# Spirit Rover Gets Ready To Follow the Water on Mars

*The Mars Exploration Rovers begin the intensive study of the planet Mars, which can lay the basis for its human exploration in the future. Marsha Freeman reports.*

A highly complex and extraordinary representative of man's intelligence is sitting now in Gusev Crater on the surface of Mars, preparing to begin a geological study of the history of water on the red planet. From its full stand-up height of nearly five feet, *Spirit* is transmitting back to Earth full-color, three-dimensional photographs of Mars, which are comparable in resolution to what you would see with your own eyes, were you standing there. Its journey will be the first step in a planned multi-decade NASA Mars exploration program.

The success of the *Spirit* landing and its initial operation have placed on the agenda, once again, Lyndon LaRouche's 40-year program, developed in the 1980s, for the establishment of a science city on Mars. (See below).

The primary task of the Mars Exploration Rovers, named *Spirit* and *Opportunity*, is to deploy a suite of scientific instruments, in order to peer into the past, and help answer the question: At some time in its history, did Mars have a climate and environment that would have supported life?

The rovers will not be searching for fossils or direct evidence of life. Experiments aboard the two Viking landers in 1976 attempted to do that, returning ambiguous results that are still being debated in the scientific community. The complex soil chemistry on the Martian surface convinced scientists that the level of robotic technology available today, would best be deployed to search for indirect evidence of possible life on Mars.

Since the 1970s Viking missions, field research in extreme environments on Earth has revealed not only that liquid water is a prerequisite for life, but that everywhere there is water, and some source of energy, there *is* life. Such environments have included hot steam vents under the ocean, lakes under the ice of Antarctica, and the inside of radioactive nuclear power plants. Where there is water and energy, there is life.

There is no evidence of liquid water currently on the surface of Mars. There is frozen water at the poles, and, as recently discovered from orbital measurements, significant caches of ice co-mingled with soil under the surface of much of the planet. There is gaseous water vapor in the atmosphere, whose concentration waxes and wanes with the change of seasons on Mars, when polar ice sublimes into the atmosphere, or freezes onto its surface.

But could there be liquid water under the surface, as ice locked in the soil is heated by interior activity on the planet? Intriguing features captured by NASA's orbiting Mars *Global Surveyor* and *Odyssey* spacecraft, such as gullies carved into the sides of craters by what appear to be geologically-recent flows of water, have led geologists to wonder.

Confirming there is a substantial amount of subsurface water or ice at mid-latitudes would also be an enabling factor in establishing a permanent human presence on Mars, for the life we will bring there.

NASA is carrying out an intensive study of the current and past history of water on Mars, over the next decade, through a series of unmanned scientific missions, to be launched every 26 months. The Mars Exploration Rovers will provide the first in this series of breakthroughs in our understanding of this remarkable world.

*This artist's rendering of the* Spirit *rover on Mars shows the five-foot-tall vehicle ready to explore the red planet. Atop the mast are the two color panoramic cameras, and two black and white navigational cameras. The arm, protruding in front, houses the scientific instruments that will reveal the geologic history of Mars, by investigating the chemical, mineral, and elemental composition of Mars' soil and rocks.*

*The rover's three-dimensional color panorama of its landing site revealed these gently sloping hills on the horizon, less than two miles away. Even if the spacecraft cannot travel that distance, as it gets closer it will reveal more of the detail of these intriguing features.*

