Great Debates

Much Ado About Nothing?

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High Voltage Mars

Summary (Feb 07, 2005): Meteorites and comets should have delivered vast amounts of organic chemicals to Mars, yet the Viking mission found no organics in the red soil. A new hypothesis by Sushil Atreya suggests how dust storms may zap away any chances for life on the martian surface.

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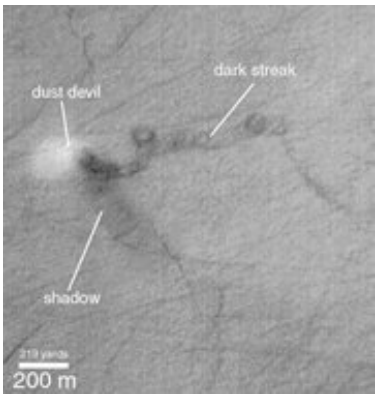
High Voltage Mars

by Leslie Mullen

Mars is often enveloped by planet-wide dust storms - their biting winds choke the air and scour the arid surface. Tornado-like dust devils dance across the planet so frequently that their numerous tracks crisscross each other, tracing convoluted designs in the red soil.

Such weather conditions would make life a hardship for any future explorers on Mars. According to Sushil Atreya, Professor and Director of the Planetary Science Laboratory at the University of Michigan, these storms also may have prevented life from ever existing on the martian surface.

Dust particles in a storm create an electrostatic charge whenever they strike one another or the ground. In field experiments led by William Farrell of NASA's Goddard Space Flight Center, electrical fields of 10 kilovolts per meter were measured in dust devils on Earth. Such experiments suggest that dust devils on Mars could generate very large electric fields of about 5 to 20 kilovolts per meter.



Active Martian dust devil caught in the act of creating a sandblast track in Promethei Terra, December 11, 1999.
Credit: NASA/JPL/Malin Space Science Systems

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1928
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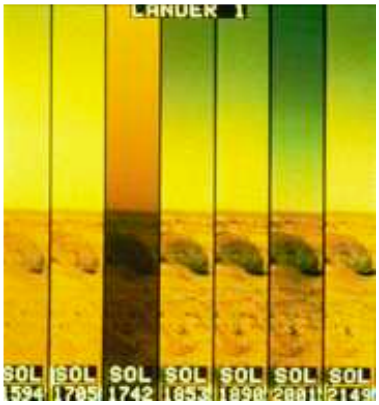
These electric fields would cause gas molecules in the martian atmosphere to break down. For example, when the electric fields break down water vapor (H2O), they would produce hydroxyl radicals (OH). According to Atreya, these hydroxyls would eventually help form hydrogen peroxide (H2O2).



Viking Lander-1 (1976) showed dramatic changes during dust storm activity. The appearance of the sky changes with the atmospheric dust content. Although the colors shown here are processed, not real, they do show relative changes in atmospheric opacity over many sols. *Credit: JPL/NASA*

The sun probably generates some hydrogen peroxide by photo-dissociating water vapor in the upper atmosphere. But Atreya estimates the dust storms might result in 200 times more hydrogen peroxide gas in the atmosphere than the sun could produce, since most of the water vapor on Mars is close to the surface - right where the dust storms occur.

"The amount of hydrogen peroxide becomes so large, the atmosphere cannot hold any more of the gas," says Atreya. "So it begins to snow out of the atmosphere, and settles on to the surface as hydrogen peroxide dust."

Hydrogen peroxide is a strong oxidant, and would destroy any organic materials existing on the planet's surface. Since life as we know it is based on organic chemistry, the hydrogen peroxide dust would snuff out any chances for such life to appear there.

The lack of organics on Mars was first established by the Viking landers in 1976. The two landers conducted four experiments to try to detect life, and one of these experiments showed that the surface of Mars was entirely devoid of carbon compounds.

Because the thin Martian atmosphere does little to shield the planet from the harsh ultraviolet radiation of the sun, scientists suspected that UV light destroyed some of the organics. They also speculated that oxidizing compounds in the soil, like hydrogen peroxide, also could destroy organics.

But hydrogen peroxide had never been detected on Mars. That changed in 2003, when two groups detected small amounts of hydrogen peroxide in the martian atmosphere. Atreya is a member of the Infrared TEXES spectrometer team, and he says they measured 20 to 50 parts per billion of hydrogen peroxide using NASA's Infrared Telescope Facility in Hawaii. Hydrogen peroxide also was detected by a team led by Todd Clancy of the Space Science Institute in Boulder, Colorado, using the James Clerk Maxwell Telescope in Hawaii.

But, says Atreya, the amount of hydrogen peroxide detected on Mars is not enough to remove all the organics that should be on the surface. Even if there were no indigenous organics on Mars, substantial amounts of organic material should have been delivered to Mars by the many meteorites and comets that have impacted the planet since the early days of the solar system. Large amounts of hydrogen peroxide or another superoxide produced by dust storms could explain why the surface of Mars is so barren today.


This high-resolution color photo of the

However much hydrogen peroxide is produced by dust storms, the sun's UV rays would ensure it would not last long in the air, breaking the molecules down after a few days. But if

hydrogen peroxide ice particles are bound to the dust particles they ride on, they could mix with the surface soils after they fall out of the atmosphere, allowing them to persist in the environment for much longer. This longer residence time would allow the hydrogen peroxide snow to eventually be converted into other superoxides by surface chemistry.

surface of Mars was taken by Viking Lander 2 at its Utopia Planitia landing site on May 18, 1979, and relayed to Earth by Orbiter 1 on June 7. It shows a thin coating of water ice on the rocks and soil.
Image Credit: NASA/JPL

If water is mixed in with the soil, or if there is sub-surface ice, the hydrogen peroxide eventually would combine with this water. Depending on the concentration of H_2O_2, this would lower the freezing point of the water, just as salt makes ocean water less apt to freeze on Earth.

Thus, while hydrogen peroxide on the martian surface would reduce the chance for life above ground, its presence in subsurface martian water would increase the odds that life could exist beneath the surface.

The dust storms block our view of what is happening on Mars, so to prove the storms really are generating hydrogen peroxide, Atreya says a measuring device would have to be sitting on the surface.

"Surfaces are hard to detect with remote sensing, especially the localized chemicals," says Atreya. "Also, the hydrogen peroxide would be mixed in with the regolith, making remote observations of it even more difficult."

The Mars Rovers Spirit and Opportunity have been traveling on the martian surface for over a year, but they are not equipped to detect hydrogen peroxide or other superoxides. Atreya says that the Mars Science Laboratory (MSL) mission, scheduled for 2009, will include a suite of instruments that are expected to measure the presence of superoxides such as hydrogen peroxide.

"This idea is new, and possibly very important," says Mike Mumma, Director of the Center for Astrobiology at NASA's Goddard Space Flight Center. "It suggests there should be abundant oxidants on dust particles. If it bears out, it could provide a very efficient way for destroying organic compounds much more rapidly than by photochemistry."

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Monday, February 07, 2005

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