Mars Exploration
"Follow the Water"

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Abstract— The red planet Mars has been a subject of imagination over the centuries, as well as intense scientific interest. As the overwhelming success of two Mars Exploration Rovers unfold before us, this article reviews the overview of NASA's Mars Exploration and rationale.

1. INTRODUCTION

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

There have been only five successful landing of spacecraft on Mars surface: Viking 1 Lander 1 and 2 in 1975, Mars Pathfinder with Sojourner in 1997 and Spirit and Opportunity this year. As we know that many Mars missions have failed, Mars missions are challenging and require extreme ingenuity and dedication of all involved team.

2. MARS VS EARTH

Mars is the fourth planet from Sun. The distance from Sun is about 1.5 times that of Earth. The mass of Mars is 10% of Earth. The diameter of Mars is 53% of Earth. The gravity of Mars is 37% of Earth. The Mars atmospheric pressure is only 0.7% of Earth atmosphere. The average recorded temperature on Mars is -63° C with a maximum temperature of 20° C and a minimum of -140° 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%), Neon (0.00025 %).

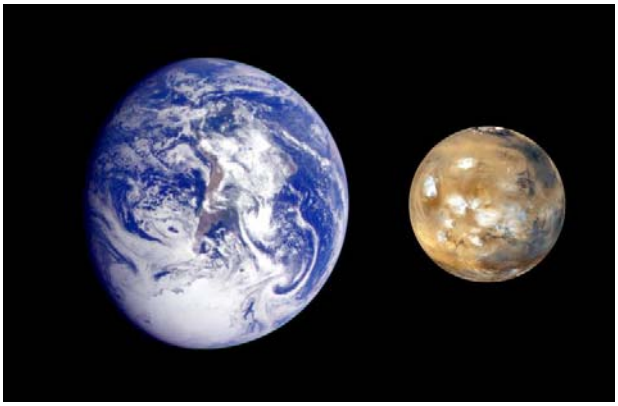

Figure 1. Earth and Mars

3. WHY MARS?

Mars is the only planet, other than Earth, that shows strong evidence of liquid water having coursed over its surface. There are many clear signs of rivers and lakes on Mars surface (Figure 2). Based on limited Mars exploration, it seems that there is no obvious sign of water on Mars surface at this time. However, there is abundance of indication that once water flowed on Mars surface at one time or another in the long history of Mars. Although our current understanding of life's origins may be limited, at least on Earth, there is life where water is. Thus, based on we see on Mars surface it is possible that Mars may have been habitable and may have harbored life.

In Figure 3, striking features of gullies are shown in the picture recently taken by Mars Orbiter Camera on Mars Global Surveyor. According to a dictionary, a gully is "a deep ditch or channel cut in the earth by running water after a prolonged downpour". No one is sure yet how the gullies are formed. One conjecture is that subsurface water or ice melted and the water may have gushed out. The implication of this conjecture is tremendous so that there may be water or ice under the Martian surface even at present time. An analogy may be permafrost on Earth in polar region such as Alaska. The permafrost is permanently frozen subsurface soil. However, caution may be required to draw such haste conclusion without further conclusive evidence.

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

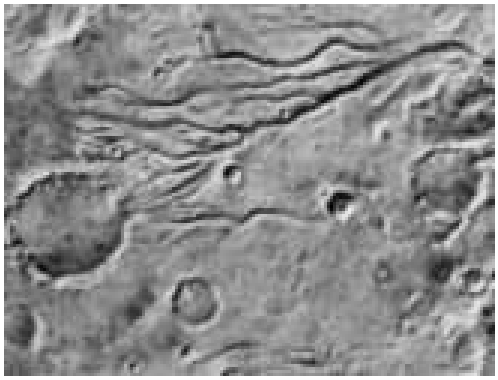

Figure 2. Mars Surface picture taken by a Mars Orbiter

Figure 3. Picture taken by Mars Orbiter Camera on Mars Global Surveyor

4. MARS EXPLORATION ROVER

Mars Explorer Rover (MER) mission is to send two rovers to Mars. 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. Each rover is 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.

Figure 4. Artist Conception of a Mars Exploration Rover.

Mars Exploration Rover A (now called Spirit) was launched on June 10, 2003 and landed on Mars on January 3, 2004. Mars Exploration Rover B (now called Opportunity) was launched on July 7, 2003 and landed on Mars on January 24, 2004. Both rovers are identical in design. The names of rovers were suggested by a schoolgirl and selected after a worldwide competition. As seen in media, both rovers are conducting their scientific mission among many challenges. Each rover has 90 Martian days for it's prime mission. Scientific instruments of each rovers are: Panoramic Camera, Mini-Thermal Emission Spectrometer, Microscopic Imager, Moessbauer Spectrometer, Alpha Particle X-Ray Spectrometer. The robotic arm includes rock abrasion tool. Also, each rover has magnet arrays. (For more information visit http://marsrovers.jpl.nasa.gov/)

MER Spirit has landed in Gusev crater area (Figure 5) and the current Mars surface does not seem to have liquid water. However, the scientists believe that Gusev crater area included flowing water, accumulated water in lakes, and deposit of sediment over a long period of time. This history makes Gusev crater very interesting exploration site. Figure 6 shows the picture where MER Spirit examines a Mars Rock.

