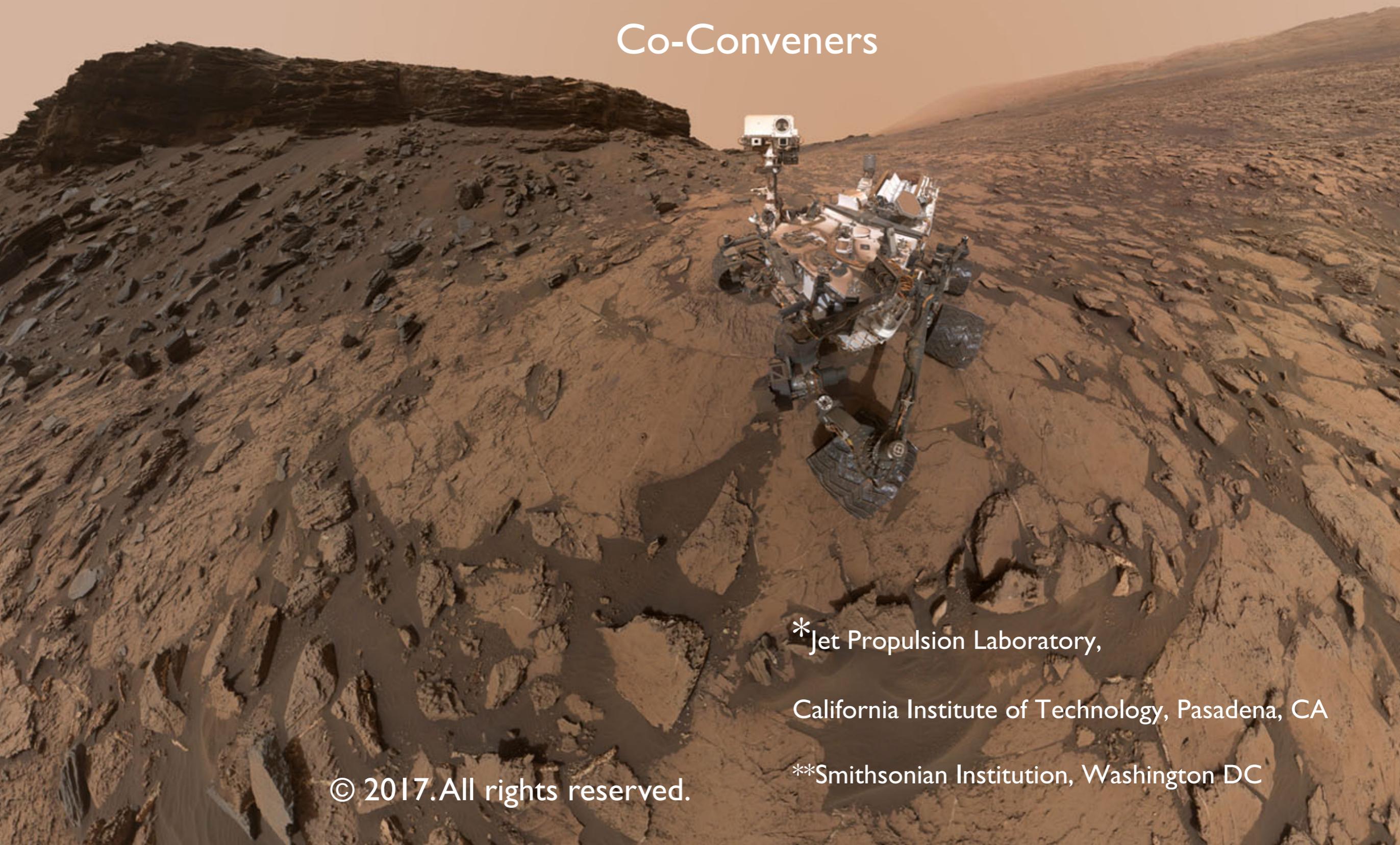


# 3rd Mars 2020 Landing Site Workshop



Matt Golombek\* and John Grant\*\*

Co-Conveners



\*Jet Propulsion Laboratory,

California Institute of Technology, Pasadena, CA

\*\*Smithsonian Institution, Washington DC

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# Guiding Principles:

- Landing site selection is critical to all aspects of 2020 mission and program success (no landing, no science)
- Final site recommendation, selection and approval is the job of the Project, 2020 Science Team, and NASA HQ, respectively.
- ***The broad expertise of the science community is crucial to the identification and assessment of optimal sites.***
- Process is open to all and has no predetermined outcome

# Participants in 2020 Landing Site Selection:

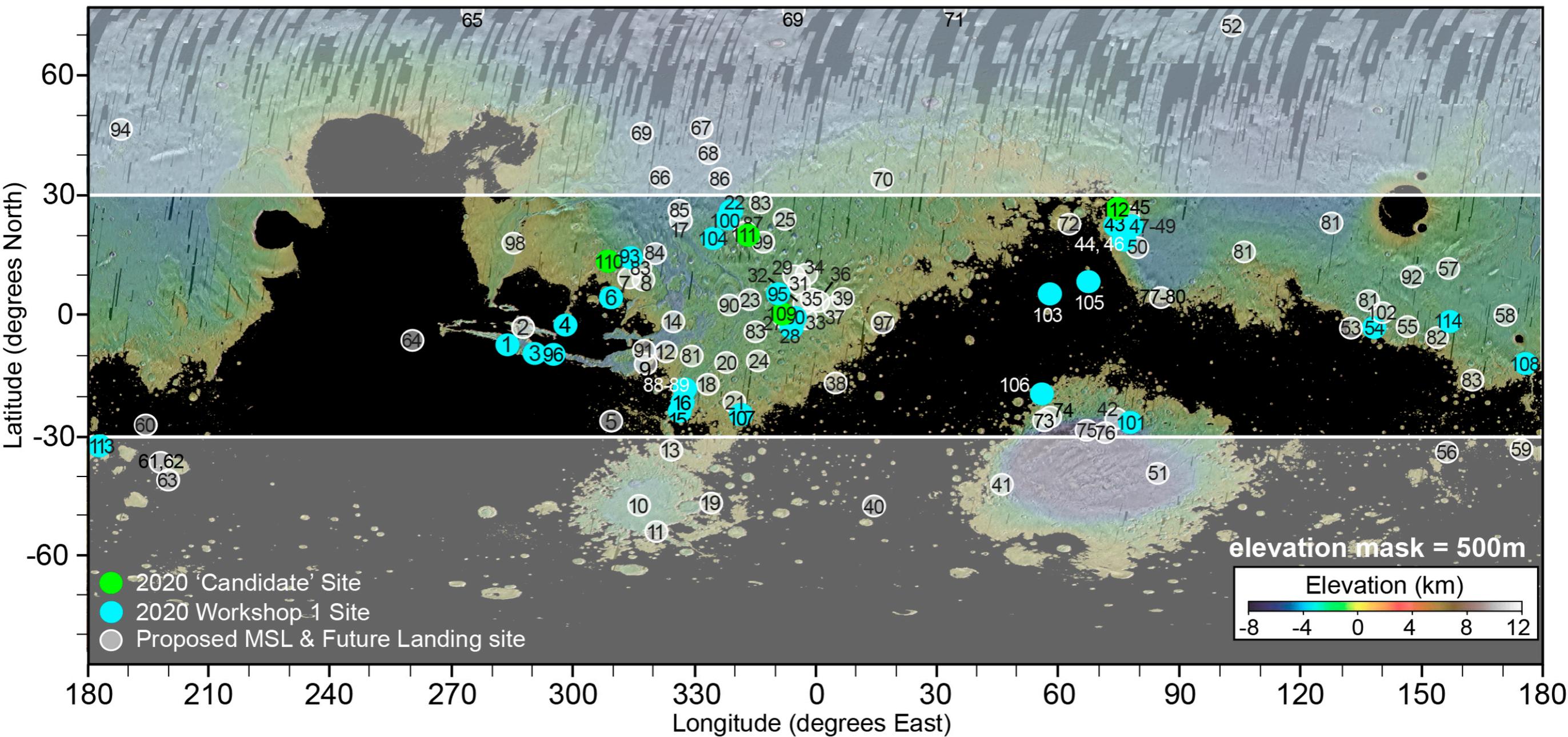
- **Science Community Input**  
Broad e-mail distribution, Workshop Attendance, Websites
- **Additional Members**  
Blend Experience and Mission Involvement  
Provides for Feed-back on Process
- **NASA-Appointed Landing Site Steering Committee**  
Co-chairs Grant and Golombek  
Other Members Appointed by NASA HQ  
Dave Des Marais, Brad Jolliff, Scott McLennan,  
John Mustard, Steve Ruff, Ken Tanaka
- **Mars Characterization Investigators** (MDAP, MFRP, CDP)  
Insight into Landing Site Science and Safety
- **2020 Science Team and Project:**  
Science Team helps identify and evaluate merits of sites  
Landing Site Working Group & Returned Sample Science Board  
Engineering teams define the engineering constraints and help analyze aspects of the surface and atmospheric environments.  
Project management and the PSG review scientific analyses of sites.
- **Headquarters and Other Ex-Officios**  
Ensures broad, relevant MEP participation  
Access to Ongoing Mission Data  
Planetary Protection Compliance
- **All Landing Site Selection Activities Documented at:**  
<http://marsnext.jpl.nasa.gov/>



