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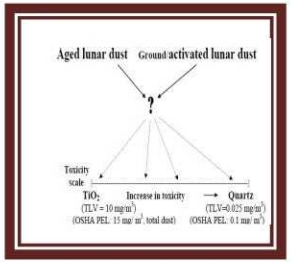
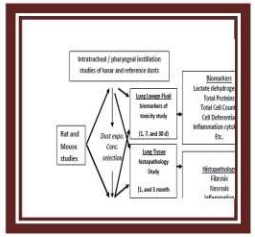
TOXICITY OF LUNAR DUST IN LUNGS ASSESSED BY EXAMINING BIOMARKERS IN EXPOSED MICE

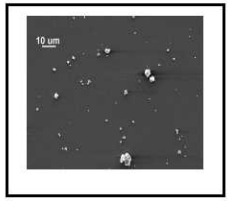
C.-W. Lam[1,2], J. T. James[1], P. C. Zeidler-Erdely[3], V. Castranova[3], S. H. Young[3], C.L. Quan[1,4], N. Khan-Mayberry[1], and L. A. Taylor[5]
[1]Toxicology Laboratory, NASA Johnson Space Center, [2]Wyle, Houston, TX; [3]HELD, National Institute for Occupational Safety and Health, Morgantown, WV; [4]USRA, Houston, TX; and [5]Planetary Geosciences Institute, University of Tennessee, Knoxville, TN.

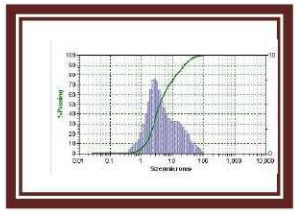
ABSTRACT AND BACKGROUND

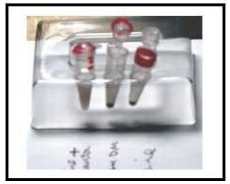


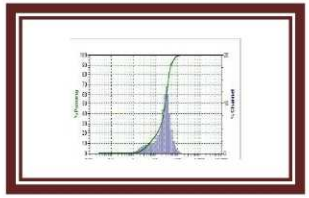


MATERIALS AND METHODS









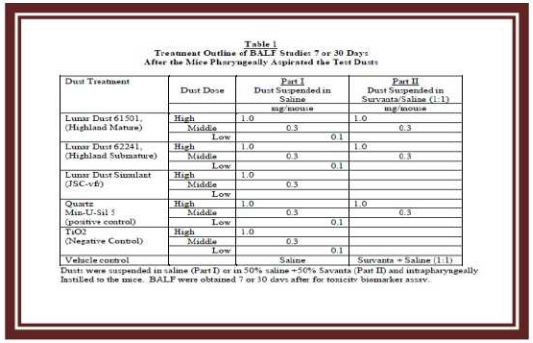
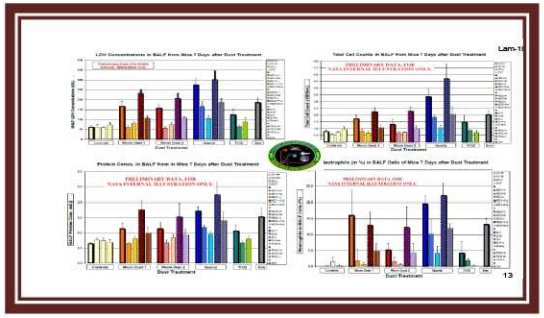
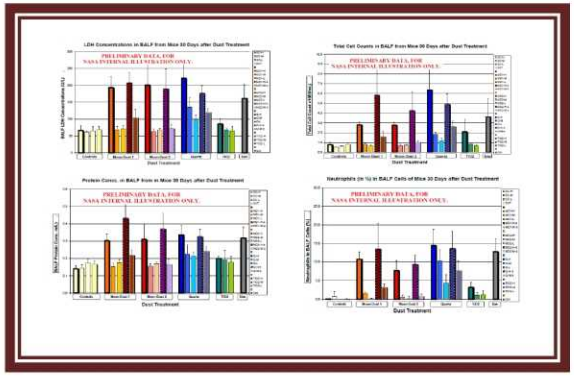


Table 1
Treatment Outline of BALF Studies: 7 or 30 Days
After the Mice Pharyngeally Aspirated the Test Dusts

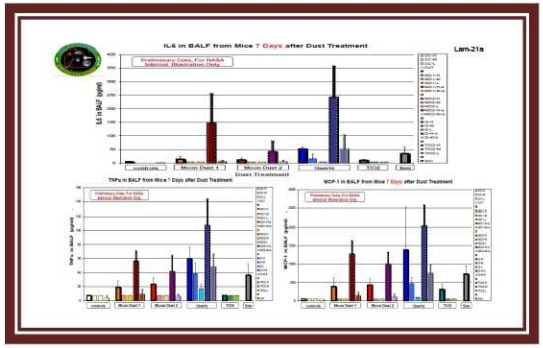
Dust Treatment	Dust Dose	Part I Dust Suspended in Saline mg/mouse	Part II Dust Suspended in Survanta/Saline (1:1) mg/mouse
Lunar Dust 61501, (Highland Matsue)	High	1.0	1.0
	Middle	0.3	0.3
	Low	0.1	
Lunar Dust 62241, (Highland Submature)	High	1.0	1.0
	Middle	0.3	0.3
	Low	0.1	
Lunar Dust Simulant (JSC-vf)	High	1.0	
	Middle	0.3	
	Low		
Quartz Min-U-Sil 5 (positive control)	High	1.0	1.0
	Middle	0.3	0.3
	Low	0.1	
TiO2 (Negative Control)	High	1.0	
	Middle	0.3	
	Low	0.1	
Vehicle control		Saline	Survanta + Saline (1:1)

