

Mars Exploration Program Analysis Group (MEPAG)

chartered by NASA HQ to assist in planning the scientific exploration of Mars



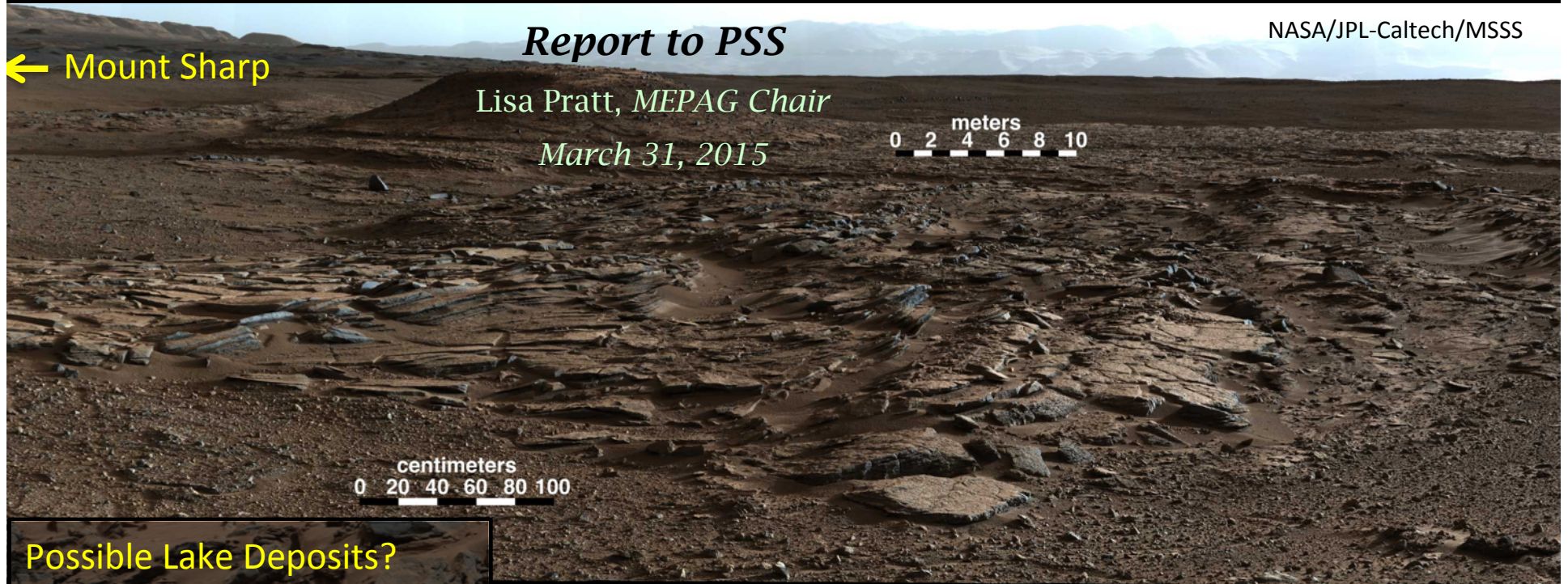
Report to PSS

Lisa Pratt, MEPAG Chair

March 31, 2015

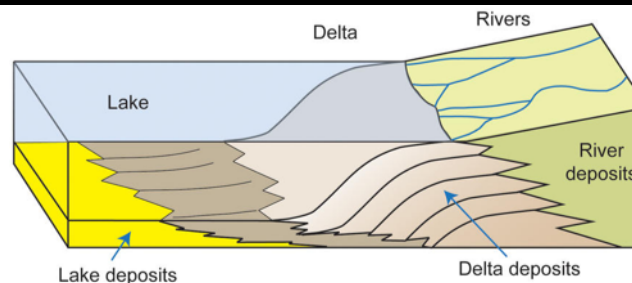
NASA/JPL-Caltech/MSSS

← Mount Sharp



Possible Lake Deposits?

Curiosity Explores Pahrump Hills site



Hypothesis: Do southward-tilted sandstone beds on Gale Crater's plains indicate fluvial transport of sediment toward Mount Sharp, building up lake deposits there?

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MEPAG Face-to-Face Meeting

Tuesday, February 24, 2015

08:15 AM Welcome, *L. Pratt* ***New Leadership***
08:35 AM NASA: MEP Status/Mars Future plans, *J. Watzin*
09:30 AM HEOMD plans, interactions, *B. Bussey/R. Davis*
10:00 AM MEPAG response to NASA presentations, *L. Pratt*

10:20 AM Break
Flight Program Status

10:40 AM Mars Science, *M. Meyer* (call-in)
11:00 AM NASA MEP Mission Status, *F. Li*
11:25 AM Update from 2020 Rover project, *K. Farley*

12:00 PM Lunch

01:30 PM European Perspective/ExoMars planning,
R. de Groot
02:00 PM Japanese Mars Planning, *H. Miyamoto*
02:15 PM Emerging Technologies/Mission Capabilities,
C. Whetsel/R. Lock

02:45 PM Break
MEPAG Goals Document

03:15 PM MEPAG Goals Revision , *V. Hamilton & Goals
Committee Members*

05:45 PM Day 1 discussion and wrap-up, *L. Pratt*

06:00 PM Adjourn

Wednesday, February 25, 2015

08:00 AM Agenda and actions for today; follow-up on Goals
presentation; future activities, *L. Pratt*

New Mission Results!

