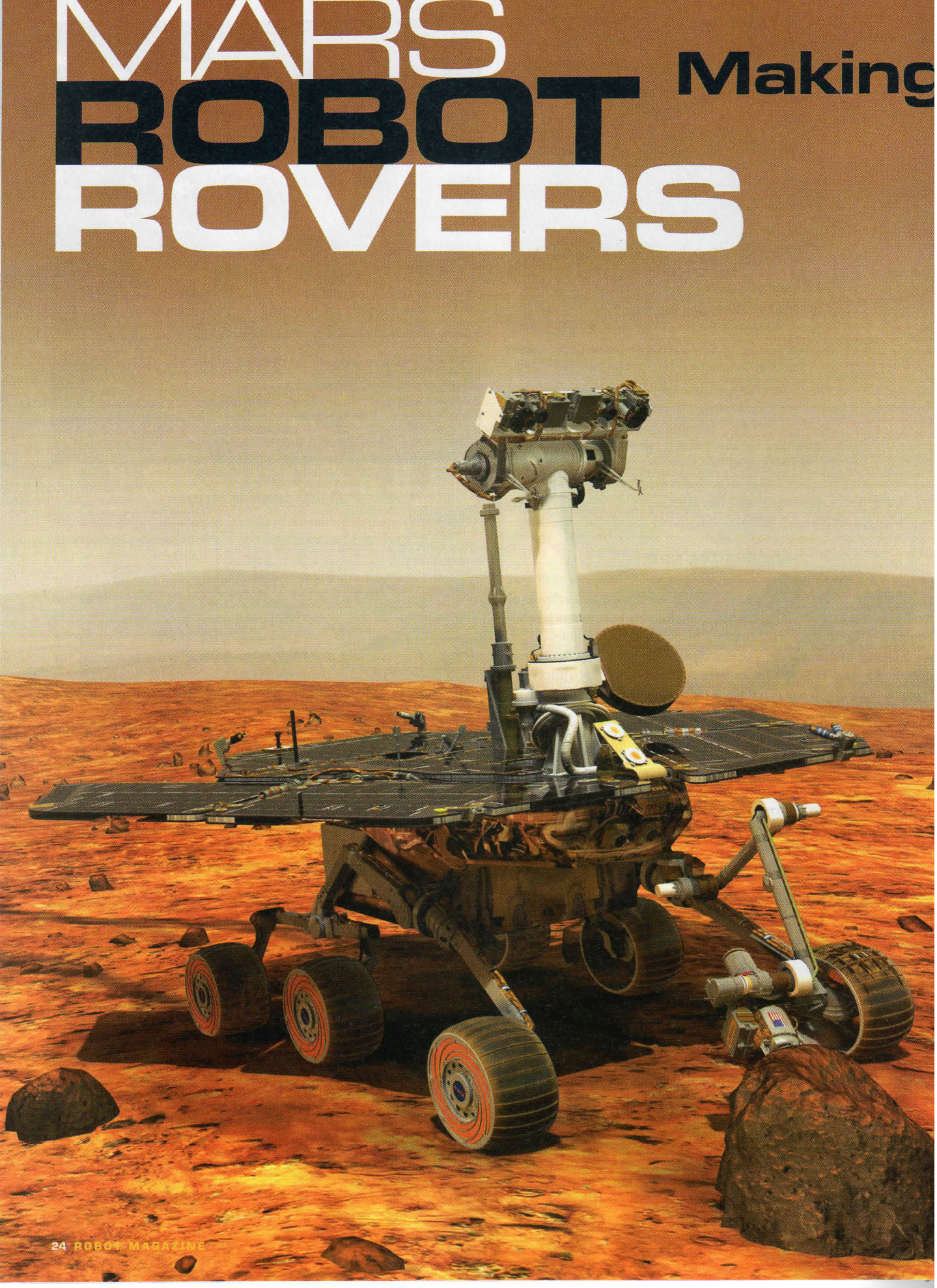
MARS ROBOT ROVERS

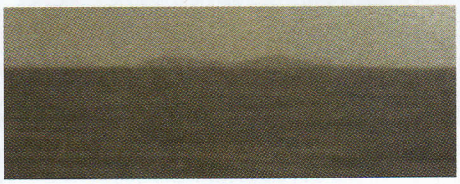
Making



Unexpected Discoveries

Spirit & Odyssey continue their mission in 7th year

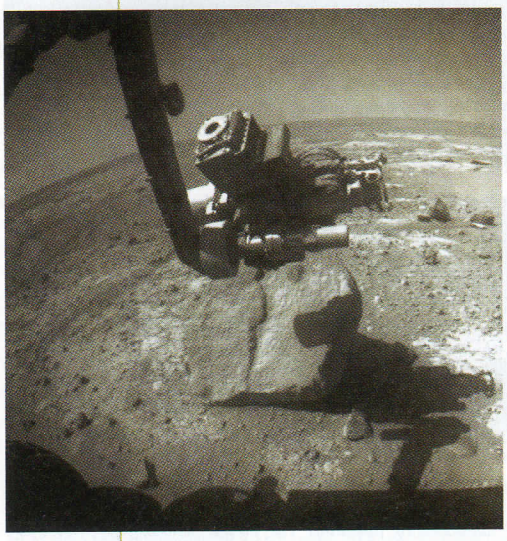
by Jim Oberg



A northern portion of the rim of Endeavour Crater is visible on the horizon of this image taken by the panoramic camera (Pancam) on NASA's Mars Exploration Rover Opportunity on March 7, 2009, during the 1,820st Martian day, or sol, of the rover's mission on Mars.

The major criticism of space robots is that since they are programmed in advance or remotely controlled along a very narrow communications link, they don't react well to surprises. More to the