Growing Prospects For Life on Mars Divide Astrobiologists

As discoveries on Mars, including warm spells and salty soil, raise the chances of finding life there, scientists consider how best to look for it within their budget

Looking good. Phoenix found water ice and benign living conditions in the martian Arctic.

THE MICROSCOPIC, WORMY-LOOKING things found in a meteorite blasted off Mars certainly reinvigorated NASA's search for extraterrestrial life in the 1990s. But the critterlike sightings and almost all of the other evidence for ancient life claimed for the martian meteorite have since faded away. Replacing them in recent years is a string of encouraging discoveries on Mars, including pervasive ice just beneath polar soils, water-wrought minerals of every sort, and soil benign enough to grow asparagus.

"Mars has met all requirements to support life," says planetary scientist and astrobiologist Bruce Jakosky of the University of Colorado, Boulder. "Life is possible." But as the planetary science community draws up its prioritized list of missions for the next decade, astrobiologists have split over the next logical step in the search for life on Mars.

Many researchers are content to follow NASA's lead as it cautiously moves from "following the water" in search of likely habitable or once-habitable environments to "following the carbon"—that is, looking for chemical traces of ancient life. Others are not so patient. "It's time to search for life by searching for life," says astrobiologist Carol Stoker of NASA's Ames Research Center (ARC) in Mountain View, California. The direct detection of life—living, dormant, or recently deceased—should be a high priority, she and others say. The planetary science decadal survey now being drafted and to be released next March will determine whether they're right.

A life-friendlier planet

The search for martian life took a body blow in the late 1970s, when life-detection experiments on the Viking 1 and Viking 2 landers failed to stir up clear signs of either living creatures or lifeless organic debris. Mars seemed to be dead, as dead as an eons-old, hyperarid, incredibly cold landscape would appear to be.

It wasn't long, however, before things started looking up again. Orbital observations from Viking onward revealed ever more evidence that water gushed across the surface of early Mars, forming lakes and perhaps even a northern ocean at about the time life was getting started on Earth. Spectra returned by orbiters in the past decade showed that liquid water on early Mars stayed around long enough to corrode rock into alteration minerals under life-friendly conditions. And the Mars rover Spirit found ancient minerals produced by hot ground waters, much as happens in the life-infested hot springs of Yellowstone.

Stymied. The Viking landers found no signs of life.

Closer to modern times, water—albeit frozen—is turning up in all manner of places. In recent years, orbiting instruments have spied widespread ice just beneath the surface soils of Mars: centimeters down in polar regions and meters down in immobile glaciers at midlatitudes. But that water might not always have been frozen. Mars's wobbling on its axis would have warmed parts of the planet. Orbitally induced climate cycles mean that Mars has become "a far more interesting place than we thought," says astrobiologist David Des Marais of ARC. The fresh-looking gullies of Mars, for example, may have been gushing meltwater in the not-so-distant geologic past.

With things looking up for biology on Mars, NASA sent the Phoenix lander to a landing site in the martian Arctic that turned out to be relatively life-friendly. "We believe we have a habitable environment in modern times," says Stoker, who is on the Phoenix team. The site is "not necessarily

CREDITS (TOP TO BOTTOM): NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA/TEXAS A&M UNIVERSITY; NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA

Published by AAAS

Following the carbon. The Curiosity rover, due for launch next year, will minutely analyze any organic matter it finds.

growing organisms today," she says, but "over the past 10 million years during warm conditions," life could have survived and perhaps thrived.

To put a number on that assertion, Stoker and 12 co-authors published a "semiquantitative" analysis of the Phoenix site's potential habitability online 16 June in the *Journal of Geophysical Research-Planets* (*JGR*). They considered the likelihood of four factors essential for life. One is liquid water. Phoenix's discovery of carbonate requires liquid water in the past to produce the mineral, they noted. The high concentration of perchlorate salt found by Phoenix offers a means of forming brines that could remain liquid even at today's temperatures. And even without brines, orbitally induced warming could have allowed liquid water in the recent past.

Phoenix's perchlorates could also serve as an essential energy source for microbes with a taste for such chemicals, the group said. Nutrients such as nitrogen and phosphorus blow in on dust. And environmental conditions, such as the Phoenix-measured pH, are benign. All that makes martian high latitudes "more tantalizing," says atmospheric chemist Sushil Atreya of the University of Michigan, Ann Arbor.

A lively Mars, ever?

An even more tantalizing hint of possible current life showed up in 2003. Researchers reported finding traces of methane gas in the atmosphere of Mars, first in spectroscopic observations returned by Mars Express and then in telescopic observations from Earth. A lifeless, subsurface water-rock reaction called serpentinization could be the source, but living, methane-belching microbes would work, too.

