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Viking and the Question of Life on Mars

Part 2: The Mission to Mars

by Andrew J. LePage

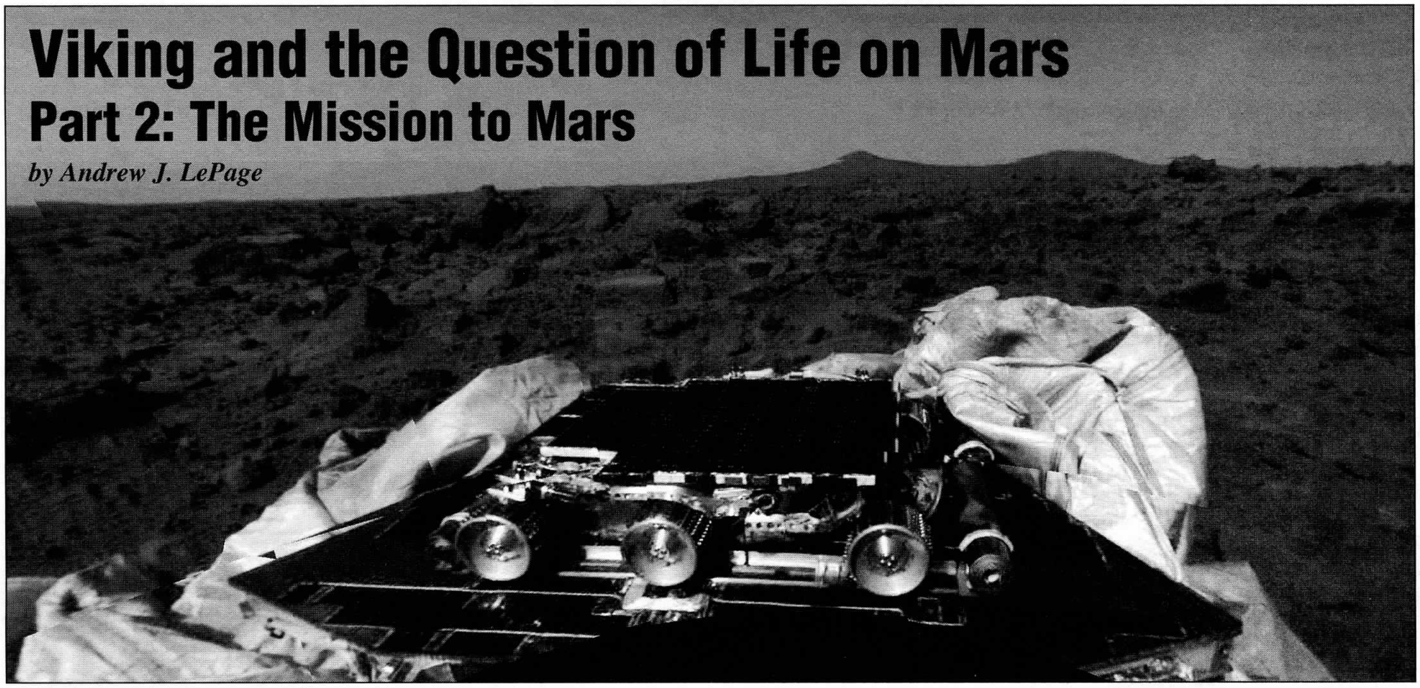

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Figure 3: *After a hiatus of more than two decades, mankind has returned to the surface of Mars. Here we see one of the first panoramas returned by the Mars Pathfinder, renamed the Sagan Memorial Station, from the planet's surface. This spacecraft, and the others to follow during the years to come, may shed more light on the question of past and present life on Mars.*

The development of the Viking spacecraft and its experiments were wrought with technical problems, schedule delays, and cost overruns. Nobody anticipated the true complexity of developing all the instruments, especially those designed to detect life on Mars. The total cost of the Gas Chromatograph–Mass Spectrometer (GCMS) skyrocketed to $41.2 million from an original estimate of $16.6 million (1). The biological experiments experienced similar price increases with the initial cost estimate of $13.7 million, significantly less than the final bill of $59.5 million (1). In the process of reigning in not only the costs of building these instruments but their growth in mass and volume, many engineering changes during development limited the flexibility of the experiments and the number of analyses that could be performed. These problems also resulted in the deletion of the Wolf Trap experiment in the biology package in early 1972 (1).

