

Mars Exploration Program Analysis Group (MEPAG)

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



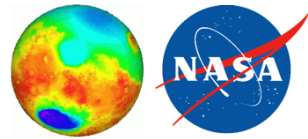
MEPAG Report to CAPS

March 5, 2014

Lisa Pratt, MEPAG Chair

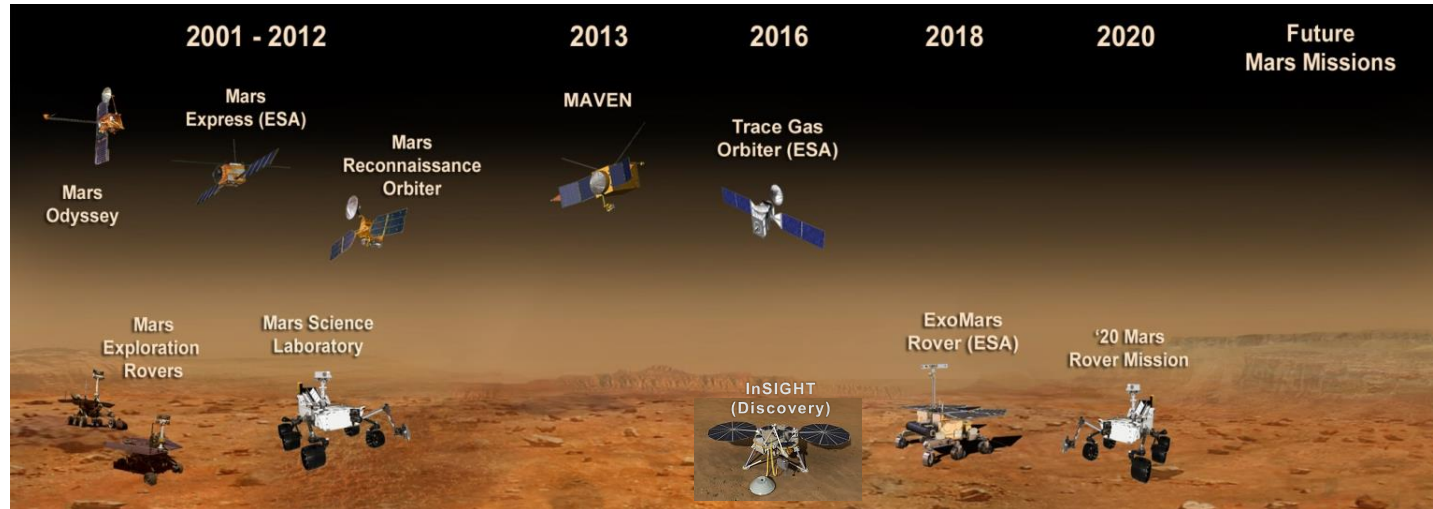
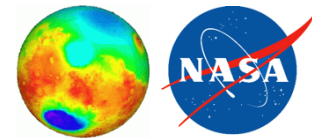
Selwyn Section & "Snake"
Yellowknife Bay, Gale Crater
MSSS / JPL / NASA

Outline



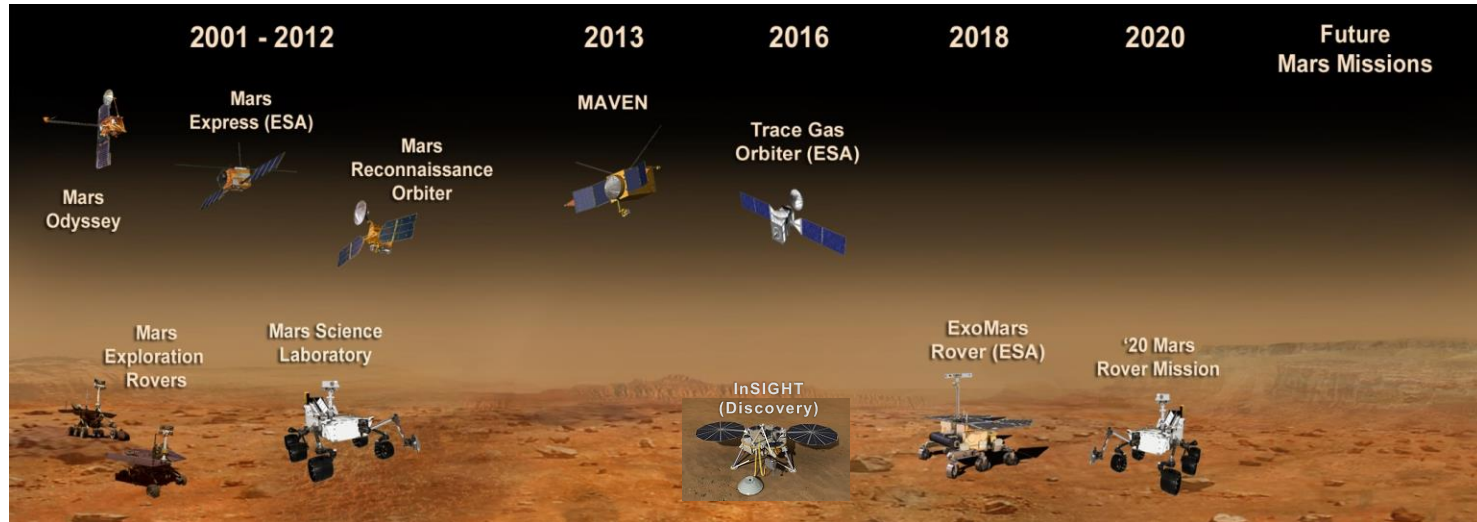
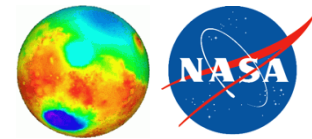
- Recent Highlights from current Mars Missions
 - Curiosity: Surface Age Dating in Gale Crater
 - Opportunity (MER-B): Aqueous Minerals in Endeavour Crater rim
 - Odyssey: Moving orbit to view early morning phenomena
 - MRO: Low-latitude Recurring Slope Lineae (RSL)
- Ongoing & Future MEPAG Activities
 - Mid-term Report from New SAG on Special Regions
 - Interactions with HEOMD
 - MEPAG Face-to-Face Meeting
- Concerns
- Bright Spots

Status of Mars Missions (1 of 2)



- MAVEN completed 2nd trajectory course maneuver, instruments and Electra relay package successful cruise check-outs. Mars orbit insertion Sept. 21.
- Curiosity is moving towards Mt. Sharp, slightly altered path to avoid punishing ground. Papers published on age-dating Gale Crater rocks.
- Opportunity is on Solander Point, slopes and power margins permitting some science. Wind-induced cleaning events added to the power margins.
- Odyssey is speeding up drift to post-dawn local times, easing strain on single battery and giving THEMIS a chance to characterize post-dawn atmosphere and surface.
- MRO is exploring mineral diversity, subsurface ice, and enigmatic features such as the Recurring Slope Lineae (RSL), 4th Mars year of daily observations.

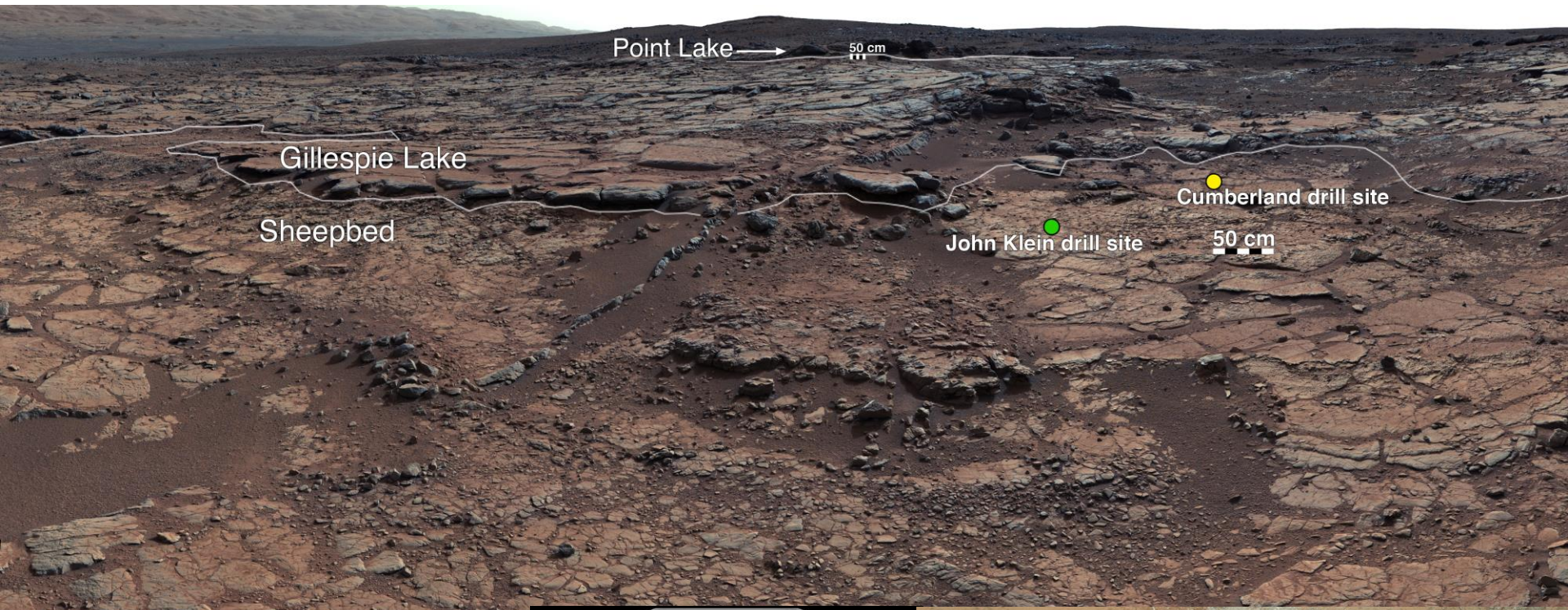
Status of Mars Missions (2 of 2)



