Fiscal Year:	FY 2010	**Task Last Updated:**	FY 12/16/2009
PI Name:	James, John T. Ph.D.		
Project Title:	LADTAG Lunar Dust Health Standard		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Environmental health		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **SHFH**:Space Human Factors & Habitability (archival in 2017)		
Human Research Program Risks:	(1) **Dust**:Risk of Adverse Health and Performance Effects of Celestial Dust Exposure (2) **Medical Conditions**:Risk of Adverse Health Outcomes and Decrements in Performance Due to Medical Conditions that occur in Mission, as well as Long Term Health Outcomes Due to Mission Exposures (3) **Renal Stone**:Risk of Renal Stone Formation		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	77058	**Congressional District:**	22
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	Directed Research
Start Date:	10/02/2006	**End Date:**	09/30/2013
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 9/30/2013 per PI (Ed., 8/17/2012) NOTE: End date changed to 8/7/2012 per HRP SMO information (Ed., 12/14/2011) NOTE: End date changed to 9/30/2011 per HRP SMO information (Ed., 10/14/2011) NOTE: Start/end dates changed to 10/2/2006-12/31/2010 (previously 4/30/2006-1/31/2011) per B. Woolford/JSC via S. Steinberg-Wright/JSC (9/2009)		
Key Personnel Changes/Previous PI:	none		
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Grant/Contract No.:	Directed Research		

Performance Goal No.:

Performance Goal Text:

Task Description:

Although there were a few early attempts to understand the toxicity of lunar dust obtained by Apollo astronauts or the Lunar probes, no scientifically defensible toxicological studies have been performed on authentic lunar dust. The multi-center LADTAG (Lunar Airborne Dust Toxicology Advisory Group) was formed and responded to a request from the Office of the Chief Health and Medical Office (OCHMO) to develop recommendations for defining risk criteria for human lunar dust exposure, and then set an environmental standard. The Lunar Airborne Dust Toxicology Advisory Group (LADTAG), chaired by Dr. John T. James, NASA's Agency Toxicologist & Dr. Russell L. Kerschmann, ARC Space Life Science Division Chief & board certified pathologist, formed a world class group of technical experts in lunar geology, inhalation toxicology, biomedicine, cellular chemistry and biology from within the agency along with the nations' leading external experts in these fields. Based upon LADTAG's recommendations, NASA decided to develop a research database on which a defensible exposure limit can be set. Lunar Dust Toxicity Research Project's analysis of lunar dusts and lunar dust simulants will include detailed particle characterizations (size distribution, morphology, and mineralogy, determining the properties of particle activation (degree of reactivity and persistence of reactivity), determining how to reactivate lunar dust, the process of dust passivation and discerning the pathological mechanisms of lunar dust exposure via inhalation, intratracheal instillation, cell culture exposure, dermal exposure and ocular exposure. The resulting set of health standards will be time-based and will vary by the duration and type of exposure. It may also be necessary to set multiple standards for different types of lunar dust, as well as, for dust in its fresh or activated state vs. aged and passivated dust Development of time-based standards, acute exposure limits, exposures of a few hours, and chronic exposure limits, episodic exposures up to six months, for inhalation (pulmonary) toxicity and human risk criteria will be developed no later than 2010. LDTRP does not rule out the development of setting other (non pulmonary) standards and human health risk criteria, for dermal and ocular exposure, contingent upon research findings of non-airborne dust toxicity studies.

Rationale for HRP Directed Research:

This research is directed because it contains highly constrained research, which requires focused and constrained data gathering and analysis that is more appropriately obtained through a non-competitive proposal.

Research Impact/Earth Benefits:

Improved understanding of the pulmonary toxicity of mineral dusts.