09:00 AM MAVEN Early Results & Prospects, *D. Brain*
09:40 AM MOM Early Progress, *R. Zurek*

10:00 AM Break

Landing Site Activity

10:20 AM The 2016 InSight Mission & L/S Process,
B. Banerdt/M. Golombek
10:50 AM Future Landing Site Observing, *J. Grant/
M. Golombek*
11:15 AM ExoMars landing site process, *J. Vago*
11:35 AM Discussion: Landing Sites for Human Missions,
R. Davis

11:55 AM MEPAG action Items; Wrap-up, *L. Pratt*

12:15 PM Adjourn

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New Leadership for Mars Activities

First opportunity for MEPAG community to meet new leadership

- *Mars Exploration Program Director:* James Watzin
- *HEOMD Chief Exploration Scientist:* Ben Bussey
- *New in PSD—Assistant Director for Science and Exploration:* Richard Davis

Focus: Activities in the 2020's and beyond


- 2020 Mars rover begins this era of future robotic and human exploration
 - Payload includes science instruments, in situ resource utilization demonstrator, sampling equipment
 - What's next?
- Studies are being initiated to follow up on near-term needs after 2020:
 - Replenish relay/reconnaissance infrastructure
 - Make scientific and technical progress on Decadal Survey priorities (e.g., sample return) and to follow up new discoveries (e.g., Recurring Slope Lineae)
 - Locate *in situ* resources for future robotic and human exploration
 - *Foster closer coordination and exploit synergies between scientific and resource measurement capabilities*

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Roles for MEPAG

- **NASA HQ has requested two analyses by MEPAG:**
 - Analyze potential science and resource objectives for a possible new orbiter to be launched in 2022/2024
 - Analyze potential science objectives for a landed human mission on Mars in the 2030's
- **MEPAG has tentatively agreed, pending receipt of the study charters.**
 - These analyses are to be co-chartered by HEOMD Exploration and SMD PSD/MEP
 - The charters are currently in work and the SAGs expected to start work in April
- **MEPAG will conduct this work via 2 Science Analysis Groups (SAGs)**
 - *Next Orbiter SAG (NEX-SAG) to analyze:*
 - Relevant scientific objectives derived from the revised MEPAG goals document
 - Needed measurement capabilities to locate *in situ* resources needed by future human missions
 - Synergies between the two sets of measurements
 - *Human Science Objectives SAG (HSO-SAG) to analyze:*
 - Our anticipated level of scientific knowledge at time of landing humans on Mars
 - What science should be advanced by humans based on the Mars surface?
 - Includes providing information about where the base(s) for humans should be.
 - This is part of a larger joint HEOMD/SMD study looking at exploration locations on Mars.



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MEPAG Goals Document Revision

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Purpose of the Goals Document

The MEPAG Goals Document aims to provide sufficient information to:

- Reflect the scientific priorities of the MEPAG community with respect to investigations for future flight missions,
- Guide NASA's Mars Exploration Program (MEP) in its advance planning of Mars flight missions,
- Help NASA develop Announcements of Opportunity and Proposal Information Packages for missions with science objectives, and
- Support the mission and instrument selection process by helping NASA distinguish those science investigations likely to make substantial (vs. incremental) advances.

This document does NOT specify implementation or imply a timeline for conducting the investigations.

Provides for direct input from the science community as to what should be the scientific core of future Mars Exploration.

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Purpose of this Revision

- **Bring the document up to date with respect to science advancements in all Goal areas**
 - E.g., science results presented at 8th Mars Conference (2014)
 - E.g., aims of the HEOMD Evolvable Mars Campaign
- **Increase cohesion and usability of the document, reflecting connections in current research**
 - Clarify language and intent
 - Many changes involve reorganization and amplification of previous content
- **Prepare for upcoming activities (e.g., SAGs)**

MEPAG Goals

Committee

Vicky Hamilton, Chair

Goal I, Life

Jen Eigenbrode

Tori Hoehler

Goal II, Climate

Scot Rafkin

Paul Withers

Goal III, Geology

Steve Ruff

Aileen Yingst

Goal IV, Preparations for Human Exploration

Darlene Lim

Ryan Whitley

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Changes to Goals Document

- **Added new level in hierarchy: Sub-Objectives**
 - Reflects detailed questions arising for a complex planet and provides a better way to distinguish priority within an Objective.
- **Extent of Changes:**
 - **Goal I, Life:** Relatively *minor*, transitioning from habitability to seeking biosignatures
 - **Goal II, Climate:** *Significant* augmentation
 - **Goal III, Geology:** *Extensive* revision and re-organization
 - **Goal IV, Preparation for Human Exploration:** *Significant* reorganization and re-prioritization
- **Status:**
 - Presented and discussed at MEPAG face-to-face meeting Feb. 24-25, 2015
 - Poster presented at LPSC and final comments were due March 20
 - Comments now being addressed => ***final release ~ 1 May***