- Odyssey, Opportunity, MEX (US), MRO, Curiosity are, with LRO and Cassini, all part of the upcoming 2014 PSD Senior Review
- Upcoming Missions
 - InSIGHT (Discovery) coming up on Critical Design Review
 - 2020 Project underway, heading to System Requirements Review end summer, payload selection anticipated by summer 2014, and 1st Landing Site workshop in May following MEPAG meeting

Gale Crater

A (Geologically) Young Surface



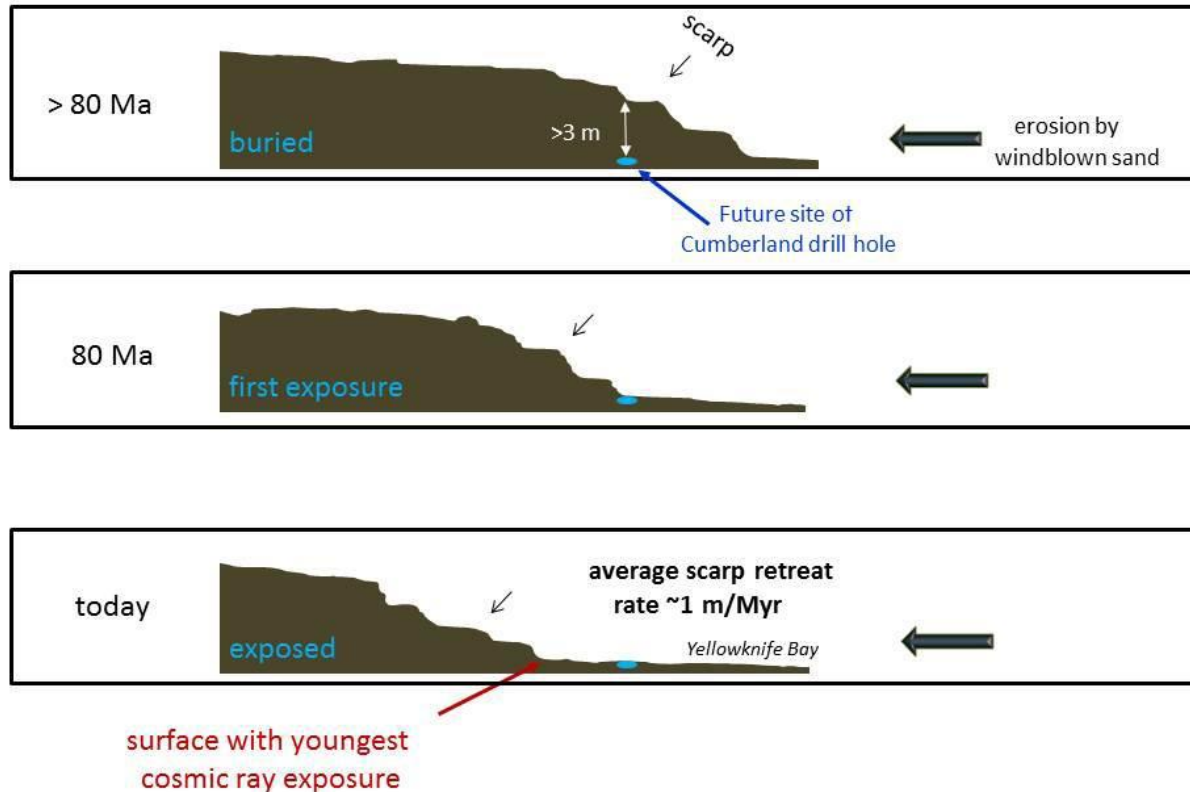
Recently Exposed Ancient Habitable Environment at Yellowknife Bay

- The John Klein site appears to have been at the end of an ancient river system or within an intermittently wet lake bed.
- The mineralogy indicates sustained interaction with liquid water that was relatively neutral, low salinity, and not strongly oxidizing.
- Key chemical ingredients for life are present (C, H, N, O, S, P).
- The presence of minerals in various states of oxidation are potential sources of energy for primitive organisms.
- Surface exposure age derived from cosmogenic ^{36}Ar , ^{21}Ne , & ^3He indicate that this surface was exposed in the last 100 Million Years

Gale Crater

(Farley, 2013)

Scarp Retreat Model and Exposure History of Yellowknife Bay

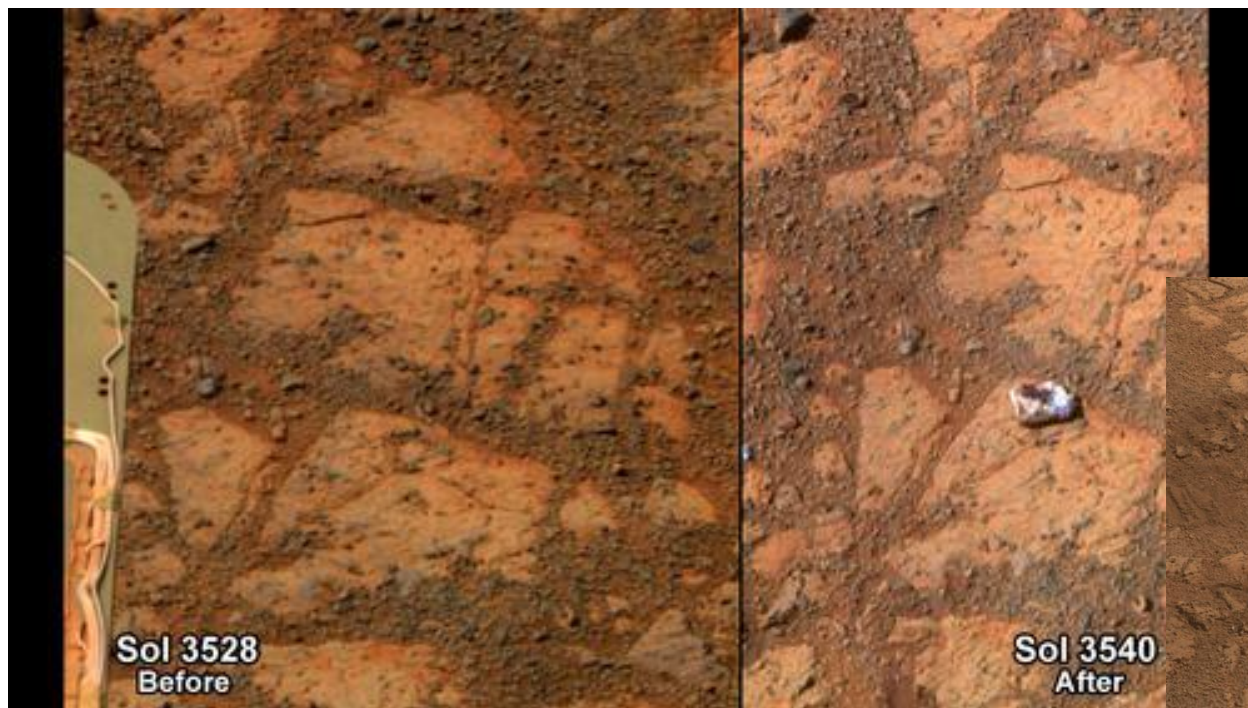


Formation age (4.2 b.yr ago) and the exposure age (< 0.1 b.yr ago) indicate the surface was buried early in Mars history and stayed that way for billions of years, implying a more rapid surface erosion on Mars in geologically recent times. Orbiter data show active processes at work today.

A young age for the exposed surface bodes well for preservation of organics and other biosignatures, because burial and shielding from cosmic rays would curtail destruction of such evidence, if it exists.

