Intriguing new discoveries on Mars

Frank Gaglioti
24 March 2004

The current National Aeronautics and Space Administration (NASA) mission to Mars has already provided significant new evidence that the planet may in the past have been considerably warmer and possessed large amounts of liquid water. The observations made by the small roving vehicle *Opportunity* raise the possibility that life may have emerged on Mars in a previous, more benign environment.

NASA associate administrator Ed Weiler on March 2 described the discoveries as "a giant leap." "*Opportunity* has landed on an area of Mars where liquid water once drenched the surface. This area would have been a good habitable environment for some period of time," he said.

The *Opportunity* set off from its landing site near the Martian equator on a plain known as Meridiani Planum on January 31. The area is halfway around the planet from the Gusev Crater, where its sister rover *Spirit* has been operating. Both areas were selected because they have an ancient layer of hematite, an iron oxide mineral that on Earth almost always forms in an aqueous environment. The central aim of the two missions is to confirm that the mineral deposits were formed in water.

The two rovers employ an arsenal of sophisticated tools amounting to a small geological laboratory, including a camera, sampling tools, a microscope and spectrometers. A high-powered abrasion tool is used to grind below the sun-scorched surface of rocks to allow other instruments to determine their chemical composition. An infrared sensing instrument is used to identify rocks from a distance.

Some of *Opportunity's* earliest photos focussed on a rock outcrop, which was named "El Capitan". The structure has a layered appearance similar to sedimentary rocks on earth and could have been formed due to wind or water action.

A closer examination indicated that liquid water may have played a role in the formation of some of its features, in particular some small stone globules that NASA workers call "blueberries." These were possibly created by the action of water seeping through the outcrop. Scientists speculate that soluble mineral deposits were probably left behind in small slits, only later to be washed away, leaving spaces in the rock.

An analysis of the El Capitan outcrop also found concentrations of soluble chemicals similar to Epsom salts, amounting to 40 percent of the rock sample in some areas. NASA science team member Benton C. Clark III commented: "The only way you can form such large concentrations of salt on earth normally is to dissolve it in water and have the water evaporate."

However, the most significant discovery was the detection of the mineral jarosite, usually associated with hot springs on Earth. Principal NASA investigator Steve Squyres explained: "This is a mineral that you've got to have water around in order to make."

Although the data collected so far is suggestive, it is only at a preliminary stage of analysis. Alternative theories may yet emerge. As University of Chicago scientist Thanasis Economou pointed out, not all scientists agree that the data demonstrated the past presence of water on Mars. It is possible that the "blueberries" may have formed from cooling lava. However, the discoveries provide a tantalising insight into the nature of the Martian landscape and the possible role played by water in its formation.

Today Mars is an extremely inhospitable place: its highest temperatures are rarely above freezing and the atmosphere is very thin, consisting mostly of carbon dioxide with traces of oxygen. If water did previously exist in liquid form, then intriguing questions are raised about the nature of the planet and its evolution.

The close proximity of Mars to Earth and its similar size have led scientists to speculate for centuries about the existence of water and life on the planet. In 1877,

Italian astronomer Giovanni Schiaparelli noted straight lines on the surface of Mars, which he thought were channels. But it was not until scientific probes began to be sent to Mars that these theories could be adequately tested.

In 1977, NASA landed two Viking spacecraft on Mars designed to test for the presence of organic matter and the action of microbes on the planet's surface. Scientists concluded that the results of the experiments showed no evidence for the presence of any life.

But a detailed examination of photos taken by the Viking craft and earlier Mariner space probes, which flew by or orbited Mars, revealed geological features that raised other possibilities. These formations included what looked like river valleys, up to three kilometres wide, complete with tributaries, deltas and flood plains. Some scientists speculated that the vast Martian "flood plains" were formed by huge inundations, representing 300 times the volume of water contained in Lake Michigan.

In 1989, NASA Jet Propulsion Laboratory scientist Tim Parker, using an analysis of survey photos from the Viking probe, speculated that he had found remnants of two ancient shorelines, which he called "contacts." In 1991, University of Arizona scientist Vic Baker theorised that Mars was not a dead planet, but that it underwent cycles: first heating up and releasing frozen groundwater that formed a vast ocean in the north which then receded as the planet froze over again. Scientists have debated the existence of Martian water ever since.

In 2003, scientists from the Los Alamos laboratory released scientific evidence of the presence of large amounts of frozen water on Mars. Photographs and spectrometric data from the Mars Odyssey Spacecraft showed extensive deposits of ice with an average of 50 percent water by mass. The photos revealed vast icecaps at the Martian poles and the presence of ice in various locations such as Vallis Marineris, the largest known canyon in the solar system.

A great deal of uncertainty still exists about the relationship between the ice in the Martian soil and the possible role of surface water in shaping the landscape. One theory posits the existence of a vast planetary water table whose thickness may be enough to bottle in geothermal heat that could melt the bottom layers of the icecap. Alternatively, there is evidence that Mars shifted on its axis about a million years ago, causing the polar icecaps to melt and to briefly create enough water in the atmosphere to spread across the planet.

Los Alamos space scientist Bill Feldman commented in July 2003: "We're not ready yet to precisely describe the abundance and stratigraphy of these deposits, but the ... spectrometer shows water ice close to the surface in many locations, and buried elsewhere beneath several inches of dry soils. Some theories predict these deposits may extend a half mile or more beneath the surface; if so, their total water content may be sufficient to account for the missing water budget of Mars."

The current NASA mission seems to confirm the past existence of water and the important part it played in shaping the planet's geological structures. Future missions are being planned to resolve the scientific questions raised.

The Mars Reconnaissance Orbiter planned for 2005 will make a comprehensive inspection of the planet's landscape. It will be equipped with the most powerful telescopic camera ever sent to orbit another planet with the capacity to record detail down to just one metre. The Orbiter will also be able to scan for underground layers of water and ice, identify small patches of surface minerals and determine their composition and origins, track changes in atmospheric water and dust, and check Martian weather every day.

In 2007, NASA plans to develop a roving long-range, long-duration science laboratory with an increased capacity to make surface measurements and even return rocks back to Earth.

Scientists will be able to use the flood of data from the *Opportunity* and *Spirit* rovers to obtain a richer appreciation of how water in its various forms shaped Mars' surface and whether life once existed or even continues to thrive in an undiscovered habitat. In the future, manned missions to Mars may be able to exploit the frozen water to help sustain interplanetary explorers.