Task Progress:

The Lunar Airborne Dust Toxicity Assessment Group (LADTAG) consists of toxicologists, chemists, physicians, astronauts, and geologists from two NASA field centers and from outside the agency. The project research team is embedded in this group. Our research goal is to develop a toxicity database sufficient to support a defensible exposure standard for lunar dust. The primary focus is a dust inhalation standard; however, secondary goals include insight into the hazards posed by entry of the dust into the eye or abrasiveness to the skin. The group was chartered in September 2005, and in November, 2005 the NASA Chief Health and Medical Officer asked the LADTAG to assess the risk from lunar dust exposure and to develop a permissible exposure standard. The group has met five times since the charter meeting: February 2006, December 2006, November 2007, April 2009, and November 2009.
The work of the researchers has not only been reviewed by LADTAG experts outside the agency, it has also been reviewed by the Institute of Medicine, an expert Non-Advocate Review (NAR) Panel, and by and expert Standing Review Panel (SRP). These reviews, and the opinions that developed from them, have originated outside the agency. The NASA research team has responded to the expert opinions, and has adjusted its research plan accordingly.

One of the most difficult problems associated with this project is to determine the best way to activate the surfaces of lunar dust and characterize the persistence of that activation. Chemically reactive dusts are known to be more toxic, and the dust originally returned on Apollo missions has presumably lost its surface reactivity due to traces of oxygen in the preservation gas [1]. Using primarily mineral coupons [2], stimulant dust [3,4], but also tiny amounts of authentic lunar dust [1,3], we have examined activation by proton bombardment (simulates solar wind), UV irradiation (solar flux), and by mechanical grinding (simulates effect of meteorite impacts). Our research to date points to mechanical damage during meteorite impact as the dominate means of surface activation; however, our conclusions are not final. The chemical index of activation has been either changes in the Raman spectrum [2] or detection of the hydroxyl radical by a terephthalate assay [1,5]. The persistence of induced chemical reactivity seems to be of the order of a few hours in an environment that would sustain life [1,2].

A key aspect of dust toxicity is the particle size distribution. We have investigated the chemical composition and size distribution of dust that was returned in Apollo sample containers [6,7], performed size-distribution studies of dust trapped in the fabric of Apollo-era spacesuits [8], and investigated the size distribution of dust from Apollo samples taken from the top surface layer of dust on the moon [9]. Together these results suggest that a considerable portion of the dust that enters the lunar habitat will be in the respirable range, and will contain dust in the ultrafine to nano-size range (0.1 to 0.01 microns). Dust in this size range can be much more toxic than an equivalent mass of larger dust particles of the same chemical composition. Additionally, the presence of reduced iron particles ("nano-iron") has been characterized because it is a major feature of lunar dust [6] and the presence of iron can increase the toxicity of dust.

Toxicity investigations in mice using intratracheal instillation of two lunar dust specimens have been completed in cooperation with scientists at the National Institute of Occupational Safety and Health. Preliminary data suggest that the lunar dust samples were only slightly more capable of eliciting toxic effects than TiO_2, which is regarded as a non-toxic dust. These were not dusts that had been activated by any of the above procedures. One discovery during this research was that authentic lunar dust is extremely difficult to suspend in an aqueous medium. Solutions designed to mimic lung surfactant (the fluid lining the lungs) were much better at suspending the dust particles. Some of these data and a plan for integrating these findings with those from inhalation studies have been published [10]. The inhalation studies will depend on dry extraction of dust particles in the respirable size range from larger Apollo samples. We have obtained 260 g of lunar dust returned by Apollo, and are perfecting a procedure to dry-fractionate it to a size that is respirable [11]. Part of the remaining dust of larger size will be ground in an inert atmosphere to a respirable size (activated) and used in the inhalation studies.

Studies of the dermal abrasiveness of non-respirable-sized lunar dust to excised pig skin are in progress [12]. Ocular studies are in the planning stage with in vitro or ex vivo testing to precede any in vivo testing, probably according to long-accepted guidelines from the OECD (Organization for Economic Development and Cooperation).

References

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Articles in Peer-reviewed Journals	Taylor LA, Pieters CM, Patchen A, Taylor DHS, Morris RV, Keller LP, McKay DS. "Mineralogical and chemical characterization of lunar highland soils: insights into the space weathering of soils on airless bodies." Journal of Geophysical Research-Planets, http://dx.doi.org/10.1029/2009JE003427 , in press, December 2009. , Dec-2009
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