MEPAG Meeting Draft of
Revised Goals Document
available on

<http://mepag.jpl.nasa.gov/>

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Mars Science Highlights

Some recently published, others reported at
MEPAG meeting and LPSC

Mars Exploration Program Analysis Group (MEPAG)

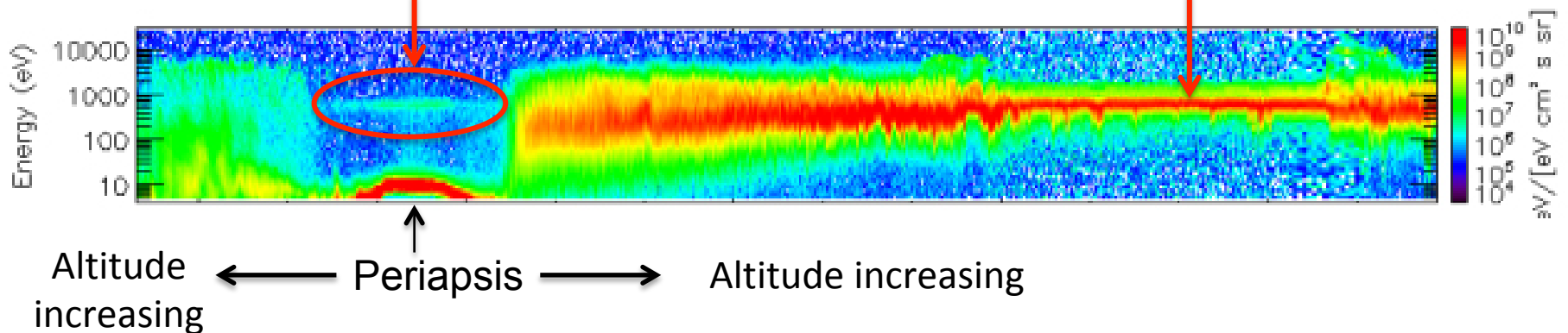
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MAVEN: New Solar-Wind Penetration Process

- **MAVEN/SWIA**
- **Finding:** High-energy Solar Wind ions were detected low in the atmosphere (near MAVEN periapsis)—how did they get there?
- **Importance:** MAVEN has discovered a new phenomena likely involving energy exchange in which high-energy solar wind ions are neutralized and able to penetrate the bow shock, only to be re-ionized lower in the atmosphere, providing an unexpected lower altitude ion source.

High-energy ions at too low an altitude to be unperturbed solar wind; they likely have penetrated to these levels by exchanging charge—twice!

