3rd Mars 2020 Landing Site Workshop

Matt Golombek* and John Grant**

Co-Conveners

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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

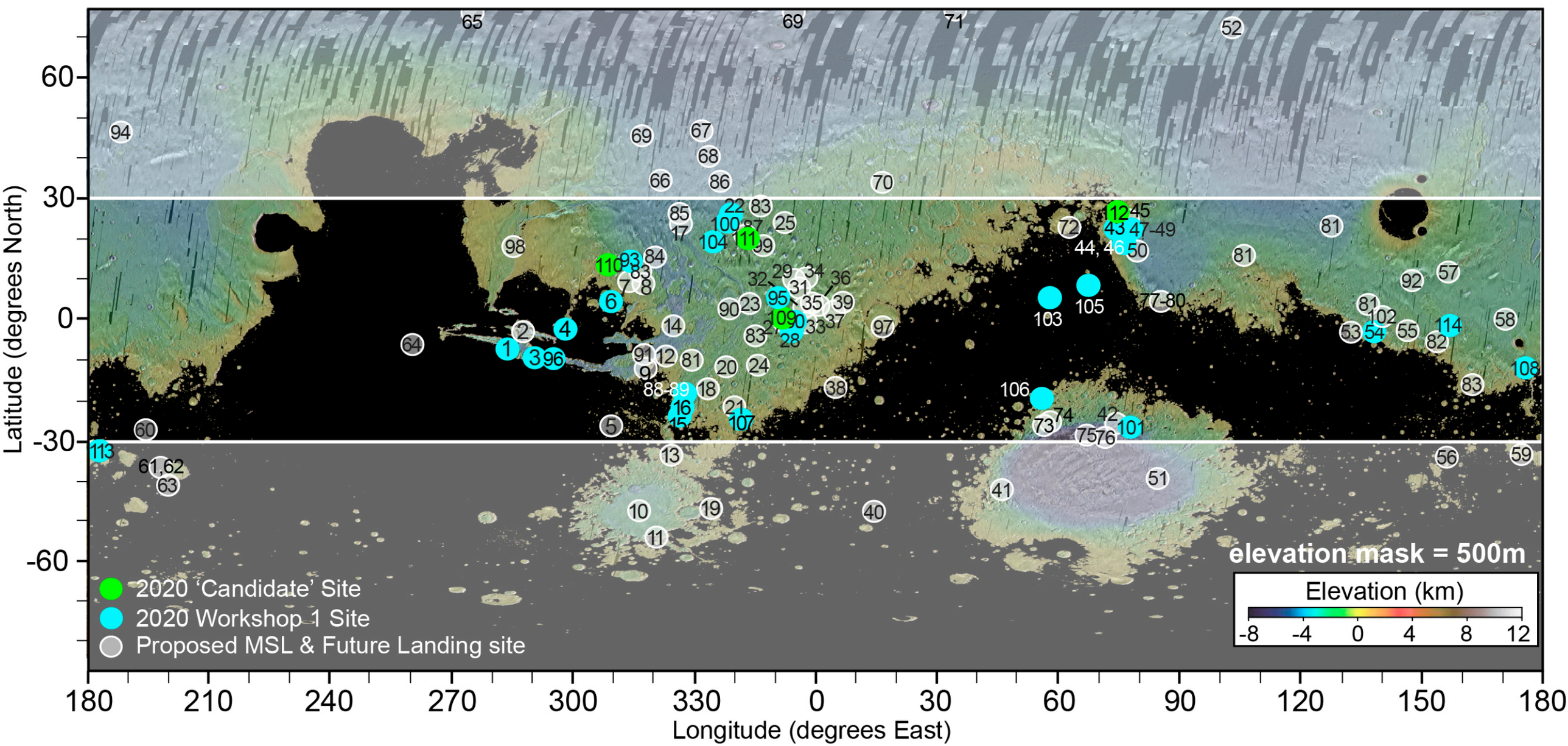
Participants in 2020 Landing Site Selection:

- **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/

Candidate Landing Sites on Mars: ~130 Locations

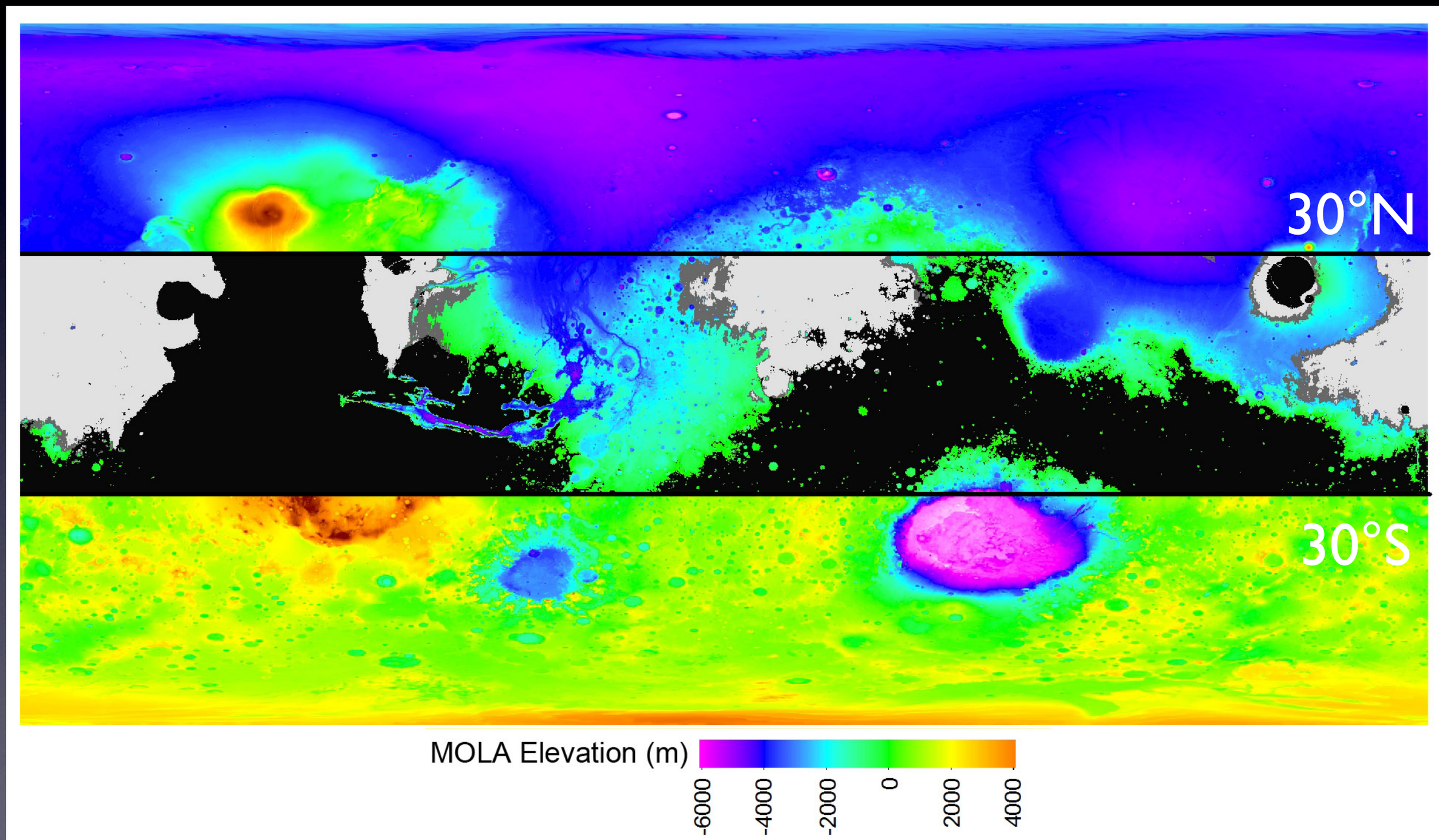
MER, MSL, 2020, MSR, Future



Where 2020 Can Land:

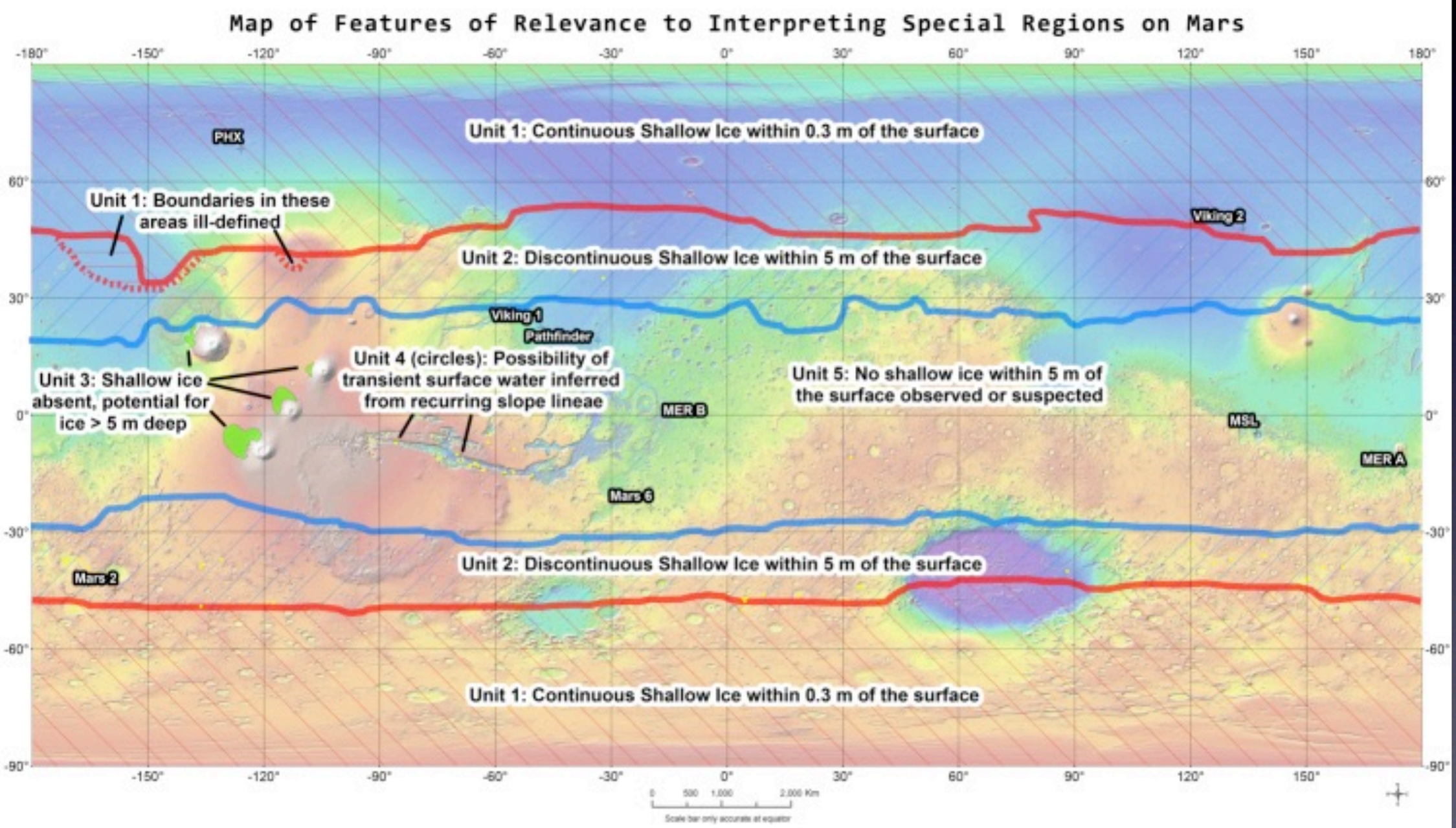
Elevation/Lat. Mask with Values of TES Thermal Inertia