Despite the delays, the experiments were finally delivered in early 1975 for integration with the landers. The final spacecraft assembly, testing, and sterilizing were completed in time for the 1975 launch opportunity. Viking 1 lifted-off on August 25, 1975, after a series of launch delays (18). Viking 2 followed its sister into a ten-month trans-Mars trajectory two weeks later on September 9, 1975 (19). Tests performed during the cruise to Mars indicated that one of the three ovens on the GCMS units carried by the two landers was no longer functioning thus decreasing the number of soil samples that could be tested (3,20). Except for this malfunction, all of the lander's instruments seemed to be functioning as intended.

Viking 1 was the first to reach Mars on June 19, 1976, when it entered its initial 42.6-hour orbit. Two days later its orbit was trimmed so that its periapsis was 1,514 kilometers and its period decreased to 24 hours 40 minutes, the equivalent of about one Martian day (21). The first orbiter images of the original landing site (which was very close to the Mars Pathfinder landing site used 21 years later, in 1997) showed that it was much rougher than anticipated (Figure 3). The need to look for a new landing site forced a postponement of the original July 4, 1976, American bicentennial landing date (22). After weeks of searching, a suitable landing site was found and the Viking 1 lander finally came to rest on Mars on July 20, 1976—seven years to the day after the Apollo 11 Moon landing. The final landing spot was to the northwest of the original site at 22.4 degrees north, 47.5 degrees west in Chryse Planitia (23).

The nominal plan did not call for the first soil sample to be taken until several days after the landing. This allowed time for scientists to review the composition of the atmosphere based on the entry science package. It also allowed time for any residual fumes from the Viking's hydrazine-fueled landing rockets to clear from the area. Both were needed before the GCMS ana-

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lyzed its first atmospheric sample. While the latter reason is obvious since the investigators wanted to avoid terrestrial contaminants, the former is more subtle. Engineering data returned from the mass spectrometer on the Soviet Mars 6 entry probe during its landing attempt on March 12, 1974, showed that its ion pump was drawing more current than expected. Unfortunately the lander did not survive its landing attempt so it never returned the actual mass-spectrometer findings. The problem with the ion pump, however, indirectly hinted that the Martian atmosphere might contain as much as 20 to 30 percent of an inert gas such as argon (24). While the Viking experiments were modified as a result of this potential problem, this amount of argon could hamper the Viking lander's mass-spectrometer measurements of the Martian atmosphere. The analysis of the entry sciences' Neutral Mass Spectrometer results showed that the Martian atmosphere contained a nonthreatening 1.6 percent of argon (25) so GCMS analysis started on July 24, 1976 (26).

Two days after landing, Viking 1 unstowed its sampling arm in preparation to secure the first samples for its surface experiments (Figure 4). There were some problems with the sample arm because a stuck retaining pin jammed the arm (27), but this problem was quickly solved and the sampling arm obtained its first subsurface soil samples on July 28, 1976 (28). Two samples were obtained for the GCMS, one for the biology experiments, and another for the X-ray fluorescence spectrometer designed to determine the presence of elements heavier than carbon in the soil. While there were indications that the GCMS did not receive its sample, the biology package did and immediately began preparations for its first experiment cycle (1).

Much to the amazement of the Viking biology team, all three biology experiments showed signs of vigorous activity almost immediately. During a news conference on July 31, 1976, Viking biology team leader Harold P. Klein and his colleagues stunned the reporters with the news of the initial biology results.

The Gas Exchange experiment produced a large volume of gas rich in oxygen right after its first injection of nutrients. The Labeled Release experiment was producing counts indicating a high degree of activity that, to a first approximation, looked biological. The Pyrolytic Release experiment was still incubating its first sample at this time but its results three days later also indicated vigorous activity. While the startling amount of activity was promising, the scientists cautioned reporters that the case for life on Mars was not yet proven. They still had to run their control experiments with heat-sterilized samples and the GCMS still had to run its analysis to look for organic molecules (28).

