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

A.D. Harrington1,2,3, F.M. McCubbin1, K.E. Vander Kaaden4, J. Kaur3, A. Smirnov3,5, K. Galdanes2, M.A.A. Schoonen1,6, L.C. Chen5, S.E. Tsirka7, and T. Gordon2

1Astromaterials Research and Exploration Sciences (ARES) Division, NASA Johnson Space Center, 2101 NASA Parkway Mail Code XI2, Houston TX 77058, Andrea.D.Harrington@NASA.gov. Dept. of Environmental Medicine, New York University School of Medicine. 3Dept. of Geosciences, Stony Brook University. 4Jacobs Technology, NASA Johnson Space Center. 5Geology Dept., Lone Star College. 6Environmental Sciences Dept., Brookhaven National Laboratory. 7Pharmacological Sciences, Stony Brook University.

INTRODUCTION

New initiatives to send humans to Mars within the next few decades are illustrative of the resurgence of interest in space travel. However, as with all exploration, there are risks. 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 [1]. Extended human exploration will further increase the probability of inadvertent and repeated exposures to celestial dusts.

EXPERIMENTAL STRATEGY

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, or Asteroid 4Vesta. Terrestrial mid-ocean ridge basalt (MORB) is also used for comparison. Since there is actually little data related to physicochemical characteristics of particulates and pulmonary toxicity, especially as it relates to celestial dust exposure, all dust samples are 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 pulmonary inflammation caused by acute exposure.

RESULTS

The MORB demonstrated higher geochemical reactivity than most of the meteorite samples but caused the lowest acute pulmonary inflammation (API) (Table 1). 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 acellually 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.

CONCLUSIONS

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


Table 1. Sample Data Comparison to MORB

<table>
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<th>Sample</th>
<th>Iron①</th>
<th>H2O2②</th>
<th>ISR③</th>
<th>PMNs④</th>
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①Iron leached from dust in simulated lung fluid after 8 days
②H2O2 formed in water after 25 minutes
③Cellular ISR at 24 hours post exposure only
④Polymorphonuclear leukocytes (PMNs) infiltration in bronchoalveolar lavage fluid (BALF)