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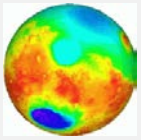
Windjana sandstone, Gale Crater
MSSS / JPL / NASA

MEPAG Report to PSS / CAPS September 3-4, 2014

Lisa Pratt
MEPAG Chair

Outline



- ***Recent Mars Events***
  - MEPAG Annual Face-to-Face Meeting
  - 8th Mars International Conference
  - 2020 Mars Rover Payload Selected
- ***Status of Mars Missions***
  - PSD Senior Review Held
  - InSight passes thru Critical Design Review gate
  - Comet Siding Spring Preparations
- ***Mars Landing Site Activities***
  - InSight, ExoMars, 2020 Mars Rover
- ***Science Highlights***
- ***Ongoing & Future MEPAG Activities***
  - Special Regions Report
- ***Looking Ahead***
- ***Bright Spots***

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MEPAG Face-2-Face Meeting
May 13-14 in Crystal City, VA

Four Major Segments (mepag.jpl.nasa.gov)

- ***Report from Headquarters***
  - John Grunsfeld (call in) and Jim Green/Michael Meyer gave SMD & PSD/MEP reports
  - John Connolly reported for HEOMD
- ***Overview of Mars Missions***
  - Reports from MEP (Gibbs for Li), ExoMars (de Groot), JAXA (Miyamoto)
  - L. May: Briefing on new activities of I-MARS, international Mars coordinating group
  - Updates on MAVEN (Jakosky) and InSight (Golombek for Banerdt)
- ***Special Reports***
  - Rummel: Special Regions-SAG2 preliminary report
  - Beaty/Liu: Mars Returned Sample Quality workshop report
- ***Landing Sites***
  - Vago: ExoMars landing site process
  - Grant/Golombek: Preview of 2020 mission landing site process

8th International Conference on Mars

- ***650 participants at Caltech on July 14-18, 2014***
  - Convened by JPL, Caltech and NASA, with funding by NASA and assisted by LPI
  - 499 abstracts in a single-track program to foster cross-disciplinary interaction
    - Invited talks to open sessions and aid discussion
    - New Mars map distributed (next slide)
    - About 100 posters daily in afternoon venues
    - Synthesis session organized to distill and debate major results from the conference
  - Preceding conference was held in 2007—a lot has happened on Mars since then!
- ***Major Gains since 2007; outstanding questions***
  - Three key discoveries:
    - Mineral diversity and variation indicating a variety of wet environments on early Mars
    - Cyclical climate variations on orbital time scales of 10^5 to 10^7 years
    - Dynamic processes on an active Mars today
  - Early Mars was habitable—but was it inhabited?
  - Major questions remain regarding the persistence of water over time and the nature of the atmosphere-surface inventory
    - Did it ever rain (unrelated to impacts)? Has water flowed in recent eras; can it flow today?
    - What was the early evolution—need to date the stratigraphic record exposed to us today.

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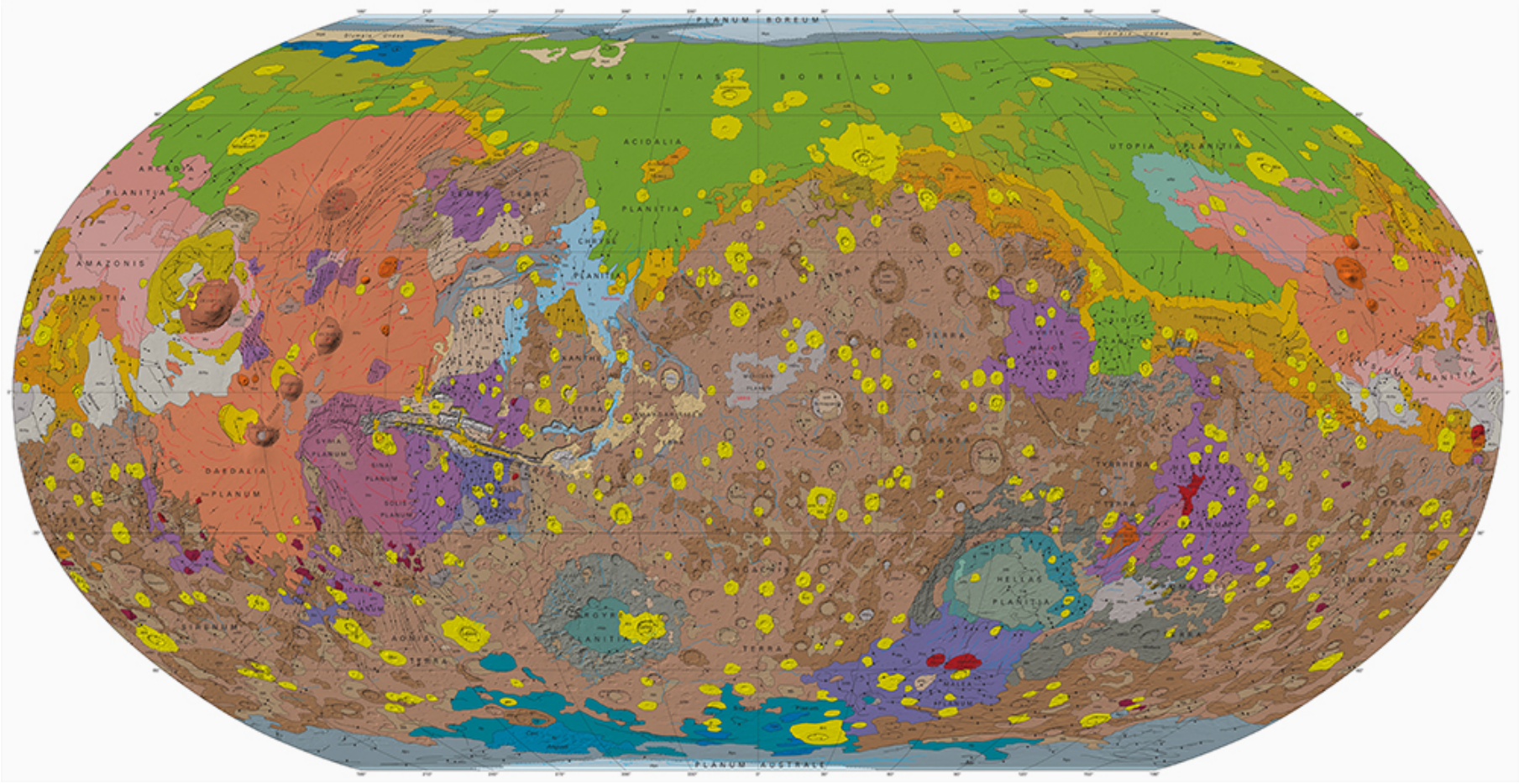
New USGS Geological Map of Mars from Ken Tanaka



16 year of data from four orbiting spacecraft

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2020 Mars Rover Payload Selected

- ***Mastcam-Z***: Advanced camera system with two zoom lenses provides panoramic and stereoscopic imaging. PI: James Bell, Arizona State University in Tempe.
- ***SuperCam***: ChemCAM combined with NIR and Raman spot spectrometers to provide imaging, chemical composition analysis (including organics), and mineralogy. PI: Roger Wiens, Los Alamos National Laboratory, Los Alamos, New Mexico, in collaboration with the Centre National d'Etudes Spatiales,Institut de Recherche en Astrophysique et Plane'tologie (CNES/IRAP) France.
- ***Planetary Instrument for X-ray Lithochemistry (PIXL)***: An X-ray fluorescence spectrometer with high-resolution imager to determine the fine scale elemental composition of surface materials. PI: Abigail Allwood, NASA's Jet Propulsion Laboratory (JPL).
- ***Scanning Habitable Environments with Raman & Luminescence for Organics and Chemicals (SHERLOC)***: Spectrometer combines fine-scale imaging and a UV laser to determine fine-scale mineralogy and detect organic compounds. PI: Luther Beegle, JPL.
- ***Mars Oxygen ISRU Experiment (MOXIE)***: This technology demonstration will produce oxygen from Martian atmospheric carbon dioxide. PI: Michael Hecht, Massachusetts Institute of Technology, Cambridge, Massachusetts.
- ***Mars Environmental Dynamics Analyzer (MEDA)***: MET package measuring temperature, winds, pressure, relative humidity and dust size and shape. PI: Jose' Antonio Rodriguez-Manfredi, Centro de Astrobiologia, Instituto Nacional de Tecnica Aeroespacial, Spain.
- ***Radar Imager for Mars' Subsurface Experiment (RIMFAX)***: Ground-penetrating radar probing the subsurface. PI: Svein-Erik Hamran, Norwegian Defence Research Establishment (FFI).

