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Water on the Moon?

SETI THURSDAY

By Brad Dalton
Carl Sagan Center, SETI Institute
posted: 05 June 2008
06:59 am ET

Recent headlines have announced a raging controversy among scientists about whether there is actually water ice in the permanently shadowed craters near the lunar poles. Because these permanently shadowed regions are extremely cold (~100K) water ice is expected to be stable there – even in the vacuum of space. If water is present, it will dramatically reduce the cost of a lunar base. The Lunar Crater Observing and Sensing Satellite (LCROSS) mission is intended to test for this water by [impacting the lunar surface](#) with its empty rocket upper stage, and looking for water in the ejected plume.

At issue is the evidence for water ice from neutron counts and radar observations of the polar regions. In the mid-1990s, Earth-based radar observations of the polar regions detected areas of higher circular polarization ratio (CPR). This is the ratio of the reflected radar signal having the same circular polarization as the incident beam to the reflected signal having the opposite polarization. High values of CPR tend to indicate blocky, irregular surfaces such as boulder-strewn fields or crater ejecta, but can also result from low-loss scattering by water ice entrained in smoother surface material such as soil or regolith. Large rocks and boulders mixed into the regolith also can have a distinct signature. The high CPRs detected at the lunar poles seemed to correlate with crater floors in these regions, where geometry and orbital mechanics conspire to produce permanently shadowed regions. This effect has been observed on Mercury, where permanently shadowed craters exhibit CPRs which resemble those from the icy Galilean satellites. The radar results for the moon were thus interpreted to be due to similar effects.

The neutron detector on Lunar Prospector subsequently found low counts of epithermal neutrons over the polar regions as well, which are typically indicative of hydrogen. However, it is not clear whether this is hydrogen in the form of pure water (H₂O), hydroxyl (OH⁻, likely bound to minerals), or hydrogen (H⁺) implanted by the solar wind. If the hydrogen is in the form of H₂O or OH⁻ bound to minerals, it could still be useful, but extraction will be more difficult and costly.

The current controversy centers around recent radar observations at higher resolution than the previous studies. These observations show high CPR's in crater walls and floors, but they are not correlated with the permanently shadowed regions. They are correlated with the rocky surfaces and ejecta blankets around young craters, and with the inner walls of some of the larger craters. They definitely do not indicate large deposits of pure ice — there are no skating rinks on the Moon, as one scientist put it. And the neutron studies detect hydrogen, not water — so there are other ways to explain those results too. The results also depend on how much solar wind

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Artist's rendition of Centaur upper stage rocket approaching the moon with the Lunar Crater Observing and Sensing Satellite (LCROSS), "shepherding satellite," attached. Credit: NASA/Roger Arno

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Artist's rendition of the 4,400-pound (2,000-kilogram) Centaur upper stage rocket hitting the moon's surface near the south pole. The impact with the moon is expected to excavate about 220 tons (200 metric tons) of material from the lunar surface. The LCROSS shepherding satellite will observe the plume of material with a suite of six instruments to look for water ice and examine lunar soil kicked up by the impact. Credit: NASA/Roger Arno

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implanted hydrogen is assumed to be present, as well as the exact locations and sizes of the permanently shadowed regions — which aren't actually very well known, since we cannot see them all from Earth. The two areas where the shadowed regions are best constrained are within the craters [Shackleton and Shoemaker](#).

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Water ice remains consistent with the neutron studies, but only in concentrations of around 0.4 to 1 percent by weight, as small chunks mixed into the regolith. Or, if the ice is trapped in small pores in the soil minerals, it could be as much as 10 to 20 percent. Surface roughness and neutron counts both vary on spatial scales much smaller than the instruments can resolve, creating additional uncertainty. So the interpretation depends on certain assumptions, and can vary — it is still consistent with water ice mixed into the soil, and possibly even large amounts, but more likely very small amounts, if any at all.

The LCROSS mission is being optimized for 0.5 to 2 percent by weight of water in the soil — consistent with the neutron results. The general consensus at present is that the radar polarization in the polar regions is consistent with soil containing small amounts of ice, or could be due to surface roughness effects. Because the polarization is not actually correlated with the permanently shadowed regions, many are now leaning toward the surface roughness hypothesis, but there are insufficient data at present to conclusively determine whether there is ice. A dry regolith is virtually indistinguishable from regolith containing tiny amounts of ice within and between mineral grains. This is why the radar experiments on Chandrayan and [Lunar Reconnaissance Orbiter](#) (LRO) are being designed to understand the relationship between CPR and ice on the moon, and why the LCROSS mission is being sent to directly probe the surface and test these hypotheses through observation and experiment.

