Mars Exploration
"Follow the Water"

Young Ho Park
Jet Propulsion Laboratory
Pasadena, CA 91109

Abstract— Over the centuries, the red planet Mars has been a subject of imagination as well as intense scientific interest. As the overwhelming success of two Mars Exploration Rovers unfolds before us, this article provides an overview of and rationale for NASA's Mars exploration program.

1. Introduction

In 2004, we observed two historic events in Mars exploration: the first Mars exploration rover, named Spirit, landed on Mars on January 3, and the second rover, named Opportunity, landed on January 24. At the time of this writing, both rovers are operating nicely, taking pictures of the Mars surface and taking various scientific measurements to reveal secrets of Mars now and many years ago.

Mars missions are challenging and they require extreme ingenuity and dedication from all team members. Although some missions have failed, there have been five successful landings of spacecraft on Mars: Viking Landers 1 and 2 in 1976, Mars Pathfinder with Sojourner in 1997, and Spirit and Opportunity this year.

2. Mars vs Earth

Mars is the most similar planet to Earth in the Solar System, and scientists believe that by studying the origins of Mars, we can learn more about the origins of Earth.

Mars is the fourth planet from Sun, about 1.5 times farther from the Sun compared to Earth. The mass of Mars is 11% of Earth, and its diameter is only 53% of Earth. Mars gravity is 37% of Earth and its atmospheric pressure is only 0.7% of Earth's atmosphere. The temperature on Mars ranges approximately from -140° C to 20° C.

The atmosphere of Mars is quite different from that of Earth. It is composed primarily of carbon dioxide with small amounts of other gases. The six most common components of the atmosphere are: carbon dioxide (95.3%), nitrogen (2.7%), argon (1.6%), oxygen (0.13%), water (0.03%), and neon (0.00025 %).

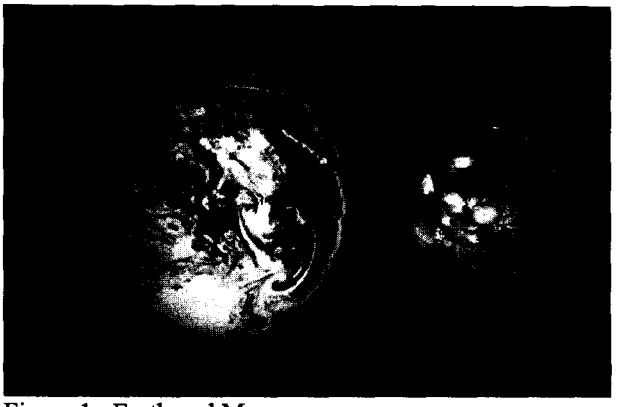

Figure 1. Earth and Mars

3. Why Mars?

Mars is the only planet other than Earth that shows strong evidence of liquid water having once coursed over its surface (Figure 2). Based on limited Mars exploration, it seems there is no obvious sign of water on Mars' surface at this time. However, there is a strong indication that water once flowed on the Martian surface. Although our current understanding of life's origins may be limited, at least on Earth, where there is water, there is life. Thus, it is possible that Mars may have once been habitable and harbored life.

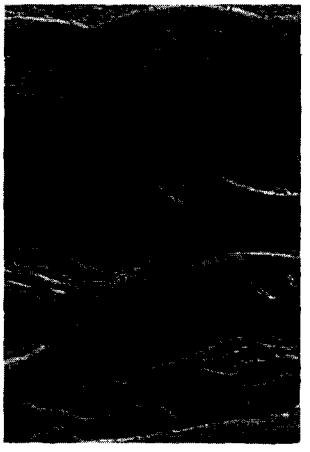

Figure 2. Mars surface picture taken by Mars Global Surveyor (JPL/NASA/MSSS)

Figure 3 shows striking features of gullies in a picture recently taken by an orbiter camera on Mars Global Surveyor. No one is sure yet how gullies formed on Mars. One conjecture is that subsurface ice melted and water gushed out. The implication of this—that there may presently be water or ice under the Martian surface—is tremendous. An analogy would be permafrost on Earth in a polar region such as Alaska. The permafrost is permanently frozen subsurface soil. However, there are other explanations and caution is required before drawing conclusion at this time.

NASA has created a Mars Program with a theme of "Follow the Water." The objective of this program is to detect conclusive evidence whether water existed on Mars, to determine if water exists on the Mars subsurface if not on the surface, and to ultimately prove whether life, even in microbiological life form, existed in the lifetime of Mars.

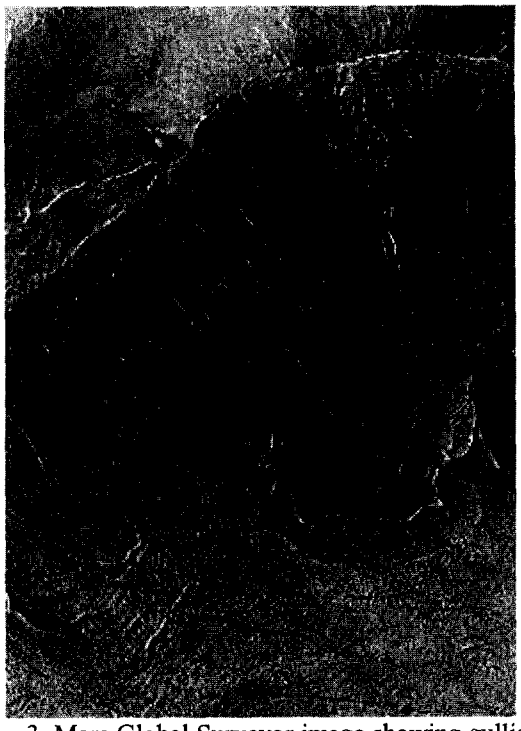

Figure 3. Mars Global Surveyor image showing gullies on the surface of Mars (JPL/NASA/MSSS).

