THE IMPORTANCE OF PRIMARY MARTIAN SURFACE AND AIRFALL DUST SAMPLE RETURN FOR TOXICOLOGICAL HAZARD EVALUATIONS FOR HUMAN EXPLORATION. A. D. Harrington and F. M. McCubbin, Astromaterials Research and Exploration Sciences (ARES) Division, NASA Johnson Space Center, 2101 NASA Parkway Mail Code XI2, Houston TX 77058, Andrea.D.Harrington@NASA.gov.

Introduction: Manned missions to the Moon highlight a major hazard for future human exploration of the Moon and beyond: surface dust. Not only did the dust cause mechanical and structural integrity issues with the suits, the dust 'storm' generated upon reentrance into the crew cabin caused "lunar hay fever" and "almost blindness [1-3]". It was further reported that the allergic response to the dust worsened with each exposure [4]. Due to the prevalence of these high exposures, the Human Research Roadmap developed by NASA identifies the *Risk of Adverse Health and Performance Effects of Celestial Dust Exposure* as an area of concern [5]. Extended human exploration will further increase the probability of inadvertent and repeated exposures to celestial dusts. Going forward, hazard assessments of celestial dusts will be determined through sample return efforts prior to astronaut deployment.

Lunar samples returned by the Apollo missions are the most toxicologically evaluated celestial dust samples on Earth. Studies on the lunar highland regolith indicate that the dust is not only respirable but also reactive [2, 6-9] and moderately toxic, generating a greater pulmonary response than titanium oxide but a lower response than quartz [6]. However, there is actually little data related to physicochemical characteristics of particulates and cardiopulmonary toxicity, especially as it relates to celestial dust exposure.

Broad Toxicological Evaluations of Meteorites. Studies investigating the role of a particulate's innate geochemical features (e.g., bulk chemistry, internal composition, morphology, size, and reactivity) in generating adverse toxicological responses *in vitro* and *in vivo* are underway [10]. The highly interdisciplinary studies focus on the relative toxicity of six meteorite samples representing either basalt or regolith breccia on the surfaces of the Moon, Mars, and Asteroid 4Vesta. Notably, the martian meteorites generated two of the greatest acute pulmonary inflammatory responses (API) but only the basaltic sample is significantly reactive geochemically. Furthermore, while there is no direct correlation between a particle's ability to generate ROS acellularly and its ability to generate API, assorted API markers did demonstrate strong positive correlations with Fenton metal content and the ratio of Fenton metals to silicon [10].

The Necessity of Sample Return for Permissible Exposure Limit Determination. Although the mitigation of risk associated with broad toxicological human hazard assessments is vital to the process, the determination of permissible exposure limits (PELs) is the essential next step. Without these limits, the astronauts are at risk of overexposure which could lead to negative health outcomes and compromise both the mission and all of the astronaut's lives.

Based on broad toxicological assessments of an array of celestial dusts, relatively small differences in geochemistry can lead to significant differences in cardiopulmonary inflammation [10]. Given this, it is crucial to determine the PELs utilizing samples of the actual dust astronauts will be exposed. In the case of human exploration of Mars, these samples are in the form of surface regolith dusts and airfall samples. Differences in chemistry, formation, and weathering preclude the use of ground core samples for PEL determination.

Although geophysicochemical features have been the focus of toxicological evaluations of celestial dusts, the presence of biological organisms is an even greater risk to human health. In fact, the presence of extant life within returned samples is such a concern that no PELs will be able to be determined based on geophysicochemical features until the dust is found to be sterile. Given this, it is important to not only bring back samples of surface and airfall dust but also to ensure the samples are pristine (e.g. free of terrestrial contamination and unaltered due to sample collection, caching, and return procedures).

Conclusions: Toxicological evaluations demonstrate statistical differences in cardiopulmonary responses upon exposure to celestial basalt and regolith samples [10]. These differences highlight the need to perform future toxicological evaluations (e.g. PELs) on primary martian surface and airfall dust samples in order to allow for the proper evaluation of risk to human health.

References: [1] Armstrong A.E. and Collins M. (1969) *NASA JSC, 81*. [2] Cain, J.R. (2010) *Earth Moon and Planets, 107*, 107-125. [3] Sheenan T. (1975) *JSC-09432*. [4] Scheuring T. et al. (2008) *Acta Astronautica, 63*, 980-987. [5] Scully R.R. et al. (2015) *HRP SHFH Element*. [6] Lam C.W. et al. (2013) *Inhal Tox., 25*, 661-678. [7] Lam C.W. et al. (2002) *Inhal Tox., 14*, 917-928. [8] Lam C.W. et al. (2002) *Inhal Tox., 14*, 901-916. [9] McKay D.S. et al. (2015) *Acta Astronautica, 107*, 163-176. [10] Harrington A.D. et al (2016) SOT 2016, Abstract# 2254.