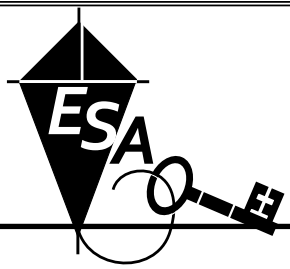
Sep/Oct 2014 • No. 227



ESA Newsletter

Electrostatics Society of America - The Friendly Society

President's Message

Dear ESA Colleagues,

In an ESA newsletter message about a year ago, I discussed my thoughts about Massive Open Online Courses (MOOCs). Being a professor, people sometimes tell me they think universities will become obsolete due to the availability of free online classes. But I feel there is an academic factor universities offer that MOOCs cannot match – intellectual interaction with peers. Physical universities will always be important due to this peer interaction. But while online courses will not replace universities, I believe online education can enhance and extend the university experience.

I recently took an online Six Sigma Green Belt certification course. For those not familiar with this topic, Six Sigma is a widely used statistical approach to quality control. I wanted to take a Six Sigma course so that I could include some Six Sigma ideas in the process design course I teach – I thought it would be good for our students to be familiar with at least the main concepts of Six Sigma.

I was deciding between two possible Six Sigma courses. The first course was an in-person executive training course at my university that met for five full days. The second course was an online course offered by another university. I would have had to pay a fee for either course. I chose to take the online course mainly because I did not want to take five full days away from work for the in-person course.

I ended up liking many of the aspects of the online course. Most importantly, I liked being able to work on the course at my convenience, and I completed most of the course during a weeklong trip to the Philippines. I did most of the reading on the long plane trips, and I watched lectures when I woke up in the morning (usually VERY early due to the 12 hour time difference) and in the evenings before going to bed.

I can now appreciate the role that online education can play. From my experience I saw how online education can be very useful for focused professional development. In another context, I see how some of my colleagues are experimenting with 'flipped' classrooms, where students watch online lectures (prepared by the professor) as homework, and then in class they work on problem sets under the guidance of the professor.

Perhaps an online course on electrostatics would serve a need. As we all know, there are many practitioners in diverse industries who butt heads with electrostatic issues. These practitioners may want to learn about the fundamentals of electrostatics, how to measure charge, charge control strategies, and so on. An online course would be an easy and relatively inexpensive way for these practitioners to pick up some needed electrostatic knowledge.

Regards,
Dan Lacks,
President, ESA
daniel.lacks@case.edu

ESA Officers

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Shesha Jayaram, Univ. of Waterloo
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Sheryl Barringer, Ohio State Univ.
Kelly Robinson, Electrostatic Answers, LLC
Rajeswari Sundararajan, Purdue Univ.

Calendar

- Electrostatics 2015, April 12-16, 2015, Southampton Solent Univ., Southampton, UK, *http://elec2015.iop-confs.org/home* Contact: IoP Electrostatics Group, +44 (0)20 7470 4800, *conferences@iop.org (abstracts due Oct. 29, 2014)*
- 33rd EIC (Elec Insul Conf, IEEE-DEIS), June 7-10, 2015, Seattle, WA, USA, *http://sites.ieee.org/eic/* Contact: Bill McDermid, *wmmcdermid@hydro.mb.ca, (abstracts due Oct. 17, 2014)*
- ESA 2015, June 16-18, 2015, California State Polytechnic University, Pomona, CA, USA, *http://www.electrostatics.org/conferences.html* Contact: Keith Forward, *kmforward@csupomona.edu*
- 3rd ISNPEDADM, Oct. 25-30, 2015, Le Recif Hotel, Saint Gilles les Bains, Reunion, Contact: Gerard Touchard, *gerard.touchard@univ-poitiers.fr*

Rock On??

Professor Stuart Hoenig of the University of Arizona has some interesting aspects on the electrical properties of rocks that he would be happy to share with interested members. Some of these aspects include:

1) detecting and predicting the location of rock pillar failures. This is of great importance to miners working underground, rock bursts from pillars are a real source of injury.

2) Speeding up grinding-milling processes n with the application of short high voltage pulses.

Anyone interested in following up with Professor Hoenig may contact him at *hoenig@ece.arizona.edu* .

Current Events (cont'd.)