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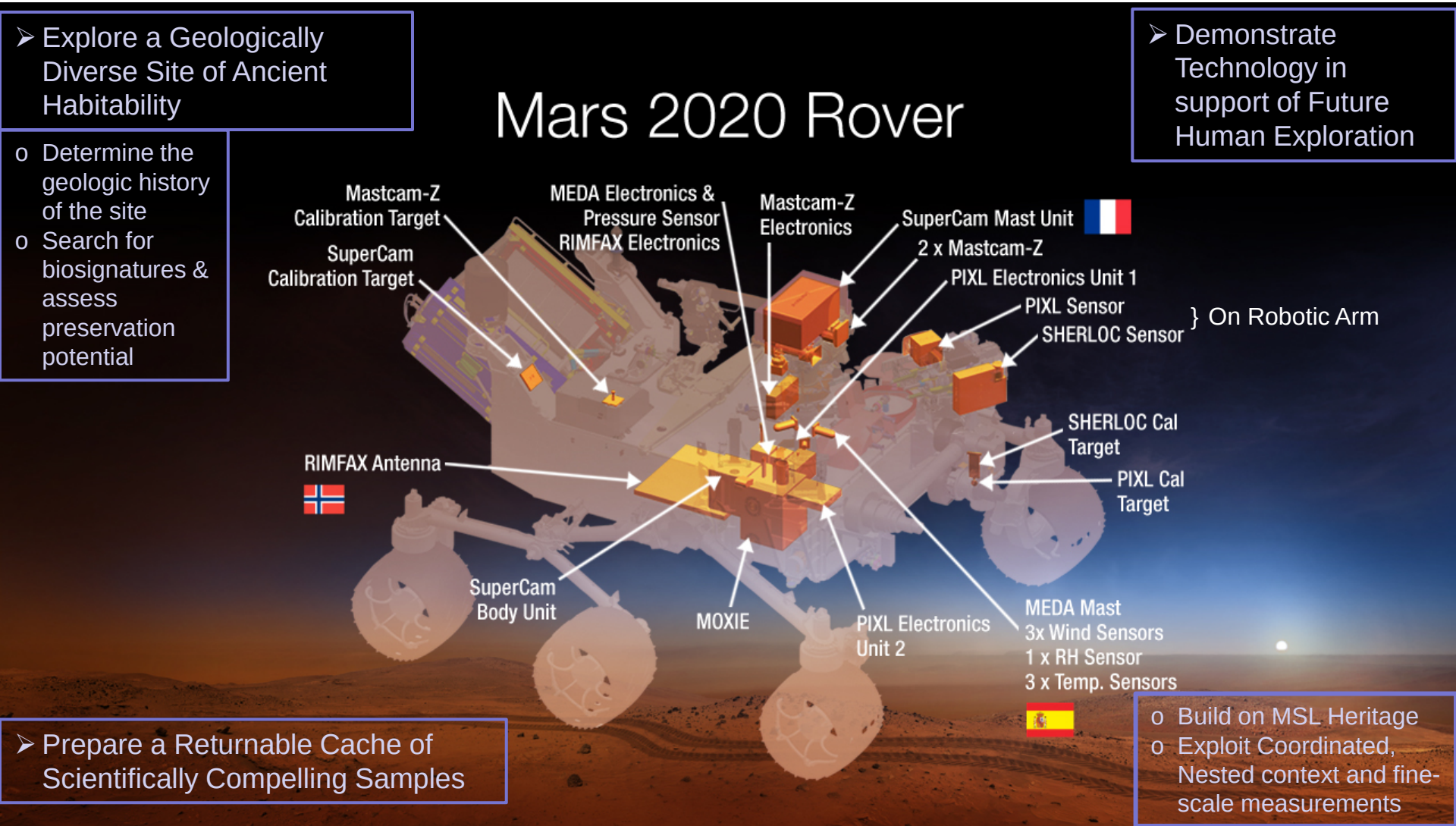
2020 Mars Rover Payload Selected!

- Explore a Geologically Diverse Site of Ancient Habitability
  - o Determine the geologic history of the site
  - o Search for biosignatures & assess preservation potential

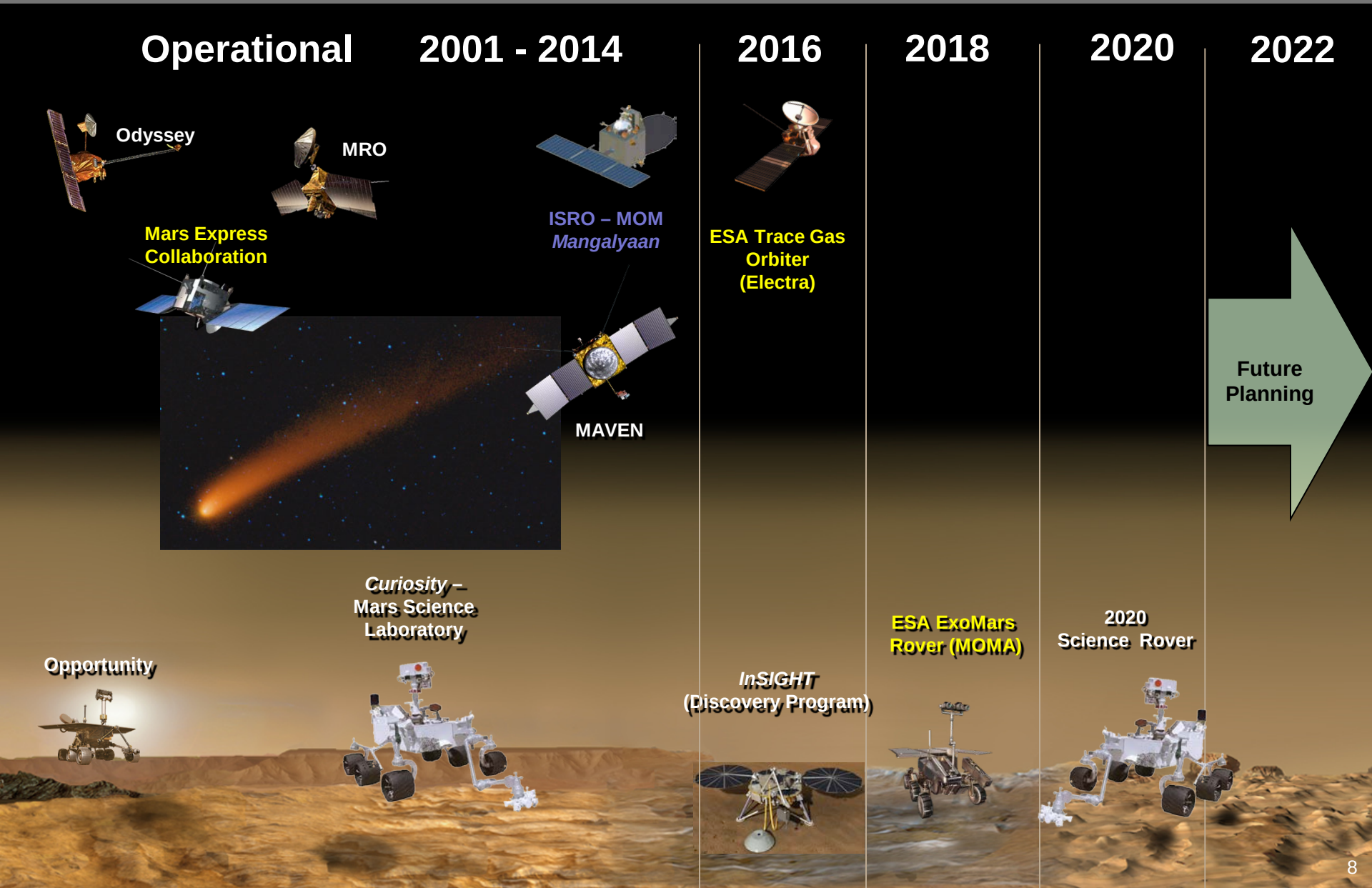
- Demonstrate Technology in support of Future Human Exploration

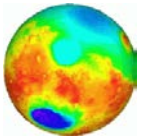


- Prepare a Returnable Cache of Scientifically Compelling Samples

- o Build on MSL Heritage
- o Exploit Coordinated, Nested context and fine-scale measurements

Mars Exploration





Current Mission Status

- **InSIGHT** (Discovery) passed CDR; down-selected to ~4 candidate landing sites
- **Electra** relay units delivered to ExoMars 2016 **Trace Gas Orbiter**
- **MAVEN:** Inserting into Mars orbit on Sept. 21
- **Mars Orbiter Mission (India)**: Inserting into Mars orbit on Sept. 23.
- **Curiosity** moving towards Mt. Sharp
- **Mars Reconnaissance Orbiter** continues to detect change on a dynamic Mars
- **MER Opportunity** moving south along Endeavour Crater western rim
- **Mars Express:** Phased for C/SS encounter; extended thru 2015 & beyond (TBC)
- **ODY, MRO, MEX**: Phased for Comet Siding Spring (C/SS) Encounter
- **PSD Senior Review** conducted May, 2014; responses communicated to projects at end of August (TBC)

