Mars Phoenix Lander provides conclusive proof of water ice on Mars

Robert Stevens
9 August 2008

The Mars Phoenix Lander landed on the planet on May 25. It has begun to return vital information taken from the soil samples, including the conclusive discovery of water ice, as it analyses the chemical composition of the planet.

The primary goal of the Phoenix mission is to assess the habitability of the Martian polar environment. The mission is the product of an international collaboration led by the Lunar and Planetary Laboratory at the University of Arizona, under the direction of NASA's Jet Propulsion Laboratory. It involves NASA, the Canadian Space Agency, the Finnish Meteorological Institute and universities in the United States, Canada, Switzerland, Denmark, Germany and the UK. Several aerospace companies were also involved in the mission. The Lander was built and tested by Lockheed Martin Space Systems.

Phoenix left Earth last August completing the 422 million mile journey to the planet—and a highly complex landing—almost to perfection.

Among its most important findings is the definitive proof that water exists on the planet. The Phoenix Lander is the first planetary probe whose primary purpose is to investigate local water supplies—a key factor for sustaining life on a planet.

Phoenix is the first probe to land on a polar region of Mars. Previous missions have landed at the dry, equatorial zone of the planet. The Phoenix mission landed at a region of the planet called Green Valley of Vastitas Borealis. This area—the equivalent latitude of Alaska or northern Canada on Earth—was selected because of the highly likely presence of subsurface ice.

In May 2002, NASA announced that the Gamma Ray Spectrometer on the Mars Odyssey orbiter had detected large amounts of hydrogen in the area. The only plausible explanation for this was that there had to be water, in the form of ice, lying within about a meter of the planet's surface.

One of the important aspects of the mission is to study active climatic processes that are taking place on Mars today. These climate changes can be closely studied in the soil samples. Unlike the equatorial regions of Mars, the contraction and expansion of the below-surface ice is changing the way the surface appears. Such changes cannot be observed in the equatorial areas of the planet, where much of the topography has not significantly changed in billions of years.

Phoenix landed on a flat valley floor with polygonal features that gives the surface a "paved" appearance. These features have been spotted in previous images taken from Mars orbiters and are believed to be caused by the expansion and contraction of ice water. Similar features exist in permafrost regions on Earth.

Following the successful landing by Phoenix, Professor Peter Smith of the University of Arizona and principal investigator for the mission, commented on the landing site, "We see the lack of rocks that we expected, we see the polygons that we saw from space, we don't see ice on the surface, but we think we will see it beneath the surface. It looks great to me."

Unlike the Spirit and Opportunity roving probes that landed on Mars in May 2004, the Mars Phoenix Lander was designed to land on the planet's surface and to remain in a stationary position. Phoenix has an array of instruments on board including cameras and an eight-foot long scoop arm with a heavy-duty drill. The arm is being used to bore into the surface in order to extract samples. The samples are then brought inside the Lander for a variety of onboard laboratory tests to be performed. These determine its chemical composition, with a particular focus on finding carbon-hydrogen-oxygen compounds. Essentially the instruments allow the mission scientists to "taste" and "smell" the samples.

One of the instruments onboard is the Thermal and Evolved-Gas Analyzer (TEGA). It was built by a team at the University of Arizona in the United States. TEGA is both a high-temperature furnace and mass spectrometer instrument able to analyze Martian ice and soil samples. TEGA is able to analyse the soil and ice samples it receives in eight tiny "ovens" about the size of an ink cartridge in a ballpoint pen. Each soil sample is a fraction of a teaspoon.

Upon viewing photos sent back by Phoenix, one of them showed that one of the spring-loaded doors on the oven complex had failed to fully open. Although this created a problem the instrument could still be used with a partially open oven door.

As well as the faulty oven door the mission encountered another problem in that they found that the polar Martian soil is of a clumpier, stickier type than had been envisaged in any previous simulations. This presented a difficult challenge for the Phoenix team as they had to continuously shake the clumpy samples before the particles were small enough to be dumped into the ovens. They were not able to do this in "real-time" and were essentially doing it "blind" due to the distance involved. A radio signal instructing the robotic arm takes about 15 minutes to reach Mars.

Once successfully dug by the robotic arm, the soil sample is then delivered to one of the ovens. Then the temperature is slowly increased at a constant rate. In a process known as scanning calorimetry, the transitions from solid to liquid to gas of the different materials in the sample is recorded. The results are critical to understanding the precise elemental composition of Mars and the character of the soil and ice of the Martian surface. Phoenix will provide TEGA with eight soil samples—one for each of the ovens with each oven being used just once.

In order to find evidence of water on Mars, the soil and ice samples had to be heated because liquid water cannot exist on the surface of Mars, except at the lowest elevations for short periods of time. This is due to its present low atmospheric pressure.

The first soil samples were gathered by the robotic arm on May 31. At the same time Phoenix took an image underneath the Lander on revealing patches of a smooth bright surface uncovered when the thruster exhaust blew off overlying loose soil. Scientists speculated that this may well be ice, but it could be a rock formation.