After a series of problems with the Viking 1 sampling arm that delayed getting another sample for the apparently empty GCMS, scientists decided that the instrument's sample level indicator was giving a false empty signal and decided to start the first analysis anyway on August 6, 1976, at 200 degrees C. The sample released some water but, much to the chagrin of the scientists, absolutely no organic molecules were detected except for traces of Freon-E type fluorocarbons and methyl chloride that was used to clean the instrument during assembly on Earth (3). The presence of these compounds did not hamper analysis and served as an independent check of the operation of the GCMS as well as a calibration standard.

A second analysis of the first sample at a temperature of 500 degrees C produced much more water and some carbon dioxide but again, no organic compounds were observed. Even though the control experiments run by the biology experiments produced significantly reduced levels of activity as might be expected by the microorganisms, the lack of any organic compounds in the first, or even in the second, Viking 1 GCMS sample hinted that the chemistry being observed was not biological.

When Viking 2 landed at 48.0 degrees north and 225.7 degrees west in Utopia Planitia on September 3, 1976, scientists were anxious to see what it would find (29). As it turned out, the Viking 2 lander's analyses produced results almost identical to those of the Viking 1 lander (30). Obviously the activity being observed was a global phenomenon and the lack of any organic compounds at either site strongly suggested that it was not biological. In order to find organic compounds away from the destructive effects of solar ultraviolet light, Viking 2 obtained a sample that was shielded beneath a large rock named "Badger" but its analysis also showed no signs of organic molecules (31). Not even the remains of organic compounds delivered by meteorites were found.

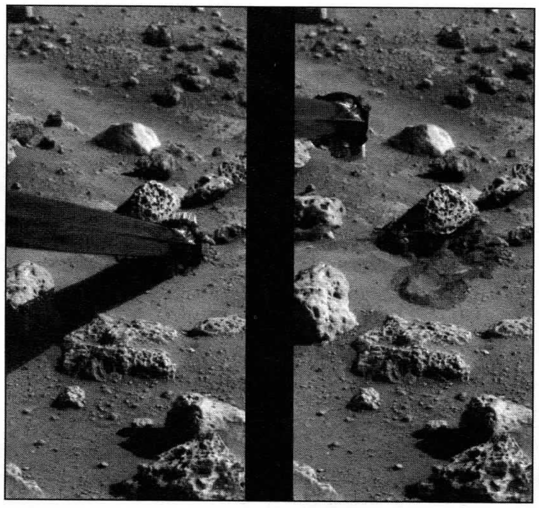

Figure 4: *The lack of organic compounds in the Martian soil led scientists to search protected areas under rocks. Here we see the sample arm on Viking 2 obtaining a sample from under Badger Rock for onboard analysis. Like the other samples examined, activity was observed by the biology experiments in the absence of detectable traces of organic compounds.*

Over the course of the next few months the biology experiments were repeated with various samples, some of which were stored inside the landers for several months. During this time all the experiments functioned well except for the Pyrolytic Release on Viking 2. This experiment malfunctioned during its fourth experiment cycle because of a nonrecoverable failure of one of its valves (7). While disappointing, the three Pyrolytic Release cycles were completed by Viking 2, and Viking 1 completed six cycles by reusing two used test cells where new samples were placed on top of older ones. The Pyrolytic Release, Labeled Release, and Gas Exchange experiments used every conceivable combination of conditions in an effort to fully characterize the reactions they were observing (7,9,32).

Nonbiological Explanations

While the biological experiments performed by both Viking landers produced results that superficially satisfied the preflight protocols established by NASA, the National Academy of Sciences, and other organizations for the existence of life on Mars, it appeared likely that this was not the case. Especially in the Pyrolytic Release and Gas Exchange experiments, the details of the reaction rates and how they varied with time and temperature did not precisely match the responses observed in tests with terrestrial samples. The inability of the GCMS to detect *any* organic compounds in the four soil samples it examined at the two landing sites made the biological interpretation of the results difficult to accept (33). A variety of reasons for this incongruity was proposed. In the end it was agreed that some sort of abiotic soil chemistry was being detected by the biology experiments.