High-energy ions in upstream solar wind

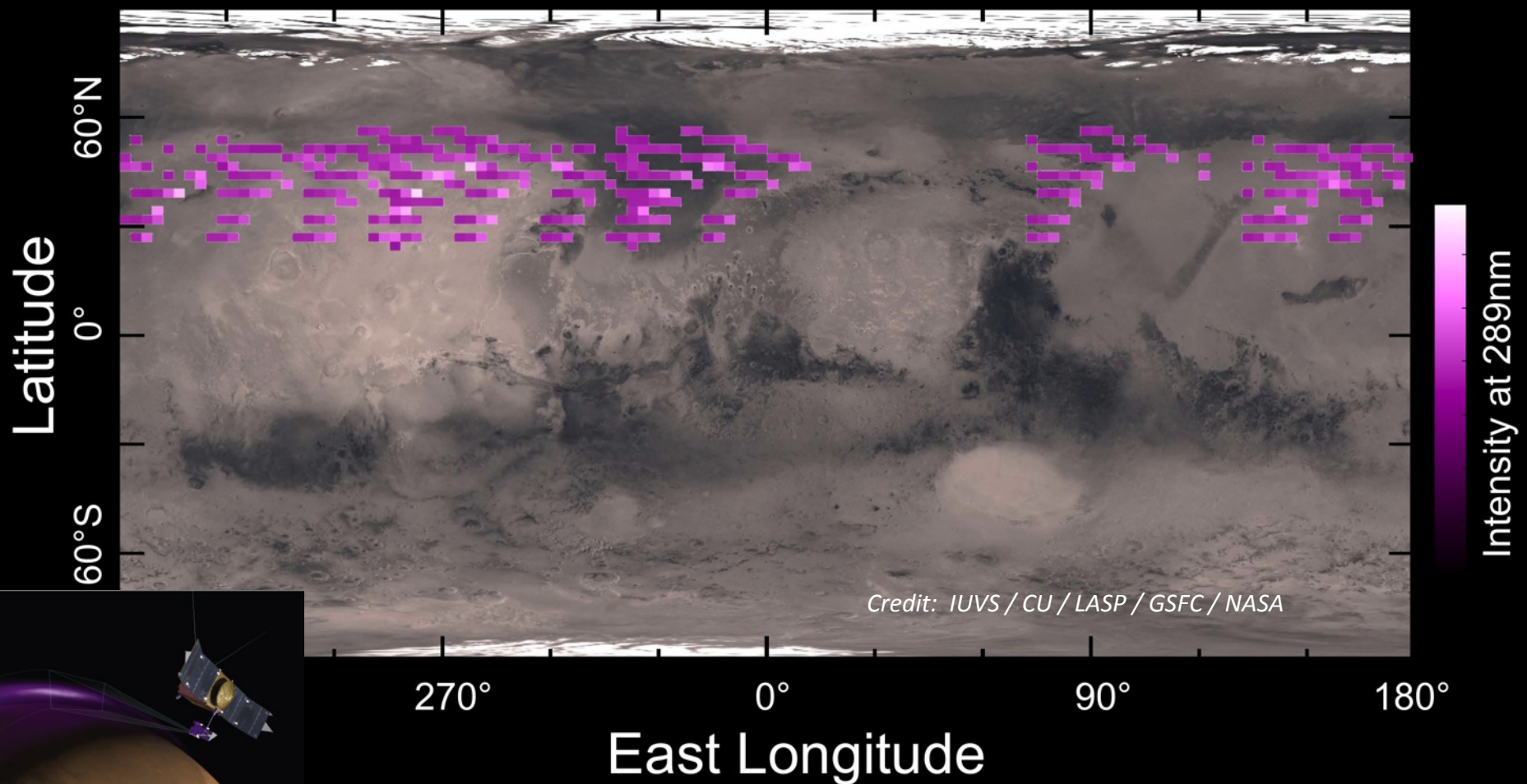


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MAVEN: New Results

Ultraviolet Aurora on Mars



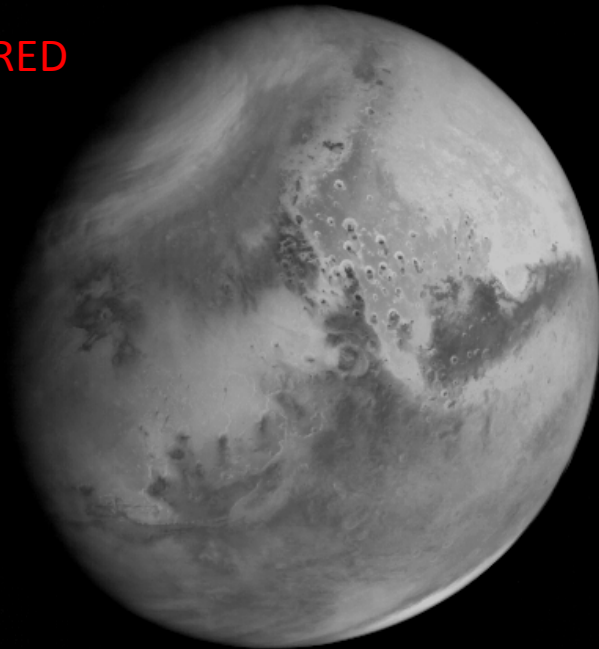
***Mars as seen in three
Colors by (MOM)
Mars Orbiter Mission
Mars Color Imager***

October 1, 2014

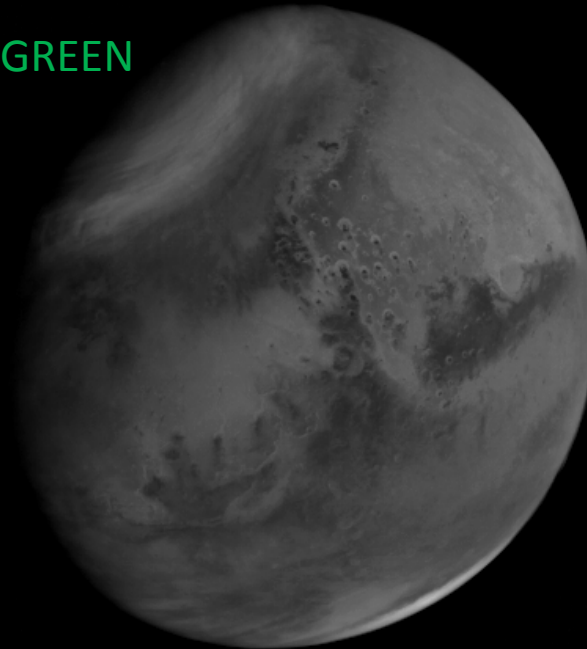
- The red wavelength shows the best surface details.
- As the Mars atmosphere scatter blue (like Earth) Martian surface details are obscured in blue wavelength.
- Blue wavelength band shows scattering by dust and clouds, mainly atmospheric phenomenon