## Hitting the 'Sweet Spot'

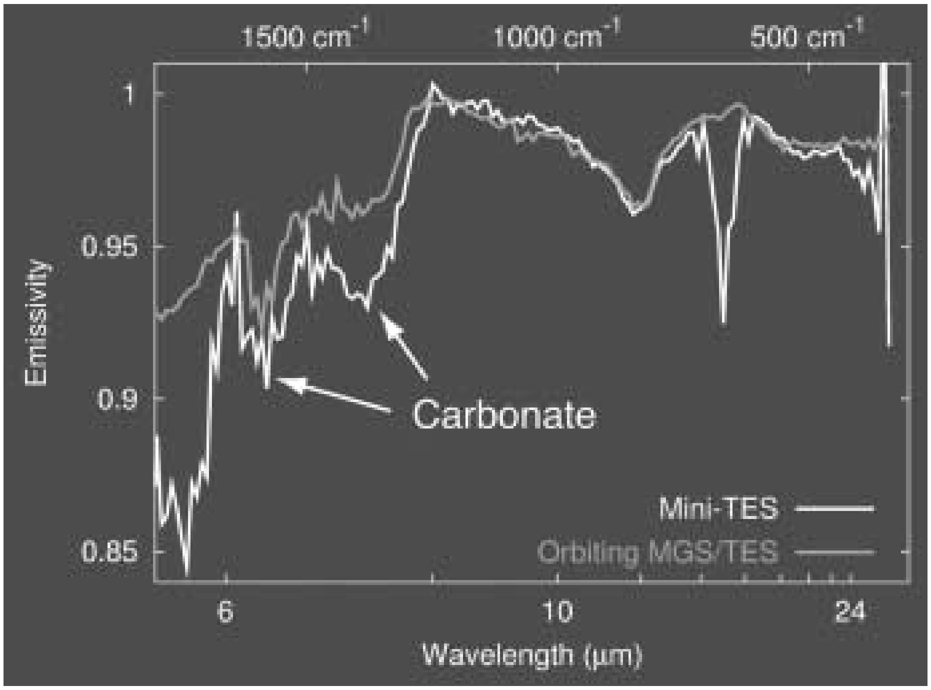
Choosing the landing sites for the two Mars rovers was a long and arduous task. More than one hundred sites were considered over a period of two years by more than 100 scientists and engineers, using orbital imaging and other data from Mars *Odyssey* and *Global Surveyor*. While the site had to be scientifically interesting, the most important criteria, as science team member Dr. Matt Golembek stated, were "safety, safety, and safety."

Gusev Crater was the chosen target for *Spirit* because there is evidence that this depression—the size of the State of Connecticut—once was home to a lake, or some standing body of water. An asteroid or comet impact created Gusev Crater as long ago as 4 billion years, and on its 95-mile diameter floor, there are younger impact craters. There is a branching valley, called Ma'adim Vallis, probably carved by flowing water, which leads directly into Gusev Crater, through a breach in its southern rim.

Water flowing down the valley could have pooled in Gusev Crater, leaving behind sediments from the highlands from whence it came, and from the river's trip into Gusev, before it exited through a gap in the crater's northern rim. The surface of Gusev Crater, which appeared relatively smooth from orbit, and confirmed to be so by photographs taken by *Spirit* on the ground, may be covered with wind-blown dust deposits, or material from volcanic eruptions. The samples of layered sedimentary rocks that would tell the history of the site, therefore, may be found in the material from the bottom of the original crater that was ejected to the surface, when secondary impacts took place.

Placing *Spirit* in a portion of Gusev Crater that was not too rocky, relatively flat, and not too dusty, required the most

## *Spirit* Finds Carbonates




*Measurements from the Miniature Thermal Emission Spectrometer aboard the Mars rover indicate the presence of carbonates, which are organic molecules that form only in the presence of water, on Earth. The bright line is* Spirit's *data; the fainter line indicates measurements from NASA's orbiting spacecraft.*

intricate trajectory planning, and the analysis of real-time data of the changing conditions in the Martian atmosphere, in order to allow last-minute adjustments.

The parameters for entry into Mars' atmosphere, descent, and landing were carefully calculated using models based on imaging and thermal data from the two orbiters. But even the best models can be bested by the red planet. In early December, a dust storm was observed on the opposite side of Mars as the *Spirit* landing site. Scientists were aware that the increased dust in the atmosphere would increase its temperature, but thought that effect would be limited to the vicinity of the storm.

But they discovered shortly before *Spirit* landed that the effects were global, and that higher temperatures than expected would have an impact on *Spirit's* landing. Small adjustments were made in the last few minutes before descent and landing, to account for the change in the weather. Images and data, including the dust deposits on the rover's solar arrays, lead scientists to conclude that visibility at Gusev Crater now is similar to a smoggy day on a big city on Earth.