Getting a charge out of water droplets
David L. Chandler

Last year, MIT researchers discovered that when water droplets spontaneously jump away from superhydrophobic surfaces during condensation, they can gain electric charge in the process. Now, the same team has demonstrated that this process can generate small amounts of electricity that might be used to power electronic devices. The new findings, by postdoc Nenad Miljkovic, associate professor of mechanical engineering Evelyn Wang, and two others, are published in the journal Applied Physics Letters. This approach could lead to devices to charge cellphones or other electronics using just the humidity in the air. As a side benefit, the system could also produce clean water. The device itself could be simple, Miljkovic says, consisting of a series of interleaved flat metal plates. Although his initial tests involved copper plates, he says any conductive metal would do, including cheaper aluminum.

In initial testing, the amount of power produced was vanishingly small — just 15 picowatts, or trillionths of a watt, per square centimeter of metal plate. But Miljkovic says the process could easily be tuned to achieve at least 1 microwatt, or millionth of a watt, per square centimeter. Such output would be comparable to that of other systems that have been proposed for harvesting waste heat, vibrations, or other sources of ambient energy, and represents an amount that could be sufficient to provide useful power for electronic devices in some remote locations. For example, Miljkovic has calculated that at 1 microwatt per square centimeter, a cube measuring about 50 centimeters on a side — about the size of a typical camping cooler — could be sufficient to fully charge a cellphone in about 12 hours. While that may seem slow, he says, people in remote areas may have few alternatives.

There are some constraints: Because the process relies on condensation, it requires a humid environment, as well as a source of temperatures colder than the surrounding air, such as a cave or river.

The system is based on Miljkovic and Wang's 2013 finding — in attempting to develop an improved heat-transfer surface to be used as a condenser in applications such as power plants — that droplets on a superhydrophobic surface convert surface energy to kinetic energy as they merge to form larger droplets. This sometimes causes the droplets to spontaneously jump away, enhancing heat transfer by 30 percent relative to other techniques. They later found that in that process, the jumping droplets gain a small electric charge — meaning that the jumping, and the accompanying transfer of heat, could be enhanced by a nearby metal plate whose opposite charge is attractive

2015 Annual Meeting of the Electrostatic Society of America

California State Polytechnic University, Pomona
Pomona, CA
June 16 - 18, 2015

Call for Papers

Abstract Submission
Opens: January 1, 2015
Closes: March 1, 2015

Important Dates

March 15	Notification of abstract acceptance
May 10	Early registration deadline
May 17	Final manuscript deadline
June 16	Conference begins (9 AM)
June 17	Conference banquet (evening)
June 18	Conference ends (noon)

Keynote Speakers
- Dr. Matti Murtomaa, University of Turku
- Dr. Zhong Lin Wang, Georgia Tech
- Dr. Kim Woodrow, University of Washington
- Dr. Leslie Yeo, RMIT Melbourne

California State Polytechnic University, Pomona (Cal Poly Pomona) is proud to be hosting the 2015 Annual Meeting of the Electrostatic Society of America (ESA). The meeting will bring together experts across the diverse field to present the latest developments in electrostatics.

Anticipated Technical Session Topics
- Contact charging and triboelectric effects
- Gas discharges and microplasmas
- Breakdown phenomena, safety and hazards
- Electrically-induced flows and electrokinetics
- Atmospheric and space applications
- Biological and medical applications
- Electrospinning and material processing
- Measurements and instrumentation

Conference information, including abstract submission, registration, student travel grants and lodging, will be updated and available at *http://www.electrostatics.org*

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Technical Chair
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to the droplets. Now the researchers have shown that the same process can be used to generate power, simply by giving the second plate a hydrophilic surface. As the droplets jump, they carry charge from one plate to the other; if the two plates are connected through an external circuit, that charge difference can be harnessed to provide power. In a practical device, two arrays of metal plates, like fins on a radiator, would be interleaved, so that they are very close but not touching. The system would operate passively, with no moving parts.

For powering remote, automated environmental sensors, even a tiny amount of energy might be sufficient; any location where dew forms would be capable of producing power for a few hours in the morning, Miljkovic says. "Water will condense out from the atmosphere, it happens naturally," he says. "The atmosphere is a huge source of power, and all you need is a temperature difference between the air and the device," he adds — allowing the device to produce condensation, just as water condenses from warm, humid air on the outside of a cold glass.

