MSL landing August 6 (EDT) at Gale Crater

Continuing Mission Highlights

• Senior Review in June

MEPAG Activities in Support of SMD/HEOMD Initiative

• P-SAG Charter and Status
• Interactions with MPPG science

Future Planning, Meetings and Milestones

Summary
Gale Crater
154 km diameter

MSL Landing August 6 EDT
(August 5 PDT)

Coverage of MSL Landing Area by HiRISE (red boxes) and CRISM (blue)
Ongoing: MER-B, ODY, MEX (US), MRO

MER-B: on the move again, having survived winter with the help of some array cleaning events

ODY and MRO: Continuing science observations even as orbiters position themselves to cover MSL arrival and prepare to support the MSL surface mission through relay

MEX (US): MEX successfully completed a north polar radar observing campaign for MARSIS

  Observations in the dark have best signal to noise as ionospheric interference is minimized

Senior Review: All 4 Mars missions are preparing proposals that are due May 30 for the June review

  Teams awaiting clarification on submittal media and on style of interaction (limited face-to-face) with Review Board
Opportunity Explores Noachian Terrain at Endeavour Crater

**Ancient Impact and Aqueous Processes at Endeavour Crater, Mars**


The rover Opportunity has investigated the rim of Endeavour Crater, a large ancient impact crater on Mars. Basaltic breccias produced by the impact form the rim deposits, with stratigraphy similar to that observed at similar-sized craters on Earth. Highly localized zinc enrichments in some breccia materials suggest hydrothermal alteration of rim deposits. Gypsum-rich veins cut sedimentary rocks adjacent to the crater rim. The gypsum was precipitated from low-temperature aqueous fluids flowing upward from the ancient materials of the rim, leading temporarily to potentially habitable conditions and providing some of the waters involved in formation of the ubiquitous sulfate-rich sandstones of the Meridiani region.

Chester Lake and all the rocks near Greeley Haven have similar textures. They are brecciated, with dark, relatively smooth angular clasts up to ~10 cm in size embedded in a brighter, fractured, fine-grained matrix. Some outcrops, notably Chester Lake, show fine-scale lineations in the matrix and alignment of some clasts (Fig. 2). Pancam spectra of the matrix exhibit a gradual decrease in reflectance toward 1000 nm. The clasts can show specular reflections, have a relatively deep absorption at 934 nm, and have a shallower 535-nm absorption than the matrix materials, consistent with relatively unoxidized basaltic material containing low-Ca pyroxene.

The matrix of Chester Lake is easily abraded. A portion of Chester Lake dominated by matrix was abraded to a depth of ~2.5 mm with the rover’s Rock Abrasion Tool (RAT). Resistance to abrasion is quantified using specific grind energy, the energy required to abrade away a unit volume of rock. The specific grind energy for Chester

Impact breccias, with evidence of syn- and/or post-impact aqueous alteration

(right) Exposed vein of calcium sulfate (likely gypsum)
Interannual similarity and variation in seasonal circulation of Mars’ atmospheric Ar as seen by the Gamma Ray Spectrometer on Mars Odyssey


- Atmospheric argon (Ar) measurements reveal annual and seasonal variations in atmospheric transport and mixing.
- Data were obtained over the period May 2002 to May 2008 (3 Mars years, MY) by the Odyssey Gamma Ray Spectrometer (GRS).
- Comparison year-by-year shows strong similarity but also some short-period (~15° –30° Ls) and interannual variations, particularly during autumn and winter.
- The GRS data do not show significant seasonal variation of Ar at equatorial and low-latitude zones.

Latitudes (a) 75° S to 90° S, (b) 60° S to 75° S, (c) 45° S to 60° S and (d) 0° to 45° S. (left) Seasonal Ar behavior in southern hemisphere zonal averages for 3 full consecutive Mars’ years and the next southern autumn. (right) Seasonal Ar behavior in northern hemisphere zonal averages for Mars’ years 26, 27, 28 and five seasons of MY 29.
Gusev Crater
J. Carter & F. Poulet
*Icarus* 219 (2012) 250-3

Phyllosilicates
Carbonates
extensive aqueous alteration of crater floor deposits

MRO CRISM

![Diagram of Gusev Crater withSpirit traverse and Home Plate](image1)

![Relative reflectance spectra of Phyllosilicates and Carbonates](image2)
Finding: Much of Mars’ oldest crust has been altered by water at high temperatures, more comparable to metamorphic rock on Earth than to impact debris on the Moon.