Towards  
Site  
Selection

# Candidate Landing Sites on Mars: ~130 Locations

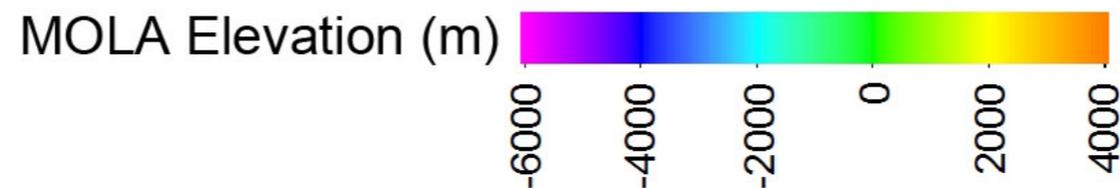
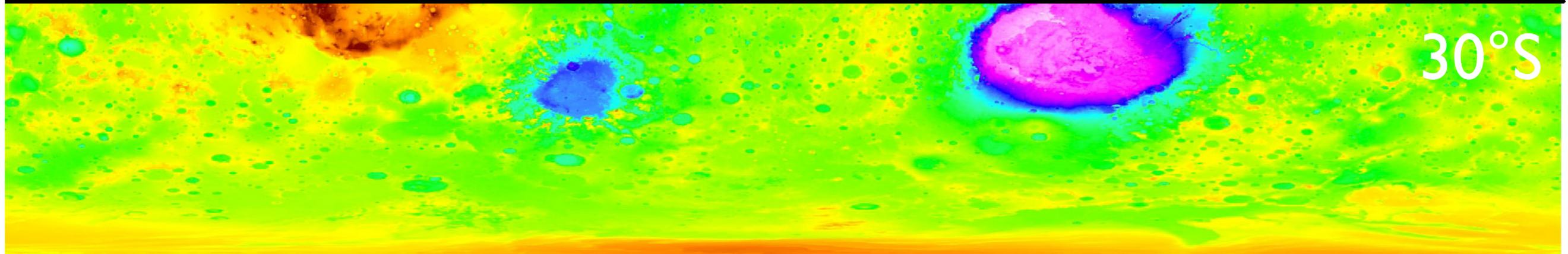
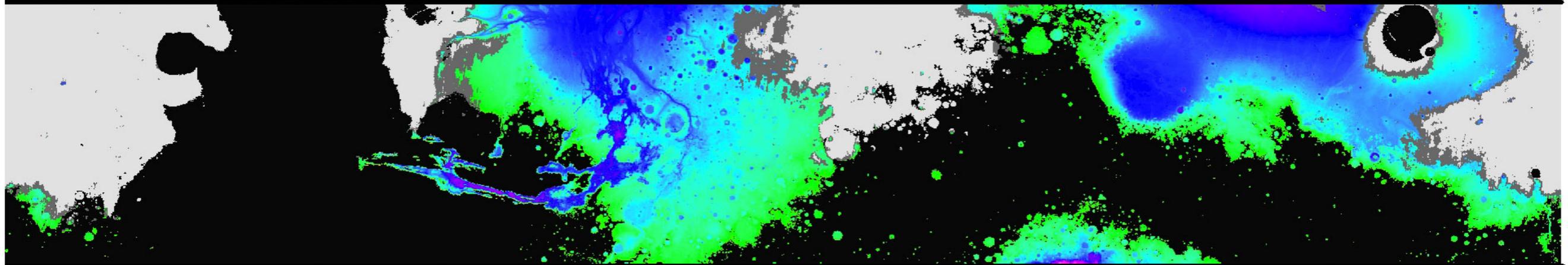
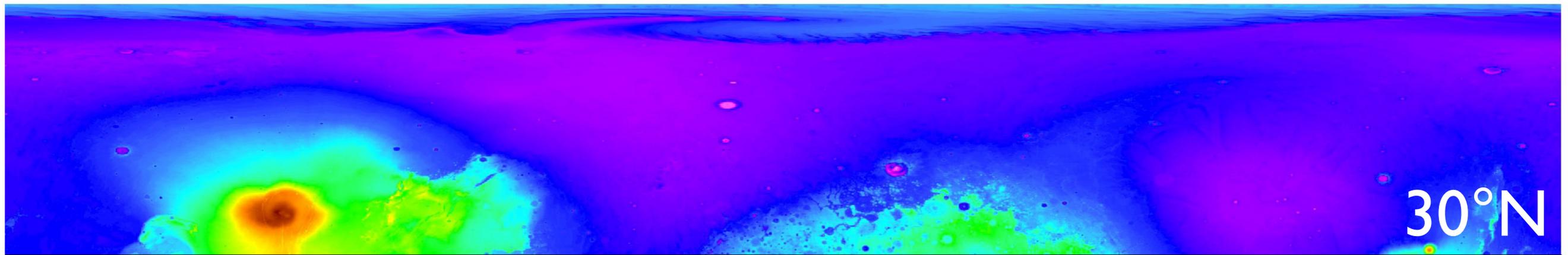
MER, MSL, 2020, MSR, Future