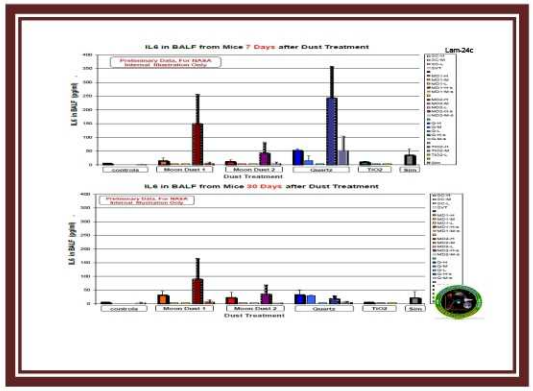
Dusts were suspended in saline (Part I) or in 50% saline +50% Savanta (Part II) and intrapharyngeally instilled to the mice. BALF were obtained 7 or 30 days after for toxicity biomarker assay.





RESULTS AND CONCLUSIONS





ABSTRACT

NASA is contemplating to build an outpost on the Moon for prolonged human habitation and research. The lunar surface is covered by a layer of soil, of which the finest portion is highly reactive dust. Dust samples of respirable sizes were aerodynamically isolated from two lunar soil samples of different maturities (cosmic exposure ages) collected during the Apollo 16 mission. The lunar dust samples, TiO_2, or quartz, suspended in normal saline were given to groups of 5 C57 male mice by intrapharyngeal aspiration at 0.1, 0.3, or 1.0 mg/mouse. Because lunar dust aggregates rapidly in aqueous media, some tests were conducted with dusts suspended in Survanta/saline (1:1). The mice were euthanized 7 or 30 days later, and their lungs were lavaged to assess the presence of toxicity biomarkers in bronchioalveolar lavage fluids. The overall results showed that the two lunar dust samples were similar in toxicity; they were more toxic than TiO_2, but less toxic than quartz. This preliminary study is a part of the large study to obtain data for setting exposure limits for astronauts living on the Moon (Fig. 1 and 2).

MATERIALS AND METHODS

Animals: C57 male mice (~10 week old), 5 per test group

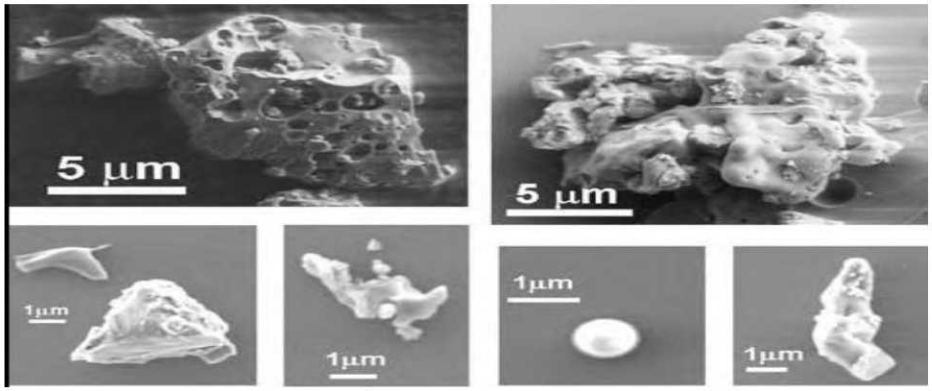
Materials: Apollo 16 sample #61501 (highland mature regolith; Moon Dust 1)
Apollo 16 Sample #62401 (highland sub-mature regolith; Moon dust 2)
Lunar dust simulant (JSC-vfr; an Arizona volcanic ash)
Quartz (Min-U-Sil 5)
TiO_2 (Rutile R-100, a DuPont Product)
Dispersant: saline (Experiment I); Survanta/saline [1:1] (Experiment II)

Procedures: Intrapharyngeal instillation (pharyngeal aspiration)
Bronchioalveolar lavage (BAL) 7d or 30 days after instillation
Assays: LDH activity, total protein concentration, total cell-counts,
cell deferential, and cytokines in BAL fluids.

RESULTS AND CONCLUSION

- **Lunar dust particles aggregated rapidly in aqueous media (Fig. 4-6). They can be satisfactorily suspended in Survanta/saline mixture (Fig. 4, left panel).**
- **The toxicity of both lunar dust samples is similar (Fig. 7-10).**
- **Lunar dust suspended in 1:1 Survanta/saline appeared to be more toxic than that in saline alone in the 7-day study; however, the difference was not apparent in the 30-day study (Fig. 7-10).**
- **The overall results show the following relative toxicity:**

  Saline < TiO2 < lunar dust< lunar dust simulant < quartz.