Importance: The Noachian crust has long been regarded as layers of impact debris, volcanic lavas, and rare sedimentary rocks. MRO/CRISM discovered exposures of hydrated minerals at thousands of sites. Comparison of these minerals with conditions required to form them indicate hydrothermal alteration at pressures to a few kilobars and temperatures to 350°C.

Recurring Slope Lineae (RSL) are narrow (0.5-5 m), dark markings on steep slopes (>25°).

- Form and incrementally grow in warm seasons (late spring to summer), then fade or disappear in cold seasons.
- Reform at nearly same locations in multiple Mars years.
- Concentrated in southern hemisphere (32° S to 48° S), favoring equator-facing slopes.
- Form and grow at temperatures at which brines (salty water) would be liquid.
- Exact mechanism not understood, but activity of brines is current best model.

Animation of MRO/HiRISE images from late spring to mid summer

(A. McEwen et al., Science, July 2011)
Outlook for Mars Program

- Cancellation of 2016 MTGO and 2018 ExoMars collaboration w/ESA
- No indication to (re)start descoped Flagship mission in notional budget
- Support for MAVEN good, but much concern over future funding for Mars extended mission ops
- Lack of R&A funding increases jeopardizes mission science return

MEPAG Feb. 27-28 Meeting, March 5 letter to PSS Chair:

- "MEPAG is appalled by the proposed drastic budget cuts to the NASA Planetary Science Division. Among the many dire impacts, the cuts threaten the very existence of the Mars Exploration Program..."
- "MEPAG is also deeply concerned about the impact of those cuts on our international partnerships and collaborations."
- MEPAG is assembling a Precursor SAG to analyze concepts and strategies that could emerge from potential integration of SMD-HEOMD Mars objectives
MEPAG Recent Activities

Precursor SAG (P-SAG) formed

- Mike Carr and Dave Beaty co-chairs
- Participants from both science and human exploration communities
- Preliminary report on updated Strategic Knowledge Gaps (SKGs; first of several deliverables due by mid-June); material posted on MEPAG website where it can be linked to LPI workshop activities

Telecon presentation to MEPAG Executive Committee from science members of the MPPG

- Discussion about ongoing formulation of pathways addressing Decadal Survey and human exploration goals
- MEPAG will support ways to engage the Mars community as fully as possible in the discussion
### P-SAG Contributors

#### Co-chairs
- Carr, Mike - USGS (ret)
- Beaty, Dave - MPO

#### Team members
- Abell, Paul - JSC
- Barnes, Jeff - academia
- Boston, Penny - academia
- Brinkerhoff, Will - GSFC
- Charles, John - JSC
- Delory, Greg - academia
- Head, Jim - academia
- Heldmann, Jen - ARC
- Hoffman, Steve - JSC
- Kass, David - JPL
- Munk, Michelle - LaRC
- Murchie, Scott - APL
- Rivkin, Andy - APL
- Sanders, Gerry - JSC
- Steele, Andrew - academia

#### Ex-officio team members
- Baker, John - JPL
- Drake, Bret - JSC
- Hamilton, Vicky - res. institute
- Lim, Darlene - res. institute
- Desai, Prasun - HQ-OCT
- Meyer, Michael - HQ-SMD
- Wargo, Mike - HQ-HEO

---

#### Additional Technical experts consulted:

* **Atmosphere/EDL**: Alicia Dwyer Cianciolo (LaRC).

* **Resources**: R.M. Hembree (JSC), Bill Larson (KSC), Bruce Campbell, Mike Wolff, Diane Linne (GRC), Phil Metzger (KSC), R.T. Clancy, M. Smith (GSFC), T. McConnochie (GSFC).