The surface of Mars is exposed to conditions totally unlike those found anywhere on the Earth. By terrestrial standards it is extremely cold, bone dry, and its surface is exposed to high levels of solar ultraviolet radiation. Even the dry valleys of Antarctica, which are the closest analogs to Mars that can be found on the Earth's surface, are not subjected to the environmental extremes that are typical on Mars. Under such conditions it would not be unexpected that the Martian soils could support some previously unexpected chemical reactions. In fact, before the Viking flight, Donald Hunten theorized that the surface of Mars would contain strong oxidants based on his analysis of Martian atmospheric chemistry (34). Laboratory experiments performed about the same time by Robert Huguenin showed that some common minerals such as magnetite could produce metastable inorganic oxidants when exposed to a simulated Martian atmosphere and ultraviolet light (35,36). Such oxidants are immediately destroyed in terrestrial soils from the small traces of water that exist in even the driest locations. But Mars is much dryer still and some of these oxidants could remain active on its surface.

Immediately the Viking biology team began to examine the possibility that the extremely dry Martian soil contained peroxides and superoxides (33). The large amount of oxygen produced in the Gas Exchange experiment strongly indicated the presence of some sort of oxidant. The results obtained from the Labeled Release experiment, and to a lesser extent the Pyrolytic Release experiment, could also be explained by oxidants in the Martian soil. Strong and therefore chemically unstable oxidants also tend to degrade when exposed to heat, thus explaining the decreased activity of the samples after they had been heat sterilized. Oxidants also make short work of any organic compounds on the surface by turning them into carbon dioxide and water vapor. The presence of oxidants in the Martian soil seemed to explain many of Viking's observations.

Simple chemical calculations showed that the amounts of oxidants needed to produce the observed results of the biological experiments are quite modest. Even the samples that displayed the highest degrees of activity could be reproduced by the presence of an oxidant that is equivalent to hydrogen peroxide in the parts per million to less than the parts per billion level (37). This is not to say that hydrogen peroxide itself was necessarily responsible for the observed reactions. While laboratory experiments have demonstrated that hydrogen peroxide could be formed under Martian conditions from water ice reacting with silicate mineral surfaces (38), it readily decomposes when exposed to ultraviolet radiation (39). Instead this calculation suggests that only trace amounts of powerful oxidants are needed to reproduce the reactions and this would make their identification very difficult.

In light of Viking's findings, scientists eagerly embraced the oxidant theory to explain the biology results. During the early analysis of the Gas Exchange and Labeled Release experiments results, the investigators concluded that peroxides would be most effective in the presence of the magnetic iron oxide mineral called maghemite (9). The ubiquity of magnetic minerals on the Martian surface had already been demonstrated by the Viking landers' Magnetic Properties experiment and maghemite was one of many candidates (40). It had been suggested that maghemite would form from the photostimulated dehydration of goethite or lepidocrocite but no experimental evidence has been found to support this (41).

Unfortunately post-Viking laboratory simulations have produced disparate results and have failed to definitively resolve the oxidant question. In one experiment, a mixture of basalt glass, magnetite, nontronite, and a variety of mineral salts was exposed to a simulated Martian atmosphere and ultraviolet light for hundreds of hours. During this test, no detectable oxidants were produced (42). Efforts to reproduce Huguenin's results that produced oxidants were also disappointing. Later experiments showed that the high rates of magnetite oxidation were due to radiant heating from the experiment's light source and not ultraviolet light as originally supposed (41,43). But in another experiment, the manganese oxide-bearing mineral pyrolusite produced a powerful oxidant via photochemical oxidation when irradiated by ultraviolet light in a humidified Martian atmosphere (44). But since there is no information about the possible presence or concentration of this mineral or even manganese on Mars, the case for a manganese-based oxidant is shaky at best.