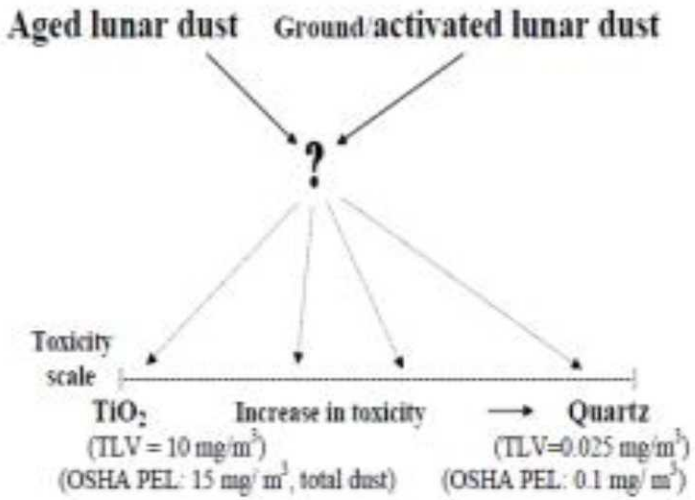


Fig. 1. Comparative pulmonary toxicity study of lunar dust with reference dusts in rats by intratracheal instillation.

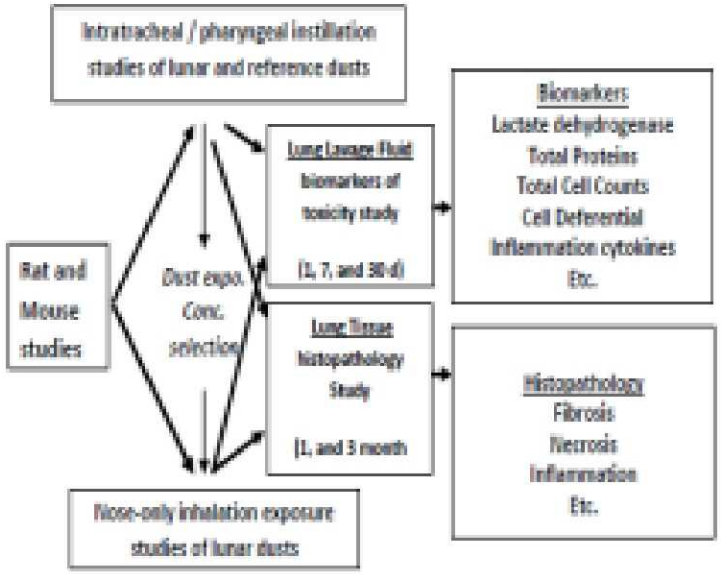


Fig. 2. Outline of toxicity studies with lunar dusts in rodents.

Table 1
Treatment Outline of BALF Studies 7 or 30 Days After the Mice Pharyngeally Aspirated the Test Dusts

Dust Treatment	Dust Dose	Part I Dust Suspended in Saline	Part II Dust Suspended in Survanta/Saline (1:1)
		mg/mouse	mg/mouse
Lunar Dust 61501, (Highland Mature)	High	1.0	1.0
	Middle	0.3	0.3
	Low	0.1	
Lunar Dust 62241, (Highland Submature)	High	1.0	1.0
	Middle	0.3	0.3
		0.1	
Lunar Dust Simulant (JSC-vfr)	High	1.0	
	Middle	0.3	
Quartz Min-U-Sil 5 (positive control)	High	1.0	1.0
	Middle	0.3	0.3
	Low	0.1	
TiO2 (Negative Control)	High	1.0	
	Middle	0.3	
	Low	0.1	
Vehicle control		Saline	Survanta + Saline (1:1)

Dusts were suspended in saline (Experiment I) or in 1:1 Savanta/saline (Experiment II) and intrapharyngeally instilled in mice. BALF were obtained 7 or 30 days later for toxicity biomarker assessment.