MER Opportunity has landed in a small crater in Meridiani Planum (Figure 5). Meridiani Planum interests scientists because it contains an ancient layer of hematite, an iron oxide that, on Earth, almost always forms in an environment containing liquid water. The site appears dry now. So how did the hematite get there? Was there once water in the area? If so, where did it go? These are main questions for which MER Opportunity will collect in-situ measurement data.

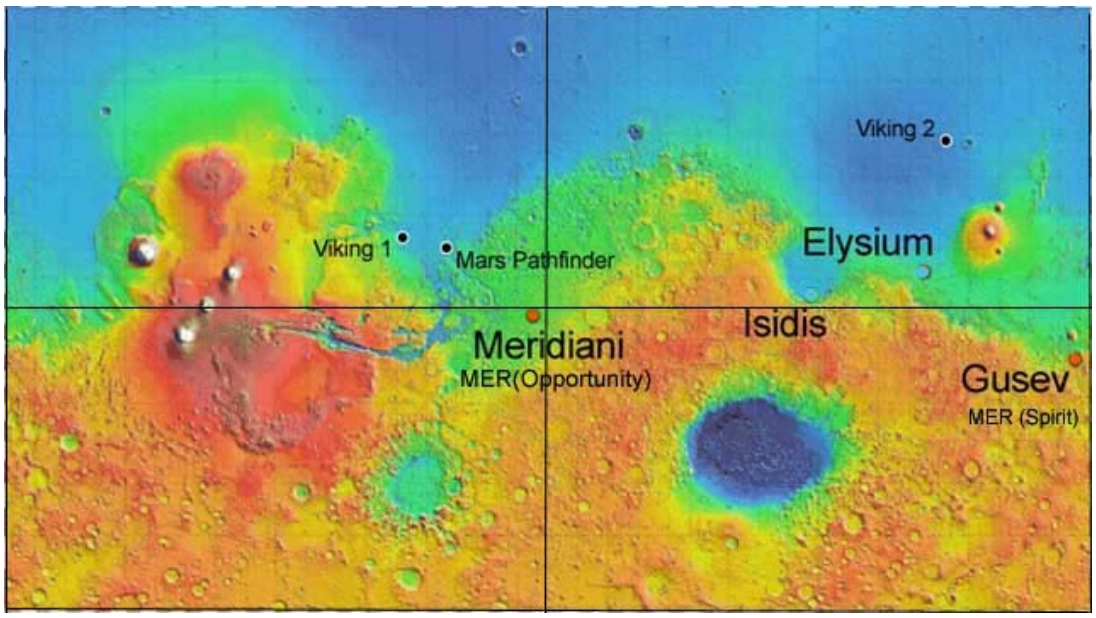

Figure 5. Landing Site for Mars Exploration Rovers

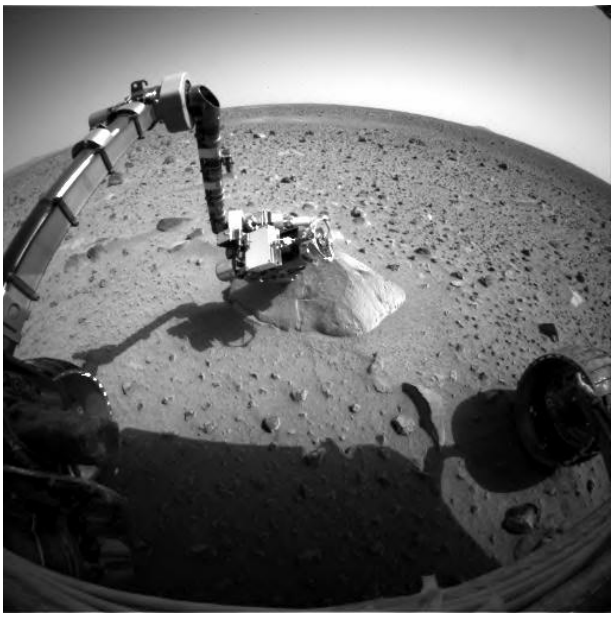

Figure 6. MER Spirit examining a Mars Rock

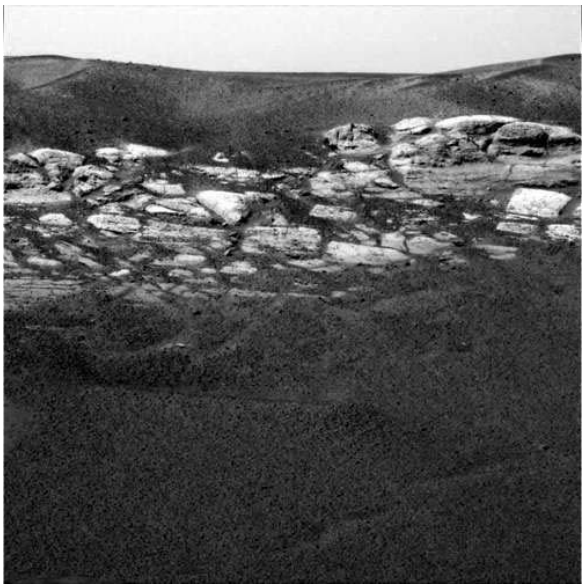

Figure 7. Layered Rock picture taken by MER Opportunity

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. 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 a long term, a Mars sample return mission is considered.

Of course, President has set a long-term goal for sending men to Mars possibly within two decades.

People ask, " Why do we do this for such a high cost?" Practical answer is that there are invaluable science and technological byproduct. Teaching science and technology and inspiring next generation are another essential part. On the other hand, continuous advancement of a civilization is only possible with the spirit of "Exploration".