Based on the results of other Viking studies of the composition of the Martian soils, it was suggested that smectite or other iron containing clay-like minerals would be abundant (45). Laboratory tests using iron-exchanged montmorillonite were able to successfully duplicate the Labeled Release experiment's result without the need for powerful oxidants. Unfortunately these minerals have been unable to reproduce either the Gas Exchange or Pyrolytic Release experiments' results. In addition it is not known how the presence of the sulfur and chlorine salts that had been detected in the surface materials would affect the results. Near-infrared spectra of Mars indicate that, instead, palagonite could be present on the Martian surface (46). But tests with palagonite tuff samples have been unable to reproduce the Labeled Release experiment's results (45).

Despite scientists' inability to date to reproduce all of the observed results through some sort of inorganic chemical reaction, the general consensus in the scientific community has been that the Viking landers did not detect life on Mars. While over the years terrestrial life has been discovered in increasingly hostile habitats on our planet, the one thing all terrestrial organisms have in common is the need for liquid water. Even in the driest parts of Antarctica, life will only exist where there is liquid water, even if only for a brief time. Given the severe dryness of the Martian surface and its low atmospheric pressure which does not allow for the existence of liquid water, the general view is that the surface of Mars is totally inhospitable to life (47).

Doubts

While the majority of scientists now believe that life was not detected by the Viking lander biology experiments and that Mars today is lifeless, there is a vocal minority that feels a biological interpretation is still viable. The linchpin of the argument against the biological interpretation is the lack of any organic compounds detected by the GCMS (33,39). As explained earlier, there were a number of engineering compromises made in the design of this instrument. As a result there are certain classes of organic compounds that the GCMS cannot detect. The two major types are polymeric carbon suboxide and the family of highly cross-linked organic polymers known as kerogens (4). Kerogens will pyrolyze only at temperatures much higher than those used in the GCMS. Polymeric carbon suboxide has the opposite problem. It will readily decompose into carbon monoxide or carbon dioxide making it indistinguishable from these gases that had either been adsorbed by the sample or came from the decomposition of carbonates. Still, it is hard to imagine why only kerogens would be present while the other less cross-linked compounds are not. Carbon suboxide, which consists of chains of units containing two carbon and three oxygen atoms, is even less likely to be present but its existence on Mars had been predicted (48,49).

The GCMS also has difficulty detecting the presence of two important inorganic volatiles that might be given off by heated soil samples: ammonia and oxygen. The detection limit of ammonia is affected by the amount of water produced by the sample during analysis. The atomic mass-to-charge ratio (m/e) for water and ammonia are almost the same at 18 and 17, respectively. If the amount of ammonia is less than 10 percent that of water, its presence will not be detected. Conceivably ammonia could be difficult to detect at levels as great as 100 parts per million given the amounts of water detected in the samples that were analyzed (4). Oxygen is not detectable at all by the GCMS because the gas spectrometer uses hydrogen as a carrier gas. As oxygen and the hydrogen carrier gas pass through the silver-palladium hydrogen separator between the gas chromatograph and mass spectrometer they are catalytically converted into water, which then becomes indistinguishable from the water produced by the pyrolyzed sample. It is difficult to accept, however, that Martian biology is based solely on common inorganic chemicals and compounds that, by coincidence, the GCMS cannot detect.

Still, there is some question as to the sensitivity of the GCMS in comparison to the biology experiments in detecting microorganisms. The GCMS is not sensitive enough to directly detect a single or even hundreds of microorganisms. But in even the least productive Antarctic soil samples that were tested, the mass of organic compounds was at least 10,000 times greater than that of the living organisms it contained (4). If the same ratio held for Mars, even a single bacteria would be accompanied by a quantity of organic compounds that the GCMS could detect. The only way the GCMS could miss Martian microorganisms is if they have adapted to an environment poor in organic compounds.

