Laser fluorescence could find life on Mars

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A team of scientists from the United States and the United Kingdom has developed a technique using ultraviolet light to identify organic matter in soils that they say could be used to document the existence of life on Mars.

The researchers' proposed instrumentation could operate on any Mars lander or rover, they say, such as the current Phoenix mission or NASA's Mars Science Laboratory scheduled for launch in 2009 – both of which are looking at habitability – or the European Space Agency's ExoMars mission in 2013 that will look directly at the past or present existence of life on the red planet.

Their research was just published in the American Geophysical Union's journal, *Geophysical Research Letters*.

Chemical compounds called polycyclic aromatic hydrocarbons, or PAHs, often are found on comets, meteorites and in space between the stars, and are considered candidates for being one of the earliest forms of organic matter in the universe. Like living organisms, these molecules fluoresce when excited by ultraviolet light, making them an ideal target for using this new technology, according to Martin Fisk, a professor of marine geology at Oregon State University and a co-author of the study.

"Since PAHs are found on meteorites, we would expect some of that material to fall from space onto the surface of Mars," Fisk said. "But we also know the surface is bombarded by ultraviolet light and cosmic rays, which would destroy organic matter. Computer simulations, including those carried out (by co-authors at) University College London, suggest that the organic material is protected under the surface of Mars, down below a meter or so, and can be brought up via a drill and identified."

Michael Storrie-Lombardi, lead author and director of the Kinohi Institute in Pasadena, said the techniques the research team are using have been employed "every day in the safety of our laboratories for almost 100 years.

"Recently the technology has become available to perform these experiments during remote surveys of other planets," Storrie-Lombardi added.

In their experiment, the scientists created a fine, dusty soil by crushing a peridotite rock from a nickel mine in Riddle, Ore., that they say closely replicates the Martian surface material. A meteorite found in France, originating from Mars, consisted of 88 percent olivine, while the Oregon peridotite was 90 percent olivine.

They infused the peridotite granules with PAHs at a level of 50 parts per million, which is what they would expect to find on a meteorite, then took about a tablespoon of the soil and exposed it to different light waves from a meter away.

Using colored filters from the panoramic camera, or PanCam, that was the backup instrument for the Beagle 2-Lander, they were able to clearly identify as little as 1.5 micrograms of the organic material and pinpoint different PAHs by variations in their fluorescent response. The Beagle 2 made it to Mars in 2003, but was lost on approach and assumed to have crashed onto the Martian surface.

Two of the study's scientists – Storrie-Lombardi and Jan-Peter Muller, of the Mullard Space Sciences Laboratory in the United Kingdom –

carried out the optic experiments in the laboratory and at Silver Lake, Calif., a well-known Mars analog study site. As part of their tests, they set up a rig that could work under different conditions not dissimilar from the final system that would be mounted on a Mars lander or rover.

"Being able to test the fluorescence signature both under laboratory conditions and in the field has been critical to being confident that such a system will work on the surface of Mars," said Muller, a co-author on the study and a professor of imaging at the University College London's Mullard Laboratory.

Andrew Coates, a co-author of the study and principal investigator of the international ExoMars PanCam team, said the challenge is to make the instrument light enough to be flown, and robust enough to survive the cold, minus-120 degree (C) Martian nights.

"With ExoMars PanCam, we already have thrilling science – stereo and zoom imagery giving the context for all the ExoMars life detection experiments and the use of colored filters to provide rock identification and atmospheric composition," Coates said. "If the team can show this is light and rugged enough, we will propose taking it to Mars."

Proving such durability will be a challenge, according to Andrew Griffiths, a co-author on the paper and the instrument manager for the ExoMars PanCam team. "Getting to Mars is tough, as we found with Beagle 2," he pointed out. "Surviving the surface conditions is even tougher, particularly with new technology."

While using fluorescence to illuminate organic material has been done for decades, light sources were too large and unwieldy to use for a robotic mission to another planet, said Storrie-Lombardi. However, new generations of light-emitting diodes, or LEDs, are very small, reliable and energy efficient, he added.

"Placed on a Mars rover, one of these LEDs positioned a few centimeters from a target can easily provide enough light to produce fluorescence in small polycyclic aromatic hydrocarbons," Storrie-Lombardi said. "But even more encouraging is the very recent development of a small 375 nanometer laser diode that can illuminate anything a PanCam can see, including geological layers and crevices high up on an otherwise inaccessible rock outcrop."

Added Muller: "This laser is now undergoing rigorous tests in the laboratory under Mars-like conditions prior to showing that it is flight-ready, even at this late stage, to be seriously considered to be launched in only five years' time."

The instrument appears to be "an ideal initial survey tool," Storrie-Lombardi pointed out.

"It requires no sample preparation, does not destroy sample material and requires only electrical power to operate, conserving precious water and other consumable resources for sister instruments," he said.

Since the Viking mission to Mars 30 years ago, no mission to Mars has focused exclusively on searching for evidence of organic material or biological activity, Storrie-Lombardi said. Now the ongoing Phoenix mission and the planned Mars Science Laboratory and ExoMars missions are positioned to reverse that trend.

"The addition of an ultraviolet triage system to search for hints of organic material fits well into the extensive suite of organic detection instruments planned for the MSL and ExoMars expedition," he said.

Oregon State's Fisk, whose research has focused in part on the study of microbes that grow in inhospitable locations, said the best chance of finding organic material on Mars would be wherever there is, or was, water – locations where rocks have experienced weathering.

"These are energy-rich environments for microbial life," said Fisk, a professor in OSU's College of Oceanic and Atmospheric Sciences.

Fisk and his colleagues have spent much of the past dozen years studying microbes that can break down igneous rock and live in the obsidian-like volcanic glass. They first identified the bacteria through their signature tunnels then were able to extract DNA from the rock samples – which have been found in such diverse environments on Earth as below the ocean floor, in deserts and on dry mountaintops.

Fisk and Storrie-Lombardi – along with other scientists at OSU and the Jet Propulsion Laboratory – previously collaborated on a study that found bacteria 4,000 feet below the ocean surface in Hawaii that they reached by drilling through the solid volcanic rock base of Mauna Kea.

Source: Oregon State University

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