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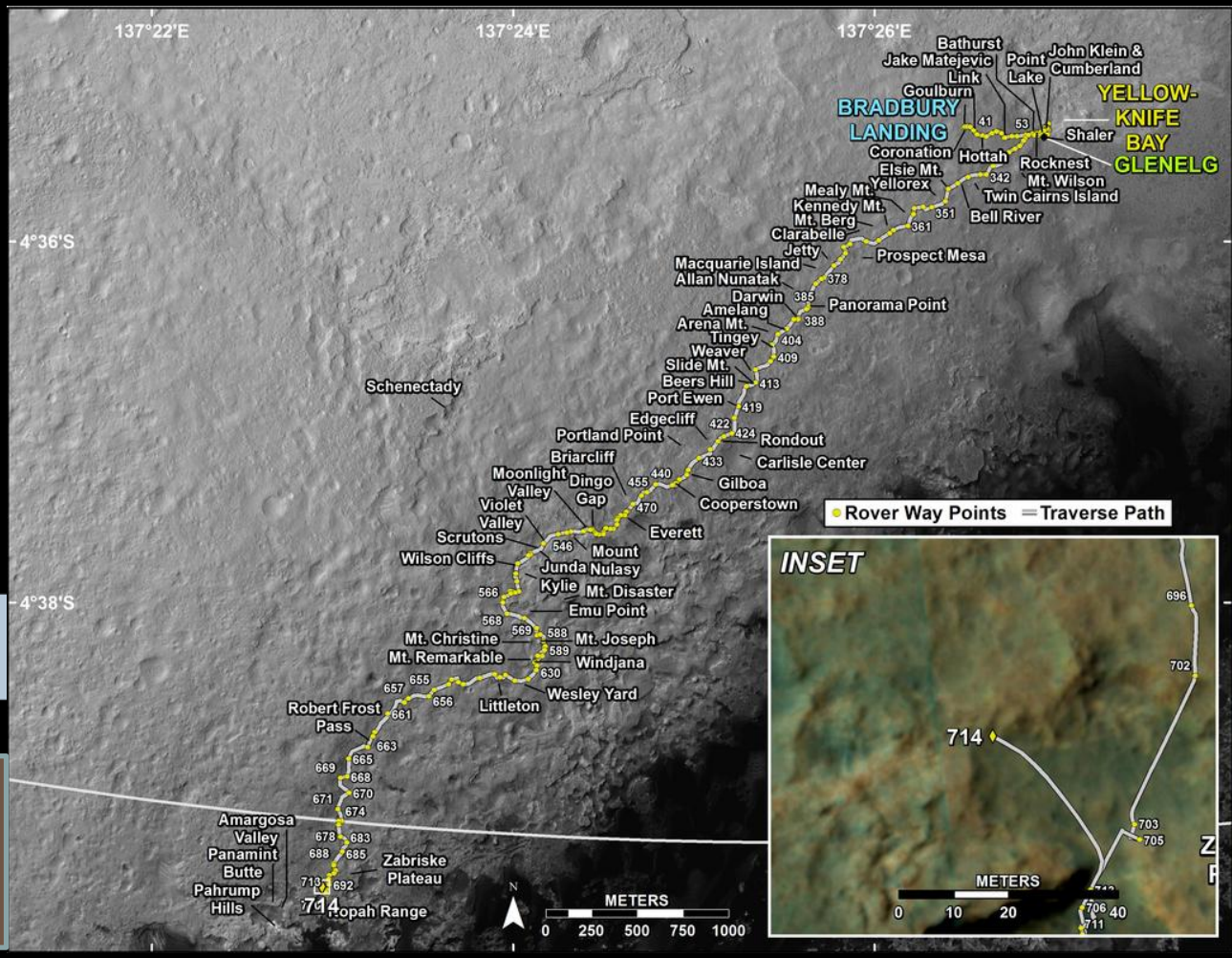
Curiosity: Closing in on Mt. Sharp

Aeolis Mons ("Mt. Sharp")



~3 km drive distance to Murray Buttes, with 9 km on the odometer now

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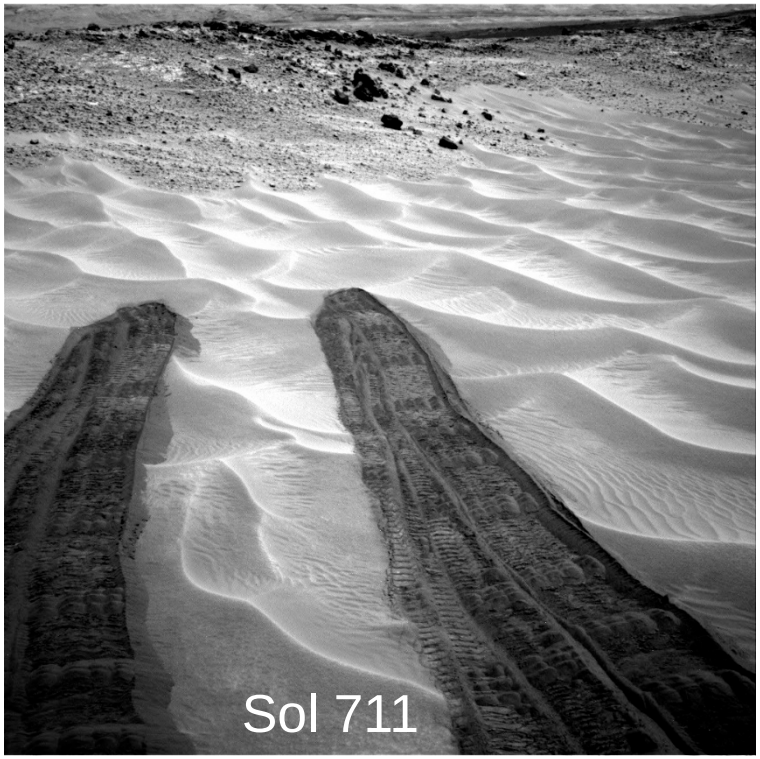
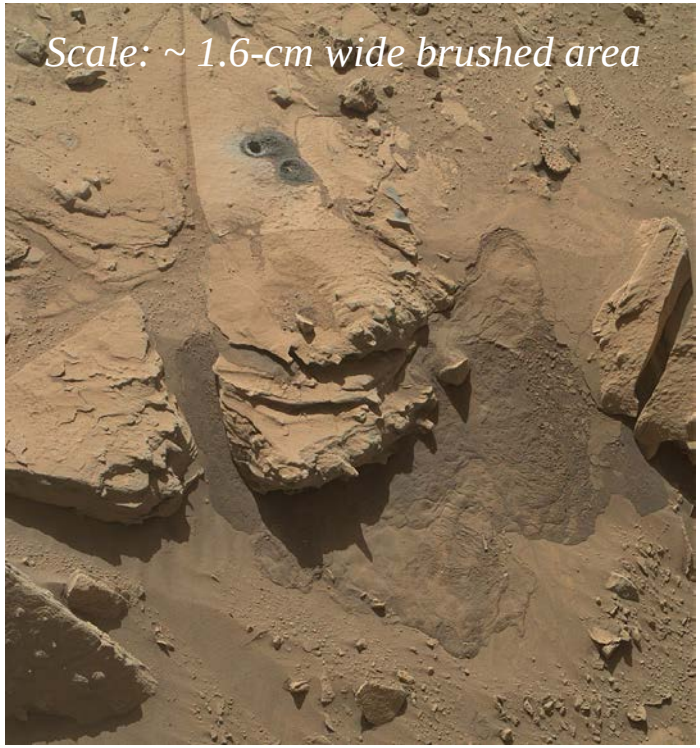
Curiosity: New Considerations for Route Selection



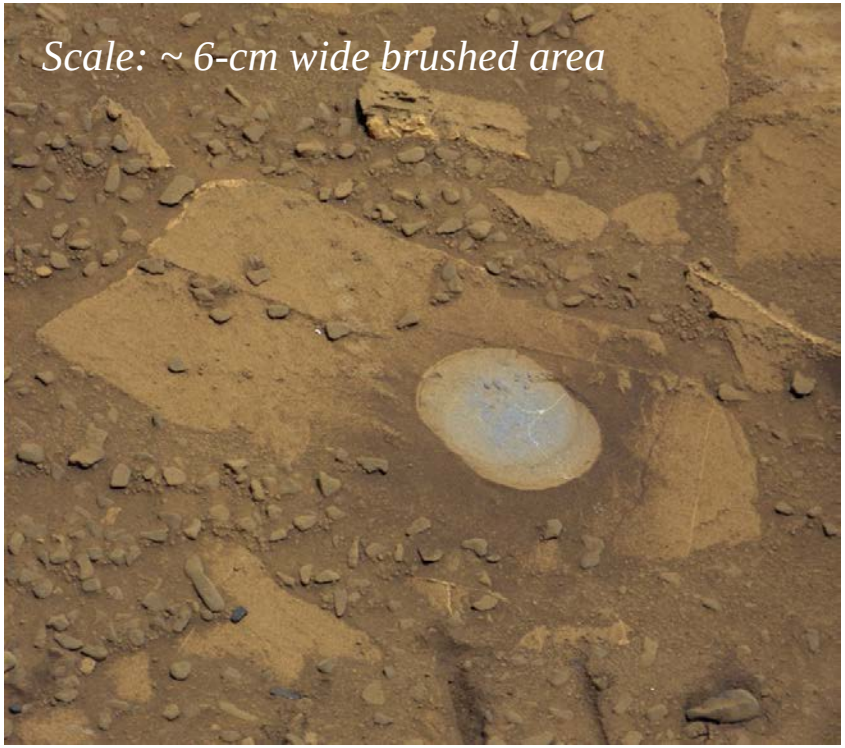
Curiosity experienced significant wheel slip in sand ripples in Hidden Valley and backed out, August 2014. While thin sand cover provides safe and easily navigable surfaces, similar valleys with deep sand deposits, steep sides and limited exit paths will now be identified from orbit and avoided.