# Where 2020 Can Land:

## Elevation/Lat. Mask with Values of TES Thermal Inertia

- < 150 = dark gray (Christensen et al. 2001)
- < 100 = light gray

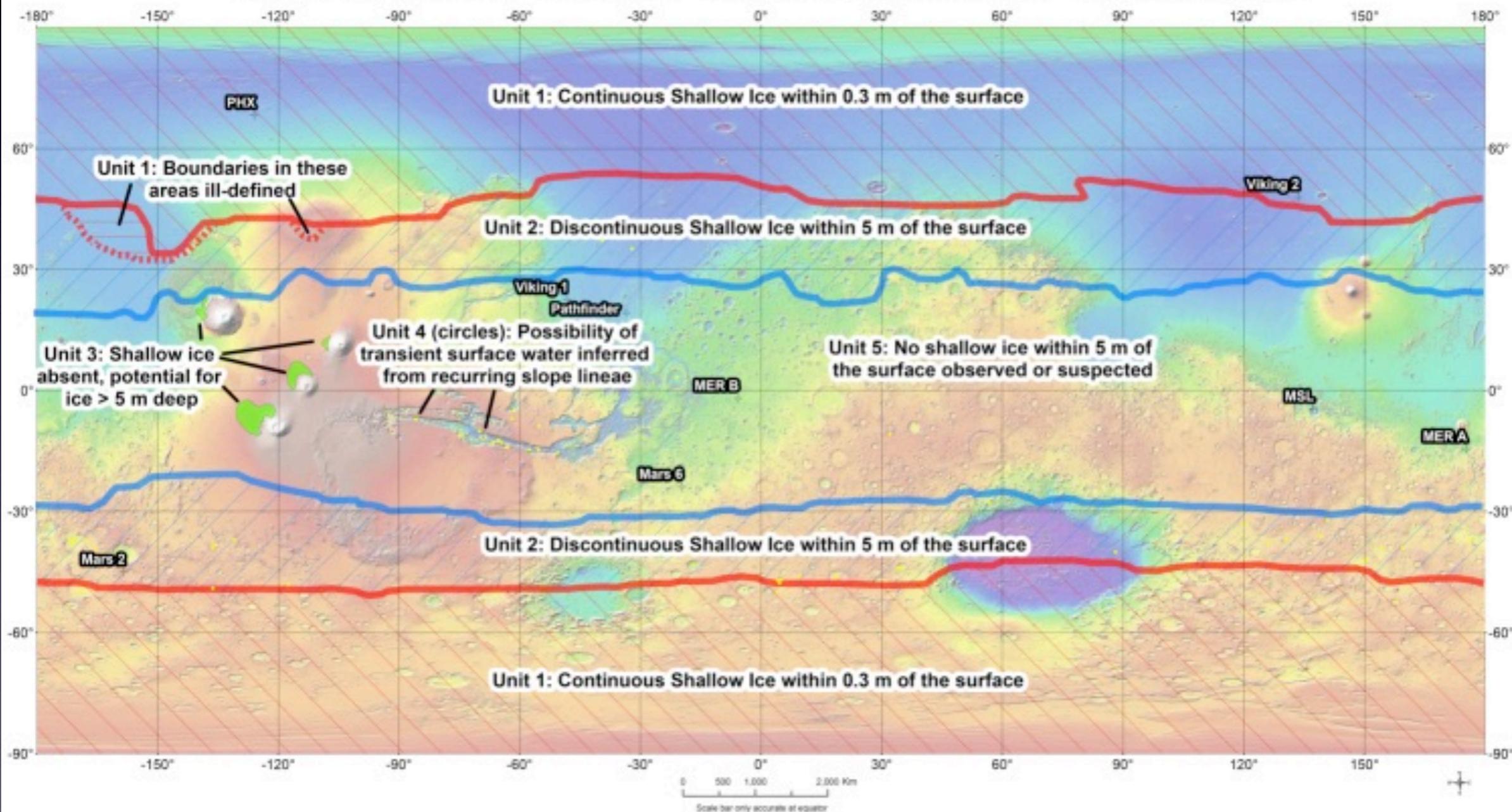


# Planetary Protection Considerations:

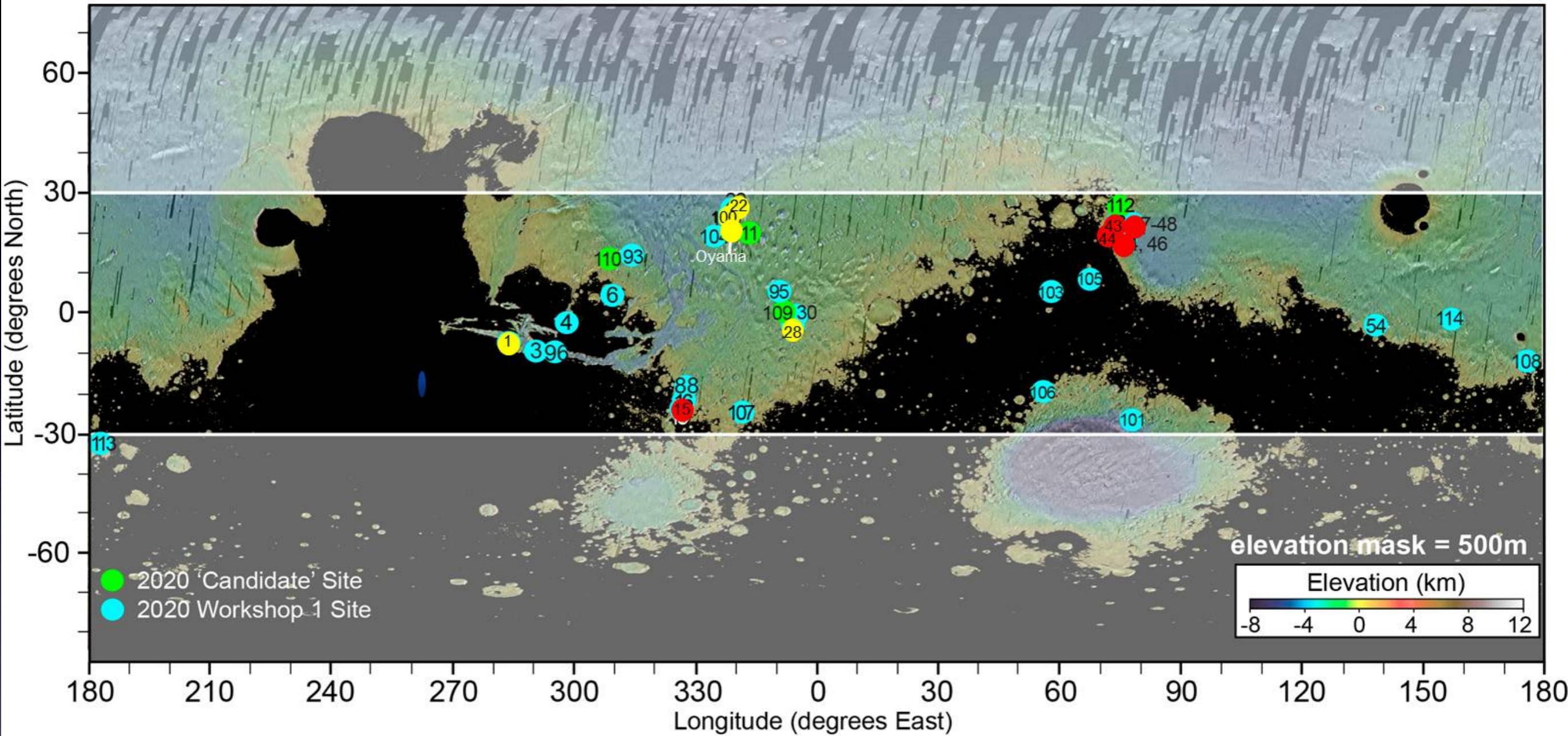


## Interpretive Map of Ice and Potential Transient Surface Water on Mars

Map of Features of Relevance to Interpreting Special Regions on Mars



# 2020 Candidate Sites at the First Workshop:



- Top 1-5
- Top 6-10

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

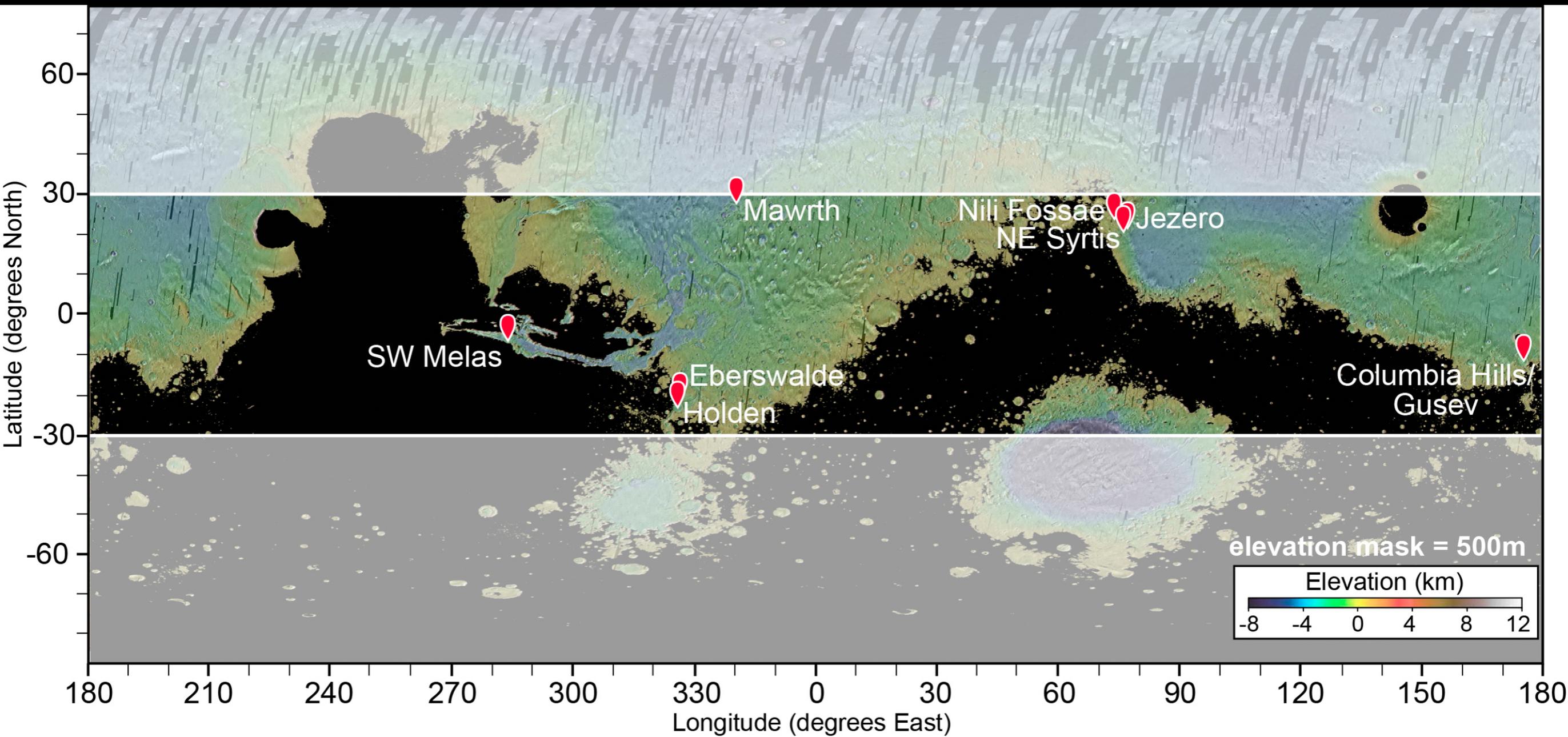
- |                                                                                           |                                                                                                      |
|-------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Dot 100: McLaughlin Crater (Michalski, J. et al.)                                         | Dot 16: Eberswalde Crater (Irwin, R. P., III)                                                        |
| Dot 103: Leighton Crater (Michalski, J. et al.)                                           | Dot 46: Jezero Crater (Gupta, S., et al. and Ehlmann, B. L., et al.)                                 |
| Dot 22: Mawrth Vallis (Loizeau, D. et al.)                                                | Dot 88: Ladon Valles (Weitz, C., et al.)                                                             |
| Dot 104: Oxia Planum (Thollot, P., et al.)                                                | Dot 93: Sabrina Vallis (Platz, T., et al.)                                                           |
| Dot 43: Nili Fossae Trough (Mustard, J. F., et al.)                                       | Dot 113: Eridania Basin (Noe Dobrea, E. Z., et al.)                                                  |
