True Fakes: Scientists make simulated lunar soil

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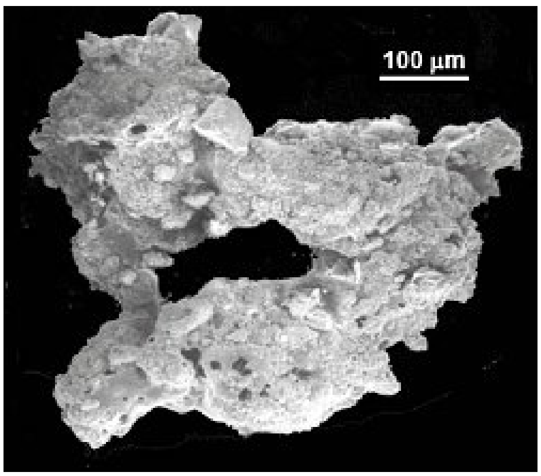


A speck of Moon dirt. The strange shape tells a tale of violence: It results from the welding of rock, mineral and glass by the heat of micrometeoroid impacts. Image credit: David S. McKay, NASA/JSC.

Life is tough for a humble grain of dirt on the surface of the Moon. It's peppered with cosmic rays, exposed to solar flares, and battered by micrometeorites--shattered, vaporized and re-condensed countless times over the billions of years. Adding insult to injury, Earthlings want to strip it down to oxygen and other elements for "in situ resource utilization," or ISRU, the process of living off the land when NASA returns to the Moon in the not-so-distant future.

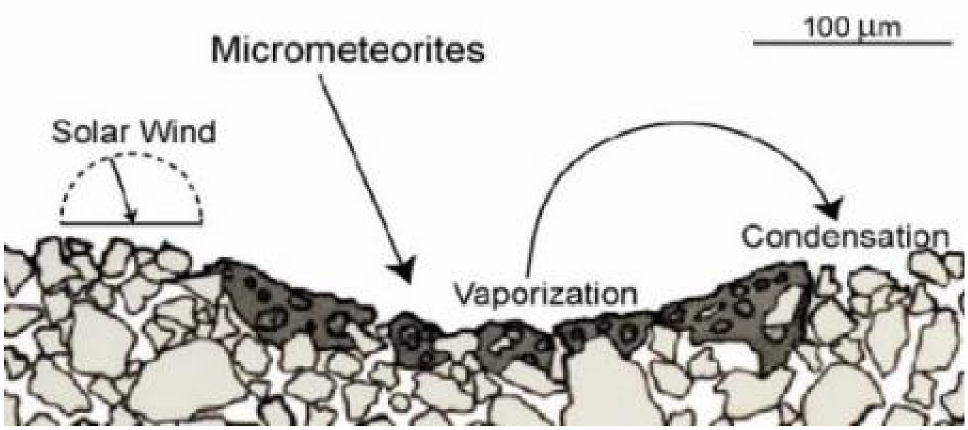
But, as Robert Heinlein famously observed, "the Moon is a harsh mistress." Living with moondust and striping it down may be trickier than anyone supposes.

To find out how tricky, researchers would like to test their ideas for ISRU and their designs for lunar rovers on real lunar soil before astronauts return to the Moon. But there's a problem:

"We don't have enough real moondust to go around," says Larry Taylor, director of Planetary Geosciences Institute at the University of Tennessee in Knoxville. To run all the tests, "we need to make a well-qualified lunar simulant." And not just a few bags will do. "We need tons of it, mainly for working on technologies for diggers and wheels and machinery on the surface," adds David S. McKay, chief scientist for astrobiology at the Johnson Space Center (JSC).

Taylor and McKay are lead members of a small group of self-styled "lunatics" whose careers have focused on lunar soil and rocks. They are among several consultants to NASA's Marshall Space Flight Center (MSFC), which manages the Lunar Regolith Simulant Development Program.