* **Radiation, Human health/performance**: Francis Cucinotta (JSC), John James (JSC), Insoo Jun (JPL),

* **Humans to Mars orbit/Phobos/Deimos**: Dan Mazanek (LaRC), Julie Castillo (JPL), TBD

* **Planetary Protection**: TBD

* **Mars surface operations**: TBD

* **Technology Planning**: Scott Vangen (KSC), Mars Program Office technical staff

* **Facilitation/Support**: Deborah Bass (MPO), Charles Budney (MPO), Rich Zurek (MPO)
# Requested Deliverables - PSAG

<table>
<thead>
<tr>
<th>Deliverables</th>
<th>April 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reconsider the strategic knowledge gaps (SKGs) in required knowledge of Mars to support the first human missions to the martian vicinity and to the surface (Goal IVa).</td>
<td></td>
</tr>
<tr>
<td>2. Identify the key science objectives (using existing MEPAG and NRC scientific planning), that could be addressed in synergy with each of the potential investigations from #1.</td>
<td></td>
</tr>
<tr>
<td>3. Identify key technology development/demonstration opportunities necessary to support science and humans-to-Mars objectives.</td>
<td></td>
</tr>
<tr>
<td>4. Classify each of the opportunities identified above by implied or potential platform (e.g. orbiter, stationary lander, rover, etc.), and evaluate relative priority.</td>
<td></td>
</tr>
</tbody>
</table>

**Final results: end of May**

**Serves as input to the Mars Program Planning Group**
PSAG: Strategic Knowledge Gaps

Gaps in the knowledge needed to achieve a specific goal

Goal A

Knowledge Gaps

Knowledge we have

Goal B

Knowledge Gaps

Knowledge we have
Structure of the Information

<table>
<thead>
<tr>
<th>SKGs</th>
<th>Knowledge-generating activity</th>
<th>Measurements needed</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>For Goal A:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SKG #1</td>
<td>Mars flight investigations</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-flight</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technology dev./demo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SKG #2</td>
<td>Mars flight investigations</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-flight</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technology dev./demo</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For Goal B: etc. . . . .
GROUP A. To Achieve the Goal of Humans to Mars Orbit

1. Upper Atmosphere. The current Martian atmospheric observations (density, pressure, temperature, aerosols and dynamics) have significant limitations for supporting aerocapture and aerobraking design, especially for human-scale missions.

2. Atmospheric Modeling. The atmospheric models for Mars have not been well validated due to a lack of sufficient observational data, and thus our confidence in them (for use in mission engineering) is significantly limited.

3. Orbital Particulates. We have insufficient information about the orbital particulate environment in high-Mars orbit.

4. Technology: To/from Mars System. In addition to the specific challenges listed above, we do not have the required technology available to: (1) sustain human life during long duration flight to/from Mars and around Mars; (2) launch and return human-scale payloads to/from Mars orbit.

NOTE: Priorities not finalized.
GROUP B. To Achieve the Goal of Humans to the Martian Surface

All of the elements of GROUP A, plus:

1. Lower Atmosphere. We do not have sufficient Martian atmospheric observations to confidently model winds, which significantly affect EDL design, or atmospheric electricity, in the forms of electric fields and conductivity, to understand the risks to ascent vehicles, ground systems, and human explorers.

2. Back Contamination to Earth. We do not know whether the Martian environments to be contacted by humans are free, to within acceptable risk standards, of biohazards that might have adverse effects on some aspect of the Earth's biosphere if uncontained Martian material were returned to Earth.

3. Radiation. We do not understand in sufficient detail the ionizing radiation environment at the Martian surface, including contributions from the energetic charged particles that penetrate the atmosphere, secondary neutrons produced in the atmosphere, and secondary charged particles and neutrons produced in the regolith.

NOTE: Priorities not finalized.
4. **Dust Effects.** We do not understand the possible adverse effects of Martian dust on either the crew or the mechanical/electrical systems.

5. **Water Resources.** We do not fully understand if a water resource on Mars occurs in a form that could change the high-level architecture of future human missions to the surface.

