Mars Exploration Program

Science Highlights, Status, Updates

Mars Exploration Program Analysis Group
October 6, 2016

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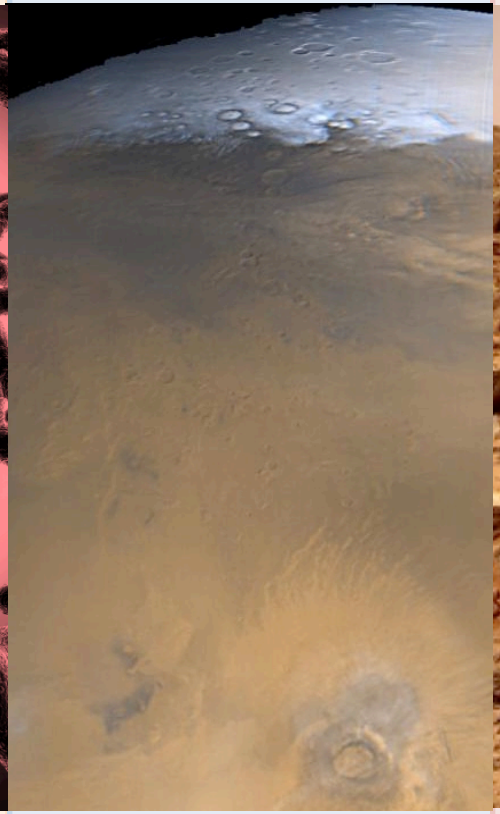
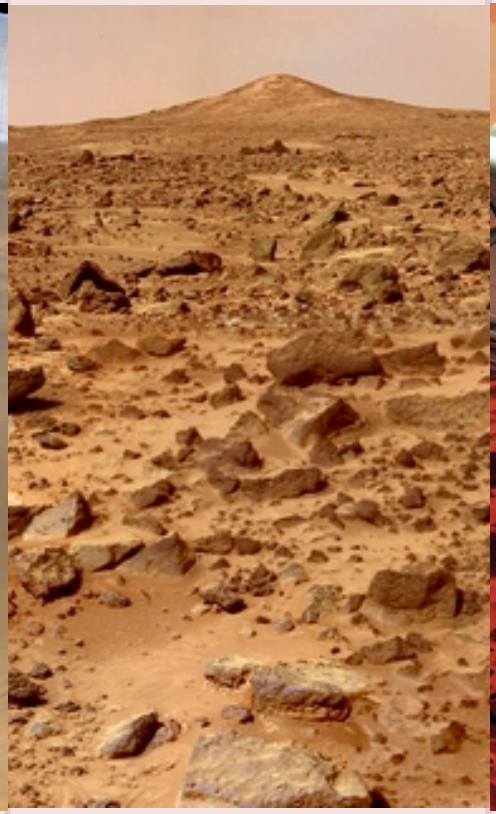
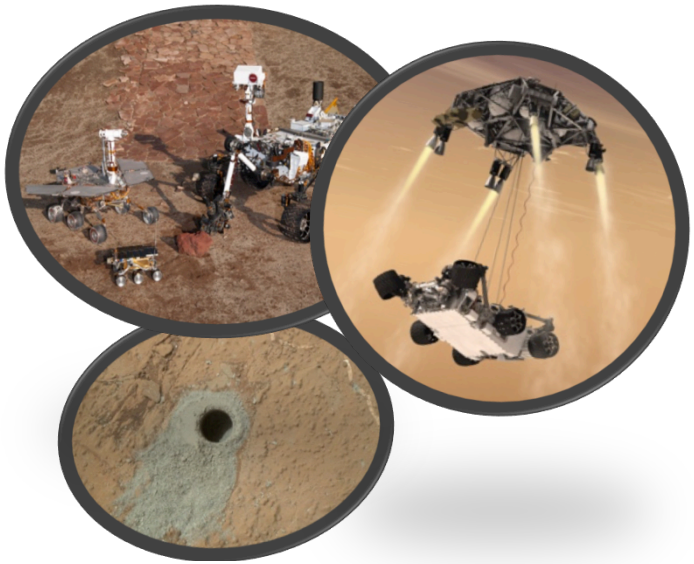
Life	Climate	Geology	Human Exploration
			
I. Determine if Mars ever supported life	II. Understand the processes and history of climate on Mars	III. Understand the origin and evolution of Mars as a geological system	IV. Prepare for human exploration

Source: MEPAG 2015

Mars Exploration Program Legacy

13 covers on Science, >2000 publications in peer reviewed journals

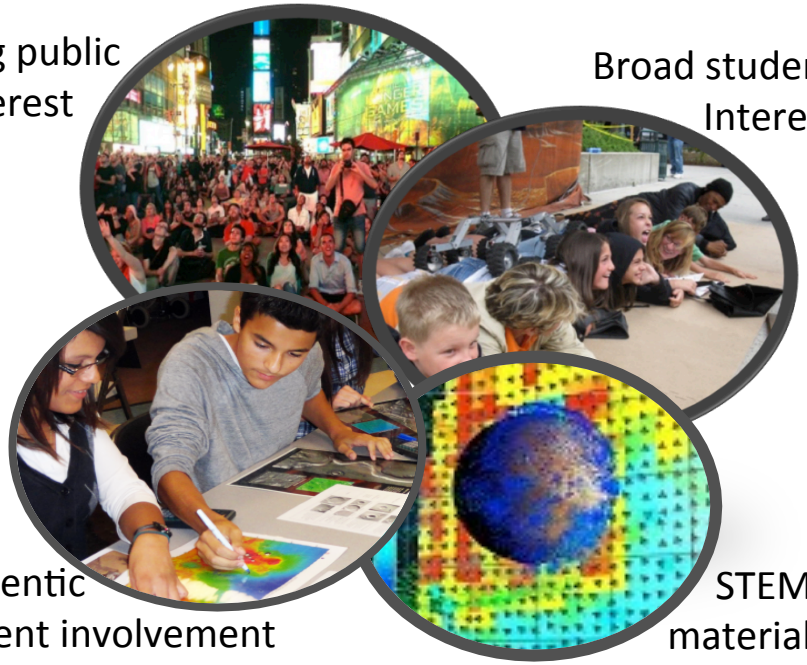
An unparalleled legacy of accomplishment at Mars