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

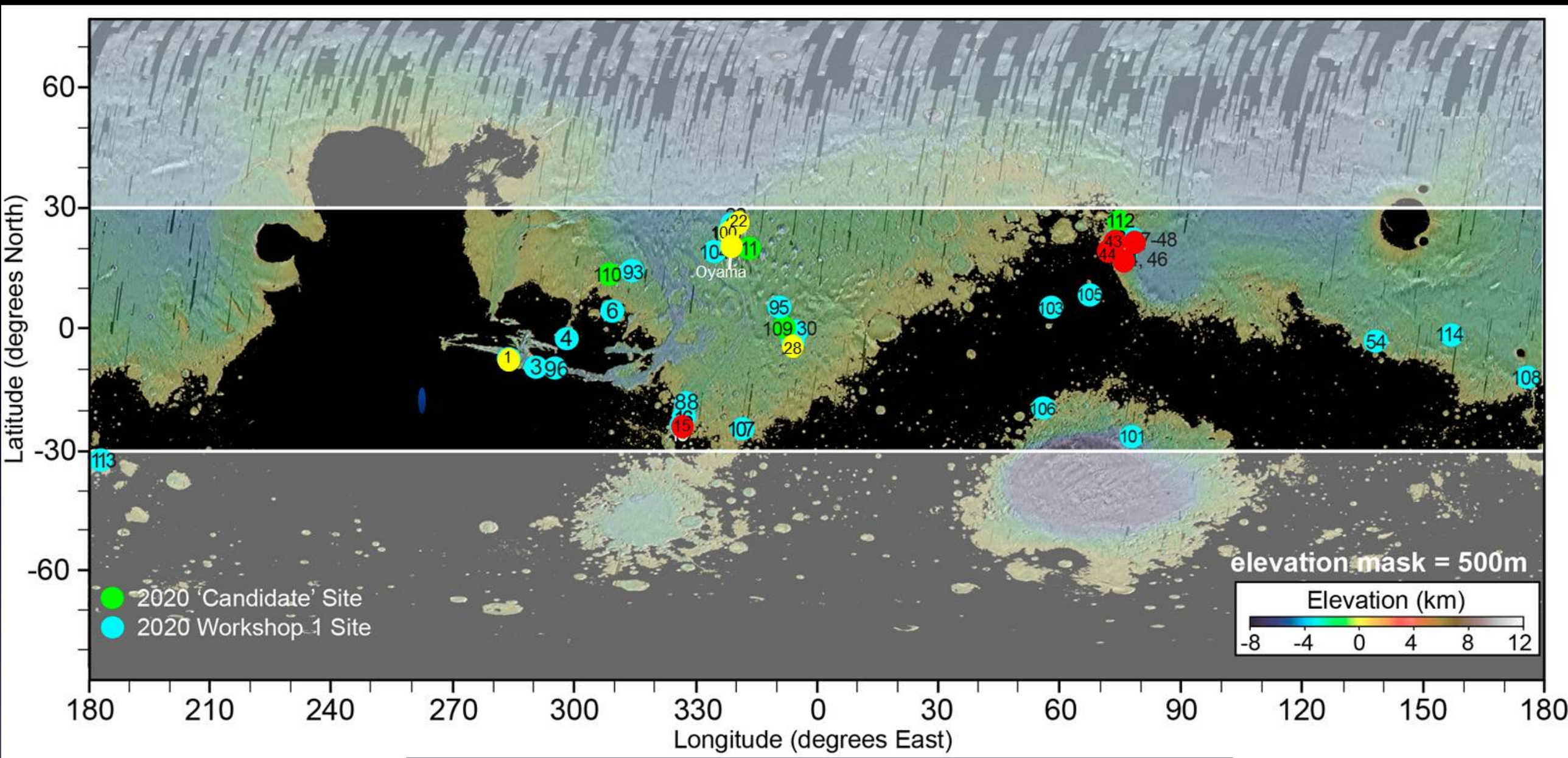


Planetary Protection Considerations:

Interpretive Map of Ice and Potential Transient Surface Water on Mars



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 103: Leighton Crater (Michalski, J. et al.)
Dot 22: Mawrth Vallis (Loizeau, D. et al.)
Dot 104: Oxia Planum (Thollot, 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 (NoeDobrea, 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 Vallis (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 30: Meridiani Planum (M. Golombek)
Dot 15: Holden Crater (Irwin, R.)
Dot 114: Aeolis (Yakovlev, V)