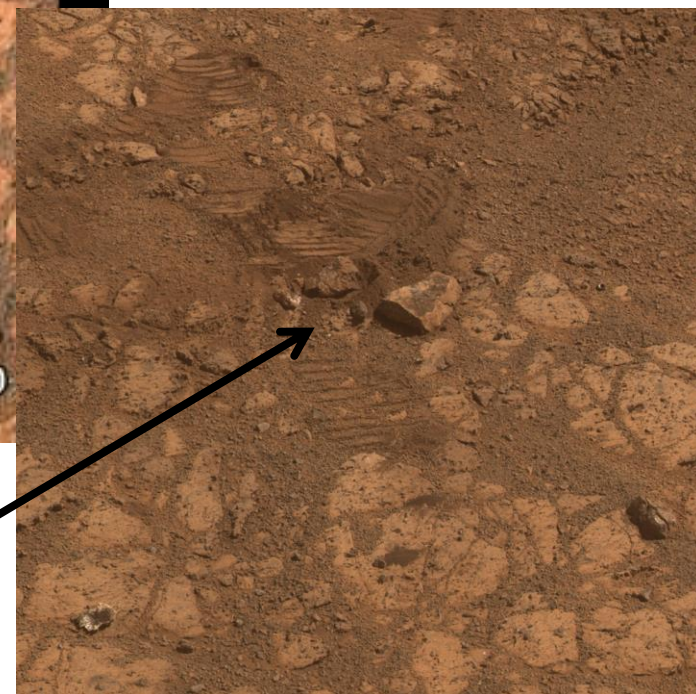
MER Opportunity

10 Years on Mars and going strong



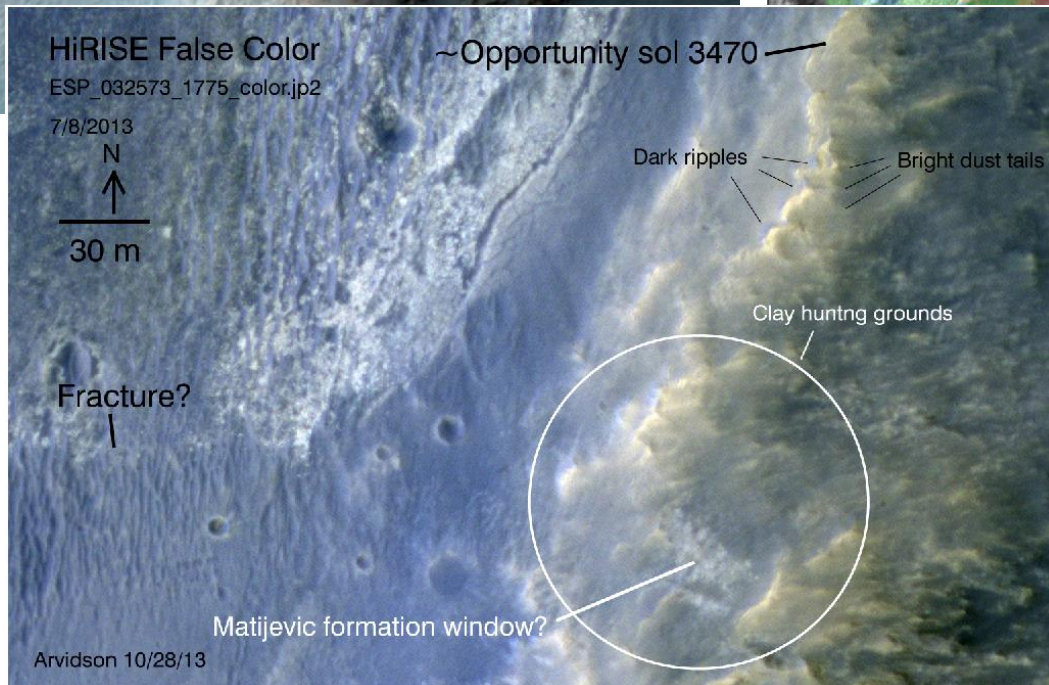
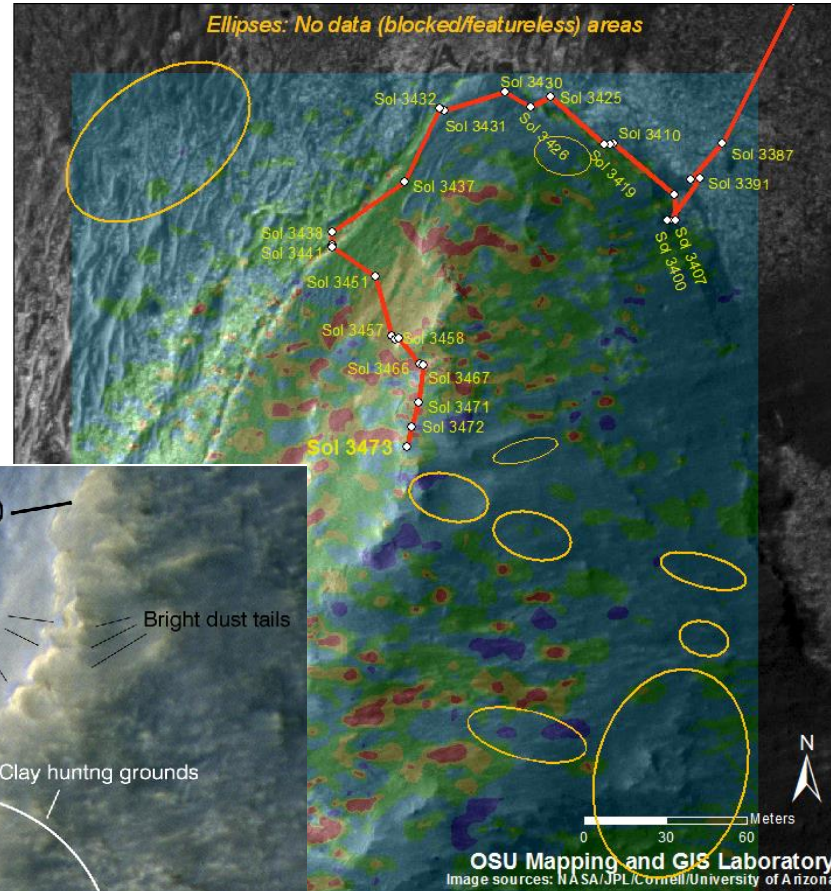
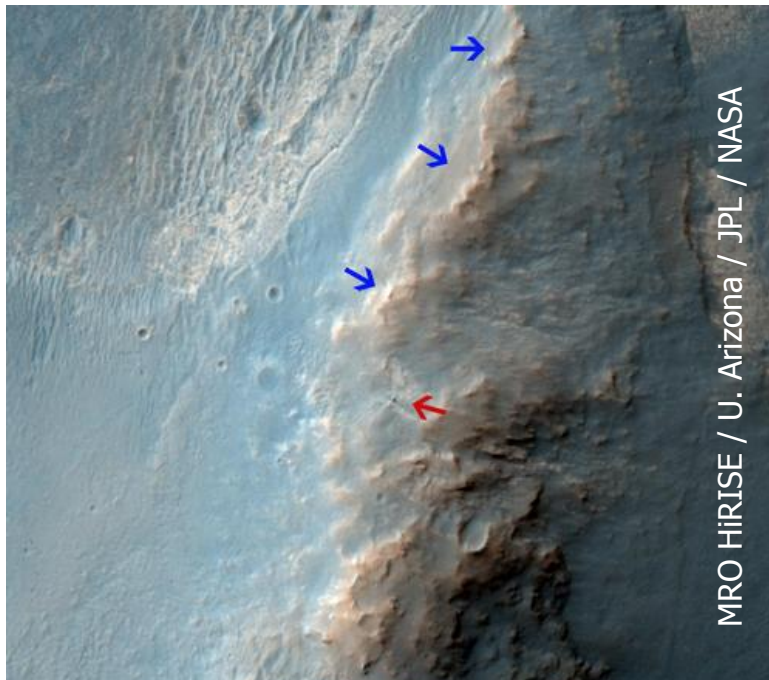
Still solving mysteries.
Where did that come from?