Gilbert Levin and Patricia Straat believe that the Labeled Release experiment was much more sensitive to the presence of life than the GCMS. In addition they hold that the Labeled Release experiment's results are not inconsistent with the presence of Martian life. Since the Viking mission, they have been able to reproduce all of the Labeled Release experiment's results with terrestrial samples containing microorganisms (50,51). Levin and Straat also reject the theory that oxidants like hydrogen peroxide are responsible for the Labeled Release experiment's results. Only the radioactively labeled sodium formate in the Labeled Release experiment's nutrient solution would react with peroxide to form carbon dioxide. The activity observed during the unsterilized experiments was much greater than could be explained by oxidizing only this one nutrient (52). Obviously the other nutrients were also involved in the reaction which would be consistent with a biological interpretation.

The second part of Levin and Straat's argument centers around an analysis of the Antarctic soil sample #726 that was obtained at Coalsack Bluff in the West Antarctic Mountains (53) years before the Viking mission. In preflight experiments, a test module version of the GCMS failed to detect any organic compounds in this sample except for the polyvinyl chloride that lined the sample bag (4). After the Viking mission, Levin and Straat retested sample #726 and found a weak but positive response using a test version of the Labeled Release experiment (51). As a result, these investigators believe that it is conceivable that the Labeled Release experiment detected life on Mars. Conventional laboratory tests at the time the sample was collected, however, showed the soil sample to be sterile (53). So another possible explanation is that sample #726 became contaminated during the years between the original GCMS tests and the follow-up experiments by Levin and Straat despite efforts to keep it pristine.

Another attack on the GCMS centers on its sensitivity. When sample #726 was analyzed using a conventional wet laboratory technique it was found to contain organic carbon at a concentration of 300 parts per million (53). Despite this, a test version of GCMS did not detect any organic compounds in this sample so it might have also missed organic compounds on the Martian surface. Combined with Levin and Straat's post-flight Labeled Release experiment results with this sample, it seems that the GCMS cannot be relied upon to definitively exclude the presence of life in low concentrations. Three members of the National Space Society's Board of Governors, Robert Jastrow, Hugh Downs, and Glen Wilson, have been trying to raise $30,000 so that the duplicate GCMS can be refurbished and tested to resolve the issue of its sensitivity (54).

But even here critics charge that Levin, Straat, and others are comparing apples and oranges. The analytic technique used during initial lab testing of sample #726 for organic carbon was the Allison Method (53). This method measures the quantity of all sources of carbon in the sample that can be removed by the strongly oxidizing mixture of heated potassium dichromate, concentrated sulfuric acid, and phosphoric acid (55). As the original investigators noted, "organic carbon" would include any source of carbon other than "inorganic" carbon compounds like carbonates. The 300 parts per million of "organic carbon" was originally attributed to the presence of anthracite coal and not organic compounds (53). In light of this it would appear that the original claims of the sensitivity of the GCMS may be correct after all.

THE OTHER LIFE-DETECTION EXPERIMENT ONBOARD VIKING

In addition to the biology experiments, there was also another instrument carried by Viking that could search for life: a pair of panoramic cameras. This pair of cameras was sensitive to several spectral bands from the near-infrared to the visible and was capable of detecting macroscopic life forms. Based on an analysis of the images returned from the two Viking landing sites, the general consensus was that Mars does not possess large life forms (62).

But as with the other life-detection experiments, there is a minority of scientists that claim that this is not entirely true. Dr. Gilbert V. Levin, who developed the Labeled Release experiment, examined the Viking surface images and a small rock at the Viking 1 landing site, called "Patch Rock," which had a greenish patch on it. Levin noted that the size and shape of this patch seemed to have changed over the course of several months. Levin believes that this patch might be some form of lichen that is eking out an existence on the barren Martian surface (63).

Critics of Levin's claim point out that there are nonbiological explanations for what was seen. First, the images used by Levin were taken under a variety of lighting conditions owing to differences in the time of day and season when the images were secured. Detailed photometric measurements of the types of strongly colored materials that cover the Martian surface show that their color and appearance are very sensitive to changes in lighting conditions (64). During the course of Viking Lander 1 operations on the Martian surface, the sampling arm accidentally dropped some material on Patch Rock which could also explain the changes observed by Levin (37). Finally, the changes can also be attributed to the deposition of wind-blown dust which was common at both Viking landing sites (65). Unfortunately it was not possible for the Viking biology experiments or the Gas Chromatograph–Mass Spectrometer (GCMS) to sample this or any other rocks. They were only designed to analyze fine-grained soil samples so they could not shed any light on Levin's claim (2).