An 8-month intense study of the wheel wear led to new drive planning strategies, new orbiter image-based terrain risk assessments, and new understanding of the wheel wear process. With careful path selection, wheel lifetime is expected to exceed the extended mission.
Scale: Wheel diameter 50 cm.

Curiosity: Close-Ups of 2 New Major Rock Units



In May 2014, Curiosity drilled Windjana sandstone, finding more magnetite and potassium-rich feldspar than previous samples. Depostional setting is a stream. Magnetite could be entirely igneous in origin or partially from water alteration.



In Aug. 2014, Curiosity brushed and analyzed a fine-grained sedimentary rock named Bonanza King, revealing a different chemistry from previous rocks. This rock might be an extension of the unit that forms the base of Mt. Sharp. (*Note added Aug. 22: Not drilled because of rock movement.*)

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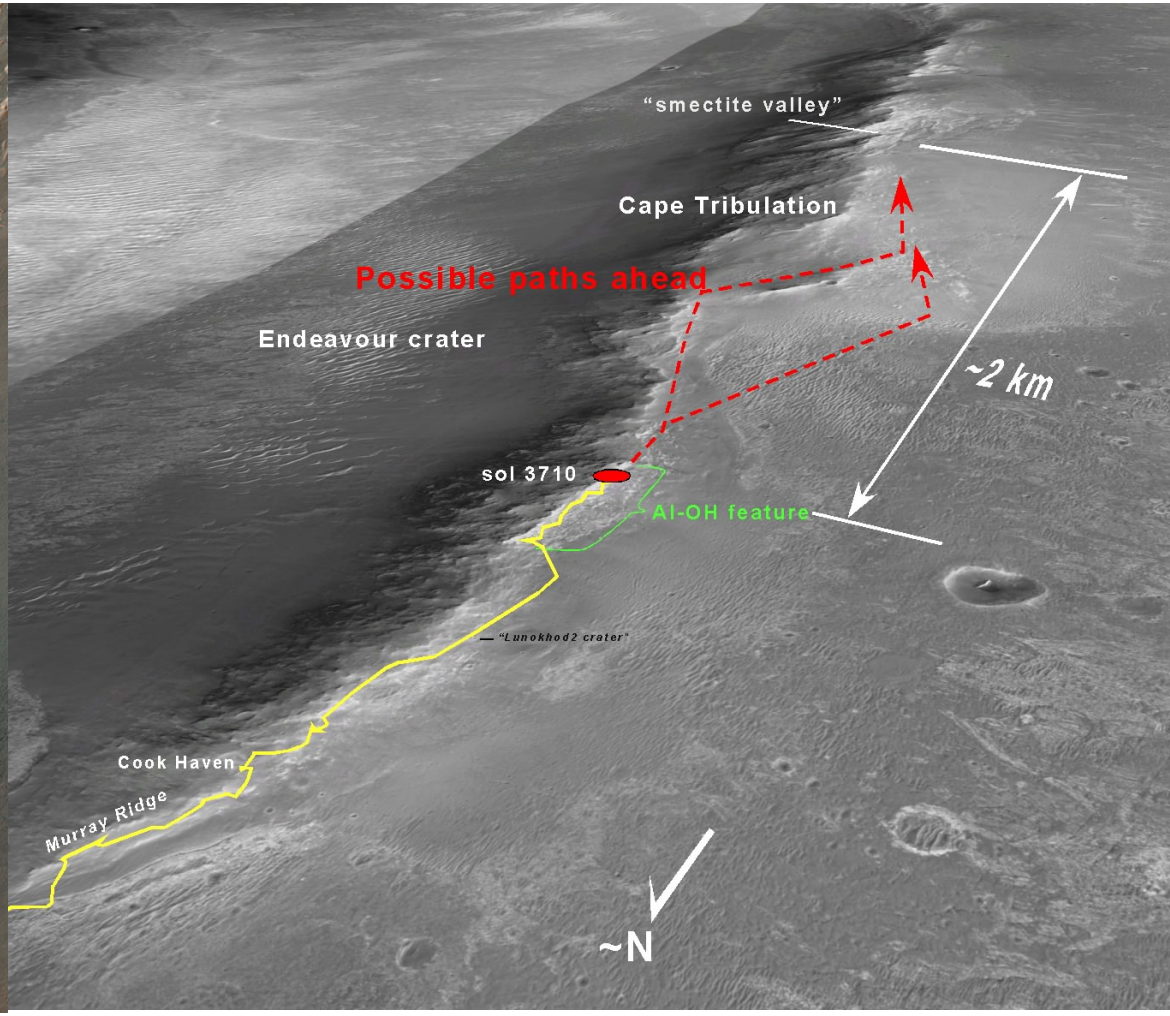
Opportunity: Roving on Endeavour Crater Rim



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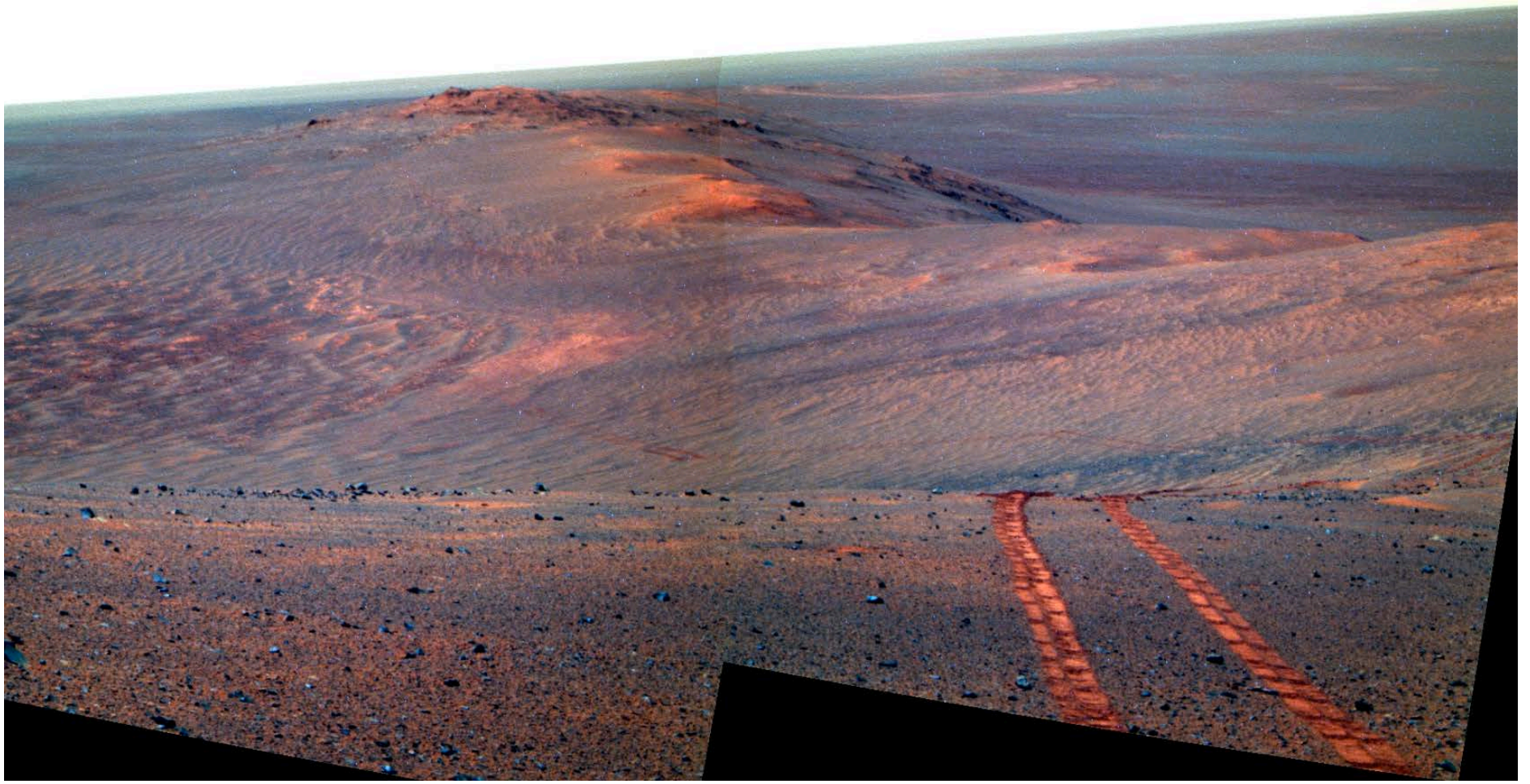
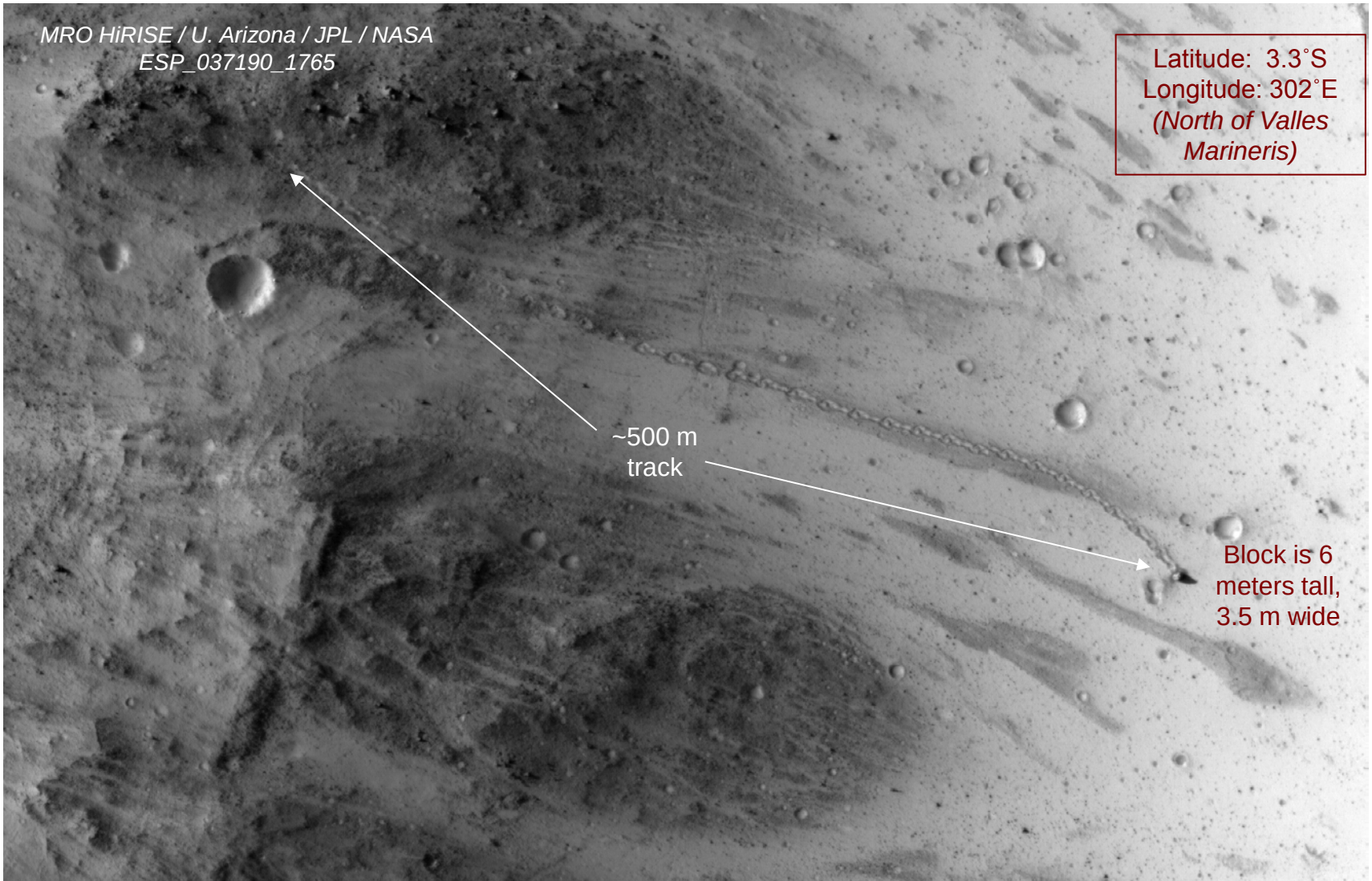
Opportunity: Roving on Endeavour Crater Rim

