

Scientific Overview of Mars Sample Return

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Compelling Reasons To Explore Mars

- Many of the key questions in *solar system science* can be addressed effectively at Mars:
 - Solar system history
 - Planetary evolution
 - Potential for life
- Mars provides the opportunity to approach, and possibly answer, origin and evolution of life questions
 - Clear potential for past and possibly present biological activity
- Mars has a well-preserved record of its climate and geologic evolution exposed at the surface
 - A comparable record of ancient planetary processes, including those possibly leading to the origin of life, exists on no other terrestrial planet, including Earth
- Mars is the most accessible place in the solar system where these highest-priority science questions can be addressed
 - A well-executed program has brought us to where the next major step in exploration can be taken

Astrobiological Focus Has Emerged

- Previous NRC studies have placed high priority on the science that can be accomplished by the analysis of samples returned from Mars
- In addition to *in situ* analyses, it is now recognized that addressing astrobiological questions also requires intensive and iterative analyses that can only be done on Earth

“The results from an ensemble of all of the relevant methodologies, combined with considerations of geological and environmental plausibility, will likely provide the best evidence for the presence or absence of life in a sample.”

From the 2007 An Astrobiology Strategy for the Exploration of Mars

- Exploration of Mars over the last 15 years has followed the logical flow laid out in the 1995 Mars Exobiology Strategy and endorsed most recently in the 2007 Astrobiology Strategy for the Exploration of Mars:
 - Identify sites of interest from orbit
 - Explore role of water on the ground
 - Investigate habitability
- Approach has matured from strategy of “Follow-the-Water” to “Search for Evidence of Life”.

There is consensus in Mars community that the return of a carefully selected, diverse suite of samples from a well-characterized site will make the greatest progress at this point in Mars exploration

ND-SAG/iMARS MSR Sample Requirements

- Sample diversity
 - Similarities and differences between samples is as important as the absolute characterization of a single sample. *Identifying and selecting samples that are different from each other is crucial.*
- Acceptable sample size/mass
 - The optimal sample size for rock samples is ~10 grams
 - ~30 gm regolith samples
- Number of samples
 - Rock samples: ~ 20
 - Regolith samples: several
 - Dust sample (if collectable): 1
 - Gas sample: 1
- No requirement to study samples on Mars
- Sample preservation needs
 - Retain pristine nature of samples (avoid excess heating, organic and inorganic contamination.)
 - Samples packaged to ensure that they do not become contaminated or mixed



This rock is chemically very different from others encountered by Spirit, implying formation by a different process.

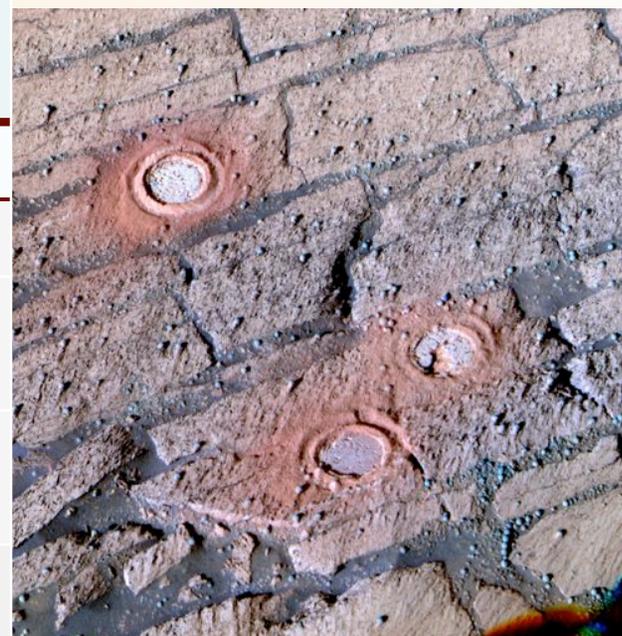


Test sample that experienced 3400 g in a tube that remained sealed—such a sample would meet ND-SAG requirements

Achieving the Science Objectives

Functional Requirements	Approach
1. Access to outcrops at a site with diverse mineralogy, some with the potential for biosignature preservation	Orbital reconnaissance for site selection; access thru mobility and Entry/Descent/Landing capability
2. Ability to select samples	~20 samples totaling 300+ gm
Locate samples	Visible and IR imaging
Determine rock textures & detailed context	Microscopic imagery and weathered rind removal
Differentiate rock types	Mineralogy & bulk elemental abundance
Detect organic carbon (if present)	Spectroscopic detection
3. Ability to cache samples and return them to a suitable facility on Earth	Acquisition & encapsulation in suitable, retrievable cache
4. Analyze Samples	Mars Returned Sample Handling (MRSB) Facility

Opportunity Pancam false color image of three RAT holes on the slope of Endurance Crater.



NASA/JPL/CIT/Cornell University

Why MSR, and not in situ?

There are three primary reasons why MSR is of such high value compared to in situ alternatives.

1. Complex sample preparation, including sample-related decision-making

2. Many critical lab-based instruments are large/complex

3. Instrument diversity. Investigation pathways are not hypothesis-constrained



Mars Mission Objectives for Next Decade

- Trace Gas Orbiter
 - Highly focused science objectives
 - Joint ESA-NASA mission
- Begin sample return campaign
 - MAX-C rover
 - Focused on collecting high-quality sample return cache
 - Modest suite of high-heritage, low-risk instruments
 - 300 kg, MER-like, solar powered, medium traverse rover
 - ESA ExoMars
 - *Exploring possibility of pathfinding seismic experiment*
- Develop key sample return technologies
- Move toward completion of sample return
- Develop geophysical/atmospheric network