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What is Lunar Regolith?

Apollo 11 is the culmination of a series of missions that allow the development of necessary space techniques, spacecraft and a giant launcher as well as the recognition of landing sites on the Moon.

It is the third manned mission to approach the Moon, after Apollo 8 and

Apollo 10, and the fifth crewed mission of the Apollo program.

The spacecraft carrying the crew was launched from the Kennedy Space Center on July 16, 1969 by the giant Saturn V rocket developed for this program.

It carries a crew made up of Neil Armstrong, mission commander and pilot of the lunar module, of Buzz Aldrin, who accompanies Armstrong on the lunar ground, and of Michael Collins, pilot of the command and service module which will remain in lunar orbit.

Armstrong and Aldrin, after a landing with a few twists and turns, spent 21 hours and 36 minutes on the surface of the Moon and made a unique spacewalk lasting 2 hours and 31 minutes.

After taking off and making an appointment in lunar orbit with the command and service module, the Apollo spacecraft returns to Earth and docks without incident in the Pacific Ocean after a mission that has lasted 8 days, 3 hours and 18 minutes.

During this mission: 21.7 kilograms of rock and lunar soil are collected and several scientific instruments are installed on the surface of our satellite.

Although the scientific objective of Apollo 11 was limited by the length of the stay on the Moon and the reduced carrying capacity of the spacecraft used, the mission provides substantial results.

Its development, in particular the first steps on the Moon filmed by a video camera and retransmitted live, constitute an event followed on the whole planet in Mondovision by hundreds of millions of people.

Once astronauts reached the surface, they reported that the fine moon dust stuck to their spacesuits and then dusted the inside of the lunar lander.

The astronauts also claimed that it got into their eyes, making them red.

And worse, even got into their lungs, giving them coughs.

Lunar dust is very abrasive, and has been noted for its ability to wear down spacesuits and electronics.

The reason for this is because lunar regolith is sharp and jagged.

This is due to the fact that the Moon has no atmosphere or flowing water on it, and hence no natural weathering process.

When the micro-meteoroids slammed into the surface and created all the particles, there was no process for wearing down its sharp edges.

The term lunar soil is often used interchangeably with lunar regolith, but some have argued that the term soil is not correct because it is defined as having organic content.

However, standard usage among lunar scientists tends to ignore that distinction.

Lunar dust is also used, but mainly to refer to even finer materials than lunar soil.

Previous missions to the lunar surface implicated potential dangers of lunar soil.

In future explorations, astronauts may spend weeks or months on the Moon, increasing the risk of inhaling lunar dust.

In an effort to understand the biological impact of lunar regolith, cell cultures derived from lung or neuronal cells were challenged with lunar soil simulants to assess cell survival and genotoxicity.

Lunar soil simulants were capable of causing cell death and DNA damage in neuronal and lung cell lines, and freshly crushed lunar soil simulants were more effective at causing cell death and DNA damage than were simulants as received from the supplier.

The ability of the simulants to generate reactive oxygen species in aqueous suspensions was not correlated with their cytotoxic or genotoxic affects.

Furthermore, the cytotoxicity was not correlated with the accumulation of detectable DNA lesions.

These results determine that lunar soil simulants are, with variable

activity, cytotoxic and genotoxic to both neuronal and lung-derived cells in culture.

Lunar dust adhering to their suits caused mild respiratory issues for Apollo astronauts returning from the Moon.

Chronic or long-term effects of such dust exposure could be a problem for future missions.

We assessed the cellular effects of exposure to terrestrial materials produced to mimic some aspects of lunar dust (simulants)

We found significant cell toxicity in neuronal and lung cell lines in culture, as well as DNA damage associated with the exposure.

Unexpectedly, these effects did not reflect the ability of the simulants to generate free radicals.

One aspect of the lunar environment that warrants more study in preparation for human exploration is the lunar regolith or soil.

Lunar soil is affected by a combination of processes that include micrometeorite impacts and the resulting agglutination, as well as exposure to the solar wind (Heiken et al., 1992)

There are important differences between the lunar and terrestrial environments that affect the surface material.

The Moon has no liquid component in the soil, so water-containing minerals, such as clay or mica, are not present (Heiken et al., 1992)

The lack of lunar atmosphere also allows the Moon's surface to be perpetually bombarded by solar wind.

The constant chemical reduction that results from this exposure causes the lunar soil to become electrostatically charged.

This charge can be so strong that the soil particles actually levitate above the lunar surface (Colwell et al., 2007; Stubbs et al., 2005)

When astronauts visited the Moon during the Apollo missions, the electrostatically charged lunar soil clung to their spacesuits, such that lunar dust was carried into the living environment by astronauts who had been exploring the lunar surface (Gaier, 2007)

Astronaut Harrison Schmitt described his reaction to lunar dust as lunar hay fever, including sneezing, watering eyes, and sore throat (Wagner, 2006)

Lunar dust in the lunar exploration module represents a potential biological hazard to astronauts, with particles of 5–10 µm capable of accumulating in the central airways and smaller particles, 0.5–5 µm, infiltrating the alveoli (Jabbal et al., 2017; Mckay et al., 2015)

A study in rats revealed that exposure to lunar soil led to a concentration-dependent increase in lung inflammation and cytotoxicity over the course of 13 weeks (Lam et al., 2013)

Additionally, there is evidence from rats that the smaller particles (≤0.1 µm) can be transported through the olfactory bulb into the brain (Oberdörster et al., 2004)

However, it is not known how deep into human brains the inhaled lunar dust might infiltrate (Oberdörster et al., 2005)

From terrestrial studies, we understand some of the risks of breathing toxic dust. The most relevant situations occur following occupational or environmental exposure.