point, say the critics, space robots wouldn't even recognize truly revolutionary discoveries—the kind that programmers and operators didn't anticipate.

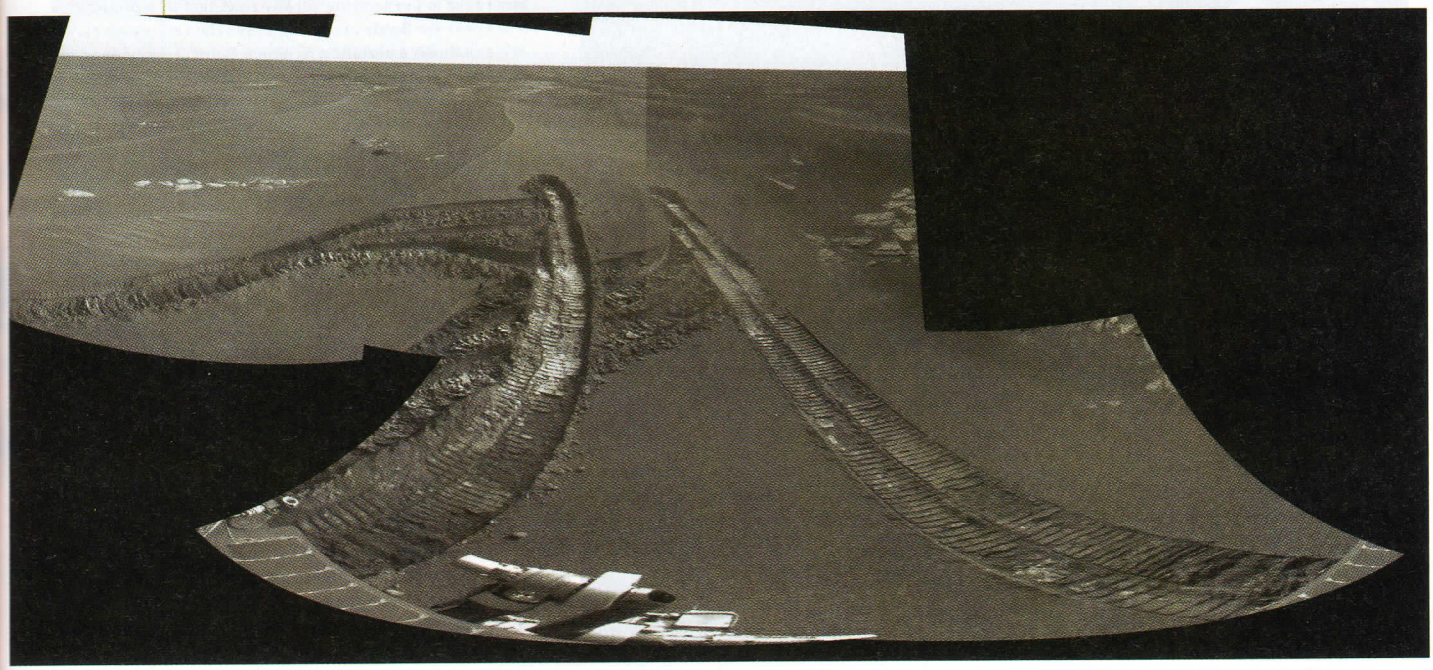
It's a fair complaint, but the point of view is also subject to surprising refutation. And on Mars, the plucky rovers Opportunity and Spirit have shown a previously unexpected ability to reveal exactly such unpredicted discoveries, thanks to their astonishing longevity and largely because of the totally unanticipated ability of Martian dust devils to repeatedly clean their solar power panels of accumulating dust. Designed to last three months, the rovers are now each finishing their sixth year on Mars.



