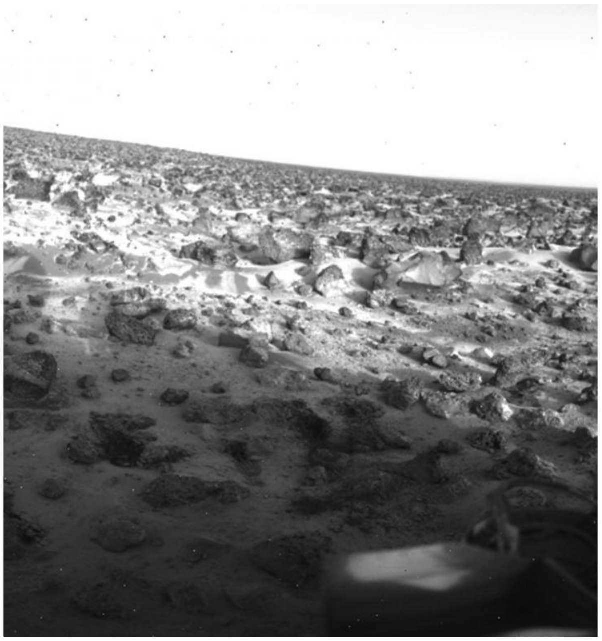
# Did 40-year-old Viking experiment discover life on Mars?

October 21 2016, by Lisa Zyga



The Viking 2 Lander site, showing frost on the ground. This image was taken by Viking 2 in 1979. Credit: NASA; Viking 2 Lander image P-21873

(Phys.org)—In 1976, two Viking landers became the first US spacecraft from Earth to touch down on Mars. They took the first high-resolution images of the planet, surveyed the planet's geographical features, and analyzed the geological composition of the atmosphere and surface. Perhaps most intriguingly, they also performed experiments that searched for signs of microbial life in Martian soil.

Overall, these life-detection experiments produced surprising and contradictory results. One experiment, the Labeled Release (LR) experiment, showed that the Martian soil tested positive for metabolism—a sign that, on Earth, would almost certainly suggest the presence of life. However, a related experiment found no trace of organic material, suggesting the absence of life. With no organic substances, what could be, or seem to be, metabolizing?

In the forty years since these experiments, scientists have been unable to reconcile the conflicting results, and the general consensus is that the Viking landers found no conclusive evidence of life on Mars. However, a small minority of scientists argues that the Viking results were positive for life on Mars.

One prominent proponent of this view is Gilbert Levin, Experimenter of the Viking LR experiment. At first, Levin thought that the LR results were unclear, and stated merely that the results were consistent with biology. However, in 1997, after many years of further experiments on Earth, along with new discoveries on Mars (which NASA has now declared "habitable"), and the discovery of microorganisms living under conditions on Earth as severe as those on Mars, he and his Viking Co-Experimenter, Dr. Patricia A. Straat, have argued that the Mars results are best explained by living organisms.

Recently, Levin and Straat published a perspective piece in the journal *Astrobiology* in which they reconsider the results of the Viking LR experiment in light of recent findings on Mars and recent proposals for inorganic substances that may mimic the observed metabolism-like processes. They argue that none of the proposed abiotic substances sufficiently explains the Viking results, and that Martian microbes should still be considered as the best explanation of the results.

## How the Labeled Release experiment worked

In the LR experiment, both the Viking 1 and Viking 2 landers collected samples of Martian soil, injected them with a drop of dilute nutrient solution, and then monitored the air above the soil for signs of metabolic byproducts. Since the nutrients were tagged with radioactive carbon-14, if microorganisms in the soil metabolized the nutrients, they would be expected to produce radioactive byproducts, such as radioactive carbon dioxide or methane.

Before launching the Viking spacecraft, the researchers tested the experimental protocol on a wide variety of terrestrial soils from harsh environments, from Death Valley to Antarctica. In each case, the experiments tested positive for life. Then as a control, the researchers heated the samples to 160 °C to kill all lifeforms, and then retested. In each case, the experiments now tested negative. To further confirm that the experimental procedure would not produce false positives, the researchers tested it on soils known to be sterile, such as those from the Moon and the Surtsey volcanic island near Iceland, which produced negative results as expected.

Once on Mars, the LR experiment was performed after the experiment searching for organic molecules came up empty-handed. So it came as a surprise when both Viking landers, located 4,000 miles apart, collected soil that tested positive for metabolism. To rule out the possibility that the strong ultraviolet radiation on Mars might be causing the positive results, the landers collected soil buried underneath a rock, which again tested positive. The control tests also worked, with the 160 °C sterilization control yielding negative results.