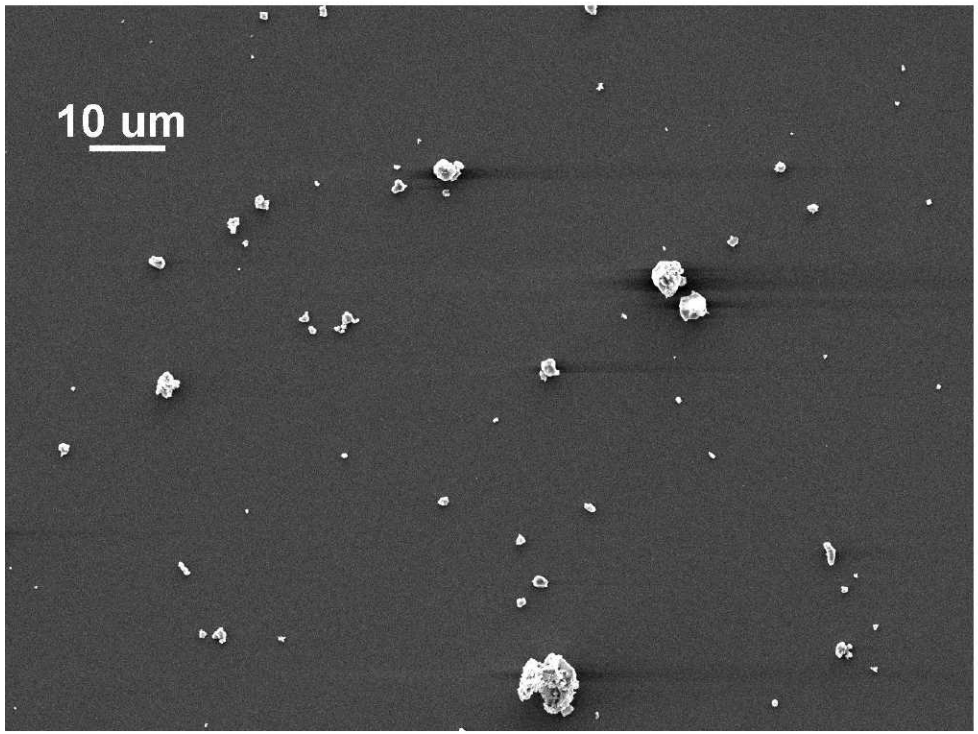


Fig. 3. Particle size of fine respirable dust prepared aerodynamically from Apollo 16 lunar regolith sample #62401. The dust had a mass median diameter <2 μm (determined in dry state).

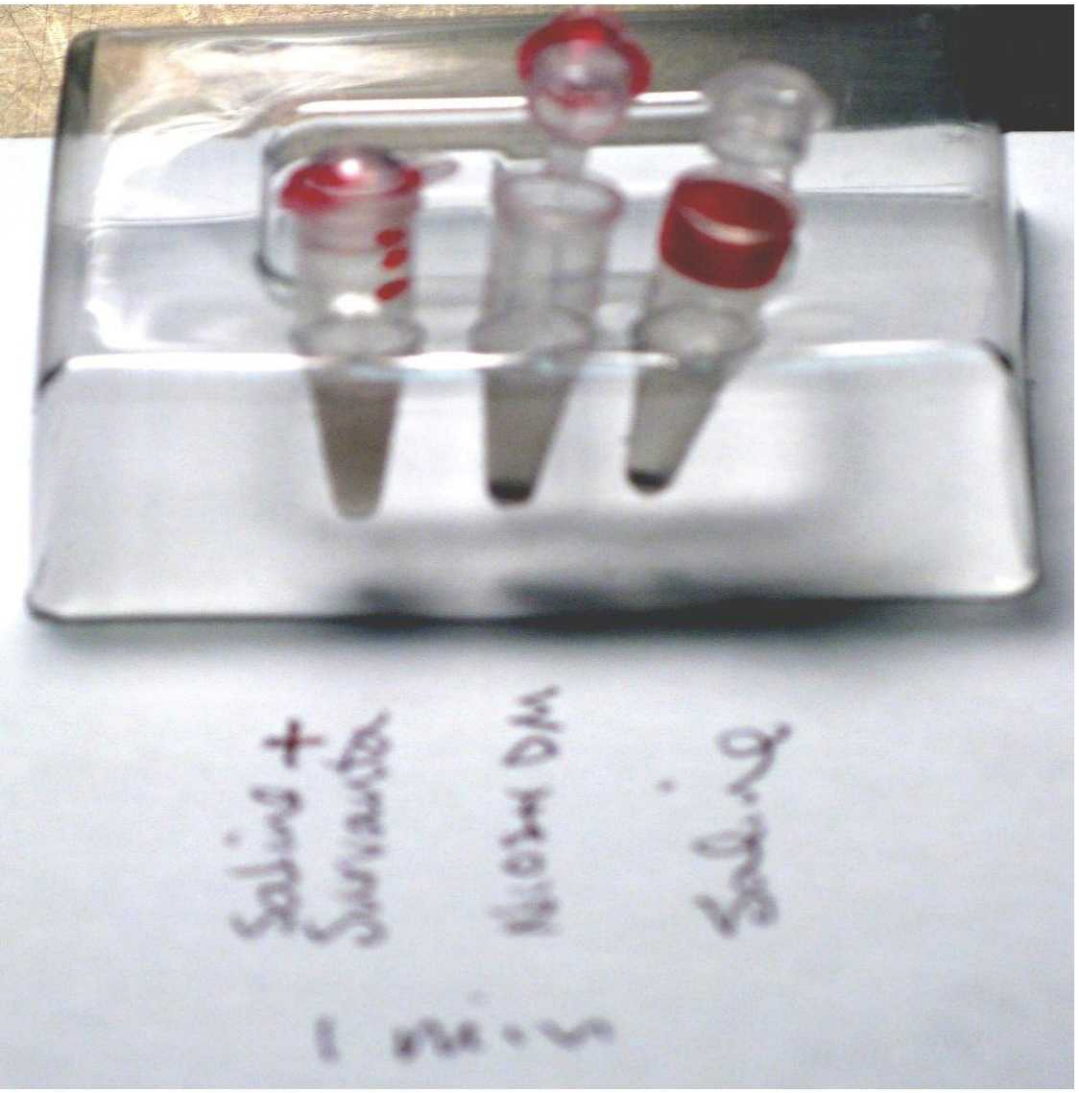


Fig. 4. Fine lunar dust samples aggregated and precipitated rapidly (center and right) aqueous media, but can be satisfactorily suspended in 1:1 Survanta/saline mixture (left).

