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Subject: FW: Interview for SPACE.com - Moondust

Attachments: Interview for Space-dot-com article.doc

From: David Powell [mailto:freelancedavidpowell@fsmail.net]
Sent: Tue 12/4/2007 3:52 PM
To: Metzger, Philip T. (KSC)
Subject: RE: Interview for SPACE.com - Moondust

Dear Dr Metzger,

Thank you for agreeing to answer my questions, please find them listed below.

To what velocity would the Lunar Module (LM) descent engine have propelled lunar dust particles?

What sized particles were propelled by the engine and how far do you estimate they travelled?

What were the effects on the Surveyor 3 lander from the Apollo 12 LM landing and are the effects of the dust visible on the pieces of the Surveyor returned to Earth?

Could some of the micro craters seen on Apollo samples have been created by the LM engine?

What damage would the dust kicked up by a LM engine do to a space-suited astronaut nearby? Would it jam up machinery?

Could dust propelled laterally from small impacts also cause similar problems if the ejecta travelled many miles?

How will future lunar bases or colonies combat the problem of sandblasting by rocket driven dust?

Thank you for your time.

Many thanks,

David

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Philip T. Metzger, Ph.D.
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==
From: David Powell [mailto:freelancedavidpowell@fsmail.net]
Sent: Sat 12/1/2007 4:14 PM
To: Metzger, Philip T. (KSC)
Subject: Interview for SPACE.com - Moondust

Dear Dr Metzger,

My name is David Powell, I've been comissioned by SPACE.com to do a story on your work regarding Moondust being accelerated by craft landing on the Moon.

Would I be able to email you a few questions on the subject?

Please let me know if you can assist.

Thank you for your time.

Best wishes,

David Powell

[winmail.dat (5.7 Kb)]

Interview questions posed to Phillip Metzger (NASA KSC) by freelance writer David Powell for a story to be published on SPACE.com

To what velocity would the Lunar Module (LM) descent engine have propelled lunar dust particles?

We are not completely sure, yet, because it depends on some details of the flow dynamics that have not been completely solved. However, the velocities could have been as high as nearly escape velocity for the Moon (2.4 km/sec), and as a lower-estimate they were almost certainly as high as 1 km/sec.

What sized particles were propelled by the engine and how far do you estimate they traveled?

The smallest particles were dust-sized (roughly 10 microns), and they were seen by the Apollo astronauts to fly right out over the horizon and keep on going. Depending on the actual velocity they may have gone halfway around the Moon or more. In most cases, however, they would only travel until they hit a natural terrain feature, such as a crater rim or a mountain range.

The largest particles that were moved may have been gravel-sized or small rocks. We actually do see some rocks as large as 10-15 cm being rolled along the surface in the Apollo landing videos. Larger particles do not get accelerated to as high a velocity and as a result they will impact at various distances, the larger particles falling closer to the landing site and the smaller particles falling farther away. You would expect some impacts at all distances, sorted by particle size and velocity.

The intermediate-sized particles, which caused the micro-craters on the Surveyor hardware, were probably in the 60 micron size range (which is approximately the size particle that constitutes the largest fraction of mass in the lunar soil). These particles are predicted to have been traveling about 600 meters per second when the lunar Module was near touchdown, or somewhat slower when the Lunar Module was higher above the surface. The estimated velocity from looking at the size of the craters was about 400 meters per second, so the theory and the estimates from actual damage are in as good agreement as could be expected so far.

What were the effects on the Surveyor 3 lander from the Apollo 12 LM landing and are the effects of the dust visible on the pieces of the Surveyor returned to Earth?

There were basically three different effects noted on the Surveyor 3 hardware, discussed below. These effects were identified after the hardware was returned to Earth. The analysis was performed at the Johnson Space Center and by several researchers around the country. I suggest you contact David McKay, who was one of the scientists who performed that research, and who still works at the Johnson Space Center. Currently, some physicists at the Kennedy Space Center are funded to re-analyze some of the hardware using the more modern evaluation techniques that are available today. We believe we can get more information about the particle sizes and velocities using these newer techniques, compared to what was possible more than 30 years ago.