In addition, it seemed that whatever was doing the metabolizing was relatively fragile, since metabolic activity was significantly reduced when heating the sample to 50 °C, and completely absent when storing the soil in the dark for two months at 10 °C. Levin and Straat believe that these results provide some of the strongest evidence that the soil contained Martian life.

## Nonbiological candidates

Ever since the LR experiments, researchers have been searching for other kinds of nonbiological chemicals that might produce identical results.

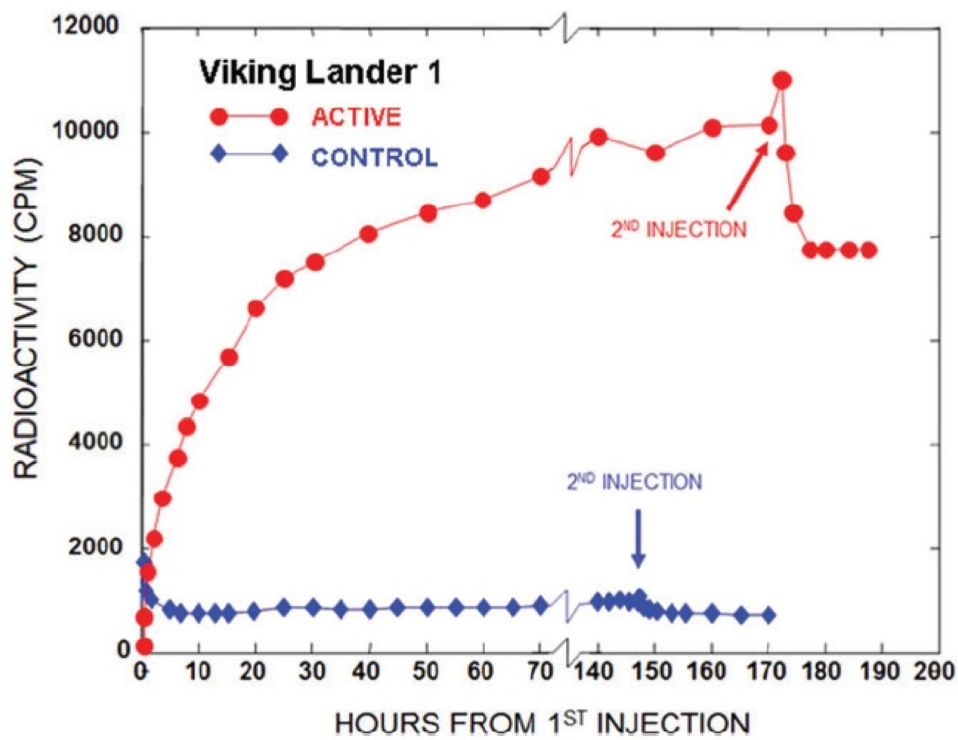
In their new paper, Levin and Straat review some of these proposals. One possible candidate is formate, which is a component of formic acid found naturally on Earth. A 2003 LR-type experiment found that formate in a soil sample from the Atacama Desert in South America produced a positive result, even though the soil contained virtually no microorganisms. However, the study did not include a sterilization control, and it's likely that the formate concentration in the Atacama Desert is much higher than that on Mars.

Another potential candidate is perchlorate or one of its breakdown products. In 2009, the Phoenix mission to Mars detected perchlorates in the Martian soil. Although perchlorates could yield a positive result because they produce gas when interacting with some amino acids, they do not break down at 160 °C, and so would continue to give positive results after the sterilization control.

A 2013 study proposed that cosmic rays and solar radiation can cause perchlorate to break down into hypochlorite, which would produce positive results and, unlike perchlorate, is destroyed by heating at 160 °C. For these reasons, hypochlorite is arguably the best candidate yet to explain the LR results.

Nevertheless, Levin and Straat note that hypochlorite has not yet been tested at 50 °C (the temperature at which the activity of the Martian soil was significantly reduced) or after long-term storage in the dark (which produced a negative result for the Martian samples). So at this point, no nonbiological agent has satisfied all of the LR results.