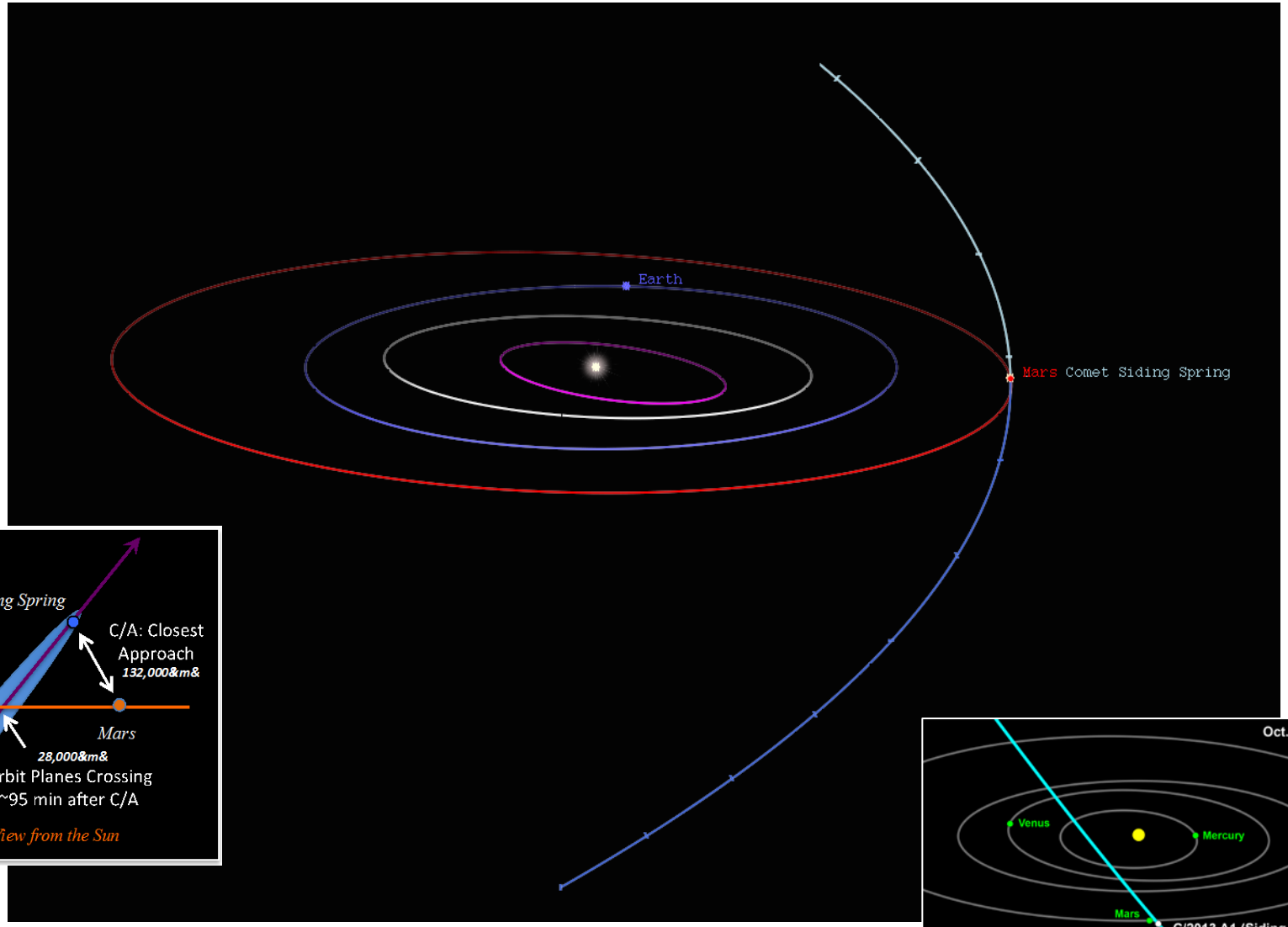


Pancam acquired on Sol 3754 showing tracks 700 m to the north along Murray ridge
Opportunity is Exploring Noachian Clays detected in MRO CRISM

MRO: Beware of Falling Rocks!



Comet /2013 A1 Siding Spring



Comet Siding Spring (C/SS) Encounter Goals for Mars Assets

- **Survive: Low dust fluence (1 particle/km^2 in 30 minute window) & orbit phasing**
- **Science Objectives Focus on Two Areas: 1) the comet itself and 2) its potential impact on the Mars atmosphere.**
- **For the comet, the goals are:**
  - First-ever resolution of the nucleus of a long-period comet.
    - MRO HiRISE: 140 m/pixel on a nucleus ~ 500 to 2500 m across
  - Characterize C/SS coma & tail: Particle size, gas composition, activity.
    - *Warning*: The Mars spacecraft instruments weren't designed for high-spectral resolution gas survey or for imaging diffuse, faint objects (as compared to Mars), but we will see what we can do.
    - The best instruments for comet composition may well be on MAVEN, which will follow orbit insertion on Sept. 21 with maneuvers and instrument deployments as they transition to their nominal science orbit.
- **For Mars, the goals are:**
  - Observe impacts of cometary gas & dust on the Mars atmosphere.
    - Upper Atmospheric heating (>150 km) from gas coma interaction
    - Ionospheric enhancement
    - Cloud seeding?
    - Aurora? Meteor Trails? (Unfortunately, these may be in twilight sky for Curiosity and Opportunity)

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Comet Siding Spring (C/SS) NASA[1] Science Observations (TBC)