(excerpted from *http://newsoffice.mit.edu/2014/getting-charge-out-water-droplets-0714*)

High-speed solar winds increase lightning strikes on Earth

Scientists have discovered new evidence to suggest that lightning on Earth is triggered not only by cosmic rays from space, but also by energetic particles from the Sun. University of Reading researchers found a link between increased thunderstorm activity on Earth and streams of high-energy particles accelerated by the solar wind, offering compelling evidence that particles from space help trigger lightning bolts. Researchers found a substantial and significant increase in lightning rates across Europe for up to 40 days after the arrival of high-speed solar winds, which can travel at more than a million miles per hour, into the Earth's atmosphere.

Although the exact mechanism that causes these changes remains unknown, the researchers propose that the electrical properties of the air are somehow altered as the incoming charged particles from the solar wind collide with the atmosphere. The results could prove useful for weather forecasters, since these solar wind streams rotate with the Sun, sweeping past the Earth at regular intervals, accelerating particles into Earth's atmosphere. As these streams can be tracked by spacecraft, this offers the potential for predicting the severity of hazardous weather events many weeks in advance.

Lead author of the study, Dr Chris Scott, said: "Our main result is that we have found evidence that high-speed solar wind streams can increase lightning rates. This may be an actual increase in lightning or an increase in the magnitude of lightning, lifting it above the detection threshold of measurement instruments. "Cosmic rays, tiny particles from across the Universe accelerated to close to the speed of light by exploding stars, have been thought to play a part in thundery weather down on Earth, but our work provides new evidence that similar, if lower energy, particles created by our own Sun also affect lightning. "As the Sun rotates every 27 days these high-speed streams of particles wash past our planet with predictable regularity. Such information could prove useful when producing long-range weather forecasts."

To arrive at their results, the researchers analysed data on the strikes of lightning over the UK between 2000 and 2005, which was obtained from the UK Met Office's lightning detection system. They restricted their data to any event that occurred within a radius of 500 km from central England. The record of lightning strikes was compared with data from NASA's Advanced Composition Explorer (ACE) spacecraft, which lies between the Sun and the Earth and measures the characteristics of solar winds. After the arrival of a solar wind at the Earth, the researchers showed there was an average of 422 lightning strikes across the UK in the following 40 days, compared to an average of 321 lightning strikes in the 40 days prior the arrival of the solar wind. The rate of lightning strikes peaked between 12 and 18 days after the arrival of the solar wind.

The solar wind consists of a constant stream of energetic particles—mainly electrons and protons—that are propelled from the Sun's atmosphere at around a million miles per hour. The streams of particles can vary in density, temperature and speed and sweep past Earth every 27 days or so, in line with the time it takes the Sun to make one complete rotation relative to the Earth. The Earth's magnetic field provides a sturdy defence against the solar wind, deflecting the energetic particles around the planet; however, if a fast solar stream catches up with a slow solar stream, it generates an enhancement in both the material and the associated magnetic field. In these instances, the energetic particles can have sufficient energies to penetrate down into the cloud-forming regions of the Earth's atmosphere and subsequently affect the weather that we experience.

"We propose that these particles, while not having sufficient energies to reach the ground and be detected there, nevertheless electrify the atmosphere as they collide with it, altering the electrical properties of the air and thus influencing the rate or intensity at which lightning occurs," said Dr Scott.

The increase in the rate of lightning after the arrival of solar winds was corroborated by a significant increase in the days in which thunder was heard, which were recorded at UK Met Office stations around the UK.

(excerpted from *http://www.iop.org/news/14/may/page_63245.html*)

Static electricity helps geckos get a grip

Ian Randall

The amazing ability of some geckos to scale smooth walls and cling to ceilings could be primarily a result of contact electrification. That is the claim of researchers at the University of Waterloo in Canada, who have made a new study of the electrostatic interactions between the lizard's feet and two different surfaces. Their conclusion contrasts with conventional thinking, which attributes the stickiness of gecko feet to Van der Waals forces.

The exceptional climbing ability displayed by many geckos comes from their specially adapted toe pads. Each pad is covered in layers of microscopic, hair-like structures – or setae – that split into smaller, spatula-shaped tips. Being so small, the tips can get close to the surfaces on which the geckos walk, forming an intimate contact. Each seta contributes only a tiny attraction, but together they produce a combined adhesive force of about 10 N for each foot, which allows geckos to hang from a ceiling by a single limb. Letting go is not a problem because the adhesive effect is directional, allowing a gecko to detach by simply re-orientating its foot. According to conventional theory, the attraction is a result of Van der Waals interactions. These are the weak dipole–dipole forces that act between adjacent atoms and molecules as a result of shifting electron concentrations.