During its initial work, Phoenix dug several small trenches, about 5cm deep, to analyse the soil. One of these was named “Dodo-Goldilocks” and scientists found that dice-sized clumps of bright material dug by the robotic arm on June 15 had vaporized over the course of four days to June 19. This confirms that the clumps were actually water ice, which sublimates following exposure. Scientists confirmed that if it were dry ice it would have sublimated at a much quicker rate and if the material been salt it wouldn’t have vaporized at all.

On June 20, Phoenix Principal Investigator Peter Smith announced, “It is with great pride and a lot of joy that I announce today that we have found proof that this hard bright material is really water ice and not some other substance. The truth we’re looking for is not just looking at ice. It is in finding out the minerals, chemicals and hopefully the organic materials associated with these discoveries.”

On July 31, 2008, NASA officially announced that Phoenix had also confirmed the presence of water ice on Mars in a soil sample taken the previous day. The presence of water was confirmed when the TEGA’s mass spectrometer detected water vapour when the sample temperature reached zero degrees Centigrade.

Following the discovery William Boynton of the University of Arizona, the lead scientist for TEGA said, “We have water. We’ve seen evidence for this water ice before in observations by the Mars Odyssey orbiter and in disappearing chunks observed by Phoenix last month, but this is the first time Martian water has been touched and tasted.”

Originally a 90-day mission, following these findings, funding for the mission was extended until the end of September, 2008—a further five weeks.

The next stage of research for the scientists involved is to try to ascertain whether the water ice ever thaws on the planet and if this is enough to allow life processes to begin.

They are also seeking to determine whether or not carbon-containing chemicals and other raw materials for life are present in the soil. Due to the immobility of the Lander, the mission can only attempt to determine whether the area immediately surrounding the Lander was ever a possible habitable zone.

The first analysis of the soil composition of Mars has thrown up some interesting findings. Samples of soil containing highly reactive salts called perchlorates were found in and around a trench dug by the robotic arm known as “Snow White”. Perchlorates are ions consisting of a chlorine atom surrounded by four oxygen atoms. It is an oxidant, meaning it can release oxygen. However, perchlorates are weak oxidants so they tend to transfer oxygen atoms in chemical reactions.

Some initial speculation in the media rushed to state that the discovery of perchlorate in the samples ruled out the possibly of life forms existing on Mars. Until further analysis is conducted by the Phoenix team, it is still unclear where the perchlorates came from. The team are looking into the possibility that the soil samples were contaminated by perchlorates transported from Earth on the Lander. The fuel used by Phoenix to land contains no perchlorates, but they were used in the boosters during its launch from Earth.

At any rate, the presence of perchlorates does not rule out the existence of life forms. On Earth, organisms have been found to coexist with perchlorates in arid places such as Chile’s Atacama Desert.

Speaking of the findings, Michael Hecht of NASA’s Jet Propulsion Laboratory, said, “finding perchlorates is neither good nor bad for life ... because different types of perchlorate salts have interesting properties that may bear on the way things work on Mars if—and that’s a big ‘if ’—the results from our two teaspoons of soil are representative of all of Mars, or at least a significant portion of the planet.”

The Phoenix team decided to release the news of the discovery of perchlorates and admitted that this was an “unusual step” as they were only half way through collecting the data and had not yet completed the laboratory analysis of the samples.

Phoenix’s Peter Smith said, “We decided to show the public science in action because of the extreme interest in the Phoenix mission, which is searching for a habitable environment on the northern plains of Mars. Right now, we don’t know whether finding perchlorate is good news or bad news for possible life on Mars.”

Phoenix is equipped with an advanced chemistry laboratory called the Microscopy, Electrochemistry and Conductivity Analyzer (MECA). MECA is a “wet” chemistry lab that measures levels of acidity, minerals, and conductivity in dirt samples. Its initial analysis of the Martian soil confirms that it is neither strongly acidic nor salty and as such can possibly support life forms. It is moderately alkaline, and contains magnesium, sodium, potassium and chloride ions. From the standpoint of the possible development of biology its pH and salinity level were determined to be benign.

As the further analysis of the samples is undertaken it will provide vital information on the biological compatibility of the soil—whether it can harbour indigenous life forms or aid future manned missions.

This is perhaps the most important stage of the mission. As Peter Smith explained, “Just the fact that there’s ice there doesn’t tell you if it’s habitable. With ice and no food it’s not a habitable zone. We don’t eat rocks—we have to have carbon chain materials that we ingest into our bodies to create new cells and give us energy. That’s what we eat and that’s what has to be there if you’re going to have a habitable zone on Mars”.

Phoenix is able to make a number of precise recordings relating to different aspects of Mars. It has an onboard Meteorological Station and is able to establish soil temperature, humidity, wind speed and atmospheric temperature. The Meteorological Station will record the daily weather on the planet and such information will be critical for further unmanned or manned missions.

Even before the completion of its data analysis the Phoenix mission has already provided critical information about the planet Mars. The next mission to the planet is scheduled to be launched in September 2009 and to land on Mars in July-September 2010. Investigating the past or present ability of Mars to support life, it will be building on the already pioneering and valuable work conducted by the Mars Phoenix Lander.