Carole McLemore is the program manager at Marshall. Back in the 1990s, she explains, researchers used a lunar simulant called JSC-1 developed at JSC. But "there is no more JSC-1 available." So, to get started, researchers at Marshall are working with the Astromaterials Research and Exploration Science office at Johnson to create a replica of the JSC-1 simulant: JSC-1A. It comes in three types based on grain size (fine, medium and coarse). MSFC has also begun work on more demanding simulants representing various locations on the Moon.



The lunar surface is exposed to solar wind and constantly pounded by micrometeorites. Credit: Larry Taylor, Univ. of Tennessee.

Until the Apollo astronauts brought lunar soil samples to Earth during 1969-72, the belief was that the Moon's dry, airless environment left the soil largely undisturbed. Reality is much harsher.

Micrometeorites, many smaller than a pencil point, constantly rain onto the surface at up to 100,000 km/hr (about 62,000 mph), chipping off materials or forming microscopic impact craters. Some melt the soil and vaporize and re-condense as glassy coats on other specks of dust. Impacts weld debris into "agglutinates." Complicated interactions with the solar wind convert iron in the soil into myriads of "nano-phase" metallic iron grains just a few nanometers wide.

These processes form the "regolith" -- Greek for stone blanket (litho + rhegos) -- covering the Moon's surface. What greets astronauts and spaceships is a complex material comprising "sharp, abrasive, interlocking fragile glass shards and fragments," Taylor says. It grinds machinery and seals, and damages human lungs.

"Some of the stuff that got into the Apollo spacecraft was very finely ground," McKay said. Dust was everywhere and impossible to brush off. All the lunar astronauts had lung reactions to this dust, some more than others, like Harrison H. (Jack) Schmitt's "lunar dust hay fever."

The Apollo specimens are America's Crown Jewels and are doled out in ultra-small samples to scientists who can demonstrate that nothing else will do for high-value experiments. Renewed interest in lunar exploration in the late 1980s meant that lunar simulants were needed to test schemes for building structures on the Moon or for extracting oxygen and other materials.

That led to JSC-1 in 1993, made of basaltic volcanic cinder cone deposits from a quarry near Flagstaff, AZ. The 25-ton lot -- distributed in 50-pound bags -- proved popular.

"We're totally out, but that's soon to be corrected," said McKay. MSFC has a Small Business Innovative Research (SBIR) contract with Orbitec of Madison, WI, to manufacture about 16 metric tonnes of three types of JSC-1A: 1 tonne of fines (delivered); 14 tonnes of moderate grains (being delivered); and 1 tonne of coarse grains (coming soon). The U.S. Geological Survey in Denver and the University of Colorado at Boulder -- key partners -- are checking the chemical, mineralogical, and geotechnical properties.

MSFC is developing three new simulants. Two will represent mare and polar highlands regions. A third will represent the glassy, sharp, jagged edges of regolith that test the best of hardware and humans. But matching every location on the Moon would require large numbers of small, unique, expensive batches.

"Instead, we will develop root simulants and manufacture specific simulants from these, but also enable investigators to enhance the products as needed," McLemore added. "I liken this process to baking a cake: depending on the type of cake you want, you need certain ingredients for it to come out right and taste right. Getting the recipe right whether for a cake or lunar simulants is critical."

For example, the new mare simulant will be enriched with ilmenite, a crystalline iron-titanium oxide. Source materials used to produce the three simulants will potentially come from locations as diverse as Montana, Arizona, Virginia, Florida, Hawaii, and even some international sites.

Initial lots will weigh just tens of pounds to ensure that the simulant is made correctly. "Eventually we will scale up to larger quantities when we can make sure that there is little variation from batch to batch," McLemore said.

Once NASA understands how to make the various simulants, plans are to farm the work out to companies to produce larger batches. "We will have certification procedures in place for vendors to follow so users know that the simulants meet the NASA standards," McLemore said.

And that will be the best way to tell it's a "true fake." Accept no substitutes.

Source: by Dave Dooling, Science@NASA

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