| Dot 48: Nili Fossae Carbonates (Ehlmann, B., et al.)                                      | Dot 107: Kashira crater (Edgett et al.) (2020 Candidate Site from M. R. Salvatore)                   |
| Dot 44: NE Syrtis Major (Mustard, J. F., et al.)                                          | Dot 28: Eastern Margaritifer Terra (Christensen, P., et al.)                                         |
| Dot 105: Nili Patera (Skok, J. R., et al.) (2020 Candidate Site from Skok, J. R., et al.) | Dot 101: Hadriacus Palus (Skinner, J. A., et al.)                                                    |
| Dot 106: Hellas (Noe Dobrea, E. Z., et al.)                                               | Dot 95: Firsoff Crater (Pondrelli, M., et al.) (2020 Candidate Site from Pondrelli et al.)           |
| Dot 3: Melas Chasma (Miyamoto et al.) (2020 Candidate Site from S. M. R. Turner, et al.)  | Dot 108: Gusev Crater (Ruff, S. W. et al.; Longo, A.; Rice, J.) (2020 Cand. Site from Cabrol et al.) |
| Dot 4: Juventae Chasma (Miyamoto et al.)                                                  | Dot 54: Gale Crater (Grant, J.)                                                                      |
| Dot 1: Melas Basin (Williams, R. M. E., et al.)                                           | Dot 30: Meridiani Planum (M. Golombek)                                                               |
| Dot 96: Coprates Chasma (Quantin, C., et al.)                                             | Dot 15: Holden Crater (Irwin, R.)                                                                    |
| Dot 6: Hypanis delta in Xanthe Terra (Gupta, S., et al.)                                  | 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.)
- Dot 112: Nilosyrtis crater (Saper, L)

