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Life on Mars? Could Be, but How Will They Tell?

By KENNETH CHANG

The landscape looked lifeless. But satellite images from orbit identified geological formations containing minerals that microbes sometimes like to nestle in, and scientists dispatched a small rover to look at the rocks up close.

Fluorescent dyes sprayed on the ground lit up, proclaiming the presence of proteins and DNA. The rover also detected chlorophyll, the energy-producing molecule of plants.

And so scientists discovered life in Chile's Atacama Desert.

Life there, one of the driest places on Earth, is sparse, but no one was surprised to find it. And they weren't really hunting life on Earth. The exercise last summer was practice for the techniques scientists hope to use in the future on Mars, where the question of life remains intriguingly open.

"You've got to go look," said Dr. Alan S. Waggoner, director of the Molecular Biosensor and Imaging Center at Carnegie Mellon University in Pittsburgh and a participant in the NASA-sponsored project. "I'd give it a 50-50 shot that you could find it somewhere underground. But then that's a guess."

He is not alone. In an informal poll taken last month at a conference in the Netherlands, three-quarters of 250 scientists working on the European Space Agency's Mars Express mission said they believed Mars once possessed conditions hospitable to life. One quarter believe it still does.

Planetary scientists have long thought that early in its history Mars may have been more like Earth, warm and wet, a place where life could have taken hold. But then the climate turned cold and dry and has remained cold and dry for several billion years. For many, the presumption was that Martian life, if any ever existed, died away long ago.

Over the past year, the notion that life not only arose on Mars but persists today has become more plausible with reports of methane gas currently floating in its atmosphere. The two most likely sources are geothermal chemical reactions or bacteria, and because ultraviolet light breaks down methane within a few centuries, any detectable methane must have been put there recently.

Another possibility is that the methane comes from the remains of long dead organisms trapped underground as oil or coal-like deposits and transformed to methane by the heat of meteor impacts.

"The evidence is teasing us," said Dr. Everett K. Gibson Jr. of NASA's Johnson Space Center in Houston, a member of the research team that claimed in 1996 to have found organic molecules, bacterialike fossils and other evidence of life in a Martian meteorite found in Antarctica.

Meanwhile, biologists have in recent years discovered life on Earth in places they would not have expected, adapted to the harshest of conditions: in rocks miles underground, at the sunless bottoms of oceans, in extremely acidic waters.

Dr. Gibson said he believed that there was life on early Mars and that it could still be there. "Life tries to hang on," he said. "Life tries to do everything it can to survive."

Carbon-based life requires three essential ingredients - carbon, liquid water and energy - and all appear to be present on Mars. Carbon dioxide makes up most of Mars' thin atmosphere, and some Mars rocks, including the one that Dr. Gibson examined, are known to contain carbon.

Liquid water is no longer present at the surface, but it once was. NASA's Mars rover Opportunity found minerals, particularly an iron mineral known as jarosite, that require prolonged steeping in water to form. Images from spacecraft in orbit find signs that liquid water has burst onto the surface in geologically recent times.

Volcanic heat could provide the energy. The European Space Agency this month released photographs of Mars' north pole that showed signs of ash from eruptions.

At the Lunar and Planetary Science Conference outside Houston this month, Lindsey S. Link, a graduate student at the University of Colorado, presented calculations showing that even at temperatures not far above freezing, chemical reactions between water and minerals in the basaltic lavas of Martian bedrock could also generate energy for life to thrive on.

"It turns out there's quite a bit," Ms. Link said. "I think we're learning life doesn't need a lot more than rock and water, if it can get energy from these reactions."

But if life exists, how to find it?

Of the spacecraft that have flown to Mars, only NASA's two Viking landers in the 1970's carried biology experiments, and they found no signs of life. The surface of Mars is cold, waterless, almost airless and bombarded by deadly radiation.

Any surviving life would most likely have migrated underground, where dirt above provides shielding and heat below warms ice to water. Few expect that Martian evolution would have progressed beyond primitive microbes.

The challenge thus is to identify life that is microscopic, lives far underground and may not resemble life on Earth.

For their life-detection system, Dr. Waggoner and his colleagues at Carnegie Mellon developed fluorescent dyes that light up when they hook onto DNA or protein molecules. The dyes are designed to work even if Martian DNA and proteins do not quite come in the same forms as Earth ones.

For a test, they chose the Atacama Desert, a popular stand-in for Mars that stretches for 600 miles between the Pacific Ocean and the Andes Mountains. The wetter parts get half an inch of rain a year. The dry parts get nothing more than wisps.

The scientists brought along a nine-foot-long, 400-pound solar-powered rover named Zoë, named after the Greek word for life.