First, there were what looked like permanent shadows cast into the Surveyor. This was because the cosmic radiation in the lunar environment had darkened the surface of the Surveyor materials, and then the spray of fine dust from the Apollo 12 Lunar Module removed that darkening wherever the spray could reach. However, there were some areas that were protected from the spray by the protruding heads of bolts or other hardware, and so the darkening was not cleaned off in those areas. Those remaining dark areas are the permanent "shadows" that can still be seen today. This effect was probably caused by the finest dust, in the 10 micron size range, because these particles represent the majority of the surface area in the lunar soil and hence caused the majority of the surface "scrubbing" upon impact. They point out the problem that future assets on the Moon might be damaged by this dust-scouring if the hardware has reflective surfaces, optical coatings, or other sensitive surface treatments.

The second effect seen on the Surveyor was the existence of hundreds of micro-craters, in the tens of microns size-range. These tiny impacts were caused by the larger, more massive particles (probably in the 60 micron range), which represent the majority of the mass in the lunar soil. The problem with micro-craters is that it could damage sensitive optics, solar cell coatings, radiator surfaces, etc. The paint on the Surveyor camera shroud was also fractured in a mud-cracking pattern (random polygon-shapes formed by the cracks). Each intersection of cracks was at the location where a tiny particle had impacted the paint, drilling a tiny cylindrical hole down into the paint and causing the fractures to spread out from there like spider-legs in a car windshield. This points out how the high-velocity dust impacts can ruin paint or other surface treatments on hardware. It may not be so important to protect hardware against one exposure to this spray, but in a lunar outpost the hardware will be subjected to dozens of spray events, and so the damage would be cumulative.

The third effect seen on the Surveyor was the delivery of dust onto surfaces and into mechanical joints and crevices. When the support collar was removed from the Surveyor camera, a small sample of soil and dust particles were found inside, where they had been injected through a small inspection hole that happened to be facing in the direction of the Lunar Module. The future problem we must address is that wheels or fluid connectors or other mechanical joints may become filled with dust and jammed, or fail to move due to the increasing friction, when the highly abrasive particles are injected into small crevices.

Could some of the micro craters seen on Apollo samples have been created by the LM engine?

There were two populations of micro craters seen on the Surveyor, those that were the result of the Surveyor itself (on the bottom side of landing gear struts) and those caused by the Apollo engines.

I have not assessed whether either the Surveyor or the Apollo engine could have affected the lunar samples (rocks) brought back to Earth. Generally, impacts seen on lunar samples are hyper-velocity impacts whereas the lander-induced impacts are slower than hyper-velocity. The two types of impacts produce different crater morphologies. Hyper-velocity impacts involve vaporization and melting of material in the impact site, whereas engine-induced impacts are too slow to vaporize or melt material, and so they only break and shear the material mechanically in the impact site. As a result, investigators can tell the difference. In fact, this is partly how we knew that the micro-craters on the Surveyor were caused by engine plumes rather than natural events. The micro-craters were not hypervelocity impacts.

I would suggest speaking to David McKay or another lunar geologist to discuss hypervelocity impact craters seen on the lunar samples.

What damage would the dust kicked up by a LM engine do to a space-suited astronaut nearby? Would it jam up machinery?

I have not studied what a 1000 mps impact of a sand grain could do to a space suit. As a minimum, it could cloud up their vision through the helmet, and jam any quick disconnects for fluid transfer into and out of the suit. As discussed above, the impacts definitely could jam up machinery if enough particulates are injected into a critical mechanical joint that is exposed to the spray.

Could dust propelled laterally from small impacts also cause similar problems if the ejecta traveled many miles?

Natural impacts are very rare over a human-timescale, so I think the main answer is that it is not considered a high risk to lunar exploration. In general, though, the answer is "yes". If you happened to be on the Moon when an impact occurred within striking distance of the secondary impacts, then the results could be as bad as or possibly much worse than a rocket landing. The difference is that much larger material might be ejected at high velocity from an impact event than would be ejected by the exhaust gas from a rocket engine.

How will future lunar bases or colonies combat the problem of sandblasting by rocket driven dust?

We are currently investigating several different techniques. One idea is to use the natural terrain to block the spray between the landing site and the lunar outpost. Another idea is to use the lunar excavator to create an artificial terrain feature – a berm – around part of the landing site to block the spray in the crucial directions. It may also be possible to modify the landing surface to prevent the spray altogether. There are a number of researchers who are inventing different methods to do this.