panels (Panel 1: Mars Dust, Structure, Composition, Chemistry, Panel 2: The Impact of Mars Dust on Human Health and Panel 3: The Impact of Mars Dust on Surface Mechanical Systems and Surface Operations). The subjects of the three workshop panels were based on our earlier experience with lunar dust and its deleterious impact on human exploration during the Apollo missions. As the NASA Artemis return of humans to the Moon program was ramping up, the NESC organized a Workshop on Lunar Dust and Its Impact on Human Exploration at LPI, February 13-15, 2020, with a workshop report [5] and workshop proceedings volume [6].

The four "highest priority" NESC Mars Dust Workshop Recommendations [3] for future research are reproduced here.

R-1. *"The question of life in the atmospheric dust on Mars can and should be addressed via Mars Sample Return. Because the atmospheric dust is globally mixed, the return and analysis of a single dust sample would be sufficient for this purpose. Life detection measurements (e.g., the lab on a chip, etc.) should also be included on a future Mar rover to search for extant life in near-surface materials that would be disturbed by human activities causing potential contamination."* ***R-2.*** *"It is recommended that future Mars missions should include instrumentation to obtain missing toxicologically relevant in-situ measurements, preferably at multiple locations, and especially for respirable dust*

<10 microns for both regolith-based and wind-borne dust.” ***R-3.*** ***“****Mars sample return materials should be examined to provide information on the missing toxicology (R-2), either by direct studies on the native material or indirectly through use of returned samples to validate authentic simulants.”* ***R-4.*** ***“****Measure the size distribution and flux of the dust particles on the Martian surface in the ambient air, continuously for an extended period of time (multiple seasons), preferably on multiple platforms. A wide size range should be measured, from millimeter size downwards. Particularly important is the size range of 5nm–10μm.”*

Can potential Mars microorganisms survive a 9-month trip through interplanetary space from Mars to Earth? While this is not known, there have been some experiments to try to understand the survival of microorganisms in space. One such experiment was performed on the NASA Long Duration Exposure Facility (LDEF) in low Earth orbit for more than 6 years [7].

The LDEF “Long-term Survival of Bacteria in Space” and was conducted by G. Horneck, H. Bucker and G. Reitz [8]. In this experiment, spores of Bacillus subtilis monolayers (10^6/sample) or multilayers (10^8/sample) were exposed to the space environment for nearly six years and their survival was analyzed after retrieval. The experimenters found that if shielded against solar ultraviolet radiation, up to 80% of the spores in multilayers survived in space. They found that solar ultraviolet radiation, being the most deleterious parameter of space, reduced survival by 4 orders of magnitude or more. However, up to 10^4 viable spores were still recovered. The experimenters concluded that their 6-year LDEF study in space added to the discussion of the likelihood of “Panspermia”. However, we must remember that the LDEF “Long-term Survival of Bacteria in Space” experiment was in Low Earth Orbit for 6 years, not the interplanetary medium between Mars to Earth. Recent papers have reviewed the impact of the space environment on microbial growth [9] and Mars planetary protection (forward and backward) for human missions [10].

References: [1] Martin, T. Z. (1995) *JGR*, 100, 7509-7512 DOI: 10.1029/95JE00414[. 2] Lopez-Cayuela, M. A., M.-P. Zorzano, J. L. Guerro-Rascado and C. Cordoba-Jabonero (2024*) Icarus* 409, 115854, DOI: 10.1016/j.icarus.2023.115854. [3] Winterhalter, D, J. S. Levine and R. Kerschmann (2018*) The Dust in the Atmosphere of Mars and Its Impact on the Human Exploration of Mars: A NESC Workshop*, NASA/TM-2018-220084, 35 pages. [4] Levine, J. S., D. Winterhalter and R. Kerschmann (2018*) Dust in the Atmosphere of Mars and Its Impact on Human Exploration*, Cambridge Scholars Publishing, UK, 293 pages. [5] Winterhalter, D, J. S. Levine and R. Kerschmann (2020) *Lunar Dust and Its Impact on Human Exploration: A NASA Engineering and Safety Center (NESC) Workshop*, NASA/TM-2020-5008219, 45 pages. [6] Levine, J. S. (2021) *The Impact of Lunar Dust on Human Exploration*, Cambridge Scholars Publishing, UK, 285 pages. [7] Kinard, W., R. O’Neal, B. Wilson, J. Jones, A. Levine, and R. Calloway (1994) *Advances in Space Research*, 14, 10, 7-16 DOI: 10.1016/0273-1177(94)90444-8. [8] Horneck, G., H. Bucker and G. Reitz (1994) *Advances in Space Research*, 14, 10, 41-45 DOI: 10.1016/0273-11779(94)90448-0. [9] Urbaniak, C., D. Tesei and R. Van Houdt (2024) *Frontiers in Microbiology* DOI: 10.3389/fmicb.2024.1390100. [10] Spry, J. A. et al. (2024) *Astrobiology*, 24, 3, 230-274 DOI: 10.1089/ast.2023.0092.