Mission managers warned before landing that even a large gust of wind could end the mission. To increase the likelihood of success, a set of systems was placed on the lander to help guide its descent. These included downward-looking cameras on the lander to take three images on the way down; three small rockets to compensate for any wind gusts that might give the lander a horizontal velocity; radar on the lander to send pulses toward the ground to measure its altitude; and the ability for *Spirit* to communicate with Mars *Odyssey* during its entire descent to the surface, in order to record each step of the process.

The result was that the engineers succeeded in placing *Spirit* in "the sweet spot," as scientist Dr. Steve Squyres described it. From the first black-and-white images the rover transmitted to Earth, three hours after it landed, it was clear that its neighborhood on Gusev Crater is made to order.

### A Different Mars

Unlike the 1970s Viking and 1997 Pathfinder landing sites, this site has only 3% of its surface covered with rocks, versus 20%. There are no large boulders visible—nothing so tall that the rover will have to drive around it. Nature has saved the scientists time, Dr. Squyres has noted, by scouring the surfaces of many of the rocks through the periodic transit of dust devils, swirling through the windy crater.

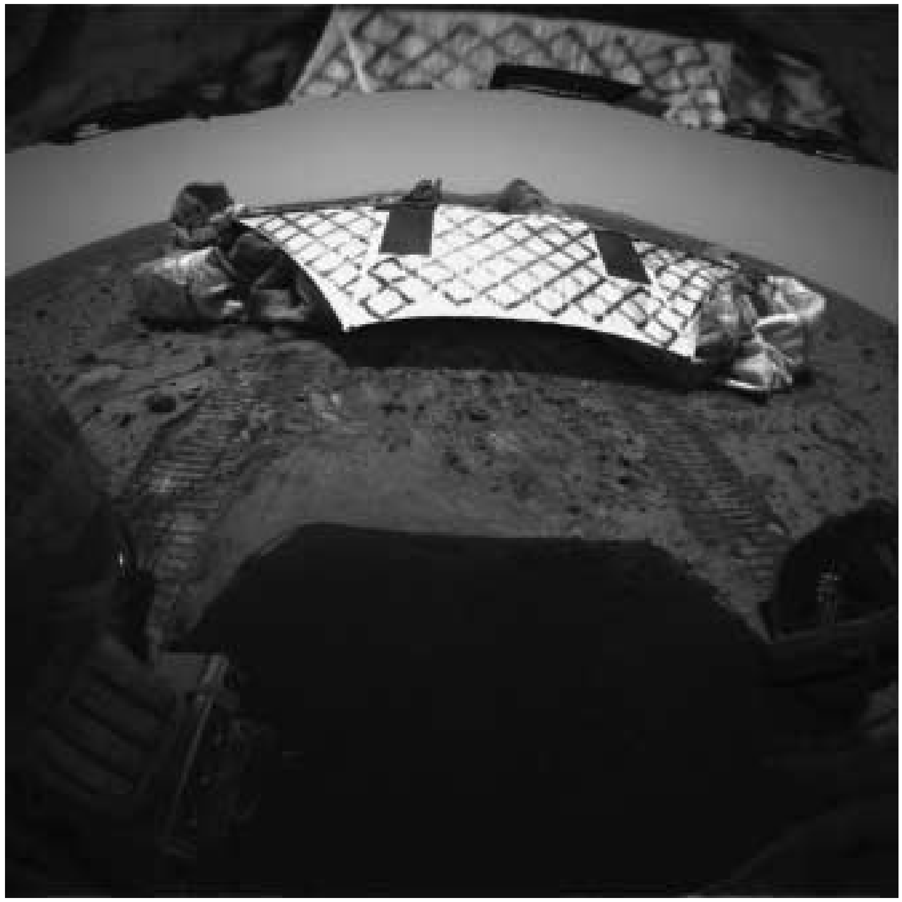
The site contains the diversity of rocks and soil the scientists had hoped for. There are rounded and angular rocks, dark-surfaced and brighter rocks, soil that appears dusty, soil that appears compacted, and insets of small craters, where ejecta may expose primary material from the past of Gusev Crater.