## Biological candidates




The Viking 1 Lander's LR results show that, when injected with the nutrient solution, the soil sample exhibited strong radioactivity, indicating metabolism. The control soil sample, which had been heated to kill any microorganisms, had a negative response. Credit: Levin and Straat, 1977, Biosystems. ©Elsevier

Today researchers know much more about Mars than they did 40 years ago. One of the biggest discoveries came in 2014, when the Mars

Science Laboratory Curiosity rover detected the presence of organic molecules on Mars for the first time.

Over the past two years, Curiosity's onboard Sample Analysis at Mars (SAM) laboratory has detected methane, chlorinated hydrocarbons, and other organic molecules. Researchers suspect that these organic substances may have formed on Mars or been carried there by meteorites.

The discovery of organic matter on Mars raises the question of why the Viking experiment did not detect organic matter back in 1976. As Levin explains, there are multiple reasons that might explain why the Viking results were negative.

"We long ago pointed out the problems with the Viking GCMS (gas chromatograph—mass spectrometer)," Levin said. "Even its experimenter, Dr. Klaus Biemann, often stressed that the GCMS was not a life-detection experiment. It required at least one million microbial cells to detect any organic matter. In addition, the instrument had frequently failed when tested on Earth. Later, it was claimed that perchlorate in the soil destroyed the organic matter. However, I view this cautiously as there is no evidence for perchlorate at the Viking sites."

In light of the recent findings, Levin and Straat believe that it's important to reconsider the LR results as having a biological origin. Other researchers who support this view have proposed that Martian life could take the form of methanogens (microorganisms that produce methane as a byproduct), halophiles (which can tolerate high salt concentrations as well as severe radiation and low oxygen concentrations), or some type of "cryptobiotic" microorganism that lies dormant until reactivated, such as by a nutrient solution like the one in the LR experiment.

## Publishing challenges

Publishing a paper about life on Mars was very different than publishing more typical studies (over the years, Levin's research has included low-calorie sweeteners, pharmaceutical drugs, safer pesticides, and wastewater treatment processes, among others). It took nearly 20 years for Levin and Straat to publish a peer-reviewed paper on their interpretation of the Viking LR results.

"Since I first concluded that the LR had detected life (in 1997), major juried journals had refused our publications," Levin told *Phys.org*. "I and my co-Experimenter, Dr. Patricia Ann Straat, then published mainly in the astrobiology section of the SPIE Proceedings, after presenting the papers at the annual SPIE conventions. Though these were invited papers, they were largely ignored by the bulk of astrobiologists in their publications." These papers are available at gillevin.com.

"At a meeting of the Canadian Space Agency, I met Dr. Sherry Cady, the editor of *Astrobiology*. She invited me to submit a paper for peer review. I did and it was promptly bounced, not even sent out for review because of its life claim.

"Pat and I decided we would produce a paper that would withstand the utmost scientific scrutiny. It took years of countless renditions and compliance with or explanation away of a myriad of reviewers' comments, but we persisted until we disposed of every adverse comment. Thus, we think this publication is quite significant in that it was scrubbed so thoroughly that the points remaining are firmly established.

"You may not agree with the conclusion, but you cannot disparage the steps leading there. You can say only that the steps are insufficient. But, to us, that seems a tenuous defense, since no one would refute these results had they been obtained on Earth."

**Future outlook**

For Levin and Straat, one of the most important reasons for considering the existence of life on Mars is a practical one that may affect future research.

"It seems prudent that the scientific community maintain biology as a viable explanation of the LR experimental results," they write in their paper. "It seems inevitable that astronauts will eventually explore Mars. In the interest of their health and safety, biology should be held in the forefront of possible explanations for the LR results."

Going forward, Levin and Straat propose that carefully designed experiments can help to answer the question of the existence of life on Mars. In particular, LR-type experiments that test for chiral preference could tell whether the metabolizing substance is biological or chemical, since only biological agents can distinguish between left and right isomers. The scientists also emphasize the importance of the continued search for organic molecules, especially those with biological significance such as amino acids, simple carbohydrates, lipids, proteins, and DNA. Future experiments may also provide the possibility of examining Martian soil under a microscope.

Despite the positive outlook, Levin and Straat note that all future experiments will have an unavoidable drawback: the potential for contamination by previous landers. In this regard, the Viking landers were unique in that they were the only pristine Martian life-detection experiment that we will ever have.

**More information:** Gilbert V. Levin and Patricia Ann Straat. "The Case for Extant Life on Mars and Its Possible Detection by the Viking Labeled Release Experiment." *Astrobiology*. October 2016, 16(10): 798-810. DOI: 10.1089/ast.2015.1464