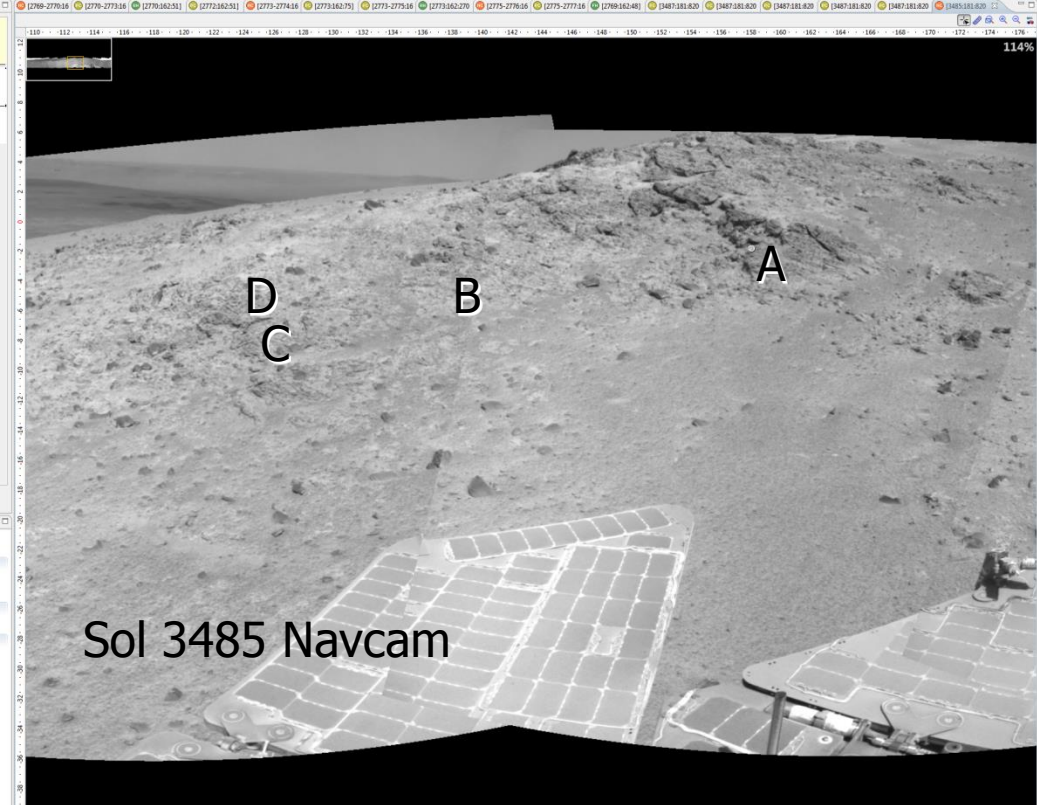
Now I see



Opportunity in Winter

Leveraging data from orbit and ground





Sol 3485 Navcam

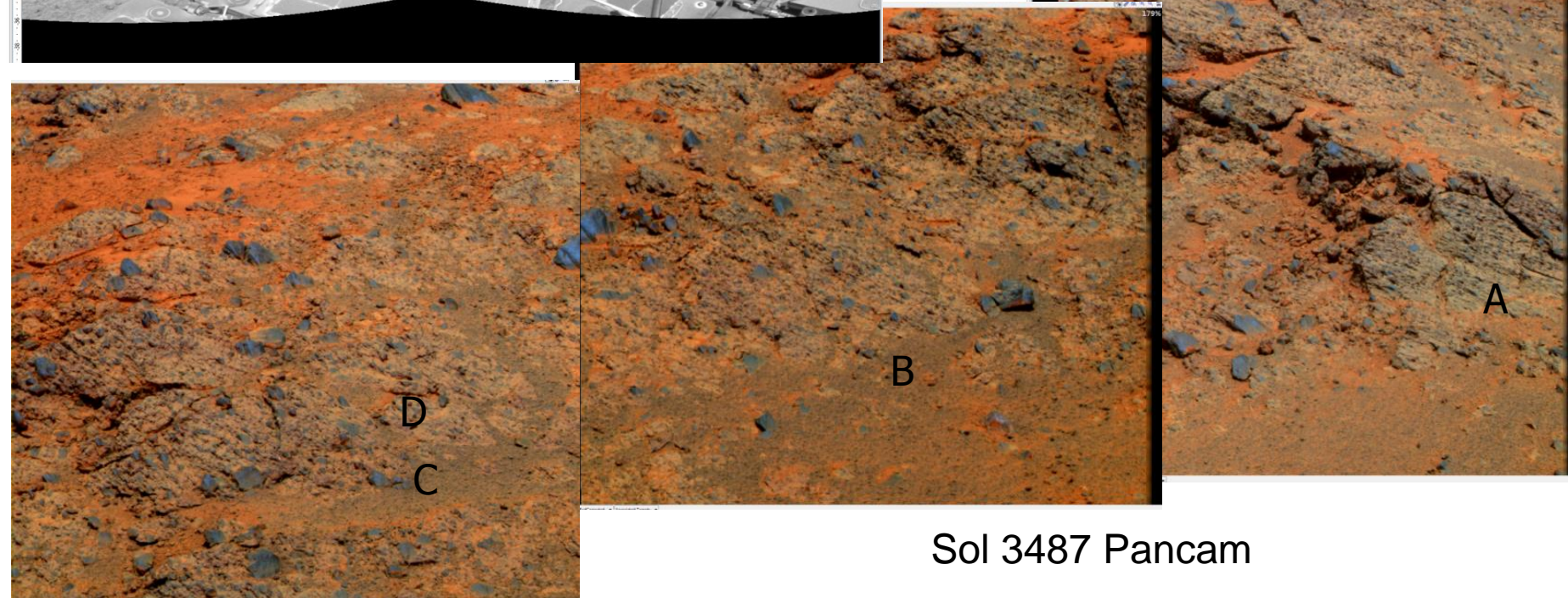
Opportunity

Interesting Targets

A = priority

less dusty, easier approach and deployment

(Arvidson 11/15/13)



Sol 3487 Pancam

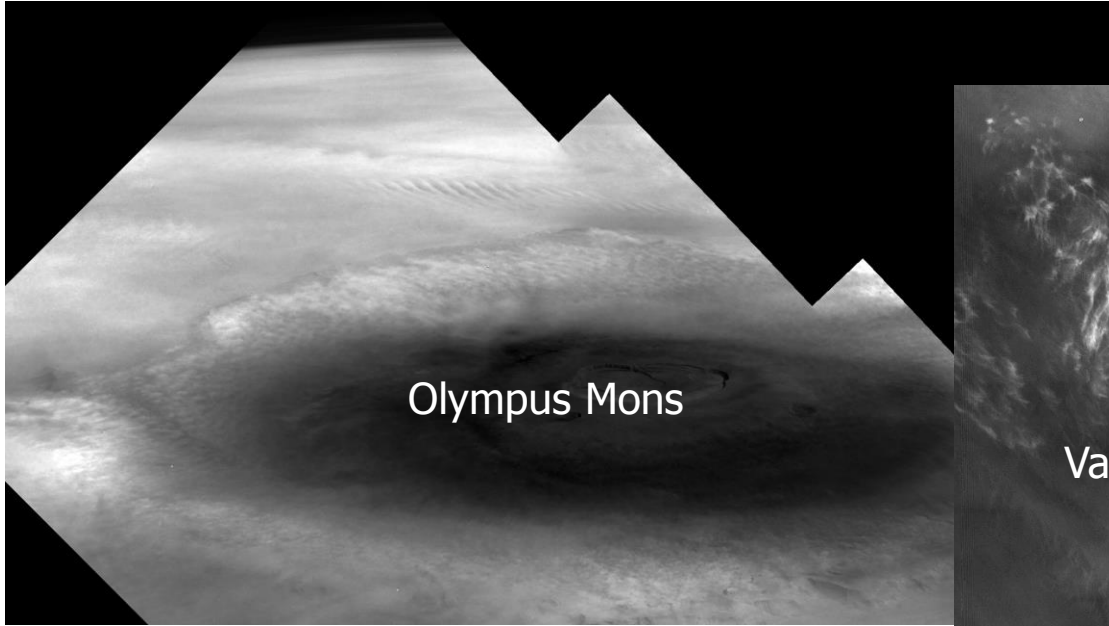
Science Rationale for Late Odyssey

Local Mean Solar Time

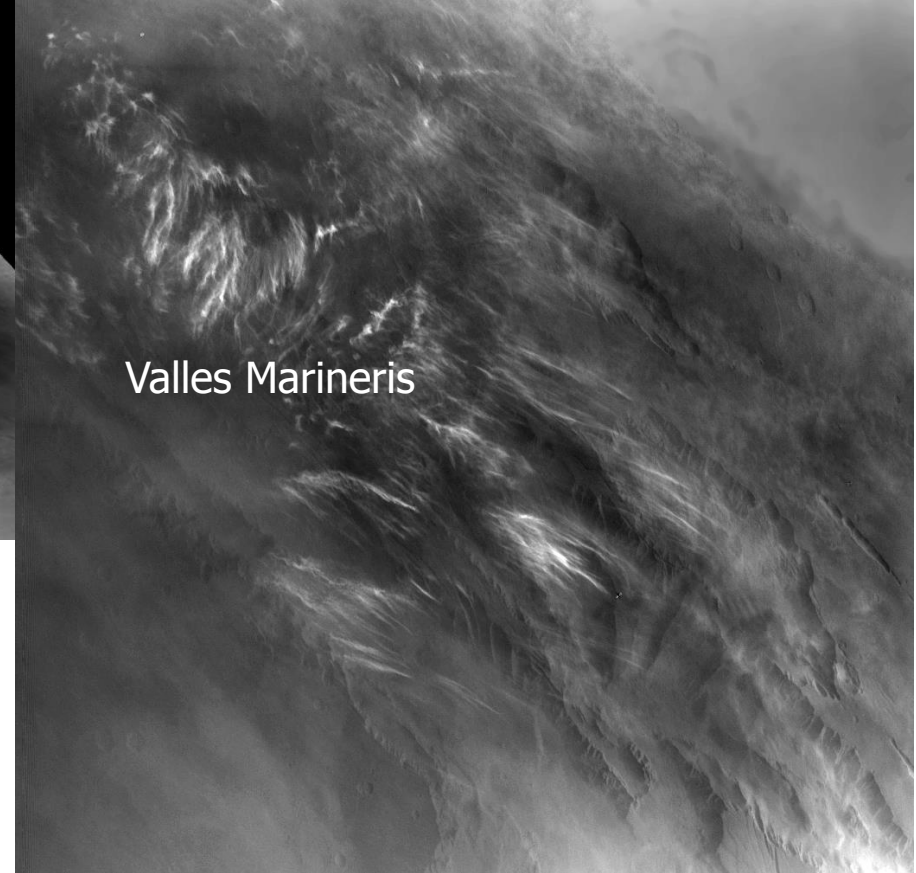
- Odyssey is changing the local time of its orbit node in order to avoid the stress of long eclipses on its single battery.
- In February Odyssey accelerated its drift to later local times to take advantage earlier of the first opportunity for systematic observations of Mars morning phenomena since Viking orbiters
 - Enables observation of atmospheric phenomena unique to morning: clouds, hazes, and fogs.
 - Extends diurnal coverage from previous afternoon/pre-dawn periods to post-dusk/early morning periods
 - Observe deviations from nominal-temperature behavior that results from sub-surface layering, ground ice, surface rocks
 - Provide better tie to MSL surface temperature observations
 - THEMIS will investigate recently discovered thermally-driven processes, such as polar CO₂ jets, active gullies and ongoing liquid brine flows. A new (early morning) view of dynamic Mars.