*Credit: India Space
Research
Organization*

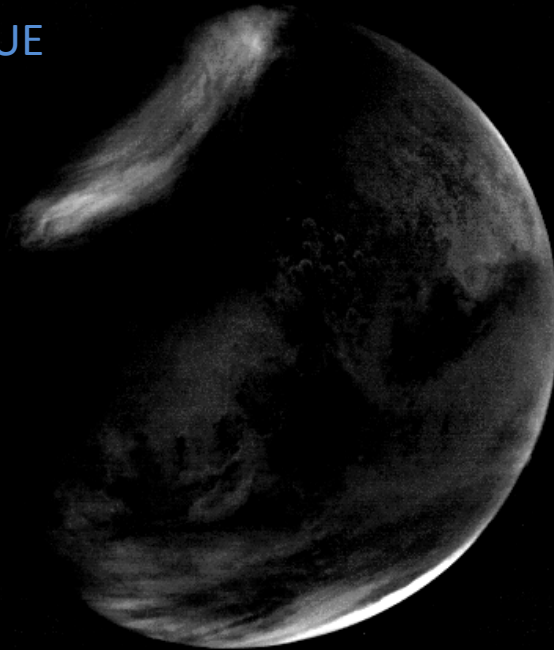
RED



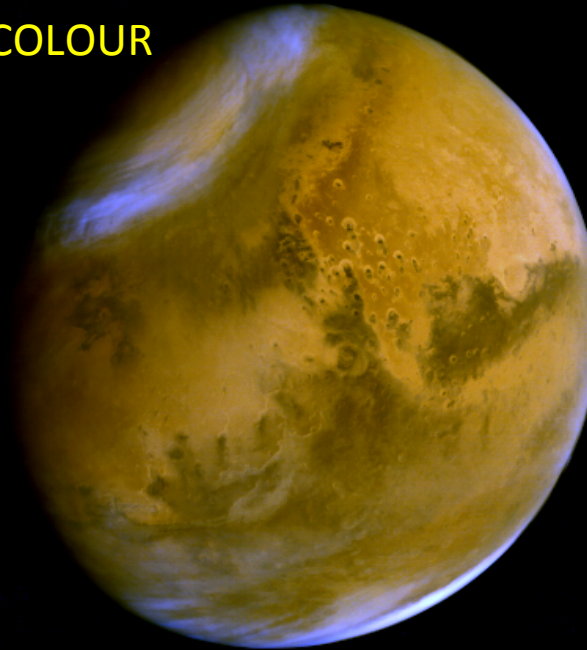
GREEN



BLUE



COLOUR



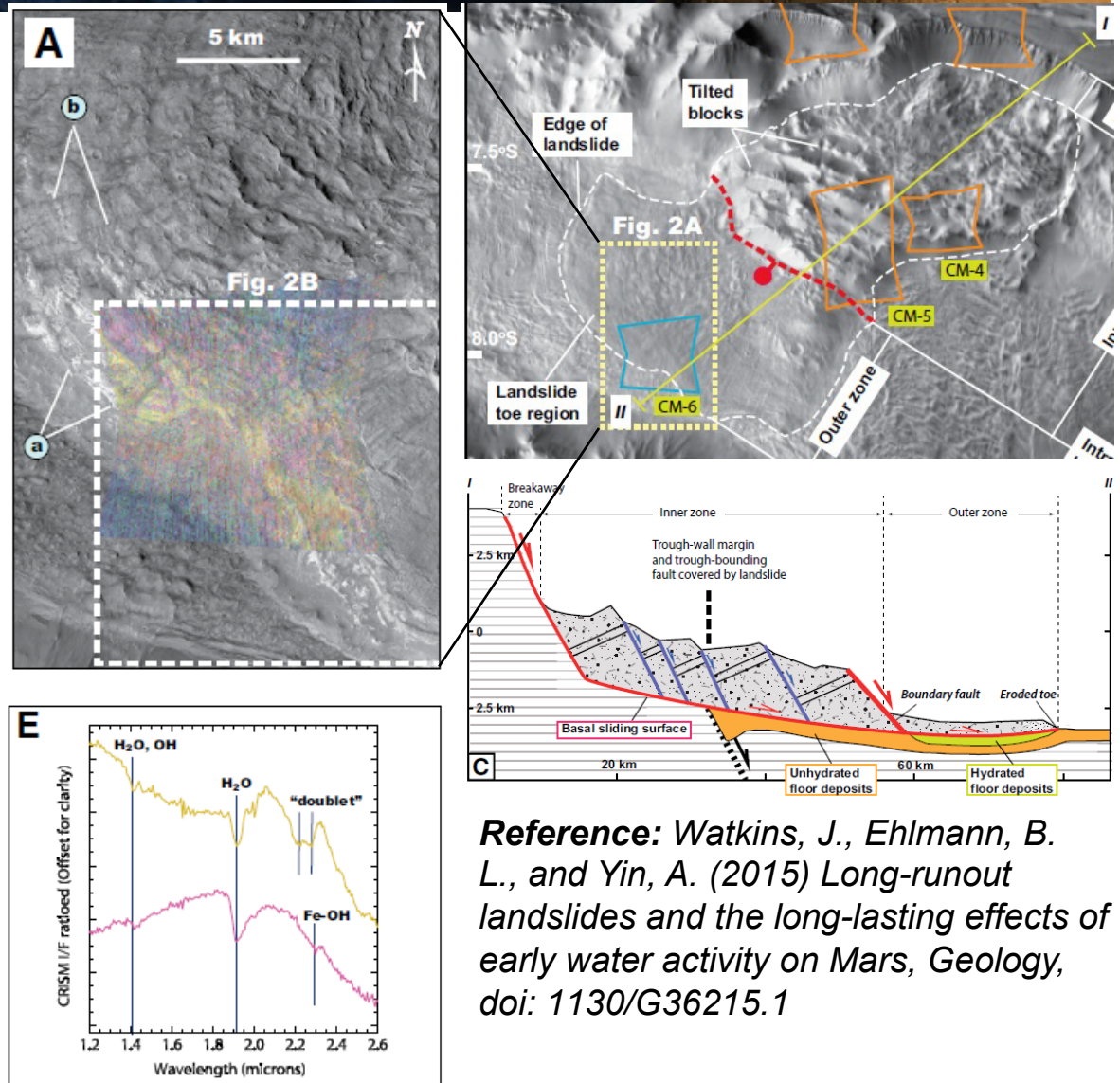
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Mystery Explained?