While the egress of the rover from its landing platform was delayed by a couple of days—in order to turn it in place so it could roll off in the safest direction—scientists have been studying the data collected by *Spirit* to make their short- and long-term exploration plans. At a briefing from NASA's Jet

Propulsion Laboratory on Jan. 13, Dr. Squyres outlined the primary objectives of each of the working science teams.

The atmospheric science team, he reported, is studying the observations of the sky taken by the rover's thermal emission spectrometer, to refine their understanding of Mars' dynamic atomsphere and weather. The team is aiming for high-fidelity temperature profiles of the atmosphere on Mars. This data will be important in fine-tuning the landing of the *Opportunity* rover on Jan. 25, as well as generally improving weather forecasting on Mars.

"There is almost an embarrassment of rocks" to study, Squyres said, in regard to the work of the geology and long-term planning science team. The first order of business will be to study the different rock and soil types in the immediate vicinity of the rover, and the team will be choosing the best targets. Visual images, as well as infrared measurements, already indicate the variety the scientists had hoped for.



*The* Spirit *rover took this photograph in the early morning of Jan. 15th, after it had rolled off its lander, to start its exploration of Mars. Scientists will be studying the tracks of the rover's wheels, seen here, to help characterize the Martian soil.*

The group interested in studying the physical properties of the rocks and soil, is most immediately anxious to gain access to the images of the tracks that the rover's wheels will leave in the soil, as it exits the lander ramp. They will study the soil's compressibility, and do little wheel maneuvers—such as holding five fixed and rotating the sixth—to provide a look at material at some depth. Later, the rover will do trenching, digging deeper down in the soil.

Following that, an intriguing piece of real estate near the lander—now dubbed the "magic carpet"—where *Spirit's* airbags apparently dragged against the soil, will be a point of interest. From the visual images, the darker, subsurface soil that was uncovered, looks like mud. Scientists caution that it is unlikely the soil is actually wet, but are anxious to discern its differences from the surrounding area.

The mineralogy and geochemistry group is deciding in which direction the rover should go, after it studies its immediate surroundings. The first order of business is to provide a map of the diversity of the site. Their job is to use the rover's suite of spectrographic instruments, which will provide the compositional data on the rocks, to do a thorough characterization of the neighborhood.

By Jan. 13, the scientists had assembled the entire 360° color 3-D panorama of photographs from the rover, seeing details that were invisible in the first, black-and-white, lower-resolution navigation images. On the horizon, in an easterly direction from *Spirit,* is a cluster of eight rolling hills. The nearest, however, is almost two miles from the landing spot, or about five times the distance the rover was designed to travel. Dr. Squyres stressed that even if the rover could not make the traverse all the way to the hills, the view and detail of the hills will "get better and better," as the rover is sent closer and closer.

One "extremely attractive target," according to Dr. Squyres, is a small crater only about 800 feet in the distance. It appears to be an impact crater that has excavated subsurface material. Once the rover is on the move, scientists and engineers will decide if it should drive over and peek over the ridge of the crater's rim.

## Meet the Field Geologists

The Mars Exploration Rovers are the most complex robotic devices for planetary study ever deployed. Each is designed to wander the red planet for at least 90 Mars days, or sols (equivalent to 92 Earth days), and cover a distance of up to 300 feet per day. Unlike the diminutive 22-pound *Sojourner* rover, which depended upon a lander for communications, the 384-pound, golf cart-sized *Spirit* and *Opportunity* rovers communicate directly with the two overhead Mars orbiters, and with the Earth. Thus, they have no limit on distance they can travel from the landing site. The amount of data, including images, that *Spirit* can send back in a day, using all three communication links, is more than ten times what was retrieved from *Sojourner* in 1997.

How far each rover will travel will depend upon how long it is operational. As Mars goes from Summer to Fall in its northern hemisphere over the next three months, and the days shorten and temperatures decline, the rovers will have to use more energy to keep their instruments and electronics warm. At the same time, there will be less solar energy available for their panels to convert into electricity. So for this mission, time is of the essence.