US leadership in capabilities to explore Mars

Strong public interest

Broad student Interest



Authentic student involvement

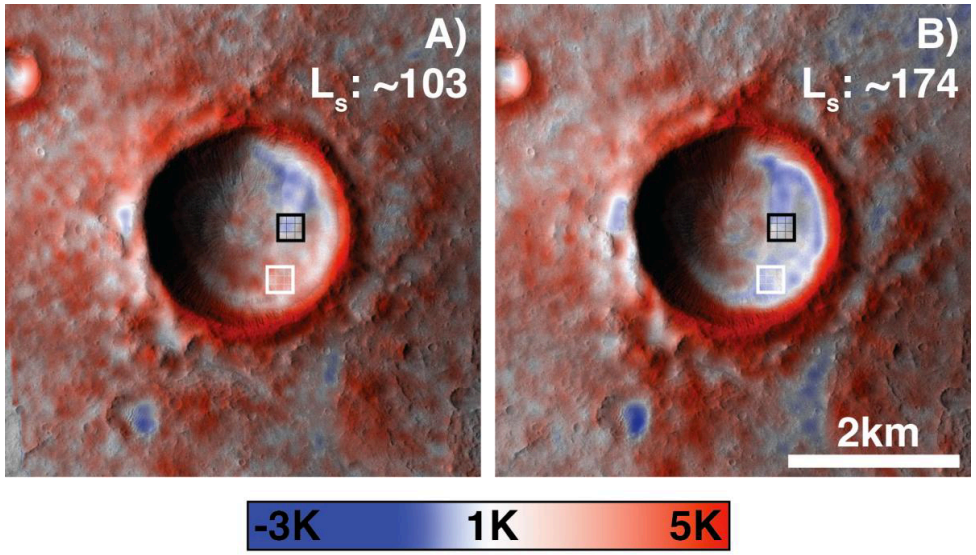
STEM material

Odyssey Science Highlight

The Water Content of Recurring Slope Lineae on Mars

C. S. Edwards and S. Piqueux, *GRL, 2016*

- Recurring Slope Lineae (RSL) have been interpreted as present-day, seasonally variable liquid water flows; orbital spectroscopy has not confirmed the presence of liquid H_2O, only hydrated salts.
- THEMIS temperature data and a numerical heat transfer model are used to constrain the amount of water associated with the RSLs
- Surface temperature differences between RSL-bearing and dry RSL-free terrains are consistent with no water associated with RSL and limit the water content of RSL to at most 0.5-3 wt%.
- High thermal inertia regolith signatures expected with crust-forming evaporitic salt deposits from cyclical briny water flows are not observed, indicating low water salinity (if any), and/or low enough volumes to prevent their formation.
- The RSL-rich surfaces experience ~100K diurnal temperature oscillations, possible freeze/thaw cycles and/or complete evaporation on timescales that challenge their habitability potential.
- The unique surface temperature measurements provided by THEMIS are consistent with a dry RSL hypothesis, or at least significantly limit the water content of Martian RSL.

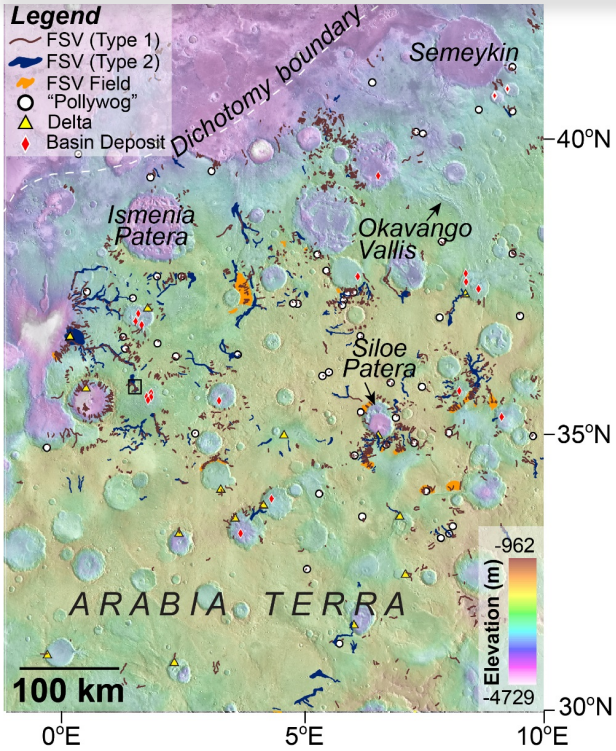


THEMIS integrated nighttime images. The white box is the location covering the most active RSL region and the black box is the chosen dry regolith reference area. These colorized ΔT images are created by subtracting the average value from the black box from entire image subset. The temperature variation observed between A & B is primarily due to the azimuthal differences between the two analysis areas and is accurately modeled as a dry regolith surface