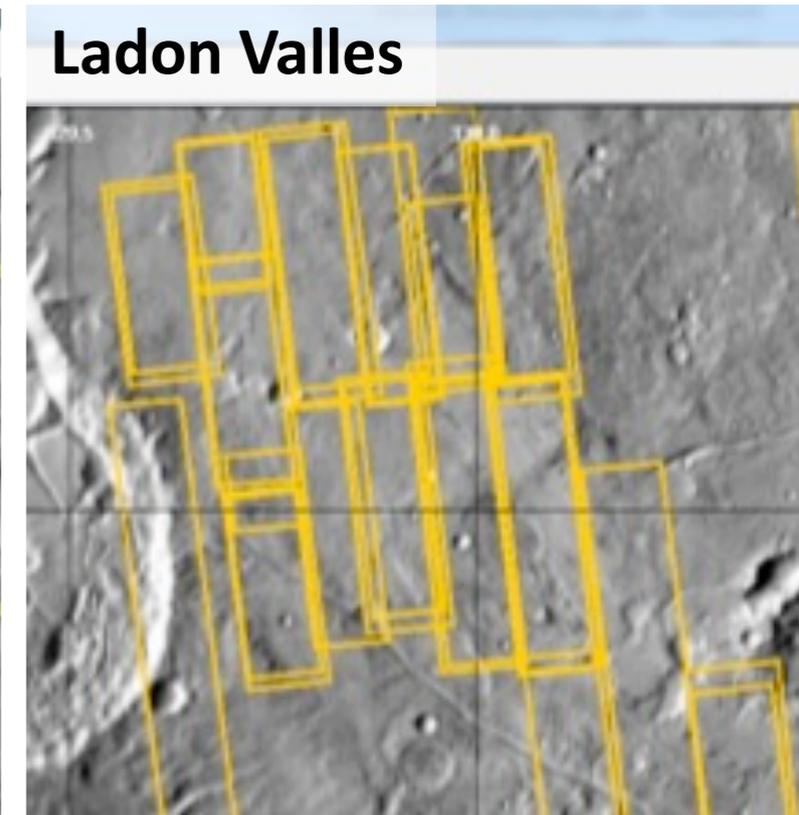
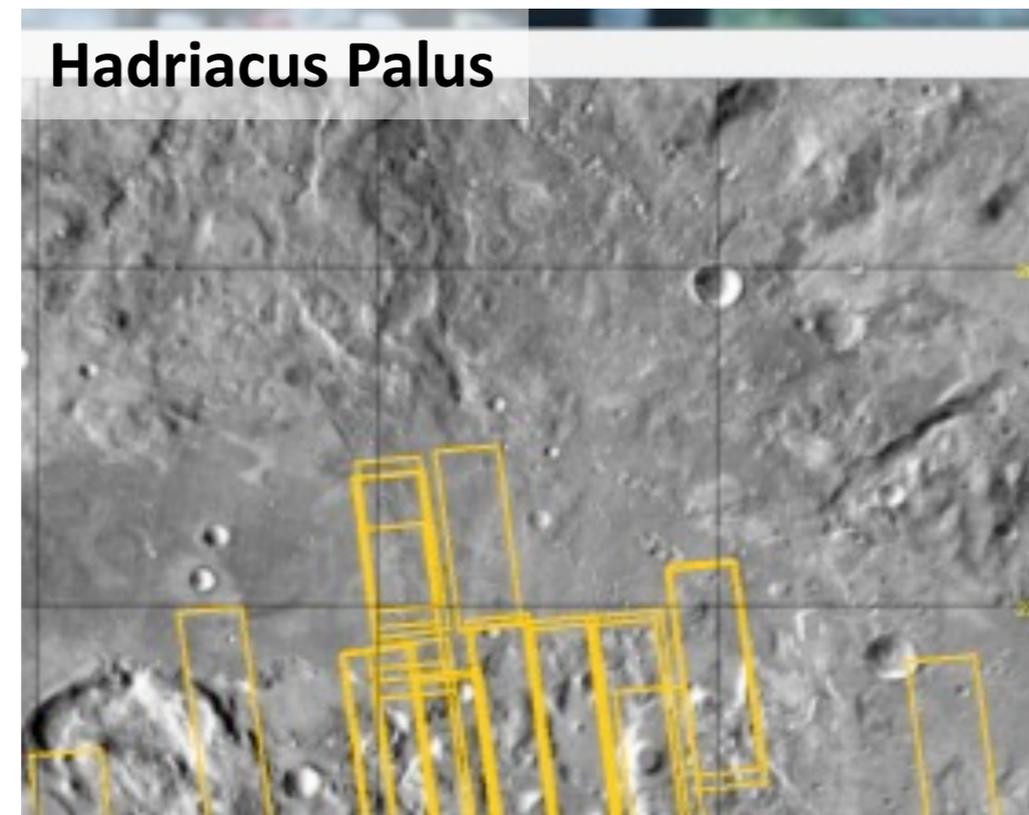
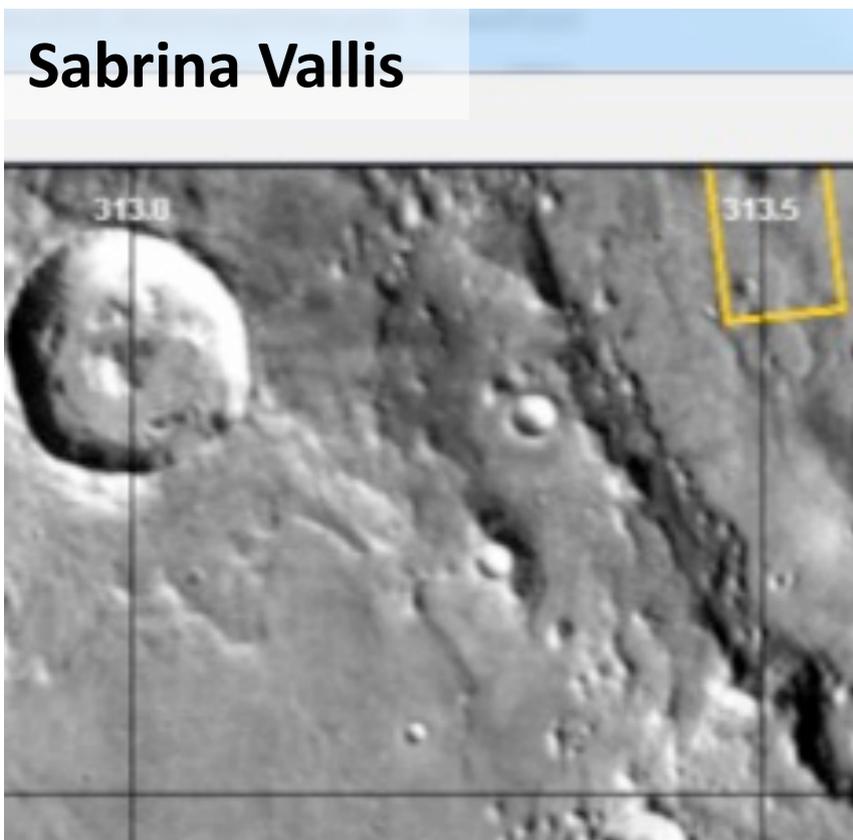
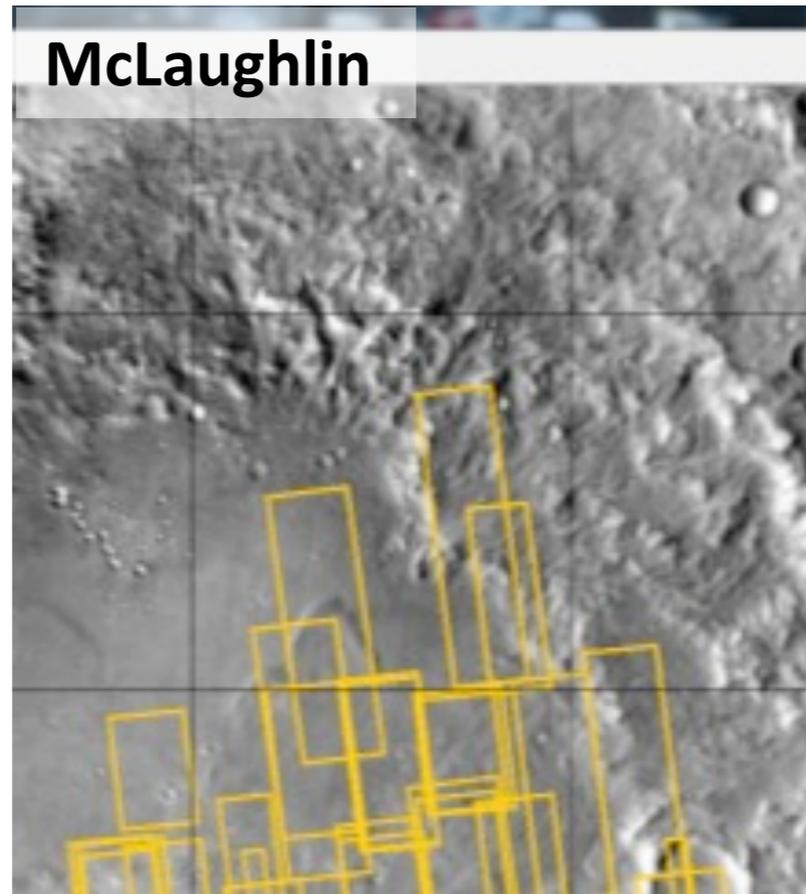
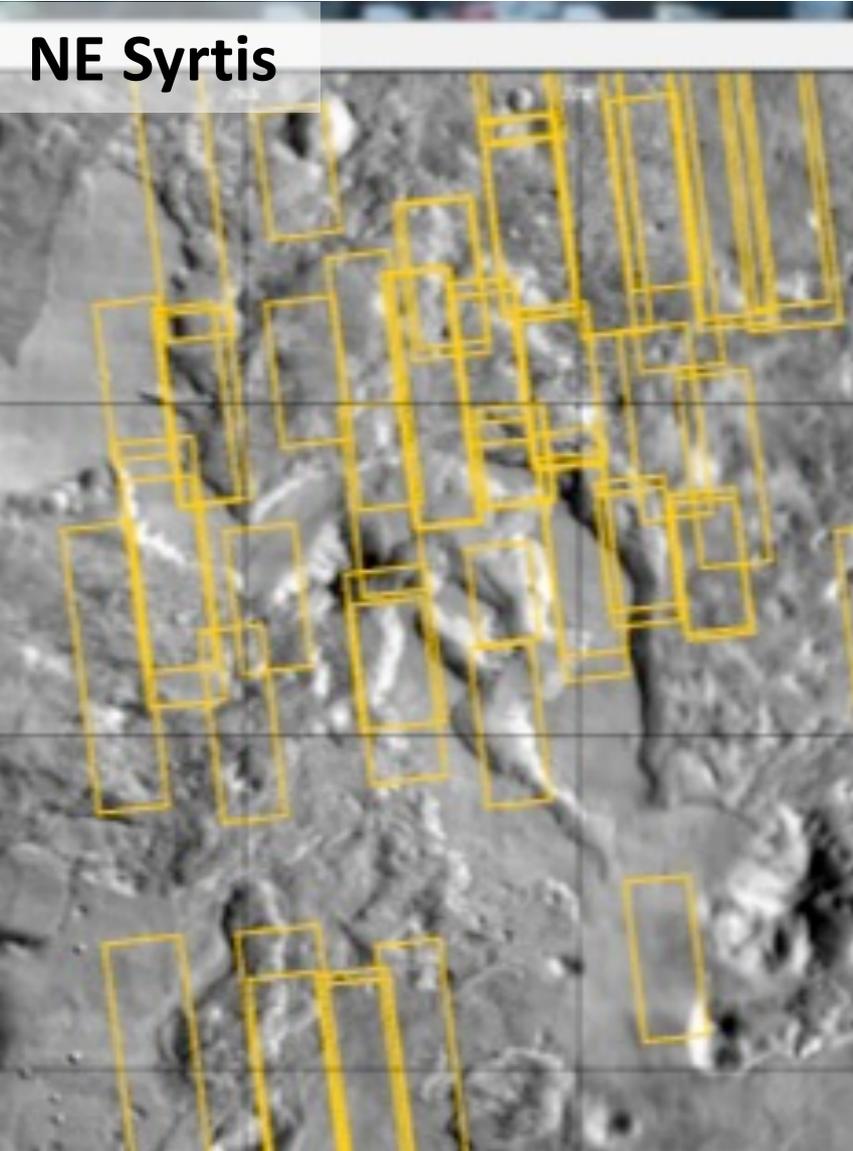
~30 Sites