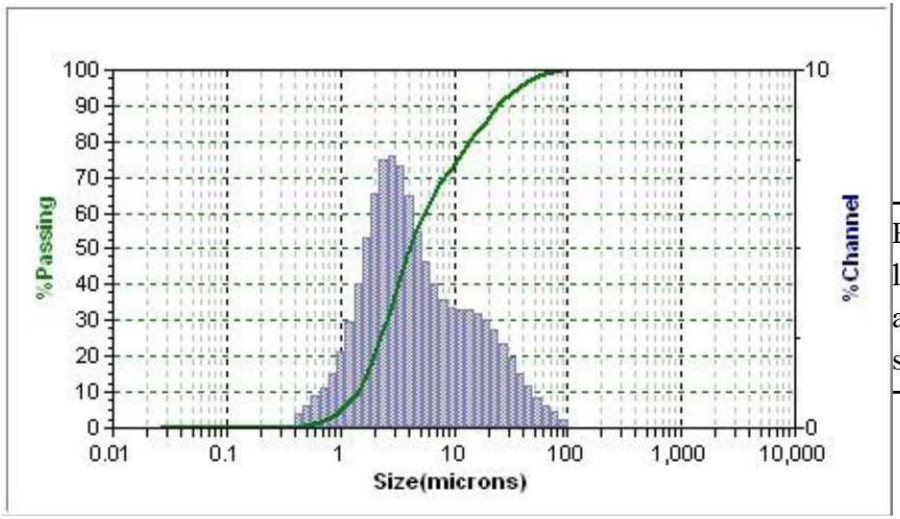


Fig. 5. The graph shows the particle size distribution of lunar dust sample #62401 in saline. Some large dust aggregates had been formed in the freshly-prepared suspension. The dry dust had a mass median diameter <2

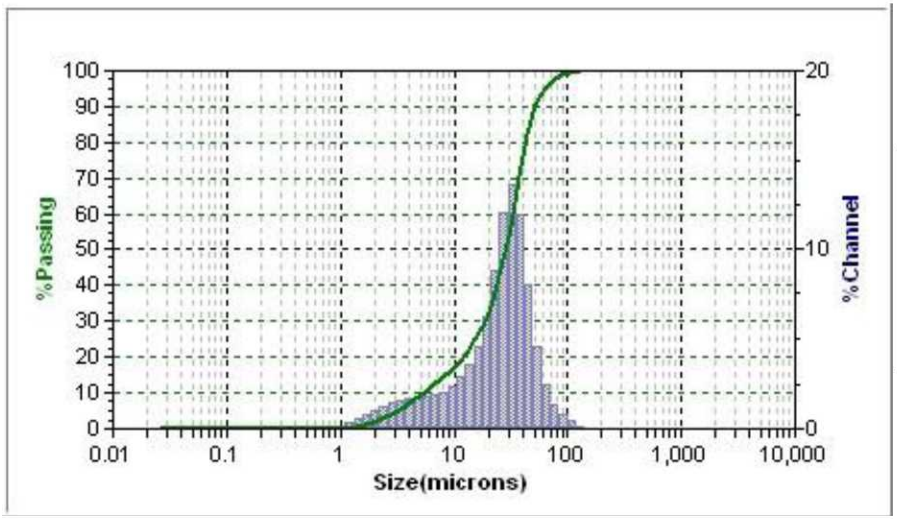


Fig. 6. The graph shows the particle size distribution of lunar dust in saline determined several hours after the suspension was prepared; it also shows that the majority of the particles/aggregates is non-respirable in size.