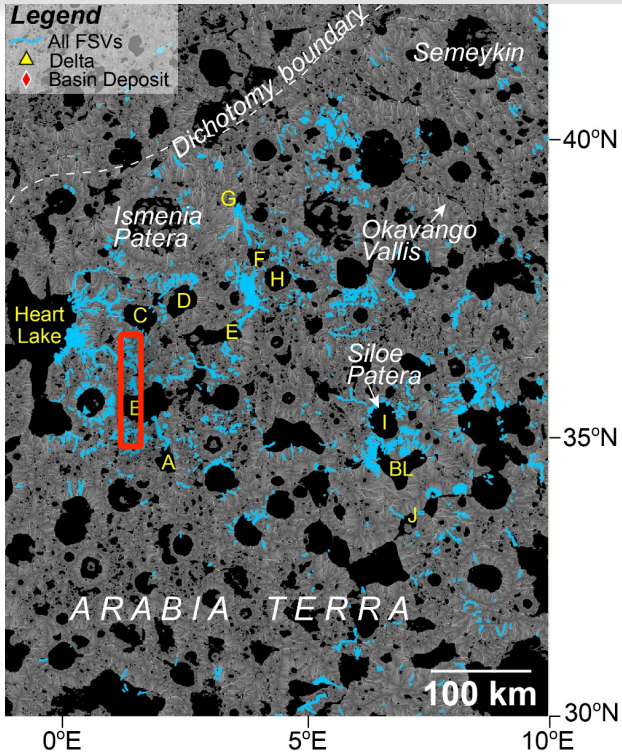
MRO Highlight - “Young” Valleys and Lakes in Northern Arabia Terra on Mars

A landscape modified by water and ice is an unambiguous marker of past climate

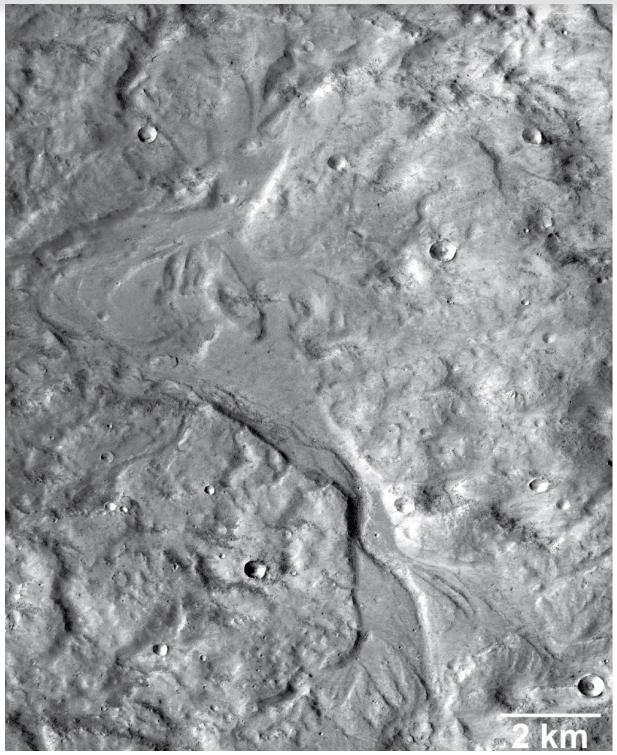
- This area located just south of the dichotomy boundary on Mars has several fresh shallow valleys (FSVs), some of which flowed into and out of large paleolakes. The extent of these systems was described using CTX data.
- Aided by HiRISE data, this drainage area is dated to be much younger (by hundreds of millions of years) than the ancient channels on early Mars.
- Modeling discovery suggests global periods of warming that allowed ice to melt and water to flow on a cold, wet Mars.



Map of study region showing high concentration of FSVs and associated landforms such as deltas. Color base is topography (see elevation scale).



Most FSVs (blue lines) stop at the edges of model-predicted paleolakes (black) and some flow into and out of paleolakes (e.g., see lake “B”).



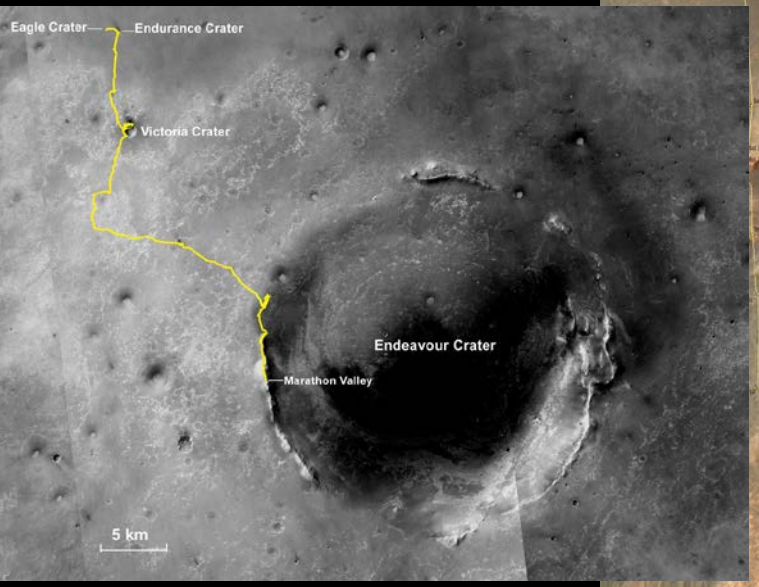
Example of FSV that formed as water spilled over the northern margin of lake “B” (red box in middle panel). Water continued to flow downhill toward “Heart Lake” (see middle panel).