In their new study, Alexander Penlidis and colleagues looked at how contact electrification could contribute to gecko adhesion. This effect occurs when two materials touch and exchange electric charges. The result is a net negative electrostatic charge on one material and a positive charge on the other, which causes an attractive force between the two. To test whether these interactions could be contributing to the adhesive abilities of geckos, the researchers measured the electric charges and adhesive forces generated when gecko toe pads were stuck on two insulating polymer surfaces – one of Teflon AF and one of polydimethylsiloxane. In both cases, on contact, the geckos' toe pads became positively charged and the surfaces negatively charged. Furthermore, the adhesion strength correlated with the magnitude of the electrostatic charge that was generated. Despite having a lesser potential for generating Van der Waals forces, Teflon AF was seen to have a much stronger adhesion than the other substrate. This, say the researchers, suggests that contact electrification plays a major role in gecko adhesion.

The finding could overturn 80 years of conventional wisdom that electrostatic interactions are not involved in gecko adhesion. Penlidis and colleagues believe this dismissal can be traced back to an experiment described in 1934 by the German scientist Wolf-Dietrich Dellit. Ionized air – which would neutralize electrostatic interactions – was blown towards a gecko clinging to a metal surface and had no effect on its ability to hang on. Penlidis and colleagues explain that Dellit's observation is consistent with their conclusion because the contact between seta and substrate is so close that ionized molecules in the air would not be able to get between the two to neutralize the interaction.

While contact electrification could play an important role in a gecko's ability to scale smooth walls, it is not clear whether the force is any help on rougher surfaces. "The [research] clearly shows how electrostatic forces can play an additional role in enhancing adhesion in geckos, which is an aspect that had not been previously considered," says Duncan Irschick, a biologist at the University of Massachusetts who is developing a synthetic, reusable adhesive based on gecko feet. Irschick questions, however, "whether such forces are relevant for natural surfaces that geckos have evolved to use, such as leaves, trees, etc". In 2002 Kellar Autumn of Lewis & Clark College in Oregon was the first to observe the Van der Waals interaction in gecko feet. Commenting on this latest research, he says that "This is a novel and important discovery, and suggests that electrostatic forces could contribute to adhesion in geckos on some surfaces, such as Teflon." However, Autumn is not convinced that electrostatic forces are dominant, pointing out that this conclusion is not supported by the results of the study. "Moreover, the use of whole animals rather than isolated setae, and only one axis of force measurement, makes the results difficult to interpret," he adds.

(excerpted from *http://physicsworld.com/cws/article/news/2014/jul/09/static-electricity-helps-geckos-get-a-grip*)

Water molecules favor negative charges

Sarah Perrin

Some say that in life, it's better to be positive… for charges immersed in water this may not be true. Researchers from the Laboratory for fundamental BioPhotonics (LBP) at EPFL have found that water molecules associate more readily with negatively charged elements when in the presence of other substances. The results of their research are published in Angewandte

Chemie Int. Ed.. By using advanced optical spectroscopy techniques, scientists studied the behavior of ions -atoms or molecules that either lost or gained an electron and which are thus electrically charged- placed in an aqueous medium. They selected two ions that were absolutely identical in terms of shape, size and chemical structure, but with opposite electrical charges. Their interactions with the electrically neutral water molecules were, however, very different depending on whether they were positively or negatively charged.

The scientists' observations showed that the hydrogen bonds -that is to say, the electrostatic force binding the hydrogen atoms with others such as oxygen or nitrogen- were more than 6 times more abundant when the ions were negatively charged. The hydrogen bonds were also much stronger. Somehow, water maintains more collaborative relationships with such negative ions. Thus, they get much more hydrated and their effects, in particular on the orientation and alignment of water molecules at the interface between the two substances, were stronger and more stable.

