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

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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 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.

Table 1. Sample Data Comparison to MORB

Sample	Iron[a]	H_2O_2[b]	ISR[c]	PMNs[d]
	% of MORB			
Tissint	83	208	618	163
NWA 7034	20	4	318	132
NWA 4734	30	83	246	172
NWA 7611	2	28	145	128
Berthoud	20	11	180	106
NWA 2060	19	53	174	120

[a] Iron leached from dust in simulated lung fluid after 8 days
[b] H_2O_2 formed in water after 25 minutes
[c] Cellular ISR at 24 hours post exposure only
[d] Polymorphonuclear leukocytes (PMNs) infiltration in bronchoalveolar lavage fluid (BALF)

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

[1] Scully R.R. et al. (2015) *HRP SHFH Element*.