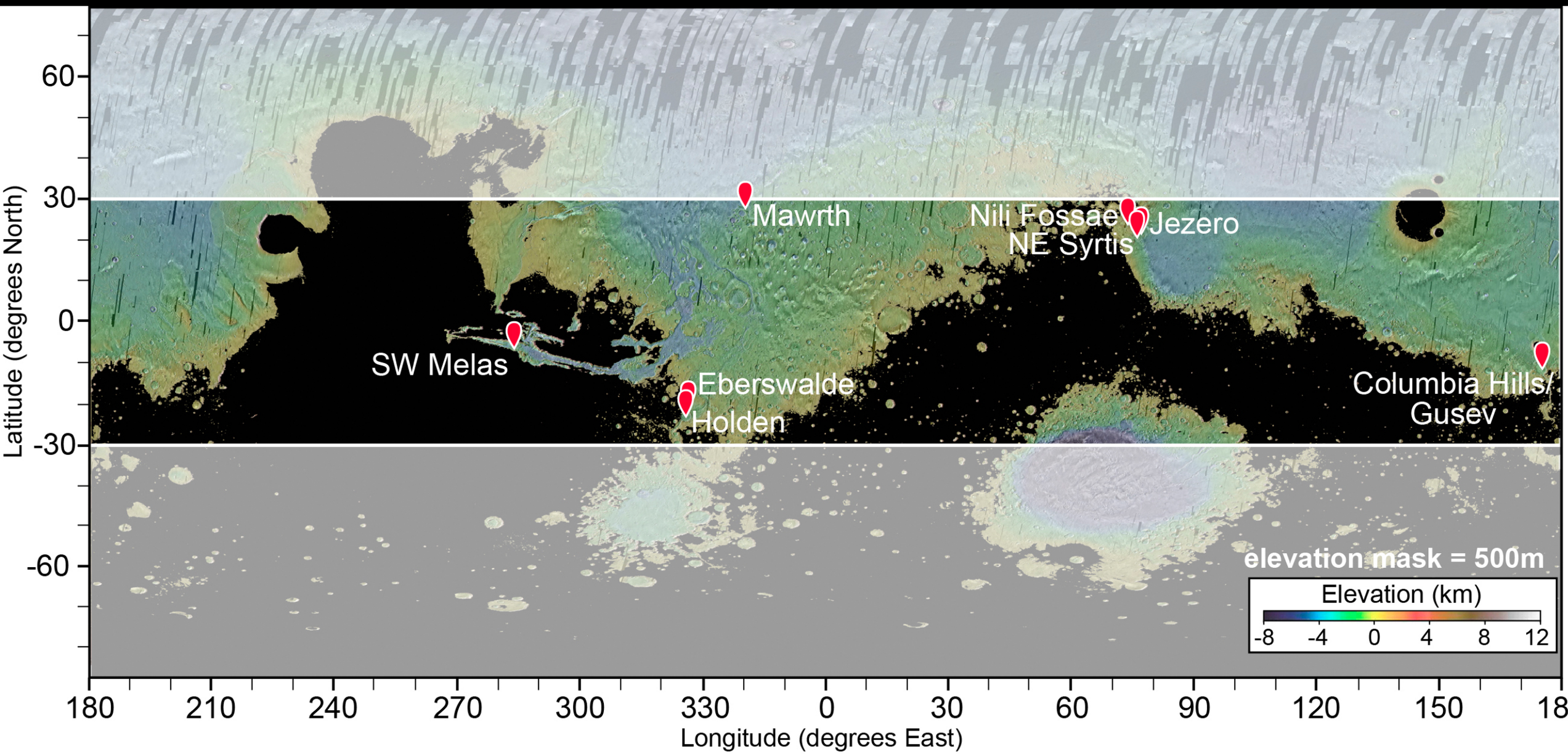
MARS 2020 CANDIDATE SITES (GREEN DOTS)