NASA's Mars Exploration Rover Opportunity used the wire brush of its rock abrasion tool during the rover's 2,070th Martian day, or sol (Nov. 19, 2009), to scour dust from a circular target area on a rock called "Marquette Island." The brushed target area, called "Peck Bay," is visible as a dark circle about 5 centimeters (2 inches) in diameter just below the tool turret at the end of the rover's robotic arm in this image. The image was taken later the same sol by the rover's front hazard-avoidance camera.

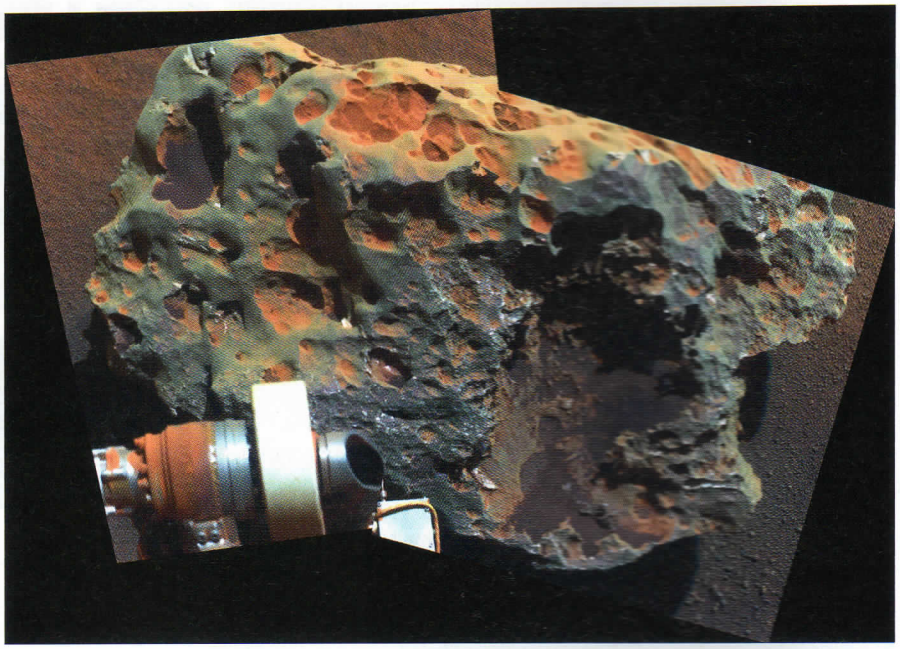
Opportunity has been exploring successively deeper craters and analyzing rock layers extending back in age by billions of years. It is currently

This view from the navigation camera on NASA's Mars Exploration Rover Opportunity shows tracks left by backing out of a wind-formed ripples after the rover's wheels had started to dig too deeply into the dust and sand of the ripple. The frames combined in this view were taken on the 1,867th Martian day, or sol, of Opportunity's mission on Mars (April 25, 2009).



PHOTOS COURTESY OF NASA AND JPL

This image taken by the front hazard-avoidance camera on NASA's Mars Exploration Rover Opportunity shows the rover's arm extended to examine the composition of a rock using the alpha particle X-ray spectrometer. Opportunity took this image during the 1,826th Martian day, or sol, of the rover's Mars-surface mission (March 13, 2009).



This view of a rock called "Block Island," the largest meteorite yet found on Mars, comes from the panoramic camera (Pancam) on NASA's Mars Exploration Rover Opportunity. Analysis of Block Island's composition using the rover's alpha particle X-ray spectrometer confirmed that it is rich in iron and nickel. The rock is about 60 centimeters (2 feet) across. This is a false-color, red-green-blue composite view generated from images taken through the Pancam's 750-nanometer, 530-nanometer and 430-nanometer filters. The exaggeraged color is used to enhance the visibility of differences among the types of rock and soil materials.

