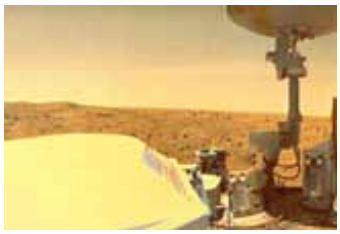

Viking Data Still Cause Stir About Mars Life

By Michael Paine
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NASA recently posted on its Web site detailed data collected at Mars 25 years ago by life-detection experiments aboard the Viking spacecraft. The scientific community's judgment on those findings is one of the longest running and most contentious debates in space science.

In 1976, two ingenious spacecraft soft-landed on Mars. Each was equipped with a miniature biology laboratory packed into less space than a domestic microwave oven. The three biology experiments within the package each produced some positive results that might have been associated with living organisms but the overall verdict at the time was that these results were caused by chemical rather than biological processes.

All these years later, scientists continue to glean information from the Viking data and still debate whether the results indicate life in the soils of Mars. The pendulum has swung back and forth between chemical and biological explanations for the Viking results.

The experiment

The Labeled Release (LR) experiment produced the most tantalizing results. Like most forms of life on Earth, when we consume food, some is processed and combined with oxygen to produce energy. The gas carbon dioxide is a product of that process and is present in our expired air. The clever idea with the LR experiment was that the carbon atoms in the food were radioactive and therefore could be detected in the air if a creature in the Martian soil processed the food and generated carbon dioxide (or some other gas containing carbon). In the LR experiment a radioactive broth was added to a sample of Martian soil in a closed chamber. A detector in a side chamber measured the amount of radioactivity in the air. A series of experiments was conducted to help eliminate non-biological processes. For example, some involved heating the soil to high temperature to sterilize any micro-organisms.

Viking scientists back on Earth got very excited when the first results from both Vikings were received. There was a burst of gas production when the broth was first added to the soil. This did not happen when the soil was sterilized -- as might be expected if micro-organisms had died. However, when the unheated sample was measured over several weeks the gas production levelled off, suggesting that any micro-organisms, if present, had failed to survive and grow. Also when more broth was added there was no substantial release of gas. These conflicting results, coupled with the results of other Viking experiments led most scientists to conclude that the LR results were produced by non-biological reactions due to (unknown) chemicals in the Martian soil.

The players

Harold Klein was Biology Team Leader for the Viking Project. He

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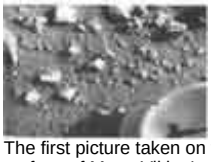
A model of the Mars Viking Lander 1


The TRW-built Mars viking biology experiment was prepared in a clean room. The equivalent of a university biology lab, it contained more than 40,000 components crammed into a space no larger than a car battery. Both Viking landers carried these devices. CREDIT: TRW Space & Electronics


The first picture taken on the surface of Mars. Viking's camera began scanning the scene 25 seconds after touchdown and continued to scan for five minutes. The picture was assembled from left to right during the 20 minutes it took to transmit the data from the Orbiter relay station to Earth.

has been described as the father of exobiology -- the study of life beyond the Earth. Despite his strong desire to find life on Mars he understood the rigorous evidence that would be needed to convince the scientific world that non-terrestrial life had been discovered. Since the 1970s he has expressed skepticism about further claims of evidence of life in the Viking data. Sadly, Klein died in July this year.

Gilbert Levin was involved in the design of the LR experiment and the analysis of the results. For 25 years he has labored to show that the best explanation for the results is that they were produced by Martian organisms. He has collected microbes from Alaska and Antarctica and subjected them to the LR experiments with results that match some of the Viking results. He has experimented with a range of non-biological chemicals see if they can produce the same results. He has questioned assumptions about the absence of liquid water on Mars and the chemical effects of bombardment of the soil by ultraviolet radiation. Levin has made a tremendous contribution to the study of extra-terrestrial life and he has designed new experiments for future Mars missions that could resolve the ambiguous Viking results. Unfortunately his enthusiasm for the issue has put off some scientists who regard his claims about the Viking experiments extravagant and unfounded. Levin has pushed the pendulum towards a biological explanation for the Viking results but, as Klein pointed out, this as a long way from unambiguous evidence of life on Mars.

In a 1998 paper Klein questioned whether there were, as claimed by Levin, terrestrial organisms that could produce the LR results under the conditions encountered on Mars. If organisms were present in the Martian soil they came from extremely cold, dry conditions with no atmospheric oxygen. They were heated to about 10 degrees Celsius and held at that temperature for several days before a small amount of broth was added. Radioactive gas was detected almost immediately and increased quickly before tapering off after about two hours. After the initial reaction died down a second quantity of broth was added. There was an initial drop in radioactive gas readings -- possibly the moistened soil reabsorbed it. After this no substantial release of radioactive gas was observed. These were not results that are usually associated with micro-organisms on Earth. Klein also pointed out that the process which produced the gas was highly selective in the type of carbon compounds that it consumed -- a result that was more likely with a selective chemical reaction than a biological process.