And that is how the scientific method deals with controversy.

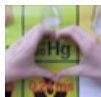
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HgMerc wrote:

"And that is how the scientific method deals with controversy."

I like that, It actually seems like they do read the Comments

posted 6/5/2008 7:25:57 AM

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Amegioa wrote:

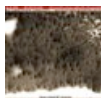
Excellent Article! More articles like this please. Good science.

Personally I believe that if there is water ice in those craters, it would only be trace amounts (unfortunately). If a comet impacted and created the crater, the ice would have been vaporized by the heat created in the impact (and the lack of gravity and absence of atmosphere combined with the forces of the impact throwing debris away from the crater would have forced the steam, ice etc far away from the crater). More likely If there is ice in those permanently shadowed craters, I think its probably ice particles that settled there from ejecta from other impacts and it settled there and accumulated because of favorable conditions. Just how much might have accumulated though is the question I suppose. It could be trace amounts, or significant amounts (we are talking about billions of years of possible accumulation)

posted 6/5/2008 9:23:42 AM



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topnotch wrote:


Why don't we send a rover "pronto" to one of the best craters and find out! (Mystery solved)


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posted 6/5/2008 9:25:16 AM

[15 Recommend](#) | [Report Abuse](#)**rreilly656** wrote:

I was part of the team at the Pentagon's BMDO that promoted "CLEMENTINE," the first probe in many a year to be sent to the Moon, and the first one that detected possible evidence of water ice. Finding significant amounts of water ice would be a dramatic and important discovery.

We shouldn't minimize the difficulty of exploiting that ice if it's found. Landing, assembling and maintaining ice-extraction and other "refining" equipment at one or both poles is a major task, as is the transportation of "finished" water, hydrogen and oxygen extracted from the sites. Humans will have had to have been back on the Moon for a couple of decades in a major way before we can even think of using this water ice for anything.

posted 6/5/2008 11:24:33 AM

[6 Recommend](#) | [Report Abuse](#)**Fernando22x** wrote:

How many nasa scientist take to change a light picture...? Well How many nasa scientist take to realize that Mars Rovers platforms and all its components should be mass produce to be implmented as SNAP ON modules to reduce cost. Why a off the shelf rover is not quickly assemble to operate in the moon they have been perform a awesome job on MARS....

posted 6/5/2008 11:51:49 AM

[1 Recommend](#) | [Report Abuse](#)**MartianSam** wrote:

I suspect that in the long run, the moon will be a base for industry and Mars will be a base for colonization. It seems recent discoveries and inventions make this the next logical step. We can't just land large spacecraft next to each other, for example - the rocks kicked up by the exhaust can fly halfway around the moon. So we need landing pads. And lo and behold, we can microwave a flat area of moondust and make a landing pad. Easy. Hmmm.

We have to have some industrial capacity there to even make a modest base. And if we have that capacity, we don't have to stop using it once the landing pads are done. We can built telescopes, larger bases, etc. Even if we don't launch anything bigger than Altair.

posted 6/5/2008 12:35:59 PM

[1 Recommend](#) | [Report Abuse](#)**sensiyomama** wrote:

It's not that easy. NASA has a budget. Theirs also idiots that think we should leave the moon alone because we will mess it up

posted 6/5/2008 1:21:42 PM

[3 Recommend](#) | [Report Abuse](#)**back2reason** wrote:

When is the space community going to realize that 1/8 th grovity, or even 1/3 rd gravity is unhealthy for long term human presence? The solution is obviously orbital settlements where a full earth gravity environment can be maintained, reducing physical presence on the moon, or mars, to what is required for any specific purpose. Comments please.

posted 6/5/2008 2:11:29 PM

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1StarRanch wrote:

I never actually thought about what Fernando22x until now. That sounds like a brilliant idea. I'm curious about the moon however, why do you think after 40+ years all these nations are trying to get back? My thinking is helium3 thoughts?

posted 6/5/2008 7:36:55 PM

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