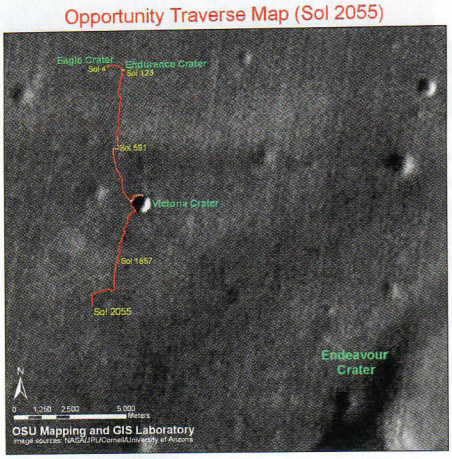
halfway through a two-year trek to a crater named "Endeavour" whose floor could swallow up all the previous craters it has ever visited.

Along the way, it has been looking for surprises. Aside from geologically interesting sand layers, it has so far come across two large meteorites lying on the surface. True; it rolled past both and had to be ordered to turn around by controllers back on earth who spotted the objects in rearview images beamed home. But little time was wasted, and extensive studies of the meteorites and the ground around them provided bonus information on the slow evolution of the surface over many millions of years.

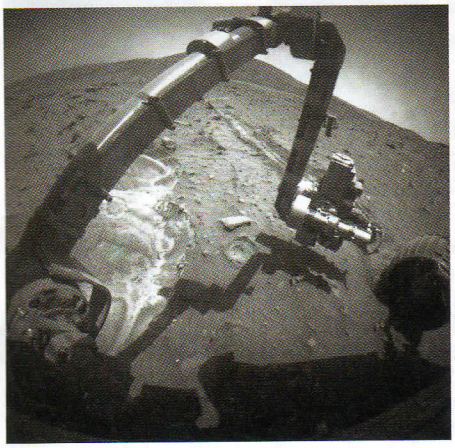
Mike Seibert and Sharon Laubach, engineers on the Mars Exploration Rover team at NASA's Jet Propulsion Laboratory, Pasadena, CA, check the exact position of a test rover in preparation for the next test of a possible maneuver for Spirit to use on Mars. The test setup at JPL simulates a situation in which Spirit is embedded in a patch of soft soil dubbed "Troy," in Mars' Gusev Crater. The July 7, 2009, preparation shown here preceded an assessment of straight-backward driving the next day—one of several possible maneuvers to be assessed in the test sandbox before further driving commands will be sent to Spirit.

Spirit, high in the "Columbia Hills," has been concentrating on an entirely different type of terrain. A salt-flat called "Home Plate" seems to be the remnant of volcanic activity and then water seepage in the distant past. But a mishap that threatened the rover's mission—and still threatens it—proved to be, in the true spirit of serendipitous science, literally a lucky break.

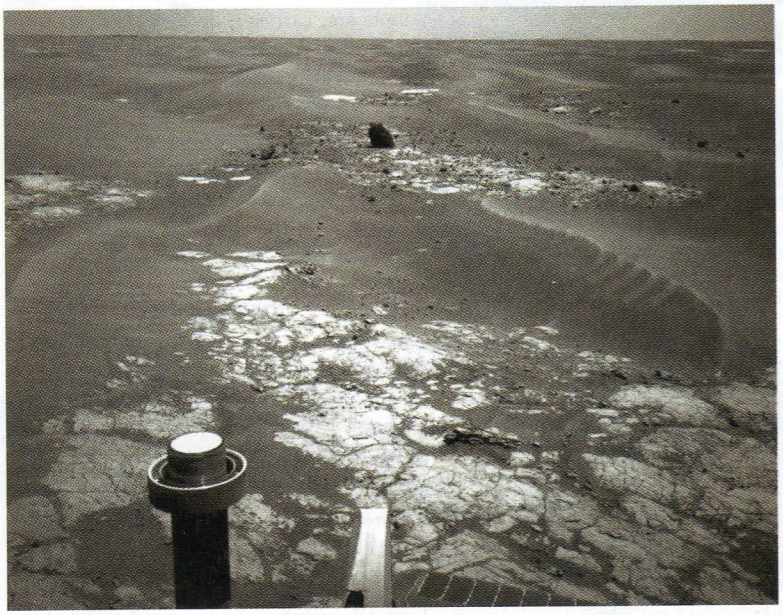
This image of "Block Island" was taken on July 28, 2009, with the front hazard-identification camera on NASA's Mars Exploration Rover Opportunity. Scientists will be testing the rock with the particle X-ray spectrometer to get composition measurements and to confirm whether, indeed, it is a meteorite.