Valles Marineris Landslides Shaped by Hydrated Silicates

- **MRO/CRISM+HiRISE**
- **Finding:** Clay minerals likely lubricated landslides from the walls so that they extend for unusually long distances.
- **Importance:** Aqueous alteration early in Mars' history has had long lasting effects, manifested by the interaction of clay minerals with large-scale surface processes even in present times.

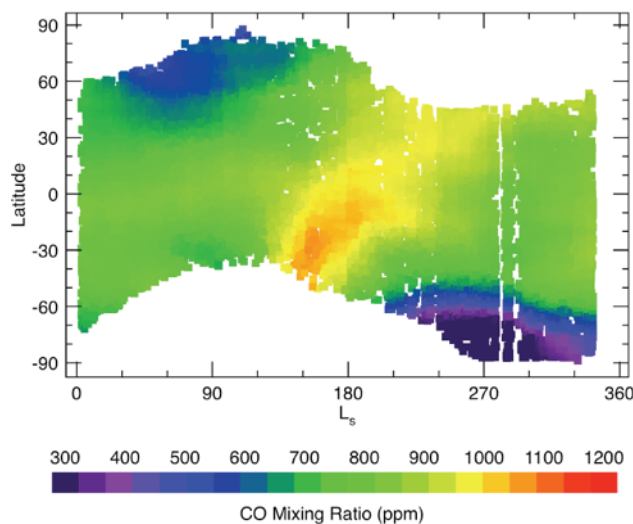


Reference: Watkins, J., Ehlmann, B. L., and Yin, A. (2015) Long-runout landslides and the long-lasting effects of early water activity on Mars, *Geology*, doi: 1130/G36215.1

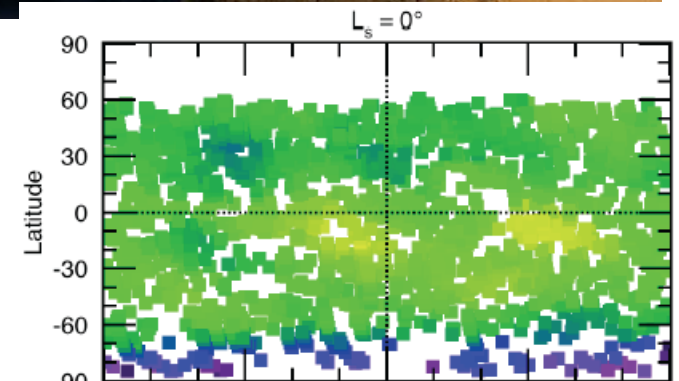
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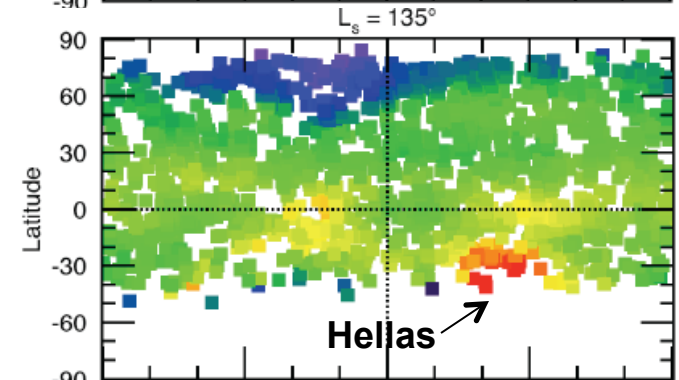
- **MRO/CRISM**
- **Finding:** The winter hemispheres have CO-enrichment in topographically low areas
- **Importance:** CO traces the circulation of CO₂-depleted air from which the seasonal cap condensed. The cold residual gas collects in topographic lows.
- **Reference:** Smith, M.D. (2014) Seasonal and spatial distribution of carbon monoxide on Mars as observed by CRISM, Fall 2014 AGU, abstract P51B-3914