For example, people who were exposed to volcanic ash after the eruption of Mt. St. Helens in 1980 suffered acute effects including bronchitis, wheezing, and eye irritation (Baxter et al., 1983)

Those with chronic lung diseases such as asthma and emphysema were disproportionately affected (Baxter et al., 1983)

A study involving the lungs of rats exposed to ashes from Arizona lava fields showed that they exhibited chronic inflammation, septal thickening, and fibrosis (Lam et al., 2002)

Furthermore, workers in the mining industry are repeatedly exposed to dust from recently uncovered mineral deposits.

A common outcome of this exposure is silicosis, a disease that develops from long-term exposure to crystalline silica (Rimal et al., 2005)

Silicosis is a potentially fatal disease, caused by silica dust particles embedded in the alveolar sacs, resulting in shortness of breath with lung irritation and in progressive fibrosis (Rimal et al., 2005)

There is also an accumulating body of evidence on the detrimental effects of particulate matter in the brain.

However, due to the inaccessibility of the brain, concrete conclusions about these effects can be difficult to obtain.

General inflammation is one result, as seen in the brains of mice exposed to airborne particles, which developed neuronal inflammation, including the increased expression of the inflammatory cytokines IL-1α, TNFα, and NFκB (Campbell et al., 2005).

DNA damage resulting from dust exposure has been less well studied but is an aspect of possible long-term significance to human health.

DNA damage can be both short-term and long-term problems, and it can affect both the nuclear and the mitochondrial genome.

Mutations in nuclear DNA may lead to cell death or cancer, and these endpoints are not mutually exclusive
(Roos & Kaina, 2013; Roos et al., 2016), because dying cells can signal to neighboring cells to promote cell division
(Labi & Erlacher, 2015)

Failure to repair the mitochondrial DNA is associated with neurodegenerative disorders (Cha et al., 2015)

In an animal study, rats exposed to particles isolated from air pollution developed nuclear DNA mutations in their sperm (Yauk et al., 2008)

For the human A549 lung cell line, treatment with various particulate materials caused DNA strand breaks and activated caspase-9, an enzyme released from mitochondria in a process of cell death (Upadhyay et al., 2003)

Due to the scarcity of lunar soil available for research, lunar soil simulants are used as a substitute (Colwell et al., 2007)

The simulants are designed to mimic various aspects of lunar soil.

This project uses five lunar soil simulants and two control particulate materials.

The simulants in this set were generated to mimic different types of lunar soil with distinctive compositions.

Chemically reactive simulants are categorized here as those that generate reactive oxygen species (ROS)

Among other mechanisms, ROS may be formed by metals exposed at surface defects in the soil particles that interact with oxygen when exposed to aqueous solutions (Turci et al., 2015)

However, even some simulants selected for their physical characteristics may indirectly generate ROS in cells by triggering an inflammatory response upon contact with the cells (Sena & Chandel, 2012)

Clearly, avoidance of lunar dust inhalation will be important for future explorers, but with increased human activity on the Moon it is likely that adventitious exposure will occur, particularly for individuals spending long periods of time on that body.

A detailed understanding of the health effects of lunar dust exposure is thus important, and further defining the cellular and biological impact of materials from various parts of the lunar surface is warranted.

It will be critical to study actual lunar regolith samples for their effects on cell function and the integrity of the cellular DNA.

In 1969, NASA completed the Apollo 11 mission, landing a man with a Camera on the Moon for the first time, this was a ground breaking moment in human history and technology.

Hasselblad was involved in researching and producing a Moon Camera for the mission, which was called the Hasselblad Space Electric Data Camera EDC, The Space Camera.

This camera is a tailored version, adapted from the Hasselblad 500EL with a few modifications.

These include being stripped of its traditional leather covering, the mount for viewfinder, the mirror and secondary shutter, and adding a magazine for loading 70mm film in open spool with a wire handle attaching to the dark slide.

The first camera in space was also a Hasselblad, the Hasselblad 500C, with a planar 80mm lens, was the first Hasselblad camera to be used by NASA in space.

It was purchased by the astronaut Walter M. Schirra from a camera shop in Houston, Texas prior to take off.

Its not surprising that the Hassalblad was the first camera ready for an out of this world experience , they were and still are unmatched on build quality.

Modifications by NASA technicians were further refined and incorporated into new models by Hasselblad.

For example,the development of a 70mm magazine was accelerated to meet the space program.

The first modified (in fact simplified) Hasselblad 500C cameras were used on the last two Project Mercury missions in 1962 and 1963.

They continued to be used throughout the Gemini spaceflights in 1965 and 1966.

A general program of reliability and safety was implemented following the Apollo 1 fire in 1967, addressing such issues as safe operation of electrical equipment in a high-oxygen environment.

EL electric cameras were introduced for the first time on Apollo 8, a heavily modified 500 EL, the so called Hasselblad Electric Camera (HEC) was used from Apollo 8 on board the spacecraft.

Three 500EL cameras were carried on Apollo 11 these were the precursor to the extensively modified Hasselblad EL Data Camera (EDC), equipped with a special Zeiss 5.6/60 mm Biogon lens and film magazines for 150–200 exposures, which were used on the moon surface on the Apollo 11 missions.

If you would like one of these cameras and haven’t got $50-100,000 lying around there is a way, apparently the Astronauts left one camera on the Moon to shed weight before they journeyed back to Earth!

Update

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