Wilson, Sharon A., A. D. Howard, J. M. Moore and J. A. Grant (2016), A Cold-Wet Mid-Latitude Environment on Mars during the Hesperian-Amazonian Transition: Evidence from Northern Arabia Valleys and Paleolakes, JGR (#2016JE005052R).

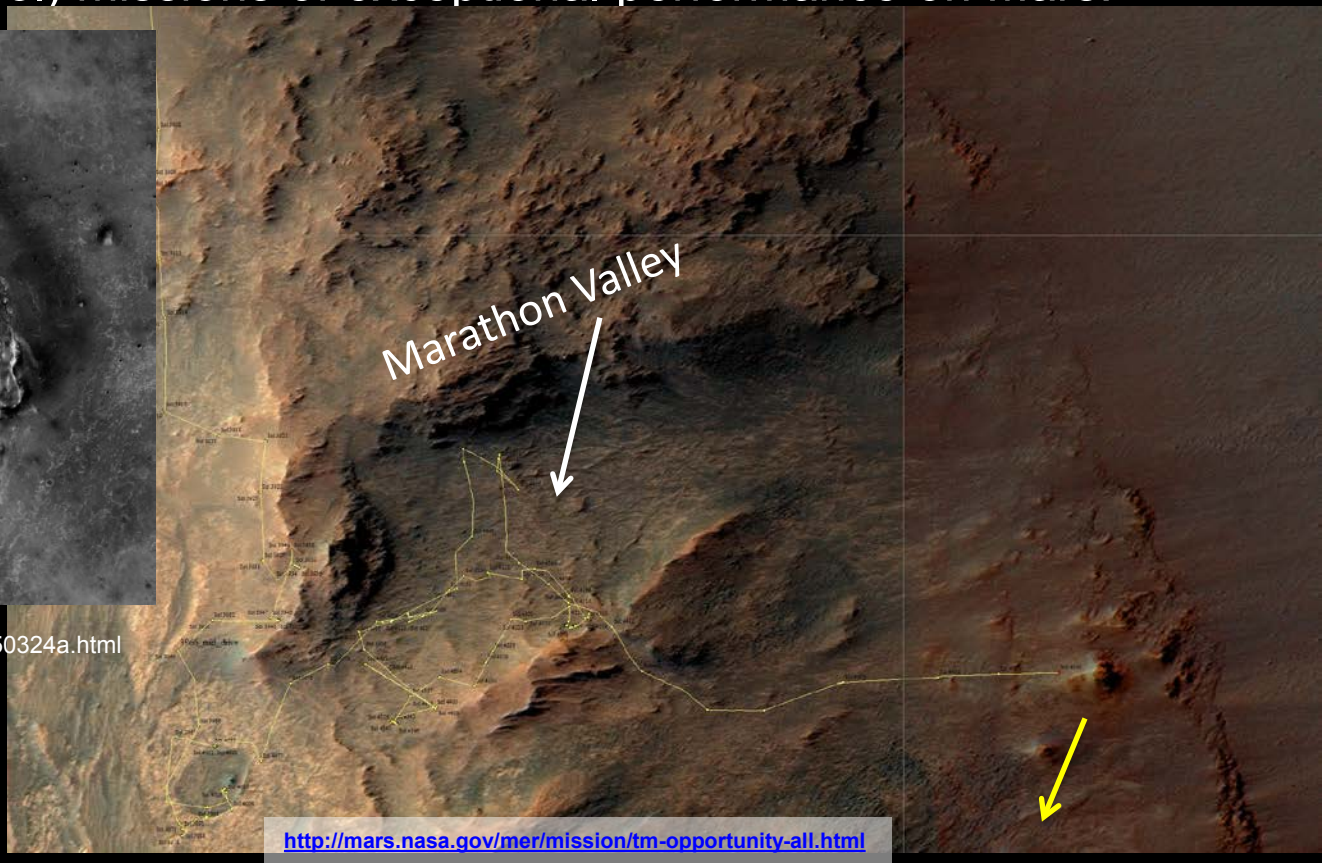
MER Exits Marathon Valley

Mission Status Highlights: MER Opportunity (@ Sol 4510)

- Opportunity left Marathon Valley and is driving east and then south along Endeavour Crater rim
  - 50 nominal (90 sol) missions of exceptional performance on Mars!