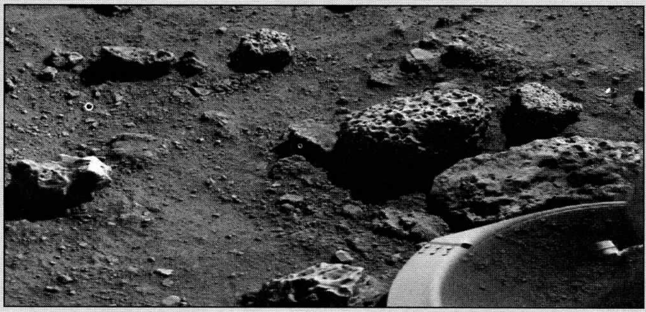

PHOTO COURTESY OF NASA

The accepted explanation for the holes in the rocks at the Viking 2 landing site, such as those seen here, and similar rocks seen on Earth is that they are the result of gas bubbles trapped in the cooling magma. Some now believe that the holes are instead trace fossils left by aquatic Martian life forms that lived at the bottom of a now dried-up sea that may have covered this area billions of years ago.

But this is not the final word on macroscopic life on Mars. In May of 1997, Barry DiGregorio of the Buffalo Museum of Science claimed not to have found signs of extant life on Mars but trace fossils made in a marine environment (66). DiGregorio's assertion is based on the presence of holes in the rocks that litter the Viking 2 landing site such as those shown above. At the time the images were taken, geologists interpreted the holes as being the result of volcanic gases trapped in the rocks as they solidified. DiGregorio's analysis indicates instead that these holes are similar in size and shape to worm holes he has studied in the coarse-grained sandstones along the shore of Lake Ontario.

While geologist and planetary scientists are skeptical of DiGregorio's interpretation, it does demonstrate that doubts linger about the generally accepted conclusions drawn from the Viking experiment results. Hopefully the successful landing of Mars Pathfinder and the deployment of its rover will allow scientists to resolve this and other questions.

But even if there was no life at the two Viking landing sites, that does not exclude the possibility that life exists elsewhere on the planet. The two Viking landing sites were chosen primarily because they were the safest places to land. There could very well be limited oases on the surface of Mars where conditions are more amenable to life. But if life proves to be impossible on the surface because of the severity of the environment, there may be habitats well beneath the surface where life can eke out an existence. Only in the past decade have such habitats been recognized on our own planet. Viking, with its simple sampling arm, could only dig to a depth of about 10 centimeters and was incapable of reaching the required depths. Recent calculations indicate that Mars's current flux of ultraviolet light is intense enough to destroy organic compounds without having to resort to exotic oxidants (56). These new calculations were also able to set upper limits on the productivity of the Martian biosphere if it exists. While low, these limits would still allow for a planet-wide biosphere that, on average, is about as productive as those found in the dry valleys of Antarctica.

In strict scientific terms, the possibility of life on Mars has *not* yet been excluded.

The Future

After a hiatus of more than two decades and a series of mission failures, the exploration of Mars is beginning to ramp up once again. During the 1980s the Soviet Union initiated ambitious plans to renew its exploration of Mars after a spectacularly successful series of missions to Venus. The failure of the new series' prototypes, Phobos 1 and 2 in 1988, and the dissolution of the Soviet Union, led to a string of delays and ultimately to the downsizing of Russia's Mars exploration program. In the end, only a single Mars 96 spacecraft remained from this ambitious program.