Target	Observation Objective	MRO						ODY		ROVERS		MAVEN[2]		
		HiRISE	CTX	CRISM	MCS	MARCI	SHARAD	THEMIS VIS & IR	HEND/NS	PANCAM	MastCAM CHEMCAM?	IUVS	LPW,MAG, SEP	NGIMS,STATIC SWEA,SWIA
Comet	Comet General Features					❖		❖		◆	◆	◆	◆	
	Comet Nucleus: Size, Shape & Rotation	◆												
	Comet Activity: Jets & Variable Brightness	◆	◆	❖				❖				◆		
	Comet Coma: Variability, particle size, gas composition	◆	❖	◆	◆	◆		◆				◆		
	Comet Tail: Particle Size		◆	❖	❖	❖		❖				◆	◆	
Mars Response	Mars Upper Atmosphere Composition: Neutrals, ions & electrons; meteor trails						❖		❖	◆	◆	◆	◆	◆
	Mars Lower Atmosphere: Temperature and Clouds			❖		❖		❖		❖	❖	❖		

Key: major contribution ◆ contribution ❖

[1]*MEX also planning observations; MOM plans TBD*

[2]*Conducted only if transition to science orbit is nominal*

Landing Sites

- **InSight**
  - MRO acquiring data to aid down-select from current 4 candidate landing sites in Elysium
- **ExoMars**
  - ExoMars Landing Site Selection Working Group requested and NASA approved for data to be taken by MRO and ODY
  - MRO officially added ExoMars as a priority (with InSight & 2020 Mars) in observation planning
    - Some HiRISE images had already been unofficially acquired;
    - CRISM observations started during their “cold cycle” (with good SNR for the IR spectrometer) in Cycle 201 (mid-July)
- **2020 Mars Rover**
  - 2020 Mars Rover Landing Site Workshop held May 14-16, also in Crystal City, VA (followed MEPAG meeting)
    - ~100 attendees with ~30 more participating via web access
    - 28 sites presented at meeting; map (next slide) shows current ranking (many more steps to go)
    - Many of the highest ranked sites would require/benefit from Terrain Relative Navigation capability
  - Data acquisition is proceeding for the identified sites (*note: lower ranked sites may be slated for earlier observation as their current ranking may reflect lack of data*)

Note: Pace of data acquisition by MRO will slow during fall 2014 due to Comet Siding Spring Encounter and to spacecraft roll limits when Earth beta angle and gimbal constraints prevent downlink during rolls

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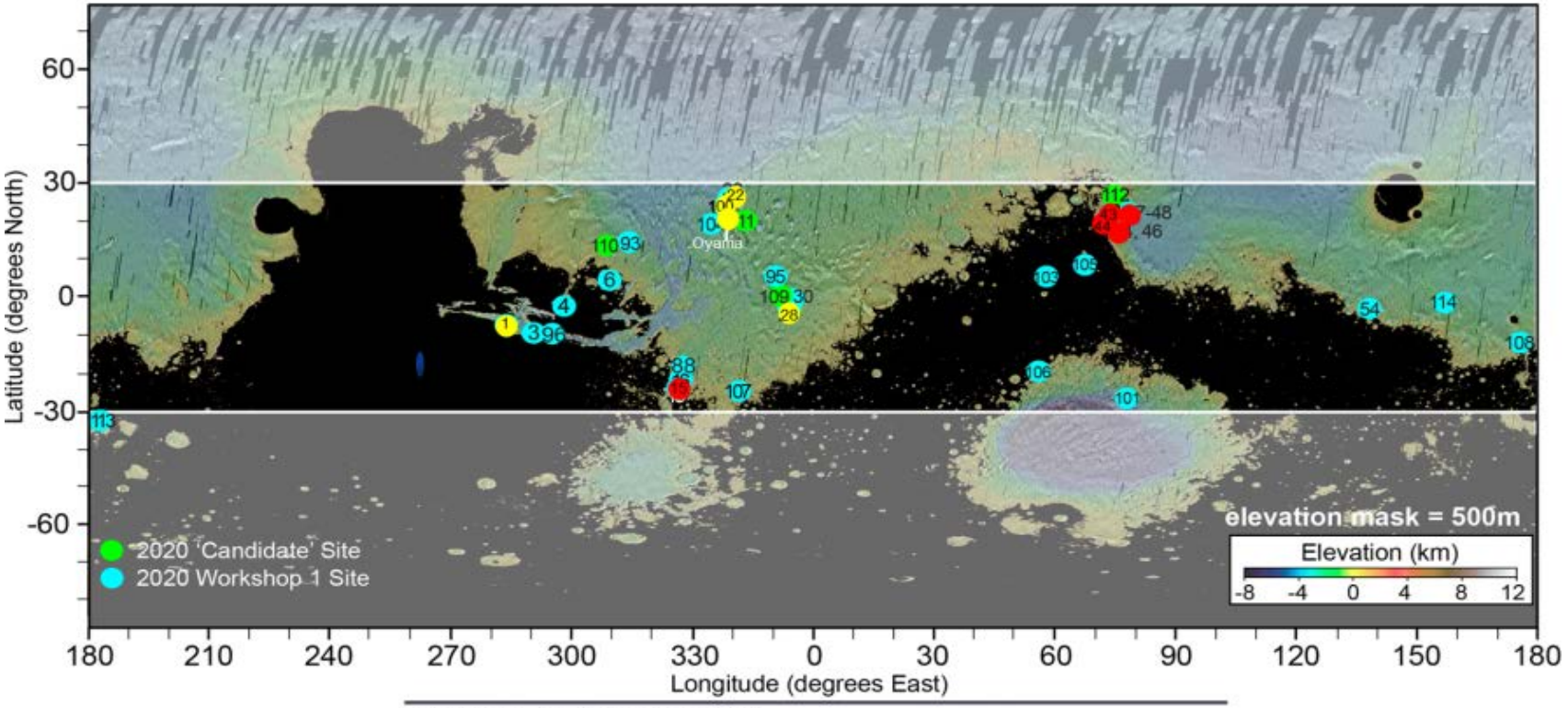
2020 Landing Site Workshop: Current Candidates for 2020 Rover



Current Rankings
Red Dots: Top 5
Yellow Dots: Next 5
Blue/Green: Others

MARS 2020 WORKSHOP SITES (Listed in order of presentation schedule, BLUE DOTS)

Dot 100: McLaughlin Crater (Michalski, J. et al.)
Dot 103: Leighton Crater (Michalski, J. et al.)
Dot 22: Mawrth Vallis (Loizeau, D. et al.)
Dot 104: Oxia Planum (Tholot, P., et al.)
Dot 43: Nili Fossae Trough (Mustard, J. F. et al.)
Dot 48: Nili Fossae Carbonates (Ehlmann, B., et al.)
Dot 44: NE Syrtis Major (Mustard, J. F., et al.)
Dot 105: Nili Patera (Skok, J. R., et al.) *(2020 Candidate Site from Skok, J. R., et al.)*
Dot 106: Hellas (Noe Dobrea, E. Z., et al.)
Dot 3: Melas Chasma (Miyamoto et al.) *(2020 Candidate Site from S. M. R. Turner, et al.)*
Dot 4: Juventae Chasma (Miyamoto et al.)
Dot 1: Melas Basin (Williams, R. M. E., et al.)
Dot 96: Coprates Chasma (Quantin, C., et al.)
Dot 6: Hypanis delta in Xanthe Terra (Gupta, S., et al.)
Dot 16: Eberswalde Crater (Irwin, R. P., III)
Dot 46: Jezero Crater (Gupta, S., et al. and Ehlmann, B. L., et al.)
Dot 88: Ladon Valles (Weitz, C., et al.)
Dot 93: Sabrina Valles (Platz, T., et al.)
Dot 113: Eridania Basin (Noe Dobrea, E. Z., et al.)
Dot 107: Kashira crater (Edgett et al.) *(2020 Candidate Site from M. R. Salvatore)*
Dot 28: Eastern Margaritifer Terra (Christensen, P., et al.)
Dot 101: Hadriacus Palus (Skinner, J. A., et al.)
Dot 95: Firsoff Crater (Pondrelli, M., et al.) *(2020 Candidate Site from Pondrelli et al.)*
Dot 108: Gusev Crater (Ruff, S. W. et al.; Longo, A.; Rice, J.) *(2020 Cand. Site from Cabrol et al.)*
Dot 54: Gale Crater (Grant, J.)
Dot 38: Meridiani Planum (M. Golombek)
Dot 15: Holden Crater (Irwin, R.)
Dot 114: Aeolis (Yakovlev, V.)

MARS 2020 CANDIDATE SITES (GREEN DOTS)

Dot 109: Farthest West Meridiani (Edgett et al.)
Dot 110: Vistula Valles/Chryse (Edgett et al.)
Dot 111: Intercrater West Arabia (Edgett et al.)