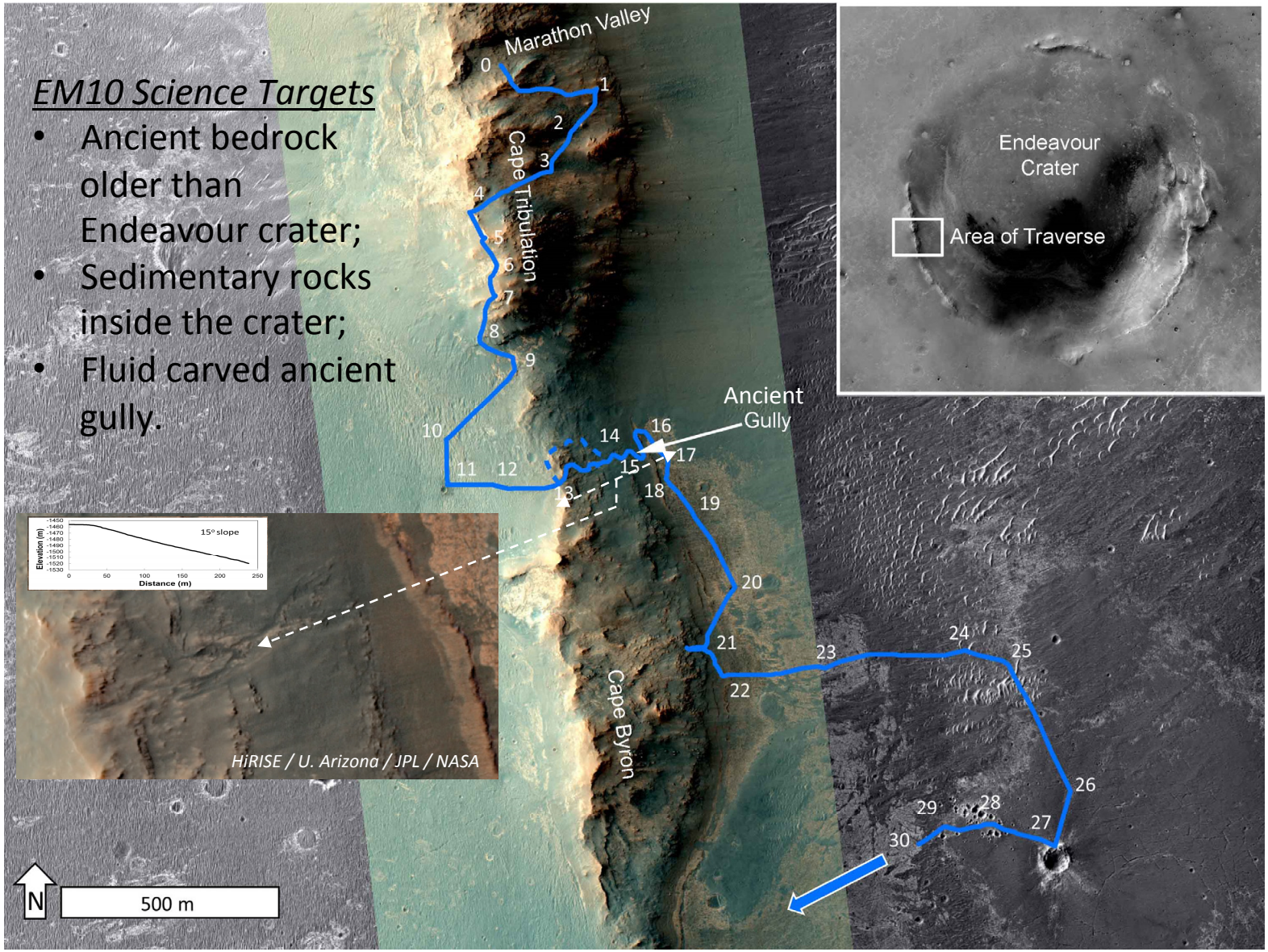


http://mars.nasa.gov/mer/gallery/press/opportunity/20150324a.html

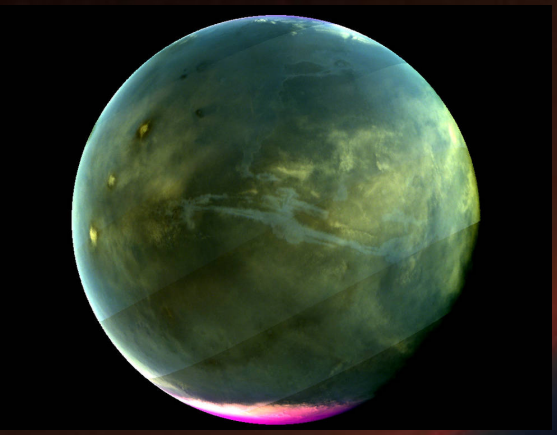


http://mars.nasa.gov/mer/mission/tm-opportunity-all.html

MER *Opportunity*: Traverse Plan for Extended Mission



MAVEN Science Highlights – 1 Mars Year

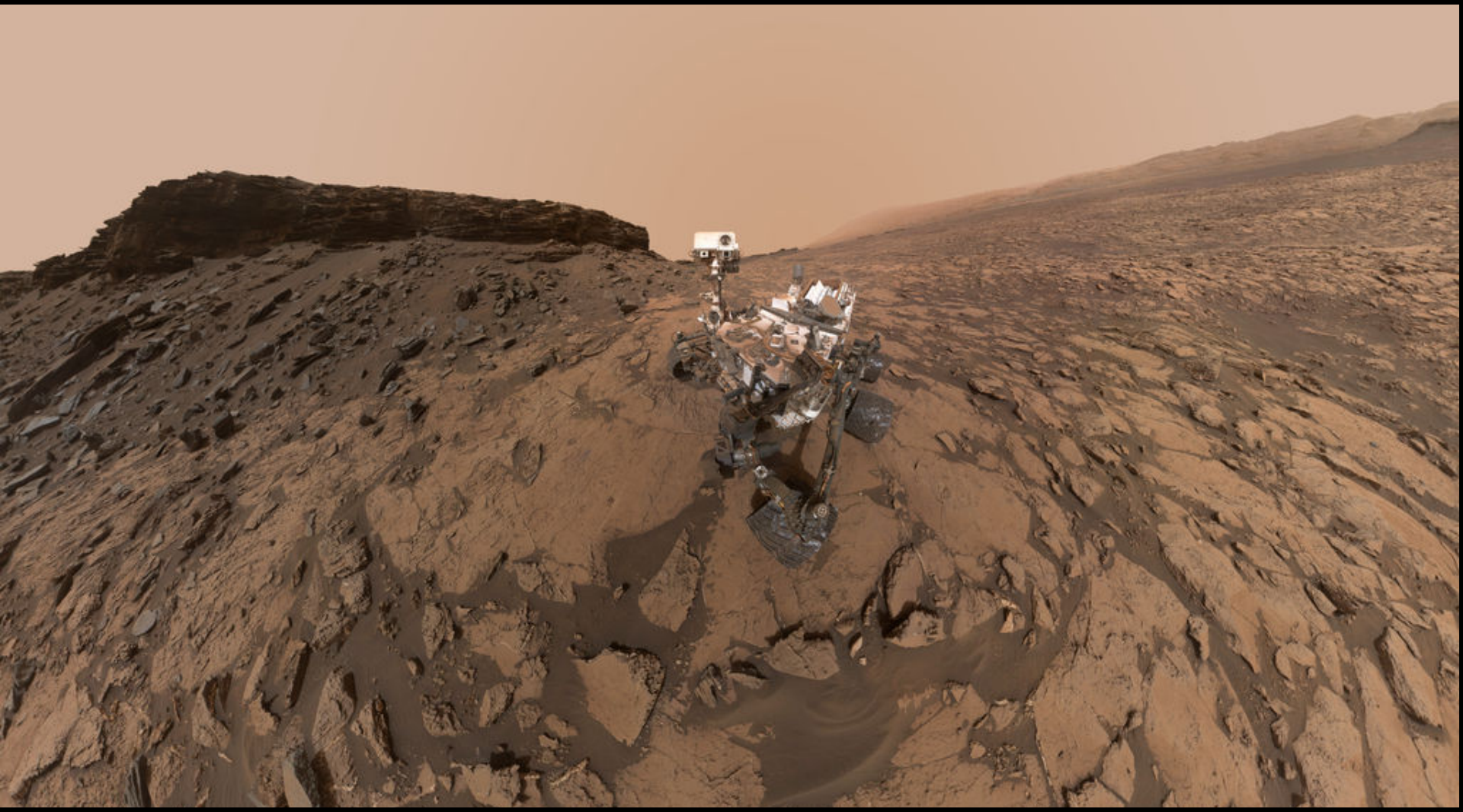


Most complete determination of the rate of loss of gas from the atmosphere to space and of how it is controlled by the sun, both during quiet times and during solar-storm events.

- Most thorough and accurate determination of the rate of escape of atmospheric gas to space in present time.
- Most thorough determination of how the sun controls the structure, composition, and variability of the Mars upper atmosphere, leading to escape of gas from the top of the atmosphere to space.
- Discovery of a cloud of dust surrounding Mars that likely is interplanetary dust (debris from comets) that is falling in toward Mars. -