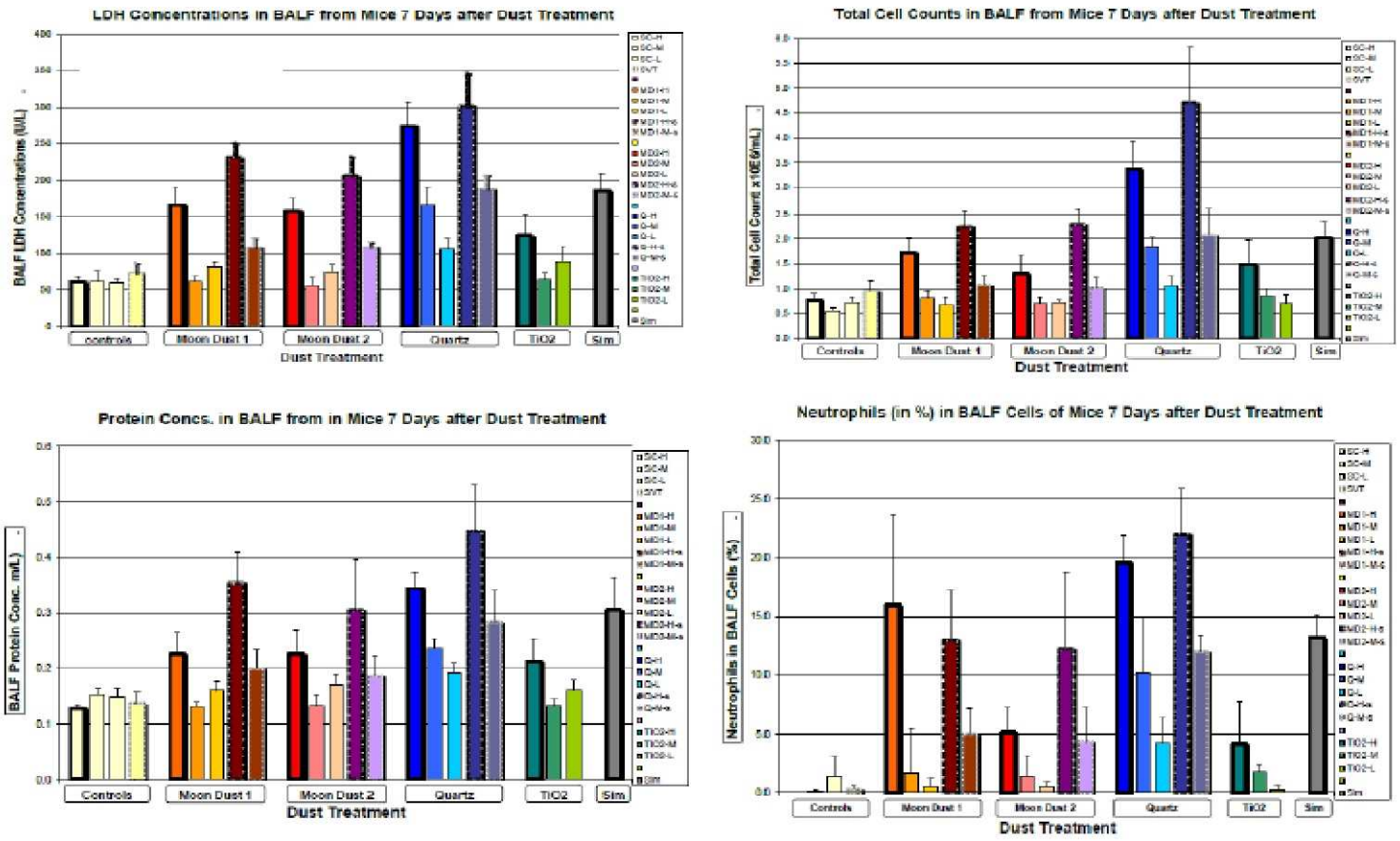


Fig. 7. BALF biomarkers of toxicity were assessed in mice 7 days after pharyngeal aspiration of suspensions of lunar dust samples and reference dusts (quartz and TiO_2). The labels for the lunar dust samples and quartz (left to right) are: high, middle, and low doses in saline; high and middle doses in Survanta.