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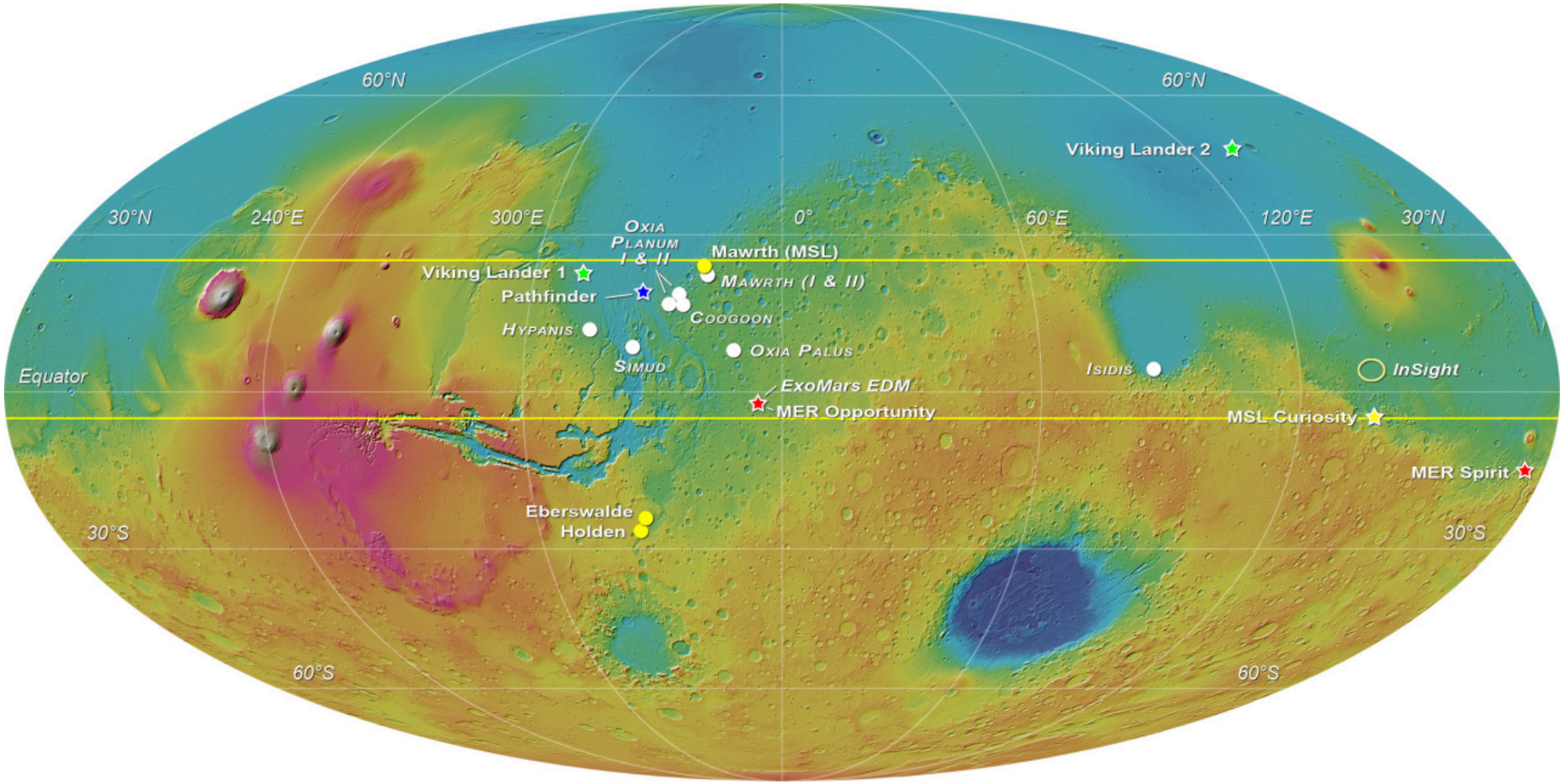
ExoMars Landing Site Candidates for 2018 Rover

(white dots)



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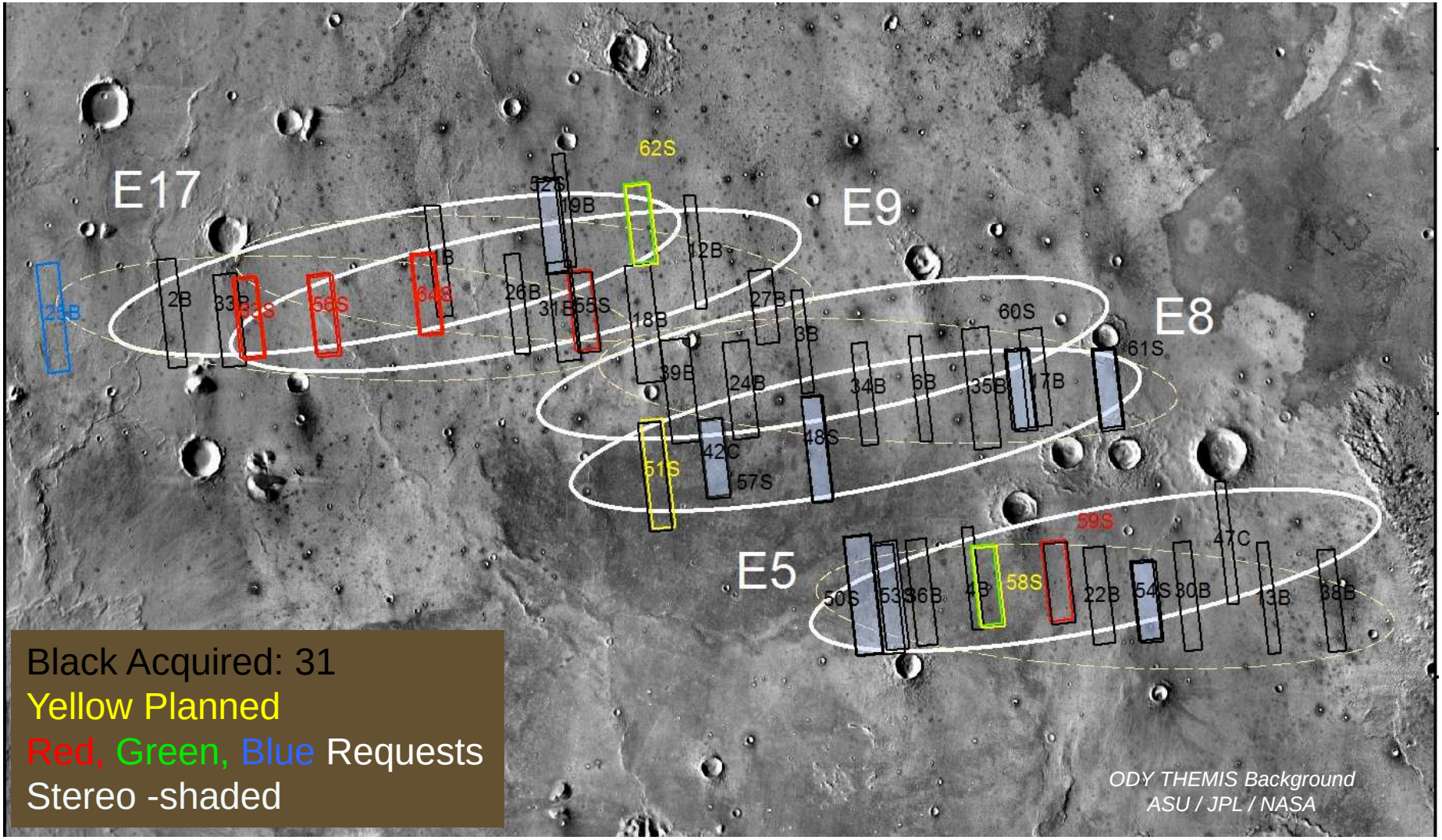
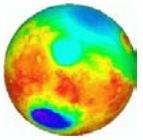
MRO HiRISE Coverage for InSight Landing Site Candidates