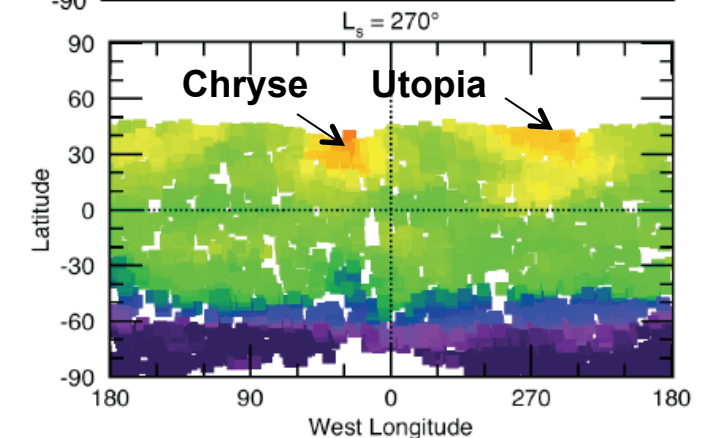
Equinox –
spatially
uniform
composition



S. winter – CO
enrichment in
S. hemisphere
low area

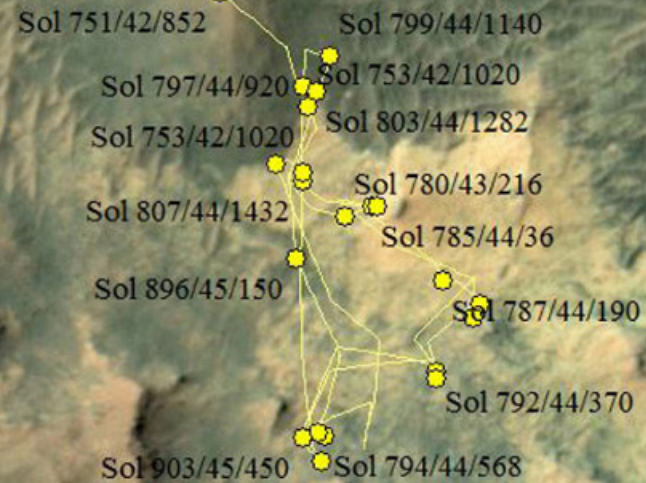


N. winter – CO
enrichment in
N. hemisphere
low areas



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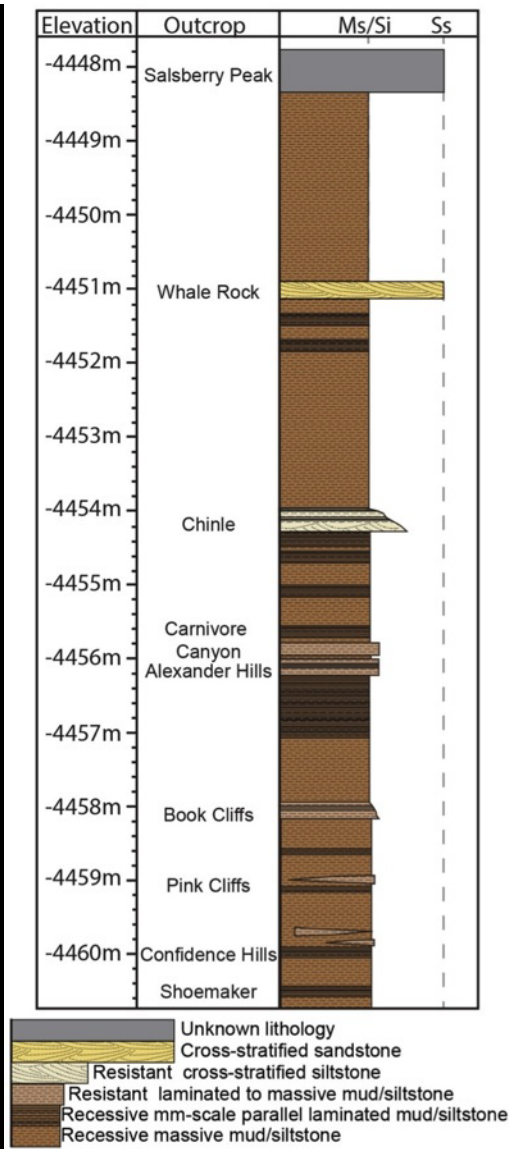
Sol 751/42/852 Sol 799/44/1140
Sol 797/44/920 Sol 753/42/1020
Sol 753/42/1020 Sol 803/44/1282
Sol 807/44/1432 Sol 780/43/216
Sol 896/45/150 Sol 785/44/36
Sol 787/44/190
Sol 792/44/370
Sol 903/45/450 Sol 794/44/568