# Eight Candidate Sites After the Second Workshop:



Landing Site	Latitude (°N)	Longitude (°E)	Approx. Elev. (km)
Columbia Hills/Gusev crater	-14.4	175.6	-1.94
Eberswalde crater	-23.0	327.0	-1.4
Holden crater	-26.4	325.1	-2.2
Jezero crater	18.5	77.4	-2.0
Mawrth Vallis	24	341.1	-2.3
NE Syrtis Major	17.8	77.1	-2.0
Nili Fossae trough (N)	21.0	74.5	0.6
SW Melas Chasma	-12.2	290	-5.0

# HiRISE Coverage for Select Landing Sites



# Mars 2020

As of February 16, 2017

## Pre-Workshop 1 (December 2013):

9 sites, 28 targets, 52 Images Requested, 51 complete (98% complete)

## After Workshop 1 (June, 2014 - April, 2015):

18 sites, 58 targets, 90 Images Requested, 89 complete (99% Complete)

## After Workshop 2 (August, 2015 – present):

9 sites, 27 targets, 52 Images Requested, 49 complete (94% Complete)\*

\*since LTM JPL requested stereo pairs for several sites,  
and J. Michalski (McLaughlin) and S. Gupta (Hypanis) also made requests

	Stereo 1	Stereo 2	Stereo 1 and 2
Released/ Acquired	106	83	189 (21 since LTM)
Suggested/ Remaining	1	4	5
Total	107	87	194

# Basis for 2020 Site Selection:

- Site Must Meet **All** Engineering Requirements

## Engineering Summary - From Al Chen



Jet Propulsion Laboratory  
California Institute of Technology

Mars 2020 Project

Site	EDL	Surface	Comments
Columbia Hills	Green	Green	
Eberswalde	Green	Green	
Holden	Green	Yellow	Likely to exceed the prime mission duration to accomplish science objectives
<u>Jezero</u>	Green	Green	
<u>Mawrth</u>	Green	Green	
NE <u>Syrtis</u>	Green	Green	
<u>Nili Fossae</u>	Green	Green	
SW <u>Melas</u>	Yellow	Green	Lack of confidence in atmosphere modeling results coupled with significant terrain hazards bordering the landing ellipse raise concerns

*All candidate landing sites are viable; however, have some engineering concerns with Holden and SW Melas*

# Basis for 2020 Site Selection:

- Focus on Workshop is Assessment of Science Merit
- Selected Sites Are Best Suited to Achieving 2020 Mission Science Objectives:
  - ✓ Astrobiologically Relevant Environment
  - ✓ Preserve Information to Understand Geological Record – Including Habitability and Preservation Potential
  - ✓ Preserve Materials Preserve Potential Biosignatures
  - ✓ Assemble Sample Cache – Include Igneous Rocks
  - ✓ Consistent with “Technology” Elements
- Vote on criteria that relate to these objectives and comprise the mission science goals

# 3<sup>rd</sup> Workshop

- February 8-10, 2017 2.5 days, Monrovia
- ~240 on First Day, ~200 on next two days
- Sessions
- Overview Science and Biosignatures and Broad Approaches to Site Selection
- Nili Fossae, Jezero
- Holden, Eberswalde
- NE Syrtis, Columbia Hills
- Mawrth, SW Melas
- Discussion
- Vote on criteria

# 3<sup>rd</sup> Workshop Scientific Selection Criteria:

## Criterion 1:

The site is an astrobiologically-relevant ancient environment and has geologic diversity that has the potential to yield fundamental scientific discoveries when it is a) characterized for the processes that formed and modified the geologic record; and b) subjected to astrobiologically-relevant investigations (e.g., assessment of habitability and biosignature preservation potential). (scoring: 1=lowest potential, 5=highest potential)

## Criterion 2:

A rigorously documented and returnable cache of rock and regolith samples assembled at this site has the potential to yield fundamental scientific discoveries if returned to Earth in the future. (scoring: 1=lowest potential, 5=highest potential)

## Criterion 3:

There is high confidence in the assumptions, evidence, and any interpretive models that support the assessments for Criteria 1 and 2 for this site. (scoring: 1=lowest confidence, 5=highest confidence).

## Criterion 4:

There is high confidence that the highest-science-value regions of interest at the site can be adequately investigated in pursuit of Criteria 1 and 2 within the prime mission. (scoring: 1=lowest confidence, 5=highest confidence).

## Criterion 5:

The site has high potential for significant water resources that may be of use for future exploration—whether in the form of water-rich hydrated minerals, ice/ice regolith or subsurface ice. (scoring: 1=lowest potential, 5=highest potential)