Viking Orbiter

Morning Images

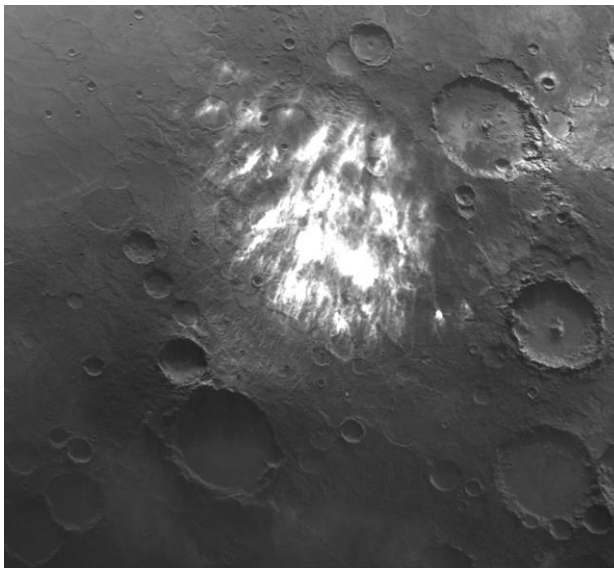


Olympus Mons



Valles Marineris

Southern
Highlands

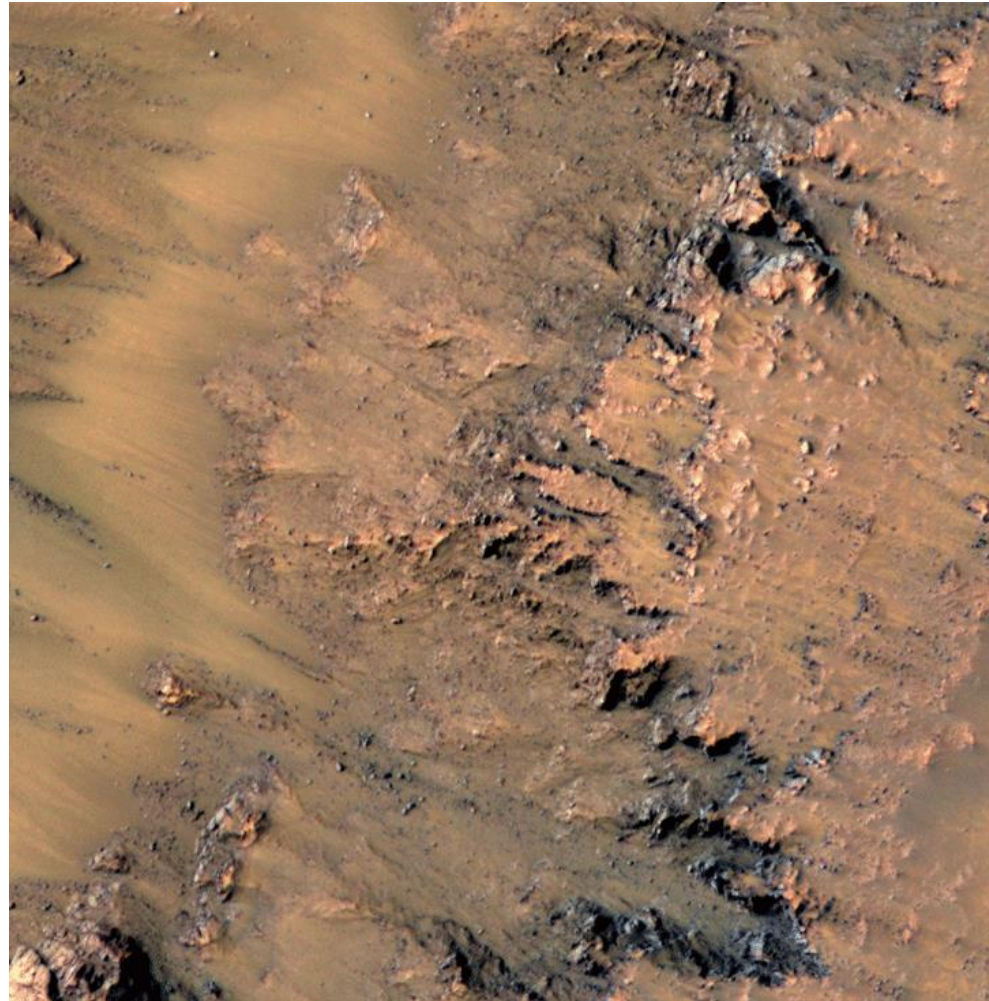


Water-ice clouds in Viking Orbiter
morning images

Seasonal Flows on Warm Martian Slopes

(McEwen et al., Science, 2011)

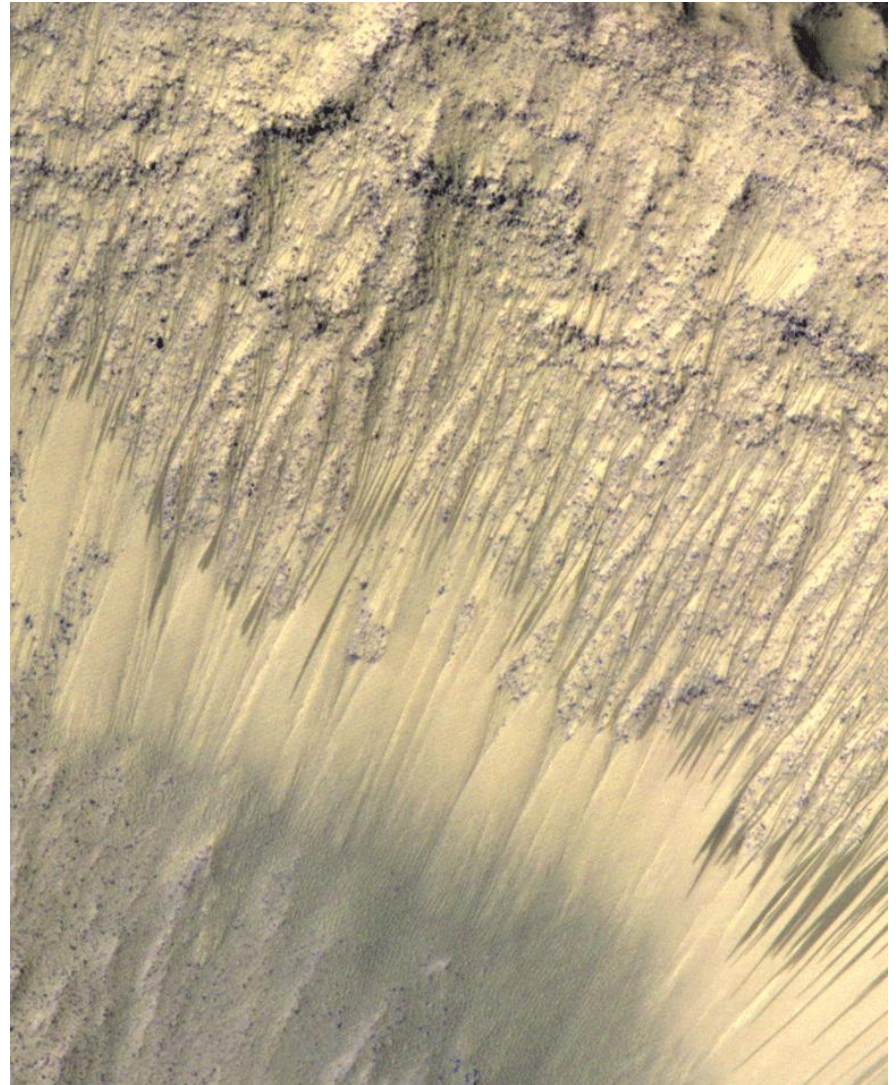
- What we knew 2 years ago:
- Recurring Slope Lineae (RSL) are narrow (0.5-5 m), dark markings on slopes $>25^\circ$.
- Concentrated in southern hemisphere (32°S to 48°S), favoring equator-facing slopes.
- Form and incrementally grow in late spring to summer, then fade or disappear in fall.
- Reform at nearly same locations in multiple Mars years.
- Extend downslope from bedrock outcrops or rocky areas; often associated with small gullies.
- RSL active in seasons when peak surface temperatures $> 250\text{ K}$.
- Seepage of brines best model.