Opportunity's traverse map through sol 2055 showing Endeavour Crater ahead. As of Sol 2049 (Oct. 29, 2009), Opportunity's total odometry was 18,622.44 meters (11.57 miles).



Left: NASA's Mars Exploration Rover Spirit recorded this forward view of its arm and surroundings during the rover's 2,052nd Martian day, or sol (Oct. 11, 2009). Bright soil in the left half of the image is loose, fluffy material churned by the rover's left-front wheel as Spirit, driving backwards, approached its current position in April 2009 and the wheel broke through a darker, crusty surface.



NASA's Mars Exploration Rover Opportunity took this picture of a rock informally named "Marquette Island" as the rover was approaching the rock for investigations that have suggested the rock is a stony meteorite. Opportunity used its navigation camera to record this image during the 2,056th Martian day, or sol, of the rover's mission on Mars (Nov. 5, 2009).

NASA's Mars Exploration Rover Opportunity has found a rock that apparently is another meteorite, less than three weeks after driving away from a larger meteorite that the rover examined for six weeks. Opportunity used its navigation camera during the mission's 2,022nd Martian day, or sol, (Oct. 1, 2009) to take this image of the apparent meteorite dubbed "Shelter Island." The pitted rock is about 47 centimeters (18.5 inches) long. Opportunity had driven 28.5 meters (94 feet) that sol to approach the rock after it had been detected in images taken during a drive two sols earlier.

In mid-2009, as "Spirit" worked its way to a new observation point, its wheels broke through a crust of hard dirt and sank into talcum-powder-fine sand. Before the autopilot noticed, some of the wheels had spun long enough to become nearly totally buried.

Since then, space robotics operators on earth have been testing an escape strategy using full-scale models. The widening effort involves at least two separate rover models and sand tables. Procedures will be tentative, and even if they work, they will take months of churning to make any progress. If they don't work, "Spirit" merely becomes a permanent weather station and can operate for many years in that mode.

In November, one particularly energetic wheel-turning session churned up an entirely new type of white soil. Controllers immediately focused the rover's instruments on it and discovered that it was a buried layer of sulfate—a material that on earth is deposited by the evaporation of water from hot springs. Because "Spirit" was not going anywhere, the instruments spent longer examining the churned-up soil than ever before. It turned out that the surface layers were calcium sulfate and the lower layers were the more soluble iron sulfate.

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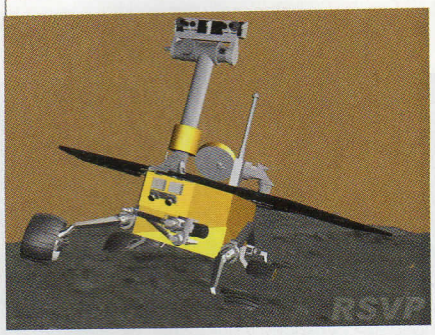

A screenshot from software used by the Mars Exploration Rover team to assess movements by Spirit and Opportunity illustrates the degree to which Spirit's wheels have become embedded in soft material at the location called "Troy." The image simulates Spirit's position on May 8, 2009, during the 1,900th Martian day, or sol, of what was originally planned as a 90-sol mission on Mars.

Tests of possible maneuvers for use by NASA's rover Spirit on Mars include use of this lightweight test rover at NASA's Jet Propulsion Laboratory, Pasadena, CA. In this scene from Sept. 8, 2009, rover team member Walter Hoffman checks for a change in the vehicle's tilt after an arc-backwards maneuver.

Geologists explained this difference by noting that the Martian climate goes through million-year ice ages that deposit snow at Spirit's present location. The snow's lower layers eventually melt, and the water seeps down into the soil, where it dissolves the iron sulfate and carries it deeper. This leaves an enriched calcium sulfate layer on top.

This evidence for "recent" water action on Mars would never have been noticed by "Spirit" if it hadn't already lasted surprisingly long and then surprisingly got stuck and surprisingly dug up soil that, surprisingly, it was mired in long enough for a thorough instrumental analysis.

CONCLUSION

Thanks to their robust and flexible construction and to the flexibility and ingenuity of their earth-bound operators, the twin rovers on Mars continue to reward us with such pleasant surprises. As the old Bedouin blessing goes, "May their tribe increase." Inspired by these surprises, let's design and build even better space robots. ◎

Links
James Oberg website, www.jamesoberg.com

Mars Exploration Rover Mission,
http://marsrover.nasa.gov/home

For more information, please see our source guide on page 89.