During the time they are functioning on the surface of Mars, the rovers have their prime objectives. These were chosen to carry out the studies that would indicate whether or not water was persistent on Mars. For *Spirit,* this means a thorough characterization of the diversity of the rocks and soil; the search for minerals that could have been deposited by water flow or precipitation; the search for minerals created in the presence of water; and the extraction of clues from its geologic investigation that relate to the environmental conditions when liquid water was present on the surface, such as erosion, or rock fracturing.

To meet these objectives, *Spirit* has a scientific payload, called *Athena.* It includes two instruments that survey the general site. The first is a pair of high-resolution color stereo cameras, whose photographs have already produced images with a clarity never before seen. The second is a miniature Thermal Emission Spectrometer, or Mini-TES, which sees objects in the infrared. From afar, Mini-TES is determining the mineral composition of Martian features, peering through the dust that coats some of the rocks, to see their spectral signature. It has already identified higher-than-expected concentrations of carbonates, which form in the presence of water on Earth.

Mini-TES also measures the gross heat emitted by objects, and will help characterize the texture of the soil (fluffy or compacted), by obtaining a profile of its absorption of heat during the day, and its release at night.

The rover has an arm (and hand, and fingers), which can reach out and deploy three instruments for *in situ* measurements. These are the Microscopic Imager—a combined microscope and camera, which will produce extremely closeup view of rocks and soils; the Mossbauer Spectrometer, to determine the composition and abundance of iron-bearing minerals, and magnetic properties of surface materials; and the Alpha Particle X-Ray Spectrometer, to determine the individual elements that make up the rocks and soil.

To clear the way for looking behind the surface and into the interior, the Rock Abrasion Tool will grind away the top layer of rocks, and expose fresh material underneath for the arm's instruments to investigate up close.

By the end of its mission, scientists hope that *Spirit* will provide them with the quantity and quality of data to come to a definitive answer to the question of whether there was a lake of some sort at Gusev Crater, and, if so, how long the water persisted there.

## Next Rover About To Arrive

*Opportunity* is scheduled to land on the opposite side of Mars, at Meridiani Planum, on Jan. 25, Eastern Standard Time; late night the previous day, at the Jet Propulsion Laboratory in California.

Like Gusev Crater, Meridiani is near the Martian equator, but halfway around the planet. The site is one of the smoothest, flattest plains on Mars, and is of particular interest due to its mineral composition. From orbit, the Mars Global Surveyor Thermal Emission Spectrometer has observed that Meridiani Planum is rich in an iron oxide mineral called gray hematite, which on Earth is usually formed in the presence of water. *Opportunity* will take a closer look.

These two complementary rover missions are taking important steps in NASA's effort to "follow the water" on Mars. Throughout the rest of this decade, future missions will extend the scope and depth of this intensive exploration of Mars, and put in place the infrastructure for the decade to follow.

In 2005, NASA plans to launch the Mars Reconnaissance Orbiter, to carry our a remote sensing study of the planet, comparable to what is carried out continuously to study the Earth. It is designed to combine the big-picture perspective of an orbiter with the level of local detail previously only obtainable from landing a spacecraft on the surface.

The Phoenix Mars Scout, scheduled for the next launch opportunity in 2007, will send a spacecraft, for the first time, to a non-equatorial landing spot, at the icy northern, arctic part of the planet.

After the Mars Reconnaissance Orbiter conducts its high-resolution examination of thousands of Mars locales, the nuclear-powered, precision-landed Mars Science Laboratory will be deployed in 2009, to intensively study the surface for a full Martian year or longer; it will be able to cover a distance on the ground an order of magnitude larger than the current set of rovers.

During the same 2009 launch window, the Mars Telecommunications Orbiter will be sent to Mars. It will be the first interplanetary spacecraft whose primary mission will be to provide a communications link for other missions. Its first task will be to provide the capability to dramatically increase the amount of data that the Science Laboratory can send back to Earth.