# Community Evaluation:

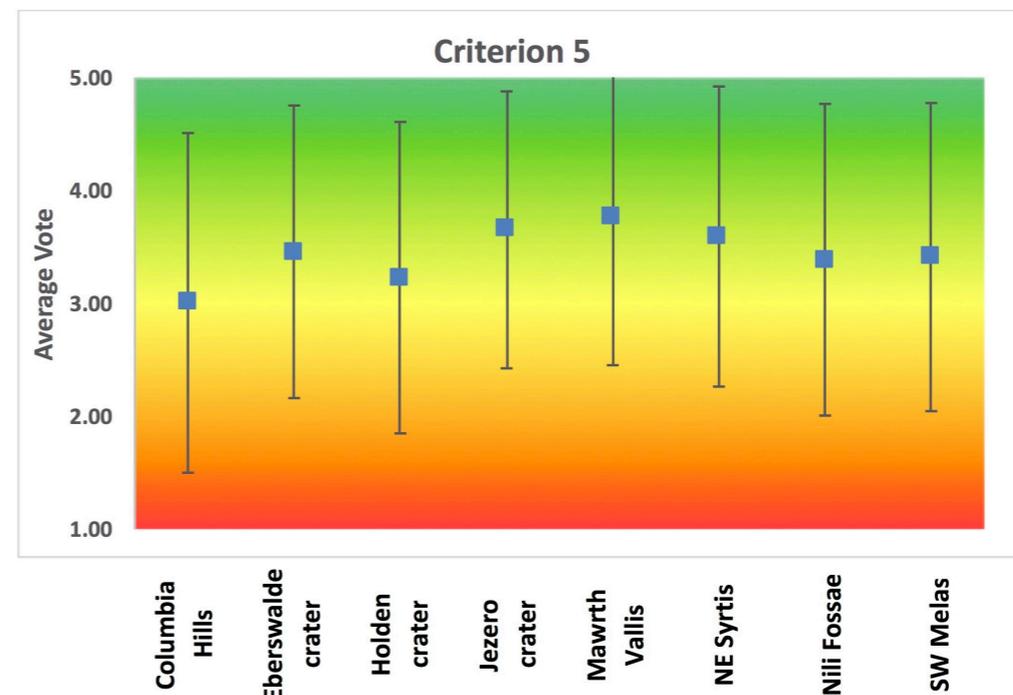
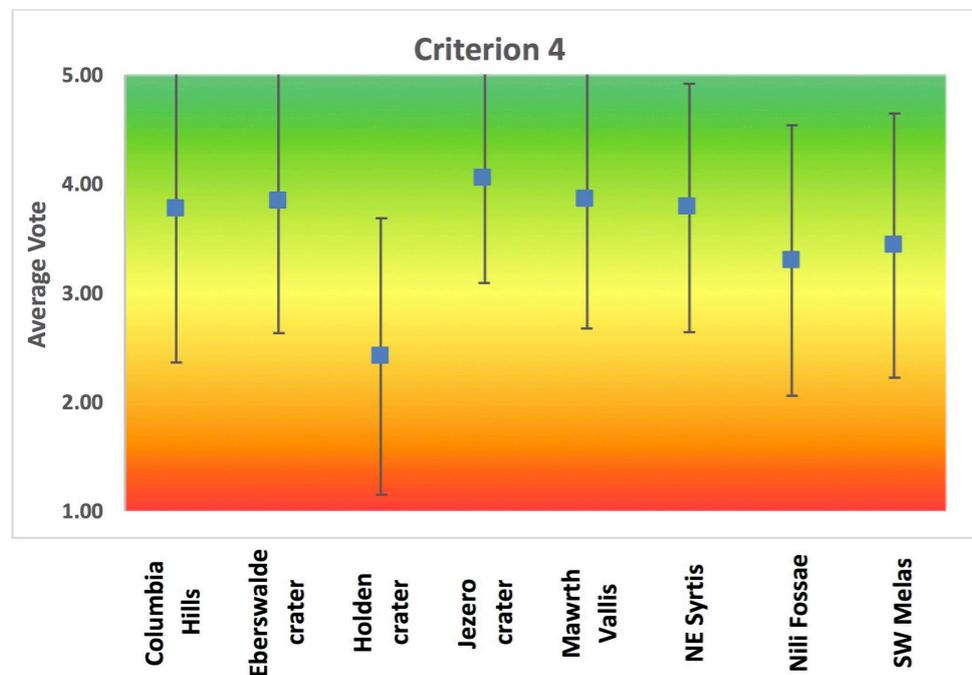
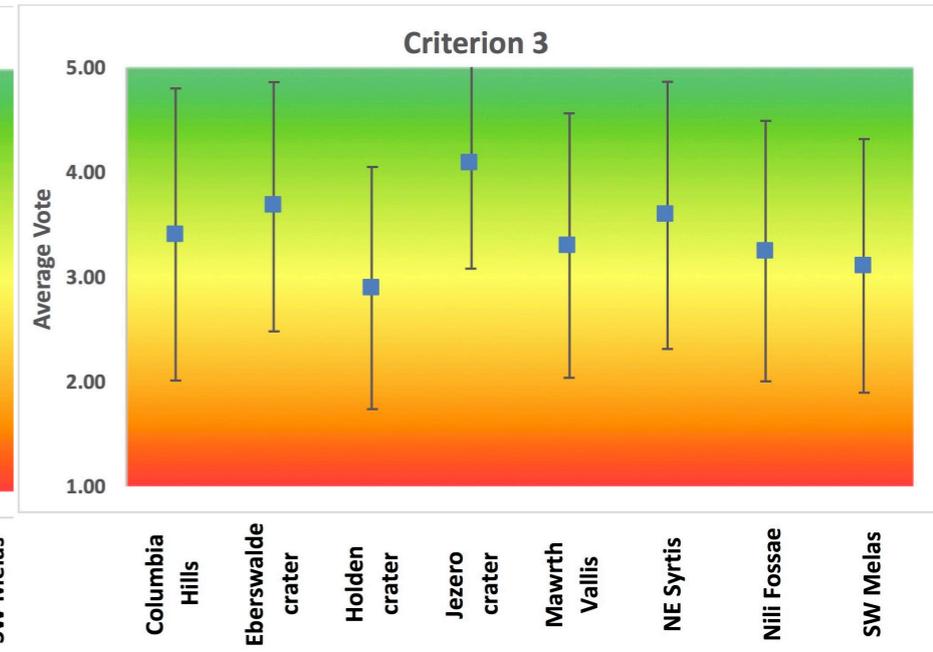
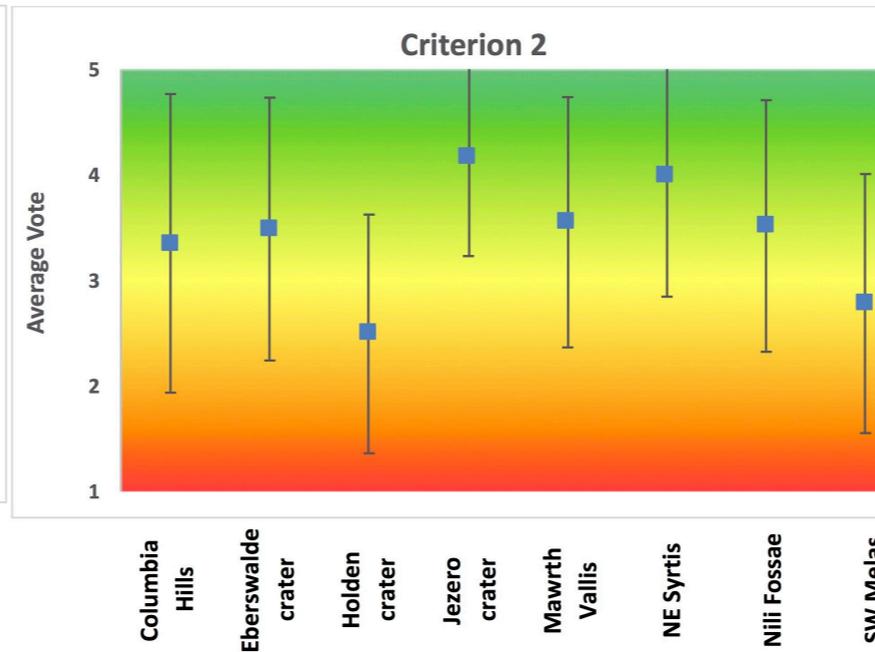
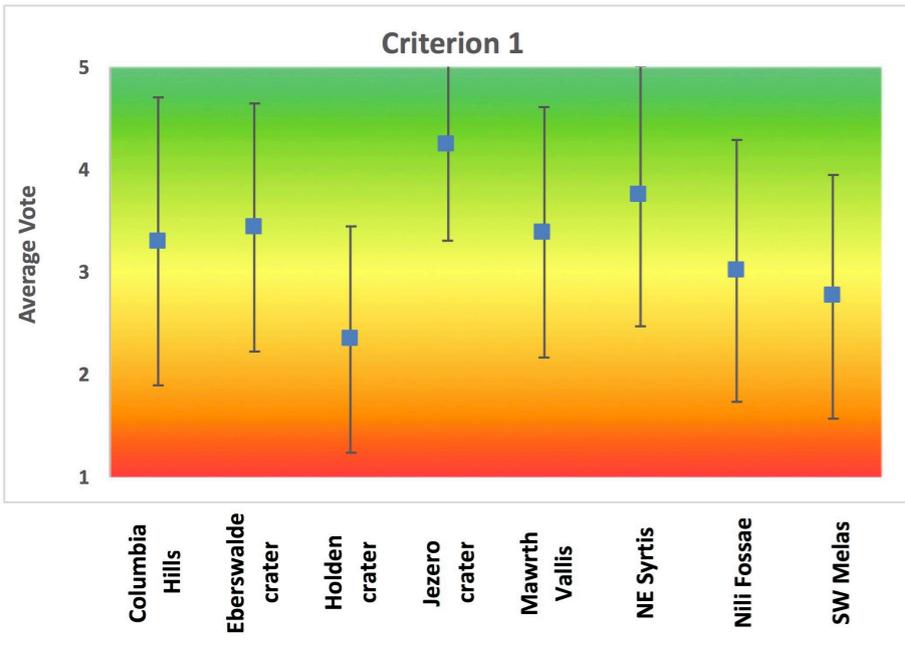
- Science community assesses the merits of the 8 candidate sites.
- Workshop attendees voted on 5 criteria
  - Used Online Voting for those in attendance – More expedient and private
- Provide a list of top 3-4 sites to Project for further consideration:
  - Rank the candidate sites as green, yellow, red based relative to science selection criteria
  - **Green** = 5 points, **Yellow** = 3 points, **Red** = 1 point
  - Each person votes on each criteria for each site
  - Similar to what was done for MER and MSL and prior 2020 workshops
  - Results comprise science input to the merits of the candidate sites
- Additional factors influence identification of 3-4 remaining sites:
  - Engineer criteria (EDL and operations constraints), Planetary Protection, etc
- The list of sites emerging from the workshop may be different from that prioritized by the Project:
  - Engineers and Science Teams are here and participating and will vote
  - They will hear the same results and interpretations that we do
  - The Project and Mars Landing Site Steering Committee met after the workshop