While the pair of small landers carried by the Mars 96 spacecraft would not include any experiments geared specifically toward biology, it did carry an American-supplied experiment among its complement of international instruments that could help shed light on the Viking biology experiment observations. Called MOX (Martian Oxidation Experiment), this instrument was designed to identify the oxidants theorized to exist in the Martian soil and atmosphere (57). This ingeniously simple device consisted of four sensor cells holding bundles of optical fibers coated with various chemicals. One pair of sensor cells would passively sample the atmosphere while the other pair would come into contact with the soil. One cell from each pair could be directly exposed to the environment while the other was protected by a membrane and would be used for comparison. By monitoring the changes in the reflectivity of each chemically coated fiber, the oxidation rate of the Martian environment could be measured. Unfortunately the Mars 96 spacecraft failed to leave its Earth parking orbit after launch in November 1996 due to a malfunction in its escape stage. As a result of this expensive failure and Russia's deepening economic problems, the former Soviet Union's ambitious Mars exploration plans appear to have been put on indefinite hold.

Out of the ashes of the failed American Mars Observer mission of 1992, two smaller and less expensive replacements were built and launched at the end of 1996. The first, called Mars Global Surveyor, carries flight spares of most of Mars Observer's original instruments. This project was one of the first to embrace NASA's new philosophy of smaller, faster, and cheaper that led to the successful Discovery program. This spacecraft, which entered orbit in September of 1997, will add significantly to our knowledge of Mars and the unraveling of its complex history. It should also be able to locate promising sites for finding either the fossilized remains of Martian microbes (58) or possibly even a handful of havens where life might still exist today (59).

NASA has now made the commitment to launch a series of simple and inexpensive spacecraft at every launch opportunity to explore Mars not only from orbit but also from its surface. The first of these landers, Mars Pathfinder, was launched in December of 1996. Mars Pathfinder, which successfully landed on Mars on July 4, 1997, and was subsequently renamed the Carl Sagan Memorial Station (60), carries only a modest complement of instruments as well as a small rover called Sojourner. Contrary to recent statements in the press, none of the Mars Pathfinder experiments are geared specifically toward Martian biology. Nonetheless the multispectral stereo cameras carried by the lander and the alpha proton X-ray spectrometer on the rover used to determine the composition of Mars's rocks and soils should aid in identifying the minerals that are present (57). Such information will be helpful in determining the source of the activity observed in the Viking biology experiments. In 1998, another American orbiter and lander will be sent to Mars that will continue to build our knowledge of this planet.

With the announcement in early August 1996 of the discovery of evidence of possible microfossils in the Martian meteorite ALH84001 (61), interest in the search for past or present life on Mars has been rekindled. When combined with the discovery over the last decade of terrestrial organisms that live deep underground, there are those in the scientific community who are publicly considering the possibility that organisms that might have arisen during Mars's more hospitable past may have taken refuge in similar environments there.

A NEW SEARCH FOR LIFE ON MARS?

ESA (The European Space Agency) took an important step this past summer toward securing its Mars Express mission, making possible an in situ search for life on Mars in the near future.

ESA (http://www.esrin.esa.it) made the commitment to fund the launch vehicle and communication system for this relatively inexpensive mission which is currently scheduled for launch in 2003.

One of the proposed "experiments" for the Mars Express is a lander that will drill core samples and examine them—and the Martian soil—for the presence of key organic compounds that could indicate biological activity. This will be accomplished with an instrument package employing a variety of chemical- and physics-based analysis techniques that build on Viking's experience.

The future for the lander is still far from secure, however. Since the entire lander is considered an "experiment," it is not eligible for direct ESA funding. In ESA space missions, the "experiment" proposers (which in this case is a British-led consortium of European scientists) generally have the responsibility for getting funding for their experiments. Assuming that the needed funding is secured, the next search for life on Mars may take place in only seven years.

There is little possibility that another Mars lander will be equipped with a life-detection experiment to renew the in situ search for life on Mars. The one lesson that was learned from Viking was how difficult and expensive it is to design and build automated instruments to detect extraterrestrial organisms. In today's budgetary environment, such an expenditure may never be approved. Instead we may have to wait until the next decade for the launch of a Mars sample return mission. Such a mission, which is currently under intensive study, could be launched as early as 2005 and would return pristine samples of the Martian surface for detailed examination. These first samples will probably help shed light on Viking's results, but it is likely that many questions will still remain.

Decades of additional research as well as more sophisticated automated probes and crewed flights to the Red Planet will probably be needed before we have a definitive answer about the question of life on Mars.

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