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Mars: Its Place in Solar System Exploration

J.M. Moore[1], L.A. Leshin[2], D.D. Bogard[3], C.K. Shearer[4], N.G. Barlow[5], A.F.C. Haldemann[6], R.J. Wilson[7], B.P. Weiss[8], A.H. Treiman[9], R.N. Clark[10], & S.M. Clifford[9]

[1] *NASA Ames Research Center, Moffett Field, CA*
[2] *Department of Geological Sciences, Arizona State University, Tempe, AZ*
[3] *NASA Johnson Space Center, Houston, TX*
[4] *Department of Earth and Planetary Sciences, Institute of Meteoritics, University of New Mexico, Albuquerque, NM*
[5] *Department of Physics, University of Central Florida, Orlando, FL*
[6] *Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA*
[7] *Geophysical Fluid Dynamics Laboratory, National Oceanic & Atmospheric Administration, Princeton, NJ*
[8] *Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA*
[9] *Lunar and Planetary Institute, Houston, TX*
[10] *US Geological Survey, Denver, CO*

Abstract. We concur with the NRC Committee on Planetary Exploration that sample return should be the primary goal of the Mars Exploration Program (MEP) and that several missions should be flown. However, we have become convinced that to execute sample return, there needs to be significant investment in technology development either implicitly (e.g., Smart Lander) or explicitly as a line item in the MEP budget. We also strongly recomment that Scout missions should be given their own "sheltered" funding line. A minority of us note that it would be very desirable to place a Synthetic Aperture (Imaging) Radar in orbit about Mars.

REPORT

1. Current State of Knowledge

Mars studies have resulted in a vast wealth of knowledge that cannot be meaningfully summarized in a few paragraphs. The forthcoming NRC Committee on Planetary Exploration (COMPLEX) report "Assessment of Mars Science and Mission Priorities" has several chapters that thoroughly cover the present state of knowledge regarding Mars. Therefore we believe that it is unnecessary to repeat that material here.

2. Key Science Questions

We concur with COMPLEX (which served as the NRC Mars Discipline Panel for the decadal study) that the key science questions regarding Mars derive from the overarching science-driving theme: "What is the evolution of an Earth-like planet" and the sub-themes:

- What is the potential of Mars as a past or present abode of life?
- What is the history of climate and water on Mars?
- What is the structure and evolution of the interior of Mars ?

3. Recommendations

- We concur with COMPLEX that Sample Return is the primary goal of the Mars Exploration Program (MEP). For instance prioritization and baseline capabilities of Mars Reconnaissance Orbiter (MRO) and the "Smart Lander" are most easily justifiable if seen as essential, partially technology development-driven, prerequisites to Sample Return.
- We concur with COMPLEX that several (very bare minimum of 3) Sample Return missions must be flown to successfully address the science objectives of that activity. Though a minority of us argues for a single MEP-culminating Sample Return mission on programmatic grounds (see Appendix A).
- The Community Panel's discussion with Mars Program Systems Engineering Team (MPSET) convinced us that significant technology development is necessary to execute Sample Return and significant investment in technology development would have to come implicitly (e.g., Smart Lander) or explicitly as a line item in the MEP budget. Technology development alone pushes Sample Return missions into the next decade.
- We strongly recommend that Scout Missions should be given their own "sheltered" funding line. Otherwise it will be very difficult to effectively address significant aspects of the Sub-Themes with a program exclusively focused on Sample Return
- A minority of us note that it world be very desirable to place a Synthetic Aperture (Imaging) Radar in orbit about Mars. Such a mission would probably be difficult to place in a Scout Mission format and would probably have to be treated as a higher cost mission. Such an Imaging Radar mission could potentially reveal extent and character of shallowly buried morphologies indicative of a wetter and warmer early Mars, and the integrated relationship of these putative morphologies to each other.

4. The Place of the Mars Program in the Context of Missions to Other Planetary Objects

We note that presently approximately half of all SSE funding for planetary missions goes to Mars, and that this funding proportionality is currently planned to continue though this decade.

The Mars Community panel believes this level is appropriate and justifiable when measured against the overarching themes of planetary exploration: (1) What is the origin and what factors contribute to the initial configuration of the Solar System (Origins); (2) How far and in what forms does organic chemistry advance toward life, and what is the frequency, duration, and level of complexity of life in the Solar System (Life); and (3) What processes have operated to shape the evolution of the worlds of the Solar System throughout their histories up to their present configurations (Evolution)?

The Mars Community Panel concludes that the Scientific Goals of the MEP (including the Scout Program) bear directly and potentially most fruitfully on the "Life" theme, which is considered by both the Scientific Community and the General Public as perhaps the most interesting, thus important. But also the Martian NAS theme of "What is the evolution of an Earth-like planet" places MEP goals as a major component of the "Evolution" theme. Again the evolution of an Earth-like planet is viewed by both the Scientific community and the General Public as perhaps the most interesting, thus important.

Appendix A

Reservations About the Scientific and Programmatic Impact of Sample Return Missions on the Mars Exploration Program

Steve Clifford

No one questions the desirability of studying samples from Mars, the merits of which are discussed at some length in this report. However, there is substantial controversy within the Mars community regarding the relative priority, number, and programmatic impact of sample return missions that is underrepresented in this report's summary conclusions.

With an estimated price tag of $2 billion dollars per mission (latest JPL estimate), a sample return mission costs the same as sending 4-6 orbiters or 2-3 advanced landers/rovers to Mars. For this reason, in the context of the present Exploration Program budget, committing to even a single sample return mission places a considerable strain on the resources and opportunities available to pursue other first-order scientific investigations. While the potential return from such a mission appears sufficient to warrant the inclusion of a single, well-targeted sample return effort sometime during the next 20 years, the decision to pursue 3 such missions in quick succession (on a time scale any shorter than the next 35-40 years) would have a devastating financial and scientific impact on our ability to conduct a well-rounded Mars exploration program.

While the financial stress the program would experience from a commitment to multiple sample return missions appears obvious, the scientific impact has been less well discussed. The single, highest rated (by a considerable margin) goal of the Mars Exploration Program, as identified by MEPAG, is to identify the present 3-dimensional distribution and state of water on Mars. Approximately 5-10% of the planet's present inventory of H_2O is thought to reside in the polar caps, while the remainder is thought to reside in the subsurface as groundwater and ground ice. Although the analysis of returned samples might well provide information relevant to the past occurrence of water at a single location (or even the amount of water that may now reside in a chemically-bound state within the crust), it would contribute virtually nothing to our understanding of where the vast bulk of the planet's unbound inventory resides today.

Even after 35 years of robotic exploration, there are still many first-order investigations about the global character of the planet that have not been conducted – chief among these being meteorological and geophysical network investigations, which promise to dramatically improve our understanding of the Martian atmosphere, climate, and internal structure. Until such critical elements of our initial global reconnaissance of Mars are complete, the commitment of the exploration program's limited resources to support multiple, consecutive sample returns missions appear to be scientifically and fiscally ill advised.