# Voting Results

## Bio Rel Geo Div

## Ret Samples

## Hi Conf

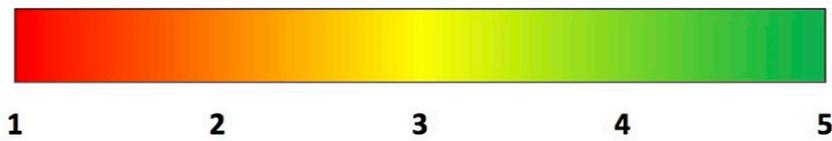


## ROI Nom Mission

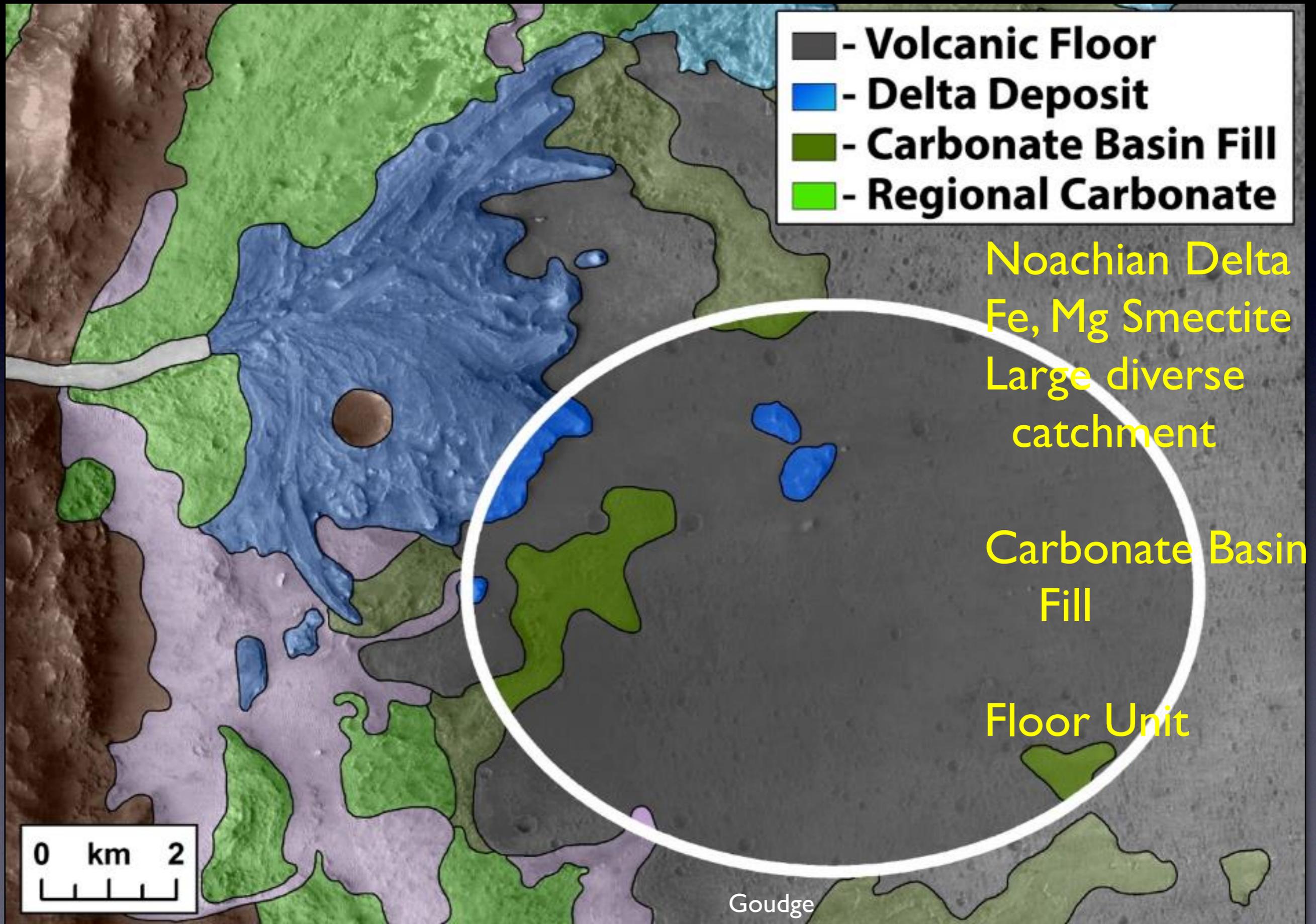
## Water Resources

# Voting Results

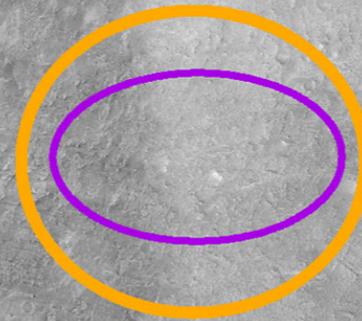
Average Vote	Columbia Hills	Eberswalde crater	Holden crater	Jezero crater	Mawrth Vallis	NE Syrtis	Nili Fossae	SW Melas
Criterion 1	3.3	3.4	2.3	4.2	3.4	3.7	3.0	2.8
Criterion 2	3.4	3.5	2.5	4.2	3.6	4.0	3.5	2.8
Criterion 3	3.4	3.7	2.9	4.1	3.3	3.6	3.5	3.1
Criterion 4	3.8	3.9	2.4	4.0	3.9	3.8	3.3	3.4
Criterion 5	3.0	3.5	3.2	3.7	3.8	3.6	3.4	3.4



# Jezero Crater



Early-Middle Noachian basement  
4 Distinct Aqueous Environments  
Carbonate, Megabreccia, Al-philosilicate



*13.3 x 7.8 km  
ellipse*

Hesperian, Syrtis Basalt  
Underlying Sulfate

Northeast Syrtis Major  
CTX mosaic

10 km

Mustard, Ehlmann



# 2020 Landing Site Selection Timeline

4-5 Workshops, 4-5 Years, Possible Selection L-2 or L-1 yr

Date	Title	Comments/Description	# of Sites
7/13	SDT report	<ul style="list-style-type: none"><li>• Preliminary engineering constraints</li></ul>	
5/14	LSW 1	<ul style="list-style-type: none"><li>• Sites prioritized into thirds by science merit</li><li>• Top 3<sup>rd</sup> to be characterized for safety and TRN need by LSW 2</li></ul>	~28
6/15	LSW 2	<ul style="list-style-type: none"><li>• Identify 8 selectable sites</li><li>- Are there enough non-TRN sites of sufficient science merit?</li><li>- If not, is TRN required? Define TRN attributes needed</li></ul>	8
2/17	LSW 3	<ul style="list-style-type: none"><li>• ~Middle of Phase C</li></ul>	3-4
~8/18	LSW 4	<ul style="list-style-type: none"><li>• Final planned workshop</li></ul>	1-2
TBD	Site selection	<ul style="list-style-type: none"><li>• Decision dependent on number of high priority sites, clustering of sites, programmatic factors</li></ul>	
7/20	Launch		