Dot 109: Farthest West Meridiani (Edgett et al.)
Dot 110: Vistula Valles/Chryse (Edgett et al.)
Dot 111: Intercrater West Arabia (Edgett et al.)
Dot 112: Nilosyrtis crater (Saper, L)

~30 Sites

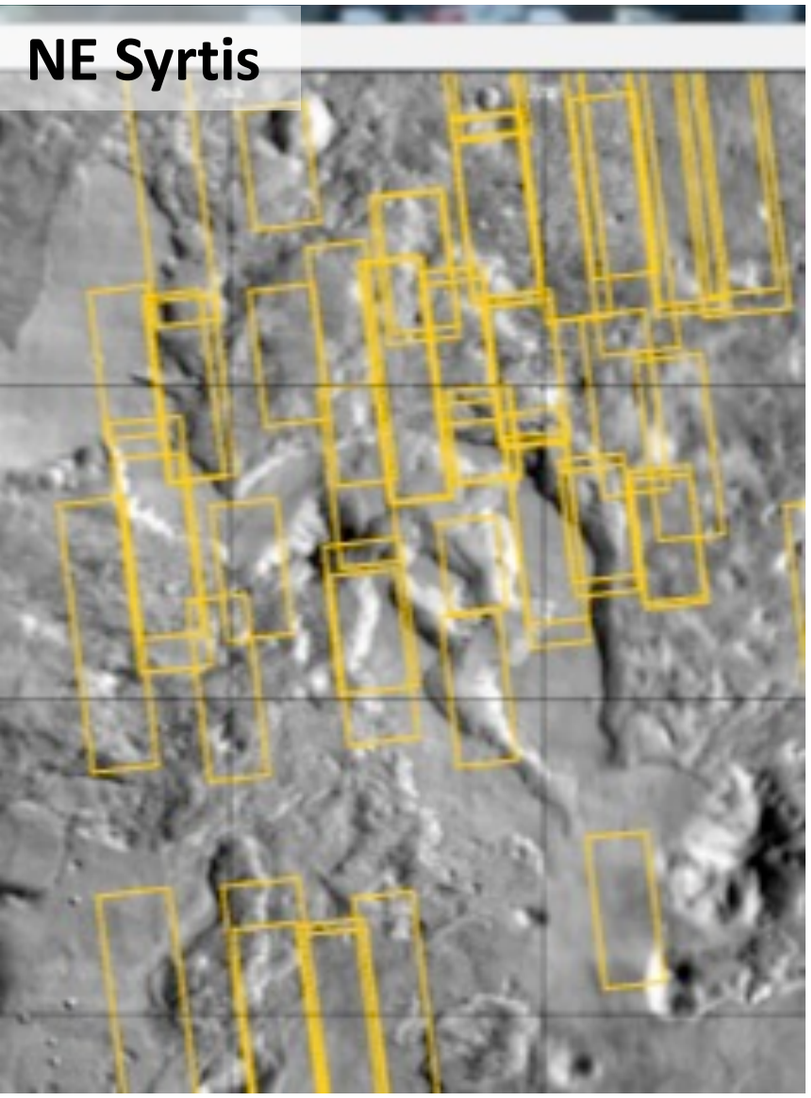
HiRISE
hirise.lpl.arizona.edu

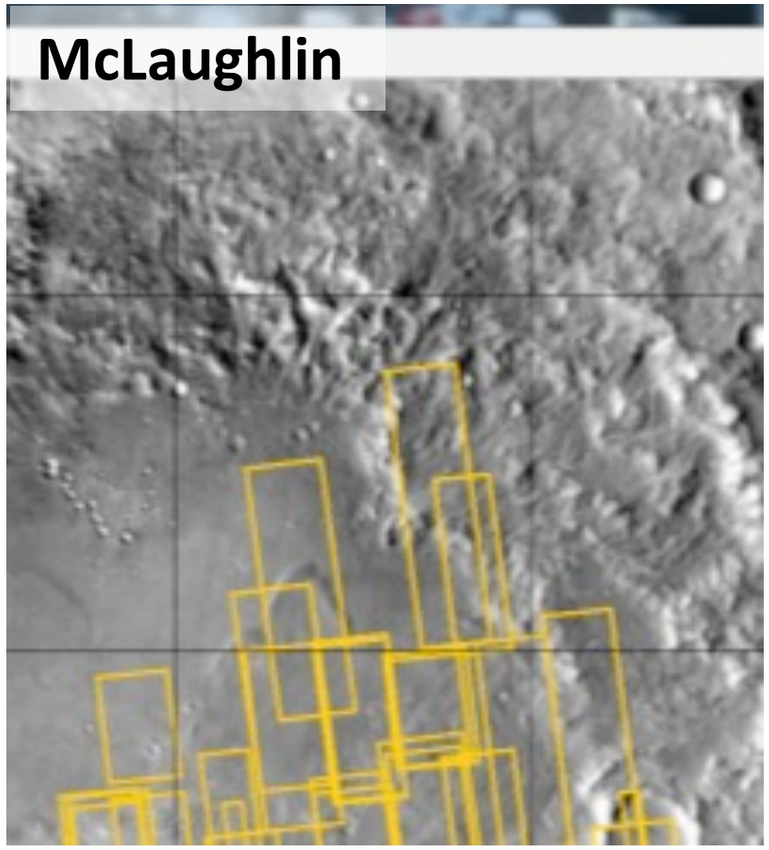
Eight Candidate Sites After the Second Workshop:

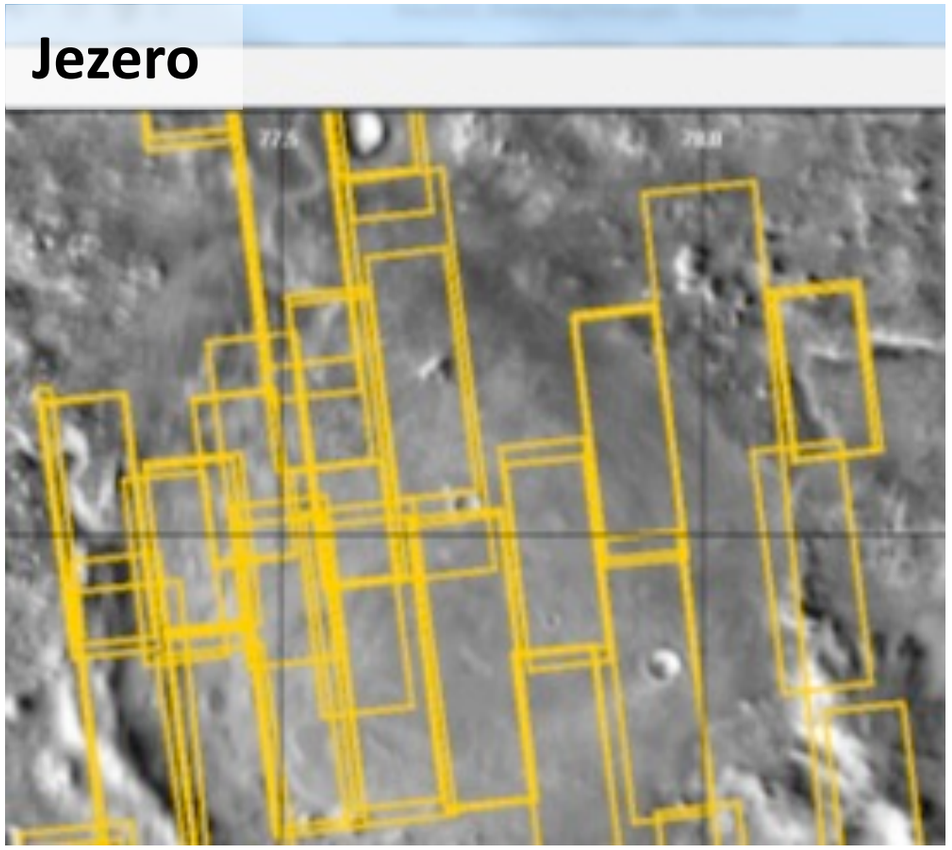