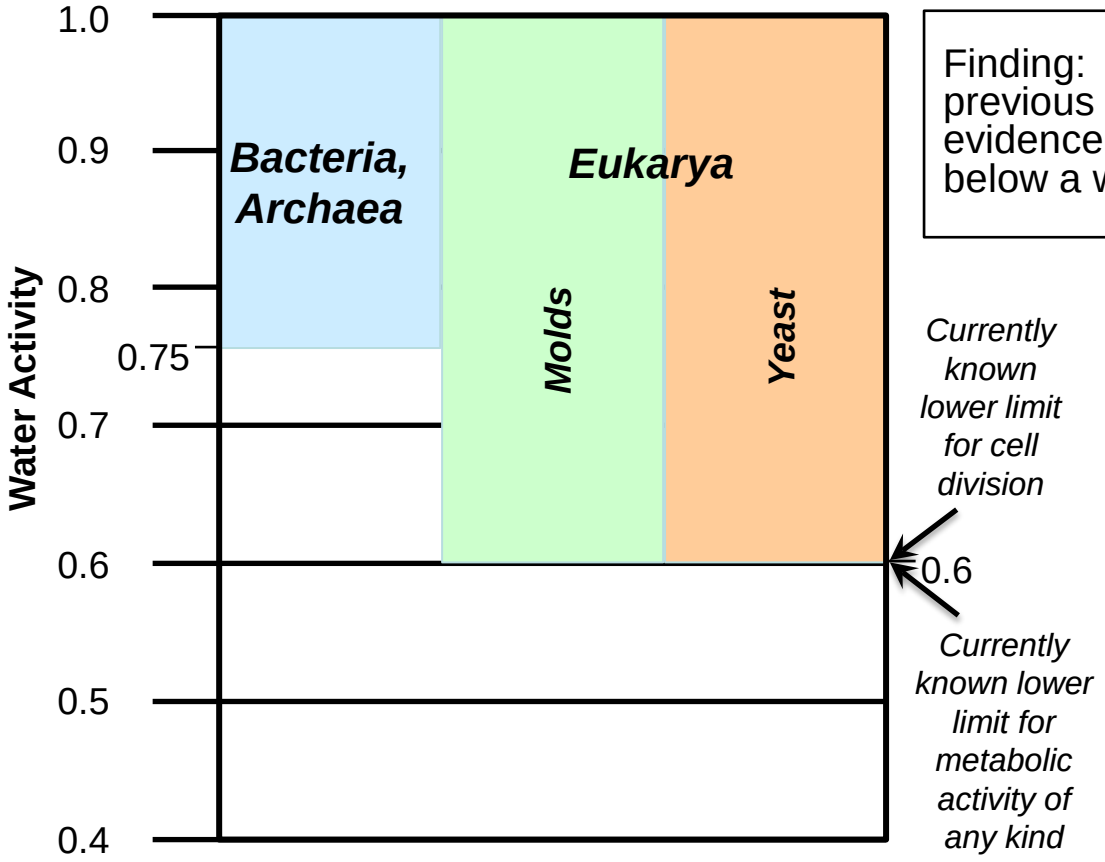


Special Regions SAG: SR-SAG2



- *Updates 2006 Special Regions SAG*
  - Phoenix results indicating perchlorates, thin water films, deliquescence
  - Recurring Slope Lineae (RSLs) are potentially brine flows
  - MSL results on hydrated minerals
  - Minerals/compounds discovered by MSL reveal electron donor/acceptor pairs
- **Preliminary Report was presented at the May 2014 MEPAG Meeting**
- **Report has been accepted by MEPAG Chair and Executive Committee**
- **Final report will be published in *Astrobiology***
- **Highlights:**
  - Reconsidered information on the known physical limits to life on Earth
  - Evaluated new observational data and new models of water variability
  - Considered observed and theoretical effects of mineral deliquescence
  - Updated definitions of the term “special region”
  - Described “special” and “uncertain” locations on Mars (see maps)
  - Assessed water-related resources on Mars for human exploration and the implications for planetary protection of accessing these resources

SR-SAG2: Low Water Activity Limit for Terrestrial Life



Finding: Review of the literature since the previous SR-SAG report (2006) shows no evidence of either cell division or metabolism below a water activity of 0.6.

No Change since SR-SAG1

SR-SAG2: Proposed Classification of Martian Environments

Special	Uncertain but treated as Special	Non-Special	Would-be Special if Found on Mars
	Caves	Gullies – Taxon 1	Groundwater (at any depth)
	Gullies – Taxon 2	Polar dark dune streaks	Thermal (hot) zones
	Gullies – Taxon 3	Slope Streaks	Recent craters still warm from impact
	Gullies – Taxon 4		
	Recurring Slope Lineae (RSL)		

Gullies – Taxon 1: Gullies forming today at CO_2 frost point
Gullies – Taxon 2: Geologically very recent gullies in relatively warm locations spatially associated with ice.
Gullies – Taxon 3: Geologically very recent gullies NOT spatially associated with ice.
Gullies – Taxon 4: Small gullies associated with RSL

Updated from SR-SAG1 (2006)

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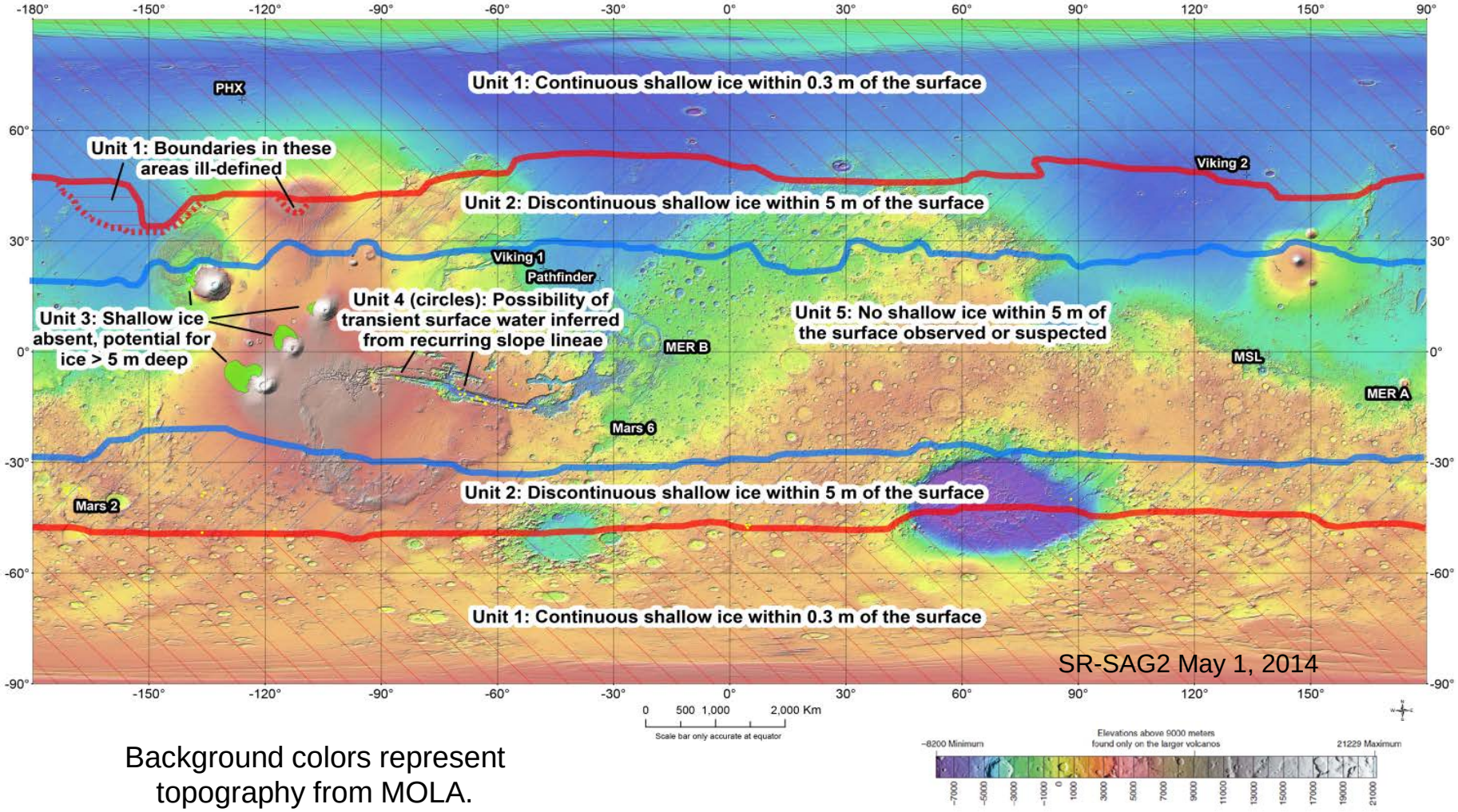
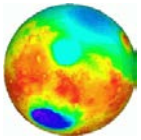
SR-SAG2 Feature Map Interpreting Special Regions on Mars



Background colors represent topography from MOLA.

MEPAG: Looking Ahead



- Watch Items
  - **Conference travel** (including reasonable foreign travel) is vital to a healthy science program, a necessity for both project and research work
  - **R&A** assess strengths and weaknesses of the re-structured process
  - **EPO** restructure is of great interest to MEPAG. Many previous missions and research groups have been leaders in producing content for STEM programs
  - **Budgets** are still tight and uncertainties remain with the present process making it difficult for projects and their science teams to plan appropriately
- Future MEPAG Thrusts
  - **Organizing** new SAG/process (possibly calling for white papers)
    - Update MEPAG Goals document in light of 8th Mars Conference and recent discoveries
    - Assess outstanding science questions and solicit ideas for missions after 2020
    - Keep an eye on emerging technologies: Solar-Electric Propulsion, CubeSats, Missions of Opportunity, Launch capabilities
    - Work on better integration with Human Exploration (Goal 4 and beyond)
  - **Anticipating** report from Organic Contamination Panel
- Plan for face-to-face MEPAG meeting in February/March 2015

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- **2020 Mars Rover** mission is moving forward with the payload selected and the first PSG in August.
- **InSight and TGO** are scheduled for launch in 2016
- **MAVEN and MOM** are about to start exciting new science missions at Mars characterizing fundamental processes of atmosphere-solar (and maybe cometary) interactions
- **Continuing orbiter and rover missions** are still very productive
  - Curiosity continues toward Mount Sharp with its 100's of meters-thick stratigraphic record and Opportunity will explore "smectite valley."
  - ODY, MEX and MRO continue to expand coverage in time and space of a dynamic planet—and get to see a new comet up-close