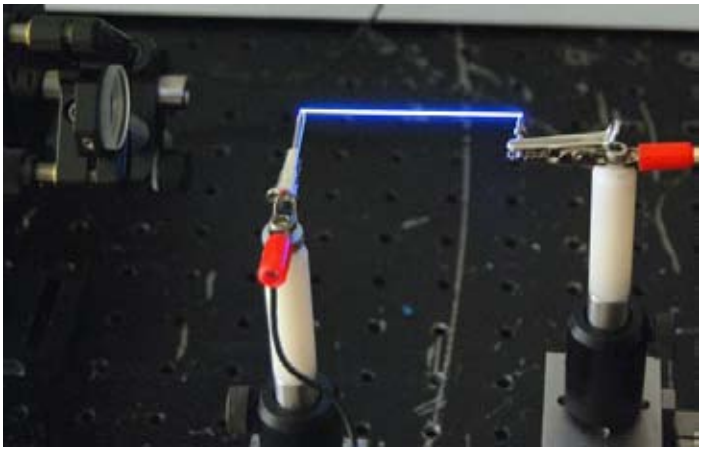
"Our discovery sheds new light on some biological, chemical and physical phenomena", notes Sylvie Roke, who heads the LBP. "It may have an impact on many studies, for example about cell formation." According to her, it could explain why the cellular membranes have charges that are either neutral or negative. She speculates that when life emerged in the oceans 3.8 billion years ago, the first unicellular organisms opted for a more stable and more economic structure, which naturally follows from water's preference for negative charges.

(excerpted from *http://phys.org/news/2014-07-molecules-favor-negative.html*)

Laser 'Lightning Rods' Channel Electricity Through Thin Air

Ian Randall

By zapping the air with a pair of powerful laser bursts, researchers at the University of Arizona have created highly focused pathways that can channel electricity through the atmosphere. The new technique can potentially direct an electrical discharge up to 10 meters (33 feet) away or more, shattering previous distance records for transmitting electricity through air. It also raises the intriguing possibility of one day channeling lightning with laser power. The team used a femtosecond laser to create a thin column of plasma – a special charged state of matter – in the air between two electrodes. A femtosecond is one millionth of a billionth of a second. Femtosecond lasers emit pulses that last only a few tens of femtoseconds. Before this narrow plasma channel has a chance to



dissipate, an almost simultaneous burst from a nanosecond laser – lasting a million times longer than a femtosecond pulse – retraces the same path, giving it an extra jolt of heat and the staying power necessary to transmit electricity.

The idea of using lasers to channel electricity through the air, which is not normally conductive, was first proposed in the 1970s and further explored through the 1990s. The research was based on the idea that by superheating a very narrow column of air, it would be possible to create a straight path along which an electric charge could flow. These early attempts used nanosecond lasers, which were the most practical lasers at the time due to their intense power and very short duration. The highly focused laser beams superheated a narrow line of air molecules, stripping off their outer electrons and producing a filament of charged plasma. The higher-than-normal concentration of free electrons in the plasma overcame the atmosphere's natural insulator properties, making it much more conductive. Under laboratory conditions, researchers were, at the time, able to produce a filament of approximately 1 meter in length.

With the advent of more advanced femtosecond lasers, however, Polynkin and his team felt they could utilize the advantages brought about by both femtosecond and nanosecond lasers and achieve much better results through combining the two types of lasers in a single powerful beam.

Earlier this year, a joint team from the UA and the University of Central Florida, which included the authors of the new Optica paper, presented a new approach involving a high-intensity laser beam inside a "dress beam" refueling the primary beam and sustaining it over much greater distances than were previously possible. "In both experiments, we used two synchronized laser pulses to produce plasma in air," Polynkin said. "But the nature of the second pulse is different in the two cases. Instead of the dress beam, which only lasted femtoseconds, we now

use a much more energetic pulse of longer duration – several nanoseconds – that we call heater pulse."

The current breakthrough was achieved by sending a femtosecond laser light pulse as the "igniter" and a nanosecond pulse as a "heater" along the same path, and by understanding how the atmosphere behaves when it was subjected to these extremely energetic light pulses. The researchers recognized that it wasn't the actual plasma created by the lasers that made the atmosphere more conductive; it was the subsequent superheating that lowered the density of the filament of air. Without some additional input of energy, however, this zone of lower density quickly collapsed. To improve both distance and duration, a second energy source was needed to rapidly reheat the air, stabilizing the filament just long enough to carry an electrical current. "Since the first femtosecond laser already blazed the trail, we were able to harness a second nanosecond laser, following the same path, to rapidly pump more heat into the system," said Polynkin. "This channel lasted considerably longer, so we had the potential to extend the previous distance record by more than tenfold."