- Discovery of a layer of metal ions in the ionosphere that comes from the falling in of interplanetary dust.
- Discovery of diffuse aurorae that are widespread over the planet and that do not depend on the presence of a global or local magnetic field to focus the particles from the sun that drive them.
- Detection of a "polar plume" of ions escaping to space that had not previously been seen.

A sharpened ultraviolet view of Mars was acquired when the Imaging Ultraviolet Spectrograph team took advantage of the higher data rates possible during the recent close passage between Earth and Mars to collect its highest resolution data

Quela Drill Site – Murray Buttes

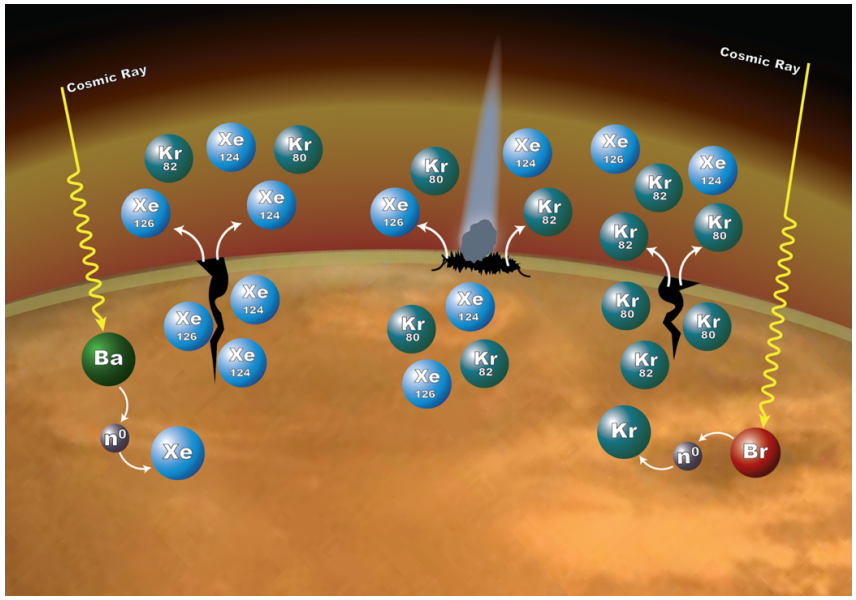


Sol 1463 Sep 17, 2016

The martian atmosphere: not what we thought!

SAM on Curiosity, has measured the isotopes of krypton (Kr) and xenon (Xe) in the martian atmosphere - good tracers of planetary processes (6 & 9 isotopes, respectively).