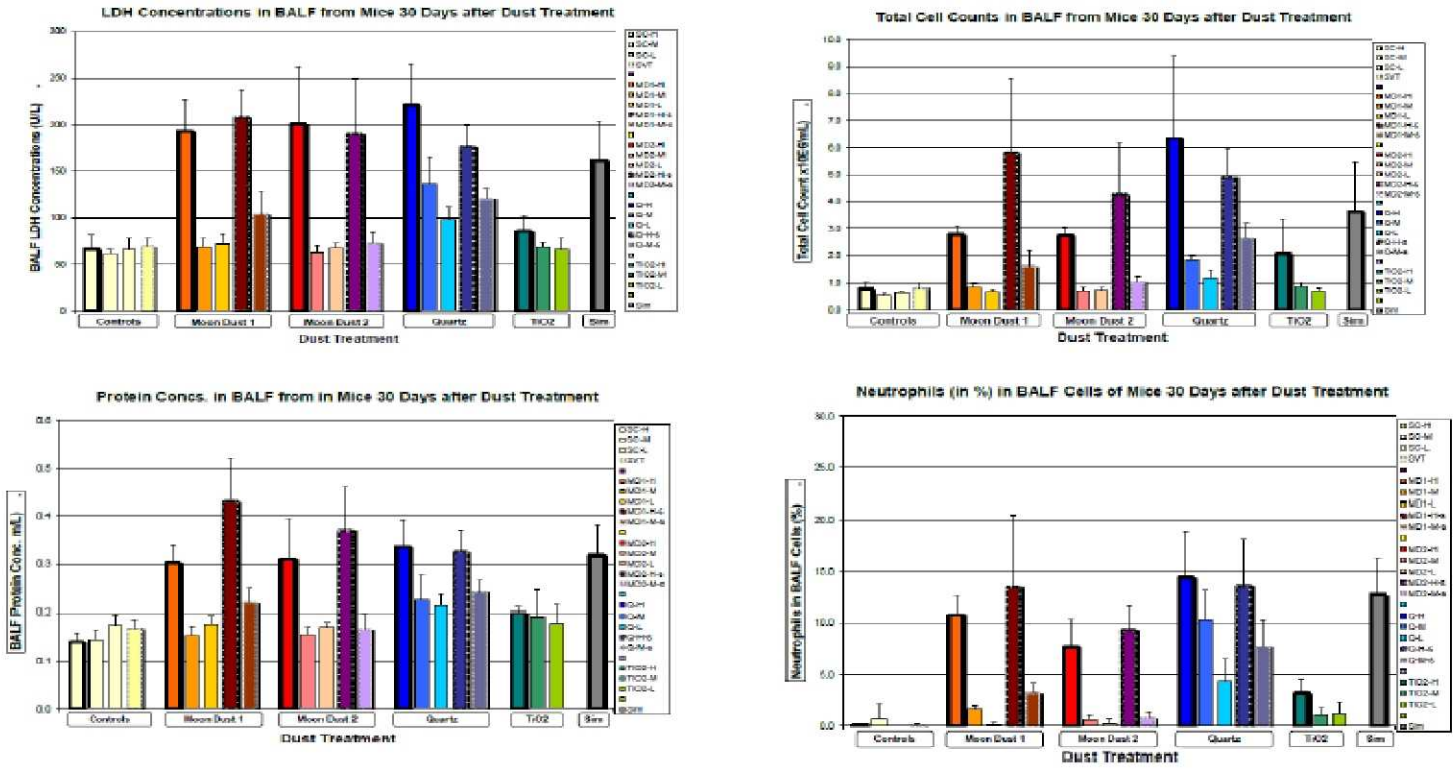


Fig. 8. BALF biomarkers of toxicity were assessed in mice 30 days after pharyngeal aspiration of suspensions of lunar dust samples and reference dusts (quartz and TiO_2). The labels for the lunar dust samples and quartz (left to right): high, middle, and low doses in saline; high and middle doses in Survanta.

