View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by NASA Technical Reports Server

PULMONARY INFLAMMATORY RESPONSES TO ACUTE METEORITE DUST EXPOSURES – IMPLICATIONS FOR HUMAN SPACE EXPLORATION

A.D. Harrington[1,2,3], F.M. McCubbin[1], K.E. Vander Kaaden[4], J. Kaur[3], A. Smirnov[3,5], K. Galdanes[2], M.A.A. Schoonen[3,6], L.C. Chen[2], S.E. Tsirka[3], and T. Gordon[2] [1]NASA JSC. [2]NYU School of Medicine. [3]Stony Brook University. [4]Jacobs, NASA JSC. [5]Lone Star College. [6]Brookhaven National Laboratory.

New initiatives to begin Lunar and Martian human surface operations within the next few decades are illustrative of the resurgence of interest in human space exploration. However, as with all exploration, there are risks. The previous 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].

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]. The presence of reactive oxygen species (ROS) on the surface of the dust is implicated as the potential cause of the pulmonary inflammation [10,11]. However, there is actually little data related to physicochemical characteristics of particulates and cardiopulmonary toxicity, especially as it relates to celestial dust exposure.

As a direct response to this deficit, the present study evaluates the role of a particulate's innate geochemical features (e.g., bulk chemistry, internal composition, morphology, size, and reactivity) in generating adverse toxicological responses. This highly interdisciplinary study evaluates the relative toxicity of six meteorite samples representing either basalt or regolith breccia on the surface of the Moon, Mars, and Asteroid 4Vesta. Terrestrial mid-ocean ridge basalt (MORB) is also used for comparison. All material is fully characterized and evaluated for geochemical reactivity (e.g. iron solubility and acellular reactive oxygen species (ROS) generation). Both *in vitro* and *in vivo* toxicological techniques are used to determine the cardiopulmonary inflammation caused by acute exposure.

The MORB demonstrated higher geochemical reactivity than most of the meteorite samples but caused the lowest acute pulmonary inflammation (API). Notably, the two Martian meteorites generated some of the highest API but only the basaltic sample is significantly reactive geochemically. Furthermore, while there is a correlation between a meteorite's soluble iron content and its ability to generate acellular ROS, there is no direct correlation between a particle's ability to generate ROS acellularly and its ability to generate API. However, assorted *in vivo* API markers did demonstrate strong positive correlations with Fenton metal content and the ratio of Fenton metals to silicon.

In summary, this comprehensive dataset allows for not only the toxicological evaluation of celestial materials but also clarifies important correlations between geochemistry and health. Furthermore, the utilization of an array of celestial samples from Moon, Mars, and asteroid 4Vesta enabled the development of a geochemical based toxicological hazard model that can be used for: 1) mission planning, 2) rapid risk assessment in cases of unexpected exposures, and 3) evaluation of the efficacy of various *in situ* techniques in gauging surface dust toxicity.

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] Vallyathan V. et al. (1998) *Environ. Health Perspect., 106 Suppl 5*, 1151-1155. [11] Harrington A.D. (2010) *Geochem Trans 13.*