The filaments the researchers created significantly lowered what is known as the electrical breakdown point, the voltage that is needed to overcome the insulating effect of the atmosphere. Lightning, because of its incredibly high voltage, routinely overcomes the air's natural resistance, although in highly random and unpredictable ways. Based on their initial results, the researchers believe that other forms of heater beams, such as microwaves or long-wavelength lasers, could further increase the distances they were able to achieve, though other issues would need to be addressed before applications like channeling lightning could be achieved. As a next step, the researchers are planning on using a microwave beam in place of the nanosecond laser to more efficiently heat the channel and perhaps achieve better results.

(excerpted from *http://uanews.org/story/laser-lightning-rods-channel-electricity-through-thin-air*)

Electric sparks may alter evolution of lunar soil

David Sims

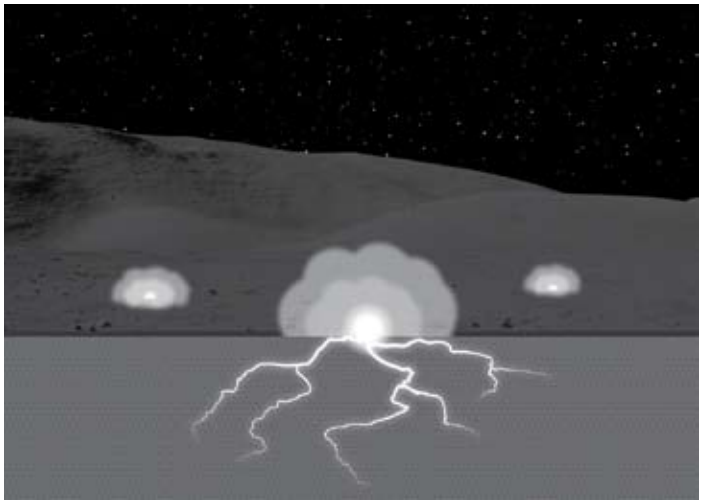
The moon appears to be a tranquil place, but modeling done by University of New Hampshire and NASA scientists suggests that, over the eons, periodic storms of solar energetic particles may have significantly altered the properties of the soil in the moon's coldest craters through the process of sparking—a finding that could change our understanding of the evolution of planetary surfaces in the solar system.

The study, published recently in the Journal of Geophysical Research-Planets, proposes that high-energy particles from uncommon, large solar storms penetrate the moon's frigid, polar regions and electrically charge the soil. The charging may create sparking, or electrostatic breakdown, and this "breakdown weathering" process has possibly changed the very nature of the moon's polar soil, suggesting that permanently shadowed regions, which hold clues to our solar system's past, may be more active than previously thought.

"Decoding the history recorded within these cold, dark craters requires understanding what processes affect their soil," says Andrew Jordan of the UNH Institute for the Study of Earth, Oceans, and Space, lead author of the paper. "To that end, we built a computer model to estimate how high-energy particles detected by the Cosmic Ray Telescope for the Effects of Radiation (CRaTER) instrument on board NASA's Lunar Reconnaissance Orbiter (LRO) can create significant electric fields in the top layer of lunar soil." The scientists also used data from the Electron, Proton, and Alpha Monitor (EPAM) on the Advanced Composition Explorer (ACE). CRaTER, which is led by scientists from UNH, and EPAM both detect high-energy particles, including solar energetic particles (SEPs). SEPs, after being created by solar storms, stream through space and bombard the moon. These particles can build up electric charges faster than the soil can dissipate them and may cause sparking, particularly in the polar cold of permanently shadowed regions—unique lunar sites as cold as minus 240 degrees Celsius and known to contain water ice.

Says Jordan, "Sparking is a process in which electrons, released from the soil grains by strong electric fields, race through the material so quickly that they vaporize little channels." Repeated sparking with each large solar storm could gradually grow these channels large enough to fragment the grains, disintegrating the soil into smaller particles of distinct minerals, Jordan and colleagues hypothesize.

(excerpted from *http://www.unh.edu/news/releases/2014/08/ds21lunarsoil.cfm*)



This illustration shows a permanently shadowed region of the moon undergoing subsurface sparking (the "lightning bolts"), which ejects vaporized material (the "clouds") from the surface. Subsurface sparking occurs at a depth of about one millimeter. Image not to scale. Courtesy of Andrew Jordan.

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