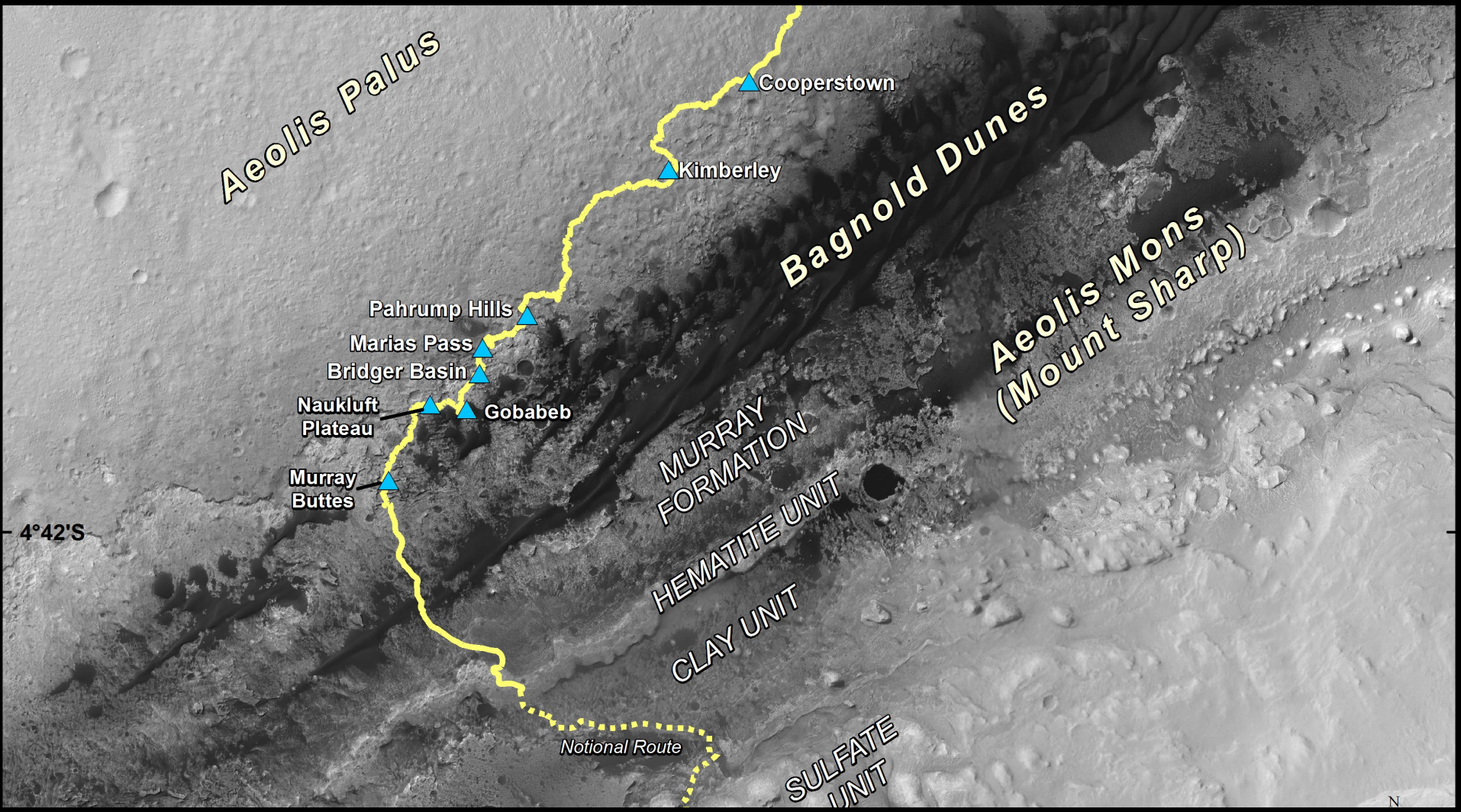
- *Results from direct measurement of the martian atmosphere is a little different than results from martian meteorites!*
- Bromine and barium interact with cosmic rays to create additional light isotopes of Kr (80, 82) and Xe (124, 126) at the martian surface! These light Kr and Xe atoms are then released into the atmosphere when the surface is disturbed by impacts and abrasion.



Impact:

- Confirms early and dramatic atmospheric loss at Mars.
- Differences between Earth and Mars atmospheres reveal how much their respective interiors have off-gassed and what's happened to the atmospheres AFTER they formed.
- The results make us wonder why do these three planets have different atmospheres when they all formed at the same time?
- New benchmark for Kr and Xe measurements in the Mars atmosphere from which to compare data from meteorite studies and ultimately Venus.

P.G. Conrad, C.A. Malespin, H.B. Franz, R.O. Pepin, M.G. Trainer, S.P. Schwenzer, S.K. Atreya, C. Freissinet, J.H. Jones, H. Manning, T. Owen, A.A. Pavlov, R.C. Wiens, M.H. Wong, P.R. Mahaffy . "In situ measurement of atmospheric krypton and xenon on Mars with Mars Science Laboratory." *Earth and Planetary Science Letters* 454 (2016): 1-9.


Aeolis Palus
Cooperstown
Kimberley
Bagnold Dunes
Aeolis Mons
(Mount Sharp)
Pahrump Hills
Marias Pass
Bridger Basin
Naukluft
Plateau
Gobabeb
Murray
Buttes
MURRAY
FORMATION
HEMATITE UNIT
CLAY UNIT
4°42'S
Notional Route
SULFATE
UNIT
N

MEP Updates

- All six missions approved for mission extension
  - Odyssey, Opportunity, Mars Reconnaissance Orbiter, Mars Express/ AESPERA-3, Curiosity, Maven
- Calendar
  - Our Red Planet Sept. 20-22, 2016
  - Oct. 3, MAVEN 1 Mars year of science operations
  - MEPAG virtual Meeting, Oct. 6, 2016
  - ExoMars TGO MOI & EDM landing, Oct. 19, 2016
  - AGU public lecture Dec. 11, 2016
  - Landing site Workshop Feb 8-10, 2017
- Mars Program
  - MDAP proposals: Step-1 in Aug 26; Step-2 due Oct. 28, 2016
- Mars 2020 – Contamination Control and Planetary Protection Working Group
- Planetary Protection Technology Definition Team