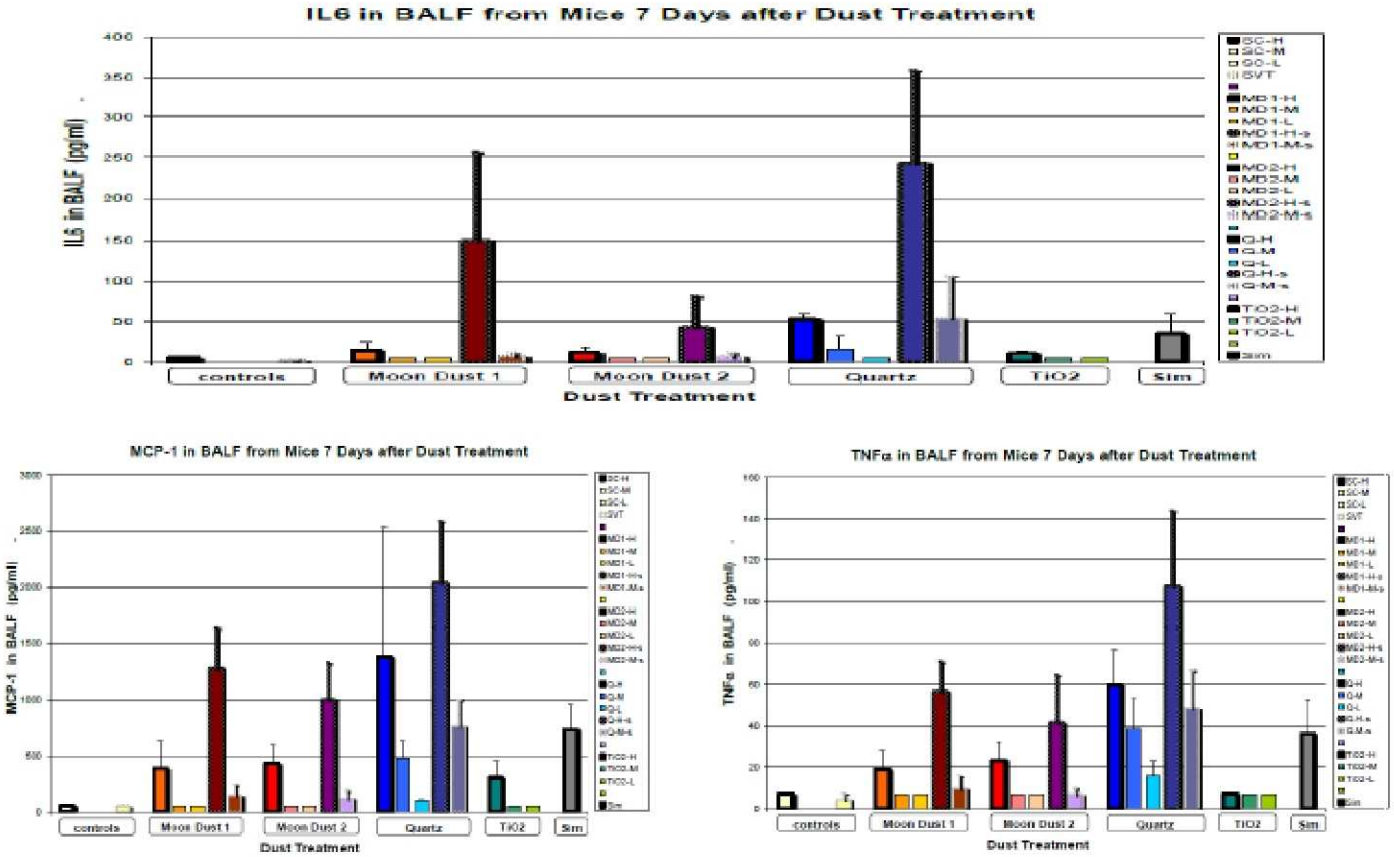


Fig. 9. Cytokines in BALF samples were assessed in mice 7 days after pharyngeal aspiration of suspensions of lunar dust samples and reference dusts (quartz and TiO_2). The labels for the lunar dust samples and quartz (left to right): high, middle, and low doses in saline; high and middle doses in Survanta.

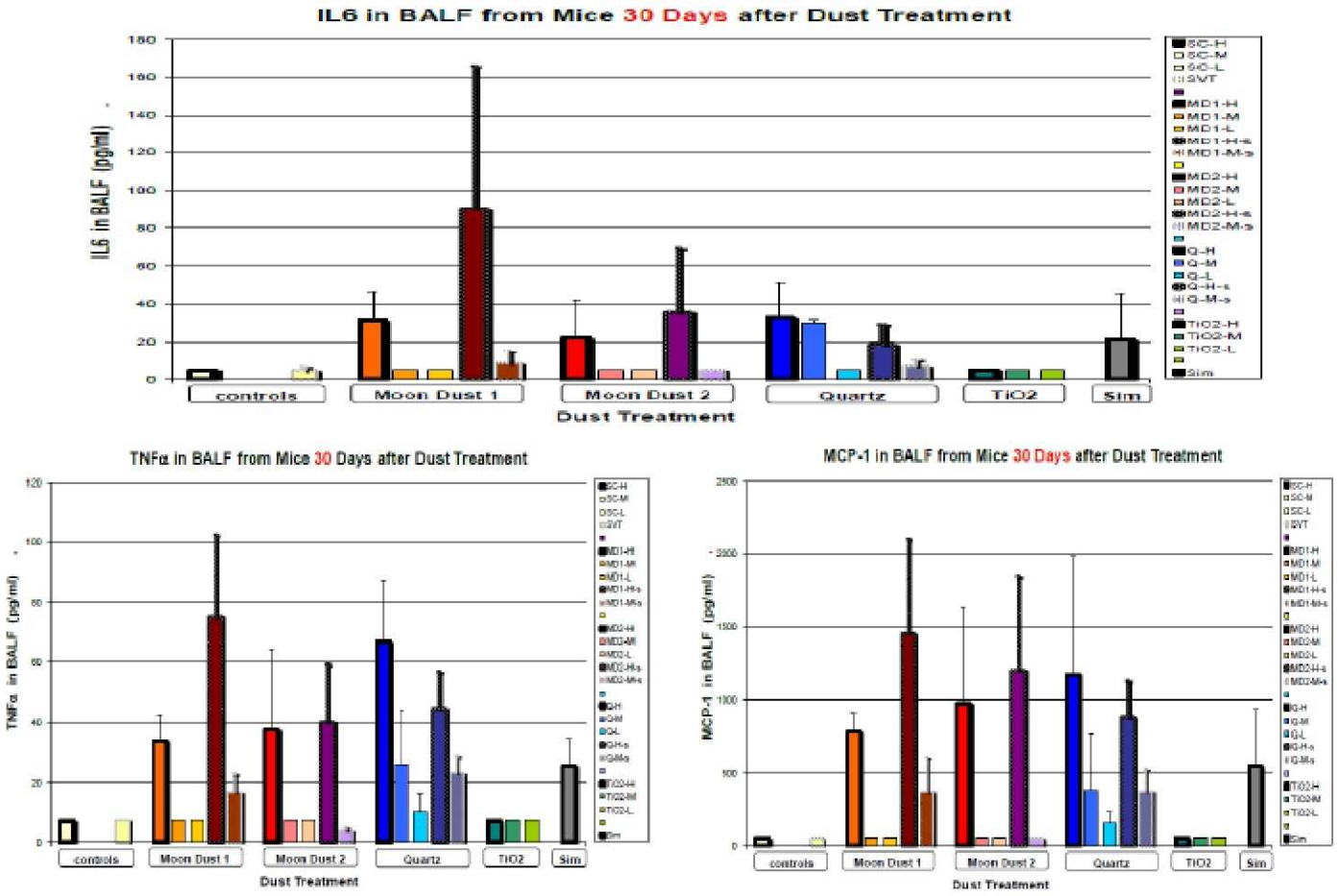


Fig. 10. Cytokines in BALF samples were assessed in mice 7 days after pharyngeal aspiration of suspensions of lunar dust samples and reference dusts (quartz and TiO_2). The labels for the lunar dust samples and quartz (left to right): high, middle, and low doses in saline; high and middle doses in Survanta.