Chemical guidebook may help Mars rover track extraterrestrial life

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To help a NASA rover eventually hunt for life on Mars, scientists are writing a chemical guidebook to aid the search for extraterrestrial life. Using new imaging tools and earthly parallels of ancient Mars environments, they're recording the types of subtle chemical changes that Martian microbes may have left on the planet's rocks. The researchers hope someday to arm a Mars rover with a suite of tools – a guidebook, precise chemical imagers, and human-like reasoning ability – and let it search for signs of alien life on its own.

Scientists from the U.S. Department of Energy's Idaho National Laboratory, University of Idaho, and University of Montana are developing the chemical guidebook as part of what they hope will be a definitive method to determine whether extraterrestrial rocks have ever harbored life. The group, supported by a $900,000 grant from the NASA Astrobiology Program, will be using chemical imaging technology that was previously developed at the INL and awarded a patent in November 2004.

The technology will be discussed during the 15th Annual Goldschmidt Conference, "A Voyage of Discovery," the premier annual meeting in geochemistry and mineralogy. The conference will be in Moscow, Idaho, May 20-25, and will mark the 50th anniversary of the Geochemical Society.

In 1996, a group of scientists reported they had found evidence of life on a Martian meteorite. But the claims are still controversial, said Daphne

Stoner, project leader and chemistry research professor at the University of Idaho in Idaho Falls. The debates highlight the need for clear methods that will distinguish so-called "biosignatures" from look-alike signs of life.

"This project will help build a good gold standard for the unequivocal determination of life on extraterrestrial materials," Stoner said.

Stoner is collaborating with chemist Jill Scott at INL, geologist Nancy Hinman at University of Montana in Missoula, post-doctoral geochemist Beizhan Yan at the University of Idaho, and geology graduate student J. Michelle Kotler at the University of Montana. The team is using a specialized mass spectrometer to take chemical images of microbes and rocks under conditions close to what might be found on Mars, as well as developing a fuzzy logic computer program to decipher those spectral pictures. The researchers will take advantage of local exotic microbes to test the system's ability to identify signs of microbial life in minerals here on Earth.

The key to finding signs of unfamiliar life is recognizing that all organisms must change their environment somehow as they breathe and eat, Scott said, even if they don't breathe or eat the same chemicals that we're used to. Stoner compares the idea to how even careful humans will still leave behind traces of their presence when camping. "You can notice a backcountry campsite," Stoner said. "It looks different from the forest around it."

So the researchers want to scour Martian rocks in search of the unexpected. With luck, they'll stumble across the remnants of a microbe. If not, they could still glean useful information from surprises in the rock's composition.

"We can ask, 'Is there something extra there, something not common?

Or is there something that's missing -- some minerals leached away?'" Stoner explained.

Some chemical changes, for instance, would arise as organisms use raw material in their environment for food and deposit other chemicals as waste. These clues may remain even after the organism itself has moved on or died and decayed beyond detection, Stoner said. The researchers expect these environmental anomalies to show up in detailed chemical images, called spectra, taken from samples of the planet's rocky surface.

Before scientists teach a rover to analyze these clues on Mars, though, they need to train it on easier things on Earth, Hinman said. First, the team will work in the lab with basic biomolecules, such as amino acids or DNA fragments, sprayed onto a background of minerals commonly found on Mars, such as iron-rich basalt. Then the researchers will move on to living microbes and see how they might affect various rocky environments, Scott said.

Lastly, the team will leave the lab and train their system, using exotic microbes found on Earth called extremophiles. These bacteria thrive in extreme environments such as high-heat, low-oxygen geothermal pools. Since they rely on sulfur and iron for energy sources – rather than the plant-based food that humans prefer – extremophiles are good examples of the type of adaptable microbes that might survive on Mars.

Two sophisticated research tools will aid in building the chemical guidebook. The recently-patented Laser and Optical Chemical Imager (LOCI) combines a laser positioning system with a device known as a Fourier-transform mass spectrometer. The LOCI's laser can blast a rock's surface and lift off a very thin top layer of material as a small gas cloud. Sensors then create spectral images of the cloud, and scientists can decide what the surface layers were made of – minerals such as iron, say, with a sprinkling of microbial waste products.

A LOCI-type instrument would be well suited for the sorts of tricky situations Mars is likely to pose, Scott said. For instance, it could do tests on the spot, freeing the rover up to haul less cargo back to Earth. "Rock samples from Mars are going to be precious," Scott said. "We want to bring back the ones with the best chance of showing signs of life."

To help make these decisions, a fuzzy logic computer program called the Spectral IDentification Inference Engine (SIDIE) would supply the Mars rover with some extra brains. The SIDIE, developed at the INL, uses an open-ended reasoning approach that mimics a human's decision-making abilities and learning. "Fuzzy logic is a very powerful technique," Scott said.

The program can analyze spectral images very quickly, report the level of uncertainty in its conclusions, build on information from neighboring rocks, and even learn from past experiences – all of which will speed along the human analyst's job.

"The other nice thing is that it's easy for a user to understand the decision-making process," Scott said.

Source: DOE/Idaho National Laboratory

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