Senior Review

- Two Panels: Solar System Exploration and Mars Panel
  - Mars Projects: Curiosity/MSL, MAVEN, Odyssey, Opportunity/MER, MRO, MEX/ Aspera-3
- Each extended mission proposal was evaluated and graded on its stand-alone science/technical/cost merits – robust conversation on each proposal
- Only Panel members, PEs/PSs for the specific mission discussed, PMSR Leads (Bill Knopf & Michael Meyer) and NRESS attended Panel deliberations; <u>No Project or Program personnel</u>
- Because of the challenge of finding Mars scientists who are unconflicted, the approach was to form a "highly cross-conflicted" panel of Mars scientists.
  - Approach was vetted by NASA HQ OGC, and deemed acceptable since the PMSR is not a "procurement action". It is a programmatic review of existing Projects that provides findings to help PSD Management in determining level of funding going forward.

2016 PMSR – Result Summary

Top Finding: "The Panel unanimously believes that all (missions) should be approved for extension."

Project	Adjectival Rating
Curiosity/MSL	Excellent/Very Good
Dawn @ Adeona	Good/Fair
Dawn @ Ceres	Very Good/Good
LRO	Excellent/Very Good
New Horizons	Excellent
Mars Express	Good
MRO	Excellent
MAVEN	Excellent/Very Good
Mars Odyssey	Very Good/Good
Opportunity/MER	Excellent/Very Good

Citizen Science

- Our Red Planet Sept. 20-22, 2016
  - Mars scientists and engineers who are, or became, convinced of the importance and efficacy of public engagement
  - There are actionable ways to involve the public in Mars exploration
  - There are technical as well as social, cultural, and funding challenges to enable full potential of public participation to be realized.
- Step – 1: Make Mars PDS data more accessible and interoperable
- Step –2: Provide encouragement through several mechanisms to enhance public participation

Mars Data Analysis Program

- Currently 108 active grants, and 10 active NASA Earth and Space Science Fellowships, which fund graduate students.
- The August 26 MDAP Step 1 proposals are 166, an increase from previous years (134 and 139 the prior two years).
  - Step–2 proposals due Oct. 28
- Part of the increase this year may have been due to MAVEN, and to the explicit call for HEND proposals.

Contamination Control and Planetary Protection Working Group

Achievement of the stringent levels of organic and biological cleanliness of Mars 2020 returnable samples presents a unique and complex challenge.

- This independent panel of experts is formed to provide the Mars Exploration Program with expert insight into the plans, designs, and operational elements of the sample collection system on Mars 2020.
  - The Working Group will examine contamination control, microbiology, curation, and planetary protection aspects of the sampling system and assess the probable progress toward achieving the level one requirements pertinent to the sampling system and its ability to acquire, cache, and contain pristine samples of Mars.

- The CCPPWG will report to the Mars Exploration Program Lead Scientist and the results relayed to the Planetary Protection Office and the Mars 2020 Project.

Contamination Control and Planetary Protection Working Group

Francis McCubbin – chair
JSC
Astromaterial curation

Judy Allton
JSC
Curation & contamination control

Steve D'Hondt
University of Rhode Island
Subseafloor microbes

Tony Geller
Sandia National Labs
Microelectronics contamination

Danny Glavin
GSFC
Extraterrestrial organics

John Priscu
Montana State University
Polar microbes

Beth Shapiro
UC Santa Cruz
Ancient DNA

Andrew Steele
Carnegie Institution of Washington
Extraterrestrial organics

Michael Meyer - convener
NASA HQ
Mars science/astrobiology/PP

Planetary Protection Technology Definition Team

- Assess technical and engineering challenges to applying available microbial-reduction methods, including recontamination prevention, to spacecraft hardware and instruments
- Provide a list of spacecraft and instrument materials known to be compatible with existing planetary protection protocols
- Delineate planetary protection protocols/processes available or which appear promising;
- Identify areas ripe for technological development;
- Evaluate technical and engineering challenges to ensuring that spacecraft hardware and instruments can meet organic cleanliness requirements
- Propose approaches for mitigating the identified challenges, beginning with identification of commonly used materials and spacecraft hardware that are compatible (or particularly vulnerable) to planetary protection protocols
- Identify engineering, technology, and scientific research and development that could be funded by NASA to provide future capabilities to field scientific instruments and spacecraft on missions that require either subsystem or system-level microbial reduction and recontamination prevention.

Planetary Protection Technology Definition Team

Members	Role
John Rummel	Chair
Pat Beauchamp	Technology
Nancy Carosso	Contamination
Megan Casey	Radiation
Peter Doran	Polar Astrobiology
Ralph Lorenz	Environment
Betsy Pugel	Systems
David Suarez	Rad-Hard ASICS
David Steinfeld	Thermal
Michael Meyer	*Ex Officio*
Quang-Viet Nguyen	*Ex Officio*

Why More Science?

Mars discoveries leave many mysteries

- Did Mars ever have life? Is it still there?
- Recurring Slope Lineae – What are these seasonally changing streaks?
- Methane – How much? Does it really come and go? What is the nature of the source (biological or geochemical)? How can it disappear quickly?
- The great transition from a much wetter environment to the cold, dry, acidic planet of today – How, when, and how often did that happen?
- What is the nature of accessible water/ice on Mars? Can it be used?
- Can humans live on Mars? Where are the resources? What are the hazards?