6. **Forward Contamination to Mars.** We are not able to predict with sufficient confidence the potential consequences of the delivery and subsequent dispersal of a large bioload associated with a future human mission to the martian surface.

7. **Atmospheric ISRU.** We do not understand in sufficient detail the properties of atmospheric constituents near the surface to determine the adverse effects on ISRU atmospheric processing system life and performance within acceptable risk for human missions.

8. **Landing Site and Hazards.** We do not yet know of a site on Mars that is certified to be safe for human landing, and for which we understand the type and location of hazards that could affect the ability to safely carry out mobile surface operations.

**NOTE:** Priorities not finalized.
9. **Technology: Mars Surface.** In addition to the specific challenges listed above, we do not have the required technology available to:

1. land human-scale payloads on the martian surface;
2. sustain humans on the surface of Mars;
3. enable human mobility and exploration of the Mars surface environment; all within acceptable risk.

**NOTE:** Priorities not finalized.
GROUP C. To Achieve the Goal of Humans to Phobos/Deimos

All of the elements of GROUP A plus:

1. Phobos/Deimos surface Science. We do not have enough understanding of the geological, compositional, and geophysical properties of Phobos and Deimos in order to design focused human-based scientific investigations and engineering activities with precise objectives like those now possible for the Martian surface.

2. Phobos/Deimos surface Ops. We do not know how to perform close proximity and surface interactions (docking/anchoring/mobility) in the conditions present near/at the surface of the martian satellites (low gravity/loose regolith/significant temperature variations/etc.) in order to carry out probable human-based scientific investigations and engineering activities.

NOTE: Priorities not finalized.
Progress to Date

* P-SAG has opened lines of communication at the worker level between SMD, HEOMD and OCT offices—good progress and good discussion despite a very tight schedule

* Cooperation between MEPAG and SBAG is ongoing and productive with regard to SKGs for missions to Phobos and Deimos

* How this analysis will be used in the MPPG discussions is not clear, but that group has shown its intent to work with P-SAG, e.g., MPPG asked P-SAG to broaden its original charter to include missions to the Mars vicinity and possibly Phobos/Deimos

* Again, a key issue is the very tight schedule, driven by the schedule of budget discussions and delivery
**Future Planning, Meetings and Milestones**

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mars Recent Climate Change Workshop</td>
<td>May 15-17</td>
</tr>
<tr>
<td>Third International Conference on Early Mars</td>
<td>May 20-25</td>
</tr>
<tr>
<td>Third International Planetary Dunes Workshop</td>
<td>June 12-15</td>
</tr>
<tr>
<td>Conf. on Comparative Climatology of Terrestrial Planets</td>
<td>June 25-28</td>
</tr>
<tr>
<td>PSD Senior Review of Operating Missions</td>
<td>June 25-29</td>
</tr>
<tr>
<td>COSPAR 2012</td>
<td>July 14-22</td>
</tr>
<tr>
<td><strong>MSL Landing</strong></td>
<td>Aug 5 PDT</td>
</tr>
<tr>
<td></td>
<td>Aug 6 EDT</td>
</tr>
<tr>
<td>**MEPAG Meeting (Fall 2012; Pasadena) **</td>
<td>October 3-4</td>
</tr>
<tr>
<td><strong>MEPAG Meeting (Winter 2013; Washington, DC)</strong></td>
<td>February 26-27</td>
</tr>
</tbody>
</table>

* Agenda to include reports from P-SAG, MPPG & MEP; status of continuing missions; and early MSL science results*
Summary

The Mars community is encouraged by Congressional actions attempting to restore some of the funding cut from the Mars program and the accompanying language underlining the importance of the Decadal Survey recommendations.

MEPAG again notes the high scientific and programmatic value of the currently operating Mars missions and of the research and analysis programs that exploit the full value of data already in hand or soon to be acquired.

The “pathways” work—still in progress within MPPG—seems a reasonable way to capture options. MEPAG strongly urged the group to take full advantage of the recent work that MEPAG SAGs (e.g., ND-SAG, MRR-iSAG, E2E-iSAG) have done and are doing.

*MEPAG looks forward to a successful MSL EDL and Curiosity surface mission!*