From experience on Earth, if organisms were present in the Martian soil samples they were either dormant, and waiting for the "right" conditions to start the life processes, or they were extremely hardy organisms that managed to live normally in the harsh Martian conditions. If dormant, it seems surprising that they "awoke" so quickly when the nutrient was added. Levin refers to tests of Earthly lichen that gave a vigorous initial response and then apparently died from too much water. He suggests this might have occurred with Martian organisms. However, Klein noted that only a small quantity of broth was added in the Viking experiment so that a large portion of the soil was not drenched with the broth. Why didn't micro-organisms in the unaffected soil survive to produce gas in later experiments? The other puzzle is that the surface of Mars typically has not changed for millions of years so where did the dormant spores come from?

If the organisms were adapted to the Martian conditions it is surprising that they also found the much warmer and wetter conditions in the Viking chamber comfortable. Most organisms on Earth do not respond well to being heated to more than 40 degrees Celsius above their usual temperature. This does not rule out a remarkably tough Martian organism but is another reason to be cautious about the Viking results.

The other lingering question is the composition of the gas that was released. Radioactive carbon was present. This was probably carbon dioxide but could have been methane, some other gas or a mixture of gases. Earthly organisms generally require atmospheric oxygen to produce carbon dioxide but other sources of oxygen would be needed on Mars.

A Viking 1 Lander image of Mars' Chryse Planitia. The large white object at lower left and center, with the American flag on the side, is the spacecraft's radiothermal generator (RTG) cover. The shot is looking to the northwest of the lander.

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Viking Data Still Cause Stir About Mars Life (cont.)

Later acts

Rick Cavicchioli of the University of New South Wales studies extremophiles from Antarctica, including an organism called Methanogenium frigidum. It only grows in very cold oxygen-free conditions and makes a living by combining hydrogen and carbon dioxide to produce methane. Other Methanogens have been found in warmer conditions such as deep sea hydrothermal vents but the Antarctic bugs will die if exposed to oxygen or to temperatures higher than 18 degrees Celsius. They stop growing at temperatures below -10 degrees Celsius but might do quite well in the soils of Mars on a warm day, if they could find a source of hydrogen and protection from UV rays. Cavicchioli points out that M. frigidum do not require a source of carbon, other than carbon dioxide in the air. They are therefore unlikely to have been interested in the offer of carbon-containing broth in the LR experiments.

Joe Miller of the Keck School of Medicine at the University of Southern California has taken a different approach to analysis of the Viking LR data. He noticed that the radioactivity readings had a small but persistent sawtooth pattern that matched the length of the Martian day. This caught his attention because he had observed similar "circadian rhythms" in Earthly microorganisms. Careful analysis revealed that the fluctuations matched those of the temperature in the test chamber. The Viking laboratory was designed to hold the samples at near constant temperature despite the fluctuations of more than 50 degrees Celsius outside between the Martian day and night. The equipment managed a creditable 2 degrees Celsius fluctuation but Miller points out that this was still sufficient to cause some of the observed oscillation in radioactive gas due to reabsorption of carbon dioxide when the soil cooled slightly. He claims that this effect, together with other sources of variation such as equipment effects, can, at best, account for between 55 percent and 78 percent of the observed LR oscillation. He suggests that a biological response best explains the remaining component of the oscillation and several other characteristics of the experiments.

Miller is conducting further analysis of the Viking LR data to look for circadian rhythms that do not match the length of the Martian day, and therefore the temperature fluctuations in the chamber. He notes that Earthly organisms that are held under constant conditions develop rhythms that are out of step with day and night on Earth.

Miller is particularly excited about the possibility of organisms that process methane on Mars because methane is not easily absorbed by soil. The sawtooth pattern would need to be explained by other means. Also, from Earthly findings, it now seems possible to have an ecology of methane producers and methane consumers that live in a symbiotic partnership in the absence of oxygen.

While the work of Miller and Levin, if confirmed, might push the pendulum further towards biology it is unlikely that the Viking data will ever fully eliminate the possibility that the strange results were caused by exotic chemical reactions. It seems that we will need to wait for further spacecraft missions to Mars to resolve the question of whether the Viking experiments detected life. Hopefully the designers of those spacecraft are looking at the lessons learned from the stunning Viking project.

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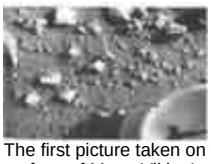
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