4. MARS EXPLORATION ROVER

The Mars Explorer Rover (MER) mission recently sent two rovers, Spirit and Opportunity, to Mars. Each rover has 90 Martian days to complete its prime mission. The scientific objective is to determine the history of climate and water at sites on Mars where conditions may once have been favorable to life.

The rovers are identical(Figure 4). They are equipped with a suite of science instruments that will be used to read the geological record at each site, to investigate what role water played there, and to determine how suitable the conditions would have been for life. These instruments include a Panoramic Camera, a Mini-Thermal Emission Spectrometer, a Microscopic Imager, a Moessbauer Spectrometer, and an Alpha Particle X-Ray Spectrometer. Each rover also has magnet arrays and a robotic arm that includes a rock abrasion tool. (For more information, visit http://marsrovers.jpl.nasa.gov/.)

Figure 4. Artist conception of a Mars exploration rover.

The Spirit rover was launched on June 10, 2003 and landed on Mars on January 3, 2004. The Opportunity rover was launched on July 7, 2003 and landed on Mars on January 24, 2004. Their names were suggested by a schoolgirl and selected after a worldwide competition.

MER Spirit has landed in the Gusev crater area (Figure 5). Observation data from previous and current Mars missions indicate that the Mars surface does not contain liquid water. However, scientists believe that water may have flowed into the Gusev crater area, accumulated water in a lake, and deposited sediments over a long period of time. This history makes Gusev crater a very interesting exploration site. Figure 6 shows a picture of MER Spirit examining a Mars rock in this crater.

MER Opportunity has landed in a small crater in the Meridiani Planum (Figure 5). Meridiani Planum interests scientists because it contains hematite, an iron oxide. On Earth, hematite almost always forms in association with liquid water. The site appears dry now, as does the rest of the planet, leading scientists ask: How did the hematite get there? Was there once persistent water in the area? If so, where did it go? MER Opportunity will collect in-situ measurement data in an effort to answer these questions.

Figure 5. Landing sites for Mars Exploration Rovers.

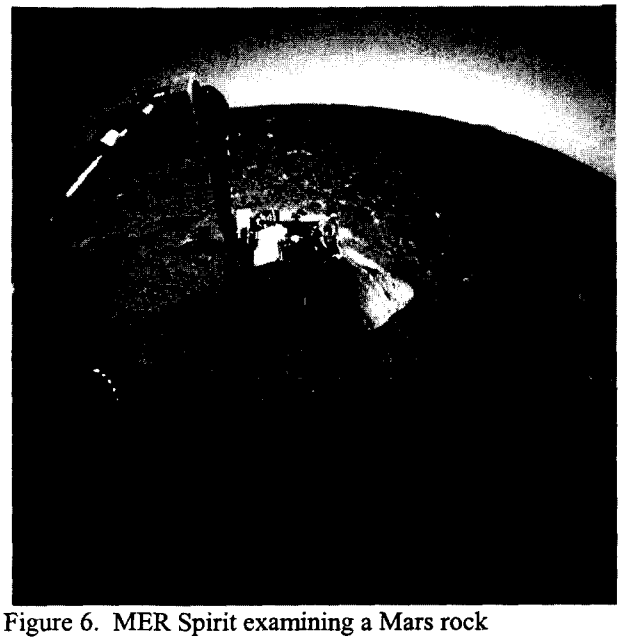

Figure 6. MER Spirit examining a Mars rock (JPL/NASA).

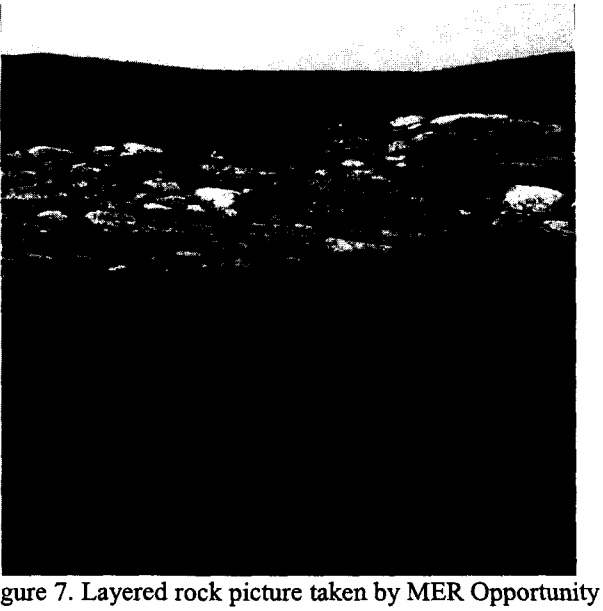

Figure 7. Layered rock picture taken by MER Opportunity (JPL/NASA).

5. FUTURE AND SUMMARY

In addition to two Mars rovers on Martian surface, NASA has two spacecraft orbiting Mars now: Mars Global Surveyor and Mars Odyssey. Both orbiters provide valuable communication links between the rovers and Earth. Also, European Space Agency has Mars Express in Mars orbit currently. NASA plans to send one spacecraft to Mars every two years. Phoenix (a lander) will be launched in 2007 and Mars Science Laboratory (MSL, a rover) will be launched in 2009. In the longer term, a Mars sample return mission is considered likely.

Recently, the President has set a long-term goal of sending men to Mars possibly within three decades.

How does exploring Mars benefit us on Earth? A practical answer is that there would be invaluable science and technological byproducts. Teaching science and technology and inspiring the next generation are other benefits. On the other hand, continuous advancement of a civilization is only possible with the spirit of "Exploration".