Recurring Slope Lineae in Equatorial Regions of Mars

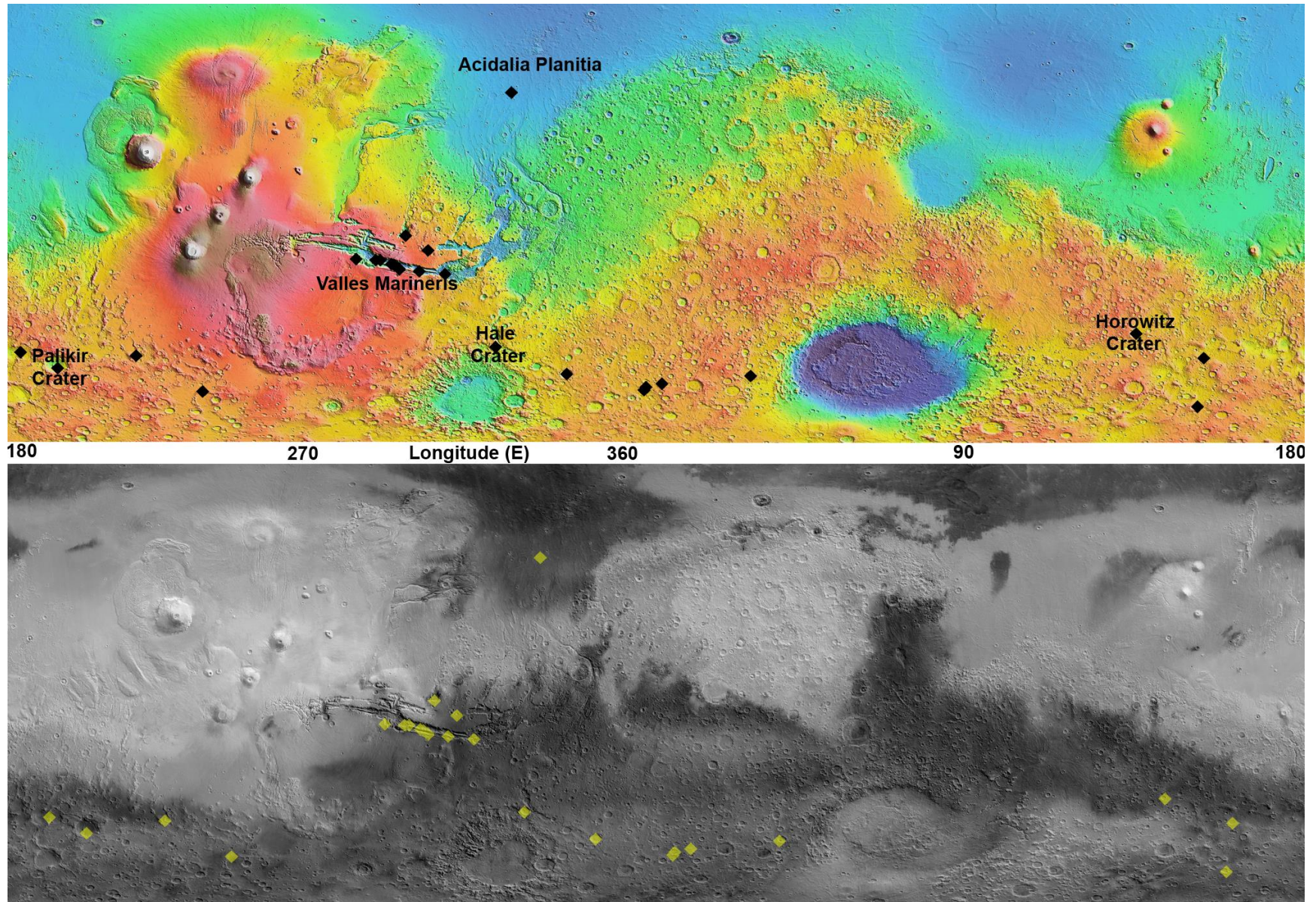
(McEwen et al., Nature Geoscience, 2014)

- What we know today:
- RSL also found in Valles Marineris (VM) on all slope aspects, plus a few in other equatorial regions
- In VM they form in every season on the Sun-facing slopes, then fade or disappear.
- Recur in multiple Mars years.
- Extend downslope from bedrock outcrops or rocky areas; often associated with “small” gullies.
- Fans at the RSL ends have Fe^{2+} and Fe^{3+} absorptions (Ojha et al., GRL in press) (greenish in HiRISE IRB color)
- Longer RSL in VM, >1 km

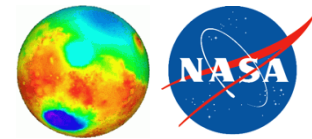


RSL sites fully confirmed by MRO HiRISE

Observed incremental growth, fading, and recurrence of many (>10) flows on a slope

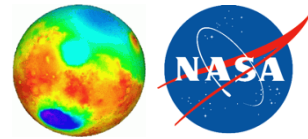


New SAG: Special Regions



- Much has changed since 2006 Special Regions SAG
 - Phoenix results indicating perchlorates, thin water films, deliquescence
 - Recurring Slope Lineae (potential brine flows)
 - Curiosity results on hydrated minerals
 - Minerals/compounds discovered by Curiosity reveal electron donor/acceptor pairs
- COSPAR is planning a workshop to revisit the issue spring 2014
 - There may be implications for ExoMars 2018 and NASA 2020 rovers
 - Site selection sample contamination (e.g., impact of deliquescence and oxidation by perchlorates)

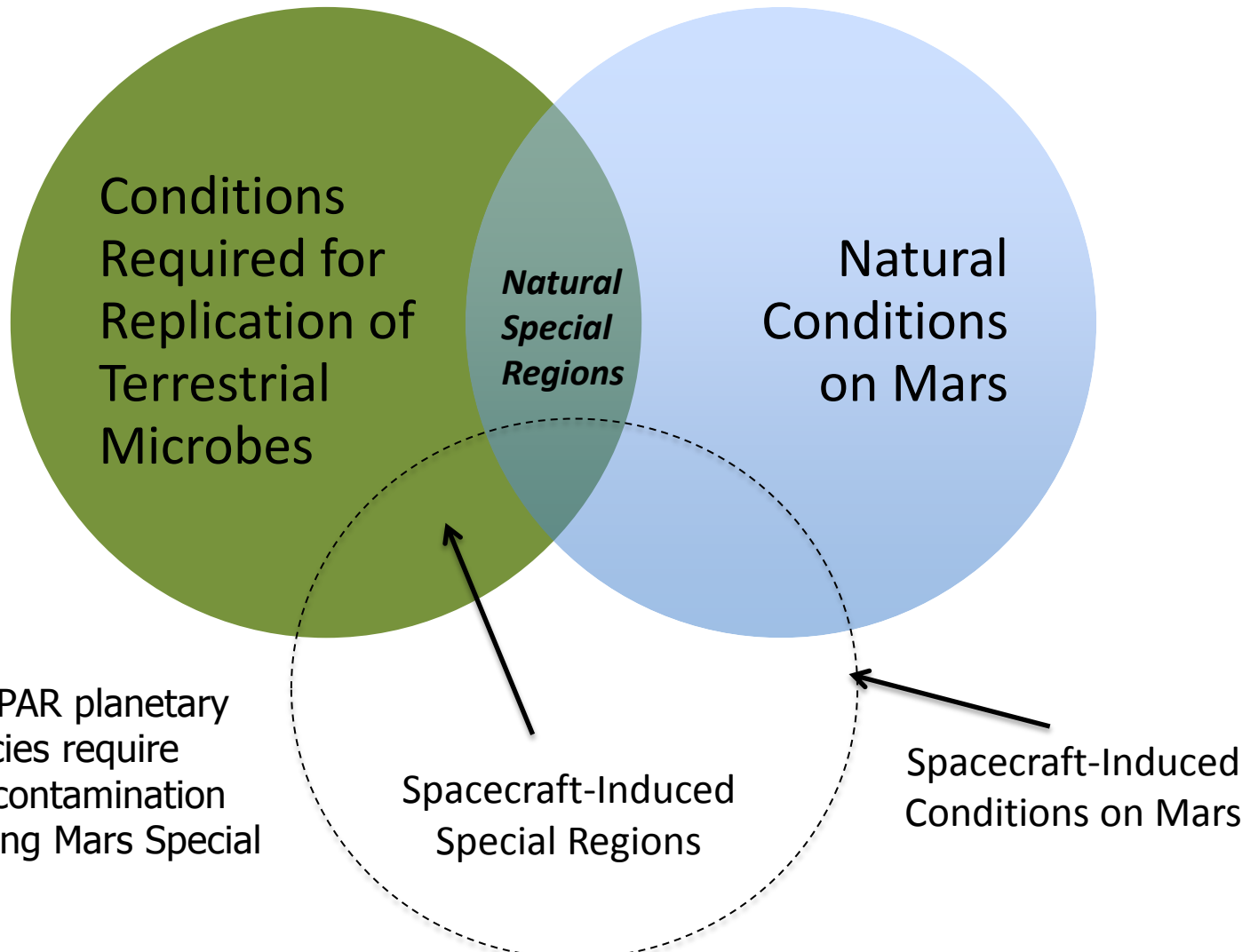
New SAG: Special Regions



- At the request of MEP, MEPAG formed a Special Regions Science Analysis Group (SR2-SAG) to update the 2006 study.
 - The group got underway in January and gave an interim status report to the MEPAG Executive Committee on February 12. There will be a full report to the Mars Community at the May MEPAG meeting.
 - SAG is not finished by any means and is working hard.
- The SR2-SAG will give a report on their work as input to the COSPAR workshop.
- The next slides give an overview of some issues the SAG is working.