To simulate a real mission, a second team of scientists led by Dr. Nathalie A. Cabrol, a planetary geologist at the SETI Institute and NASA Ames Research Center in Mountain View, Calif., gathered in Pittsburgh. The scientists there acted as mission control, reviewing images and data collected by Zoë and deciding what it should do next.

While Zoë possessed the intelligence to roam at speeds up to 2 miles an hour, its operations were not completely autonomous. For one, Dr. Waggoner and others had to follow the rover around and squirt the fluorescent dyes onto the rocks as needed when the scientists in Pittsburgh found a rock that they thought merited closer analysis.

Once the dyes soaked in, a xenon lamp on Zoë's underside flashed. If DNA, proteins or chlorophyll, which is naturally fluorescent, were present, they would glow, their presence captured by a digital camera and radioed back to Pittsburgh.

After Zoë finished its work, the trailing scientists collected rock and soil samples to verify the rover's examination. In moister areas along the coast, Zoë successfully found lichens on rocks. In a drier area, Zoë reported DNA and proteins on seemingly barren rocks. Later, scientists were able to cultivate bacteria from those rocks.

Another set of trials this fall will add dyes for carbohydrates and lipids, molecules found in the walls of cells.

Researchers at the University of California, Berkeley, NASA's Jet Propulsion Laboratory and the Scripps Institution of Oceanography have taken a different approach in developing a suite of instruments they call the Mars Organic Analyzer.

The first instrument isolates organic, carbon-containing molecules. "That doesn't tell you about life," said Dr. Richard A. Mathies, a professor of chemistry at Berkeley. "That tells you about organic molecules."

The organic molecules are dissolved in fluid and transferred to a small chemistry laboratory-on-a-microchip that separates the molecules by type, including identifying amino acids, the building blocks of proteins. The presence of amino acids is not unambiguous evidence for life; they can even form in chemical reactions in outer space.

One final test checks for a biological calling card known as chirality. Amino acids come in two versions, mirror images of each other. Chemical reactions that produce amino acids generally produce both mirror forms equally. But life, on Earth at least, uses one form exclusively. Thus, if the instrument found more of one version than the other, "That's a very strong argument those molecules are produced by a biological process," Dr. Mathies said.

The amino acid detector was successfully tested in the Atacama last year. After the Mars rover Opportunity discovered jarosite at Meridiani Planum, the researchers took their instruments to Panoche Valley, Calif., and showed that they could pick out small amounts of amino acids trapped in the jarosite deposits there.

"We did all that in the field on these samples," Dr. Mathies said. "We showed the whole thing worked all the way through."

To figure out how to get below the surface and what might be found there, Dr. Carol R. Stoker of NASA Ames has been drilling at Rio Tinto, a river in Spain that also resembles Mars, although in different ways compared with Atacama.

The Rio Tinto waters are highly acidic and stained red with dissolved iron, an environment that may be similar to Mars' Meridiani Planum when it was wet.

At the Lunar and Planetary Science Conference, Dr. Stoker reported that she and her colleagues had found vibrant communities of methane-producing microbes in drilling cores from those waters up to 500 feet deep.

"If sulfides and liquid water are both present in the Martian subsurface," Dr. Stoker said, "then resources are available to support a subsurface biosphere analogous to that at Rio Tinto and methane could be a product of such a biosphere."

This year, Dr. Stoker will also run a simulation of a Mars mission, with scientists running a drill rig at Rio Tinto remotely.

None of these projects will make it to Mars anytime soon. NASA has not put any instruments on Mars to detect life since the two Viking landers three decades ago, and no life-detection experiments will be on its next three missions: Mars Reconnaissance Orbiter, which launches in August, the Phoenix Lander in 2007 and Mars Science Laboratory in 2009.

Those missions do include instruments that will better describe the geological and chemical surroundings, which may give a better idea whether life is likely and where to look.

Reconnaissance Orbiter has ground-penetrating radar that may reveal underground water. Phoenix will repeat Viking's experiments looking for organic molecules, at higher temperatures, which may free them from the soil. Mars Science Laboratory has an even more sophisticated suite of instruments.

The European Space Agency has announced ExoMars, a rover that will carry Dr. Mathies's instruments and other life-detection experiments. The mission, originally aimed for 2009 and then delayed to 2011, probably will not fly until sometime later, said Dr. Gerhard Schwehm, head of E.S.A.'s planetary missions division.

For any mission to Mars, weight, cost and power set limits on what instruments can be used. Definitive answers may have to wait for a Mars sample return mission, when pieces of Martian rock and dirt are brought back to Earth and examined by scientists using the full complement of tools in their laboratories. That will probably be at least a decade from now.