*Base of Mt. Sharp
Murray Formation*

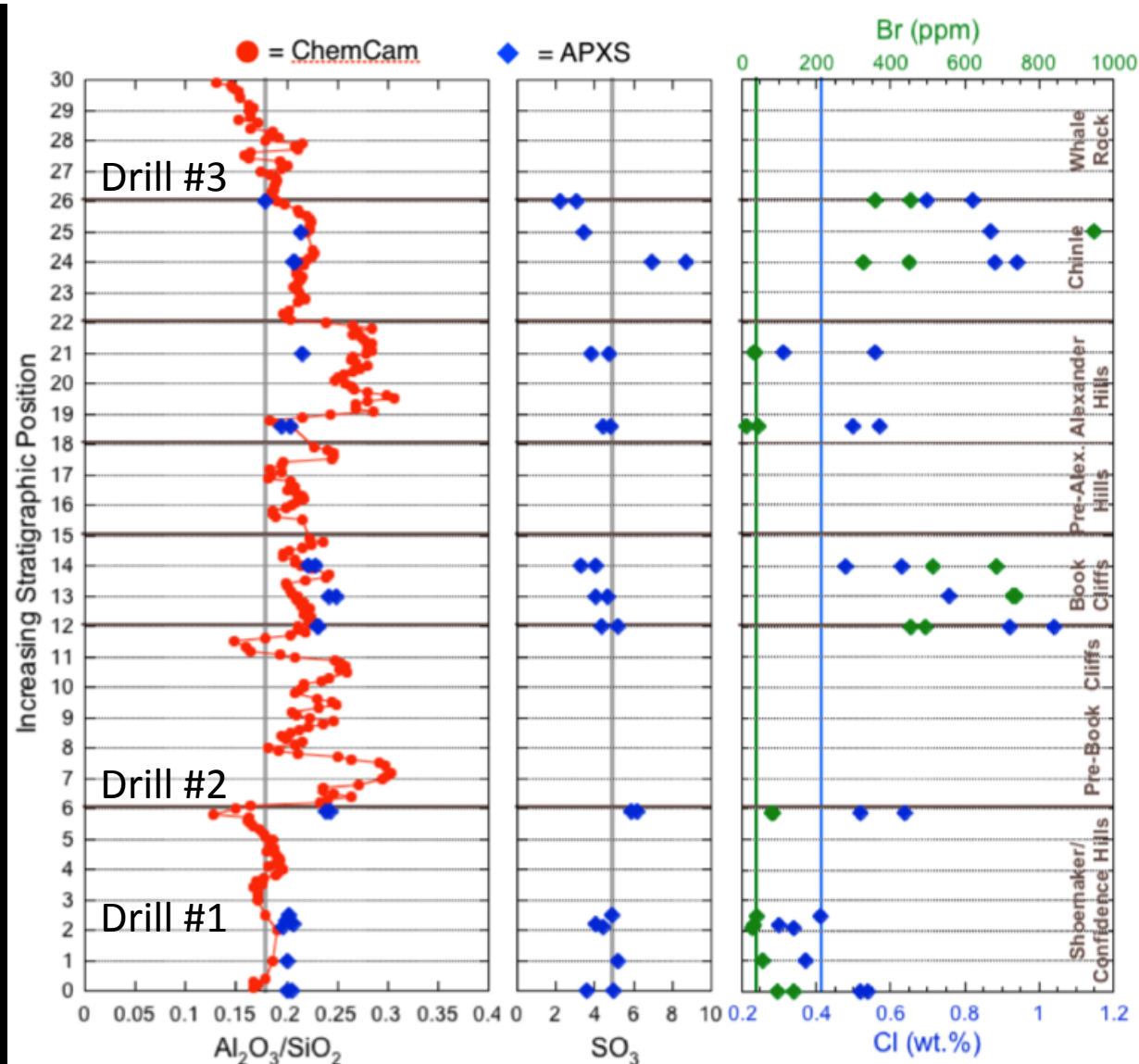
Artist's Drive

***Curiosity's
Trace in the
Pahrump
Hills***

Background: MRO HiRISE / U. Arizona / JPL / NASA



Stack et al. (LPSC 2015)



Milliken et al. (LPSC 2015)



At Pahrump Hills a first pass through the 10-m section surveyed morphology and chemistry. A second pass through the section built a large data set of physical and chemical stratigraphy (above). A third pass has provided XRD & GCMS analyses at three drill sites.

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A Sample of Recent Highlights

- **Curiosity (prime & extended mission):**
 - Measured an unexpected, short-term enhancement of methane.
 - Stratigraphic observations suggest the sediments in Mt. Sharp and in the surrounding plains were emplaced by a series of streams and lakes.
 - Found chlorobenzene, a simple organic chemical, in its analysis of mudstone from Yellowknife Bay. (Took many lab runs on Mars & Earth to confirm.)
 - *Tentative* discovery of long-chain (~10) carbon molecules in same Yellowknife mudstone.
- **MRO (extended mission):**
 - Found larger volume of buried CO₂ ice than previously surveyed, enough to double the present atmospheric mass if released.
 - South polar *surface* CO₂ ice cover results from a complex balance between the expanding pits (the “swiss cheese” terrain) and new deposition of CO₂ snow.
 - Recurring Slope Lineae now detected in near-equatorial Valles Marineris and in some northern basins, as well as in southern mid-latitudes.
- **MAVEN (prime mission)**
 - Detected UV aurora away from regions of remnant magnetism.
 - Data indicate the presence of small dust particles at 150-300 km altitude.
 - Details of solar wind-atmosphere interaction emerging as coverage expands.