The Concept of Mars Special Regions

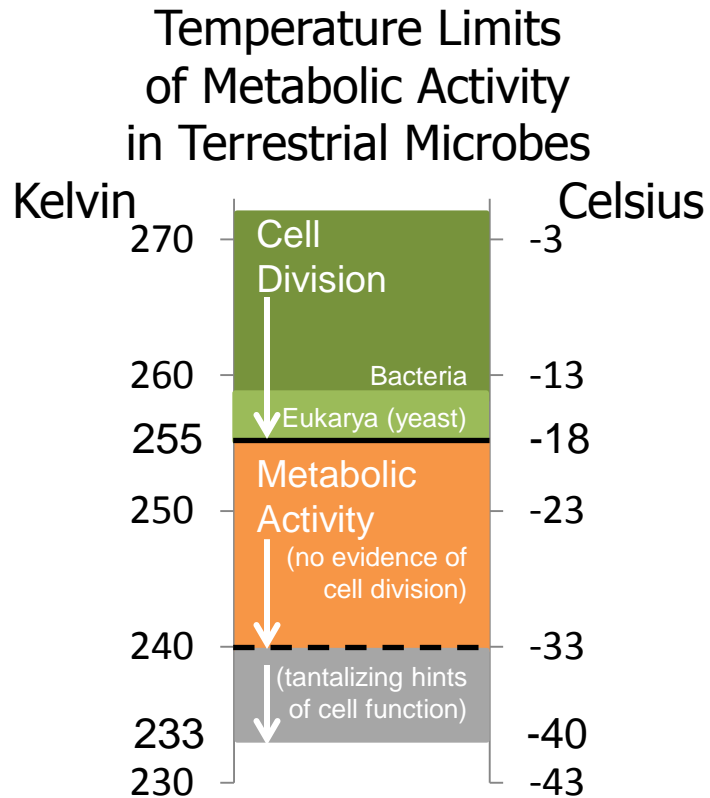


NASA and COSPAR planetary protection policies require *Viking*-level decontamination prior to accessing Mars Special Regions



Low-Temperature Limit for Terrestrial Life

Preliminary Analysis: If anybody has additional info, please contact the team



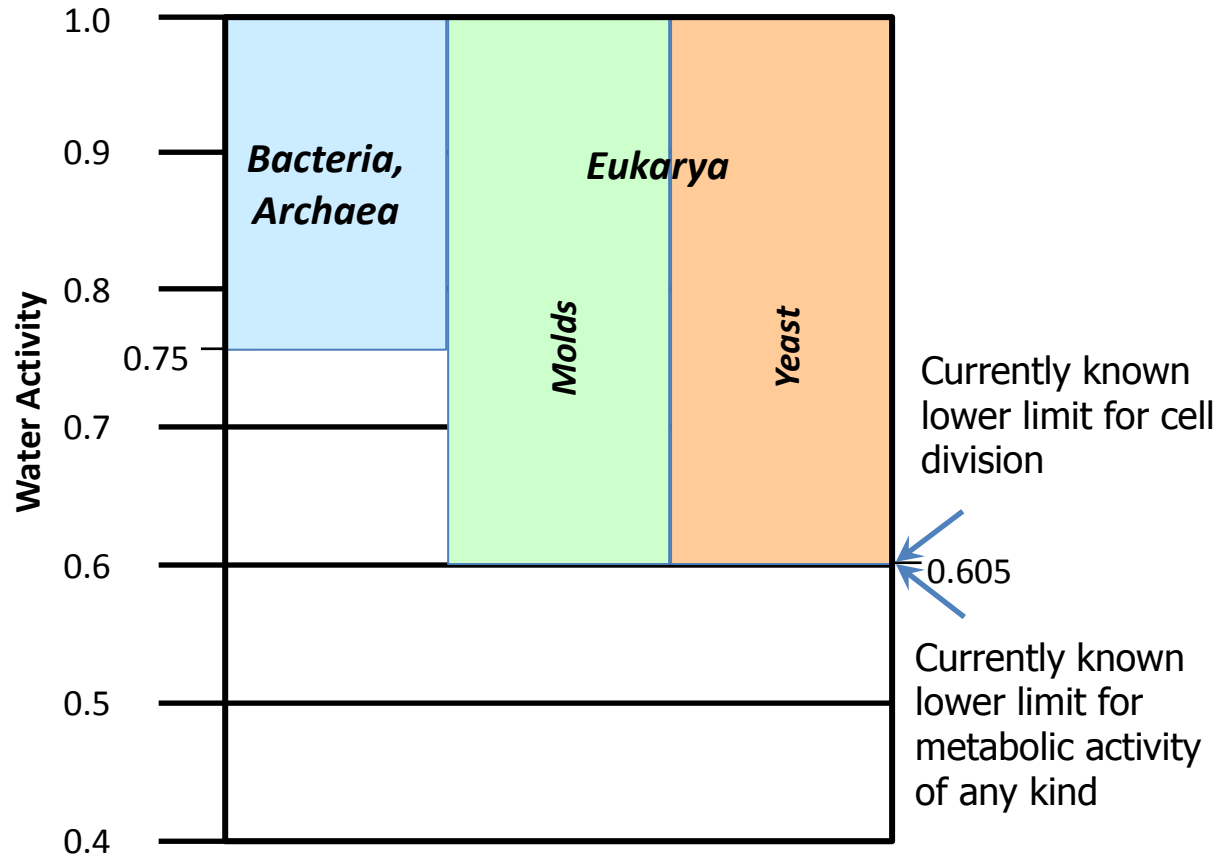
Finding 2: Cell division has not been reported below -18°C (255K).

Finding 3: Cellular metabolic activity has not been demonstrated below -33°C (240K), although some biophysical processes may be functional at lower temperatures.



Low-Water Activity Limit for Terrestrial Life

Preliminary Analysis: If anybody has additional information, please contact the team



Draft Finding: Review of the literature since the previous SR-SAG report (2006) shows no evidence of either cell division or metabolism below a_w of 0.605.



Recurring Slope Lineae (RSL)

A recent discovery of significance to Special Regions planning

- Recurring slope lineae (RSL) are narrow (0.5-5 m), abundant (>10) dark markings on steep slopes (>25°).
- They form and incrementally grow in late spring to summer, then fade or disappear in fall; they recur in several Mars years.
- When first discovered, they were found only in the southern hemisphere (32°S to 48°S), favoring equator-facing slopes.
- More recently, RSL were found in Valles Marineris on sun-facing slopes, within latitudes ($\pm 30^\circ$) accessible by MSL-type rovers
- Extend downslope from bedrock outcrops or rocky areas; often associated with small gullies.
- RSL active where peak temperatures > 250 K in Odyssey THEMIS. (Actual peak surface temperatures likely higher)



Recurring Slope Lineae (RSL)

A recent discovery of significance to Special Regions planning

- Draft Finding: RSL are currently best explained by the seepage of water at $>250\text{ K}$, with a_w unknown and perhaps variable.
 - Leads to recommendation that they should be treated as Special Regions.
 - Soft landing ellipses will not include the steep slopes where RSL are found, but a rover could drive to such slopes and probes or other experiments could reach these sites.
- Draft Finding: High-resolution monitoring was required to confirm the presence of RSL.
 - Many slope lineae look alike, temporal information is essential to identify RSL.
- Draft Finding: There are other features that have similar characteristics to RSL perhaps involving water but their characteristics are not identical.
 - Example: in Aram Chaos, slope lineae only grow a bit at their tips and have not faded over 2 Mars years.