Another encouraging sign just came from the laboratory. Astrobiologist Rafael Navarro-González of the National Autonomous University of Mexico in Mexico City and his colleagues report in a paper in press in *JGR* their terrestrial version of the Viking search for organic matter on Mars. In the Viking experiments, a martian soil sample was heated to 500°C and the resulting gases analyzed. Instead of organics from the soil, Viking detected only carbon dioxide and two chlorinated methane compounds. The latter were considered to be contaminants brought from Earth, even though they did not appear when the experiment was run without soil while Viking was in space.

Navarro-González and his colleagues, including Christopher McKay of ARC, reran the Viking experiments in the lab using the most Mars-like soil available, one from the heart of the Atacama Desert of Chile containing a trace of organic matter. When they added a bit of perchlorate before the heating, in line with the Phoenix discovery, they duplicated the Viking results: no volatilized organics, some carbon dioxide, and the same two chlorinated methane compounds.

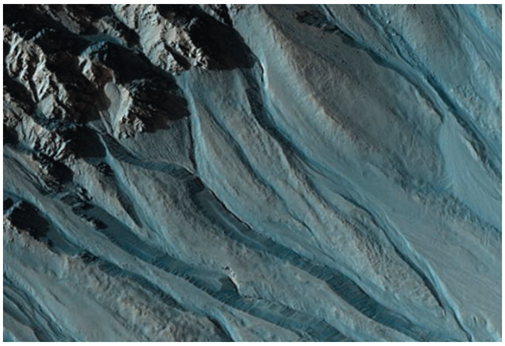
"The simplest explanation is that there was perchlorate and organic matter in the Viking soil samples," says McKay. When heated, the perchlorate would have oxidized most of the organic matter to carbon dioxide and chlorinated a small amount of it. If the Viking soil did contain organic matter, it could have come from lifeless meteorites and cosmic dust that rains onto Mars. But "we did dispel the idea that there's no point in searching for" molecular traces of life in martian organic matter, McKay says.

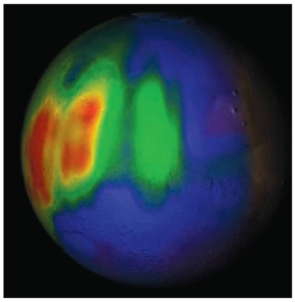
Go for it?

All the upbeat developments have some astrobiologists raring to go. "The theme has been 'Follow the water,' " says Stoker, "but we understand enough to take the next step." That step would be attempting to directly detect active or dormant present-day life. "The probability of identifying life is higher for modern" than for ancient life, says Stoker. The best approach, McKay says, is to send modern biochemical sensors to Mars capable of directly detecting complex biomolecules like DNA from living or dormant organisms. Such a prospect has made some astrobiologists "impatient to do something directly relevant to the search for life," says McKay, "rather than taking 'more pictures of rocks.' "

NASA's astrobiology plans for Mars are "geared much more toward ancient life than present-day life," notes Jakosky. In 2011, NASA will send the Mars Science Laboratory, now dubbed Curiosity, to follow the carbon at a low-latitude site. In a joint 2016 effort with the European Space Agency, it will send the Trace Gas Orbiter to check on the methane. And for 2018, NASA is considering a rover that would collect likely samples for eventual return to Earth and detailed laboratory analysis for ancient life.

A search for ancient life has plenty of supporters. "A majority [of astrobiologists] would say ancient life will be easier to find than present-day life," says Jakosky. To find present-day life, researchers have to first identify a likely site, he says. Then they would have to choose which measurements would detect alien life. In hindsight, Viking scientists erred in designing their life-detection experiments for microbes accustomed to Earth's most benign conditions. And ruling out microbial contamination from Earth would be challenging. Although going after present-day life could yield "the most profound result," says Jakosky, it would be "very risky. The odds are against it even if life is present."





Getting closer? Viking (*left*) found no life, but apparent recent water flows (*top*) and methane (*above*) hint at it.

A committee of the National Research Council is now balancing the odds of success of the two approaches against the available funding in the United States as it finishes the first draft of the Planetary Science Decadal Survey. Its prioritized list of missions for 2013 to 2022 is "exciting and actually implementable," says committee chair Steven Squyres of Cornell University. How lively its missions to Mars will be remains to be seen.

–RICHARD A. KERR

CREDITS (TOP TO BOTTOM): THOMAS A. DUTCH SLAGER/NASA/JPL/CALTECH; NASA/JPL/UNIVERSITY OF ARIZONA; NASA/JPL; NASA

Published by AAAS