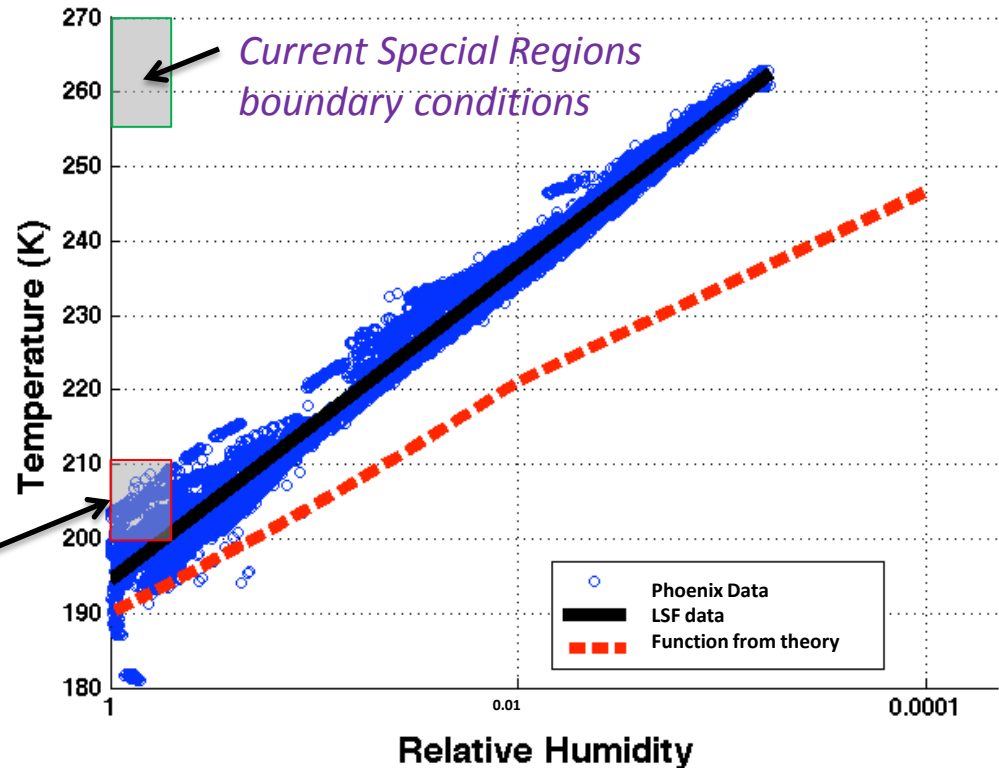


Natural Deliquescence at the Phoenix Site

Preliminary Analysis: If anybody has additional info, please contact the team

- Relative humidity often reaches 100%
- Liquids are only possible at lowest T (<210 K), highest Rh (>0.5)
- Compatible with a few salts: Ca, Mg-perchlorates, Mg-chlorate

Bounding field of natural deliquescence
(if the right salts are present)



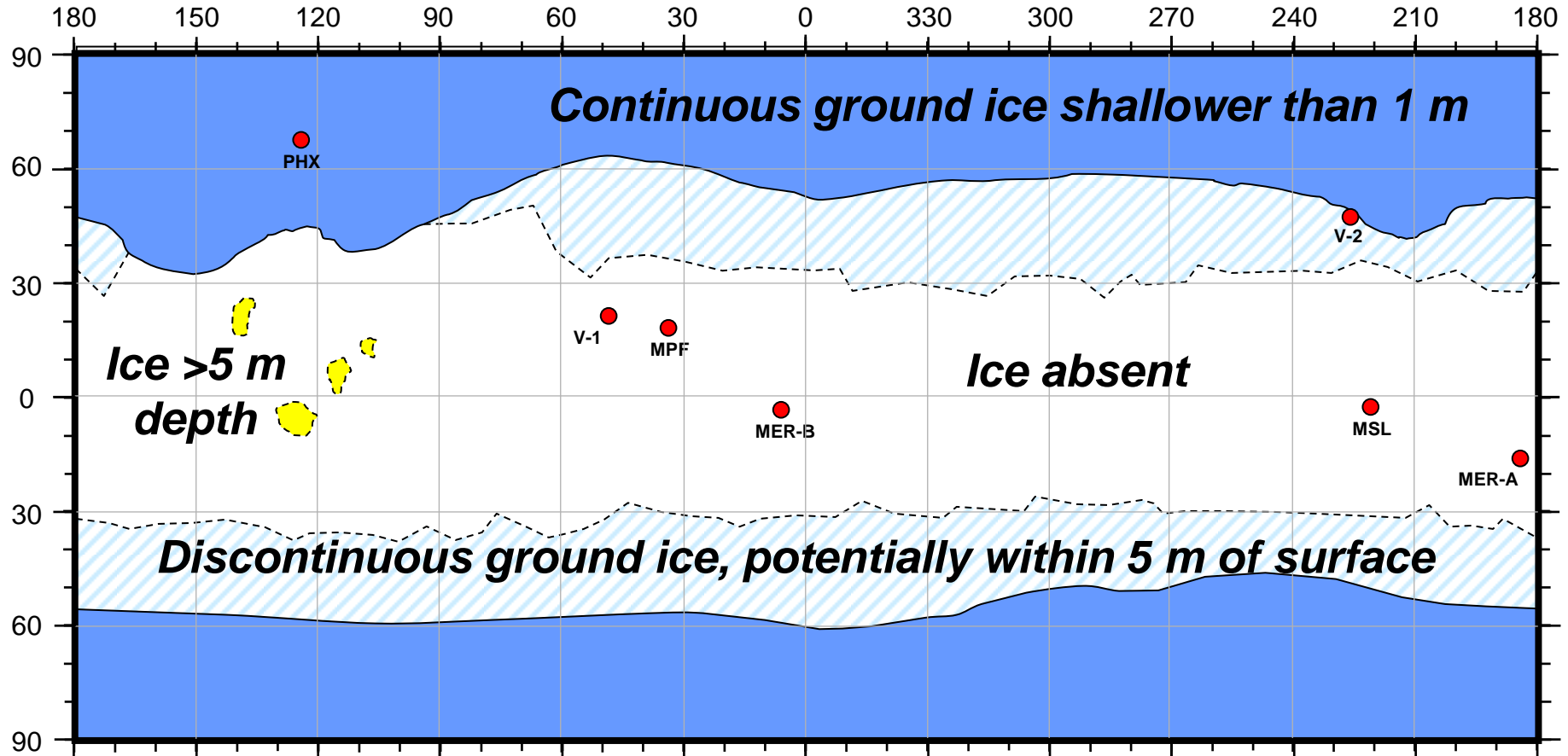
Draft Finding: Phoenix results (TECP and WCL) suggest that perchlorate (Ca^{2+} , Mg^{2+}) liquid brines are possible during specific conditions for a few hours per day. Liquids can form by melting of ice-salts mixtures or direct deliquescence.

Note: Deliquescence need not create a Special Region to have other effects on physical parameters, including water availability, nearby.



Preliminary Interpretive Map of Ice on Mars

Preliminary Analysis: If anybody has additional info, please contact the team



MAP BOUNDARY A. 6 counts/second isopleth from GRS instrument (summer data only) on Mars Odyssey.

MAP BOUNDARY C. Observed equatorward extent of ice-related geomorphic features and mantled terrain.



Selected Topics in Work

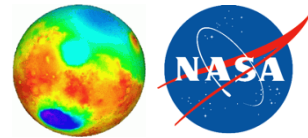
Derived from Phoenix Results and Investigations with Earth Organisms

- Spatial scale issues (remote sensing to microbial environment)
- Asynchronous temperature & humidity cycling within limits
- Limits on microbial use of vapor phase water for reproduction
- Additional parameters for defining Special Regions based on the above
- Extend mapping of identified Special Regions or Uncertain features



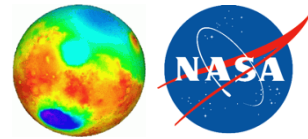
Phoenix struts with droplets

MEPAG and Human Exploration



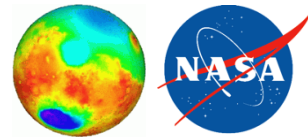
- MEPAG is building collaboration with HEOMD
 - Supported definition of Strategic Knowledge Gaps (SKG) and proposal of possible Gap Filling Activities (GFA) with Mike Wargo's urging.
 - Mike Wargo presented regularly at MEPAG meetings and participated in several SAGs
 - Looking to update Goal IV: Preparations for Humans
- John Connolly, HEOMD, and the MEPAG Executive Committee discussed joint interests
 - HEOMD Exploration Chief Scientist would join the MEPAG Executive Committee
 - MEPAG welcomes suggestions for the (rotating) leads of Goal IV
 - John invited to present at the face-to-face MEPAG meeting in May

Next MEPAG Face-to-face Meeting



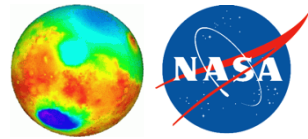
- In Washington DC area, May 13-14
- Agenda:
 - Budget implications
 - Presentations from SMD/PSD/MEP and HEOMD
 - Status of the current NASA Mars Missions
 - Report by the Special Regions (SR2) SAG
 - Landing Site Selection Activities: InSight, ExoMars, 2020 (preview)
- This meeting will be followed, in the same location, by the first of a series of 2020 Landing Site workshops.

Concerns



- Travel Restrictions
 - Conference travel is vital to a healthy science program
 - Foreign travel, in many cases, is a necessity for both project and scientific work
- Role of EPO in NASA is still uncertain despite NASA being a leader in development of inspiration content for STEM programs
- Still a lot of anxiety about the R & A re-organization (see Jonathan Rall presentation)
- Community concerns about potentially tight FY15-16 funding
 - R & A and Data Analysis Programs likely to be impacted.
 - Funding levels for the continuing missions (Curiosity, Odyssey, Opportunity, MEX(US), MRO, LRO, Cassini) will be a challenge.

Bright Spots



-
- Positive steps in R& A: Getting the calls out in ROSES
 - MAVEN (and MOM) are on their way to Mars
 - 2020 Mars Rover mission is moving forward
 - InSIGHT is approaching its Critical Design Review milestone
 - An amazing fleet of Mars craft are working productively at Mars

Active Processes on Mars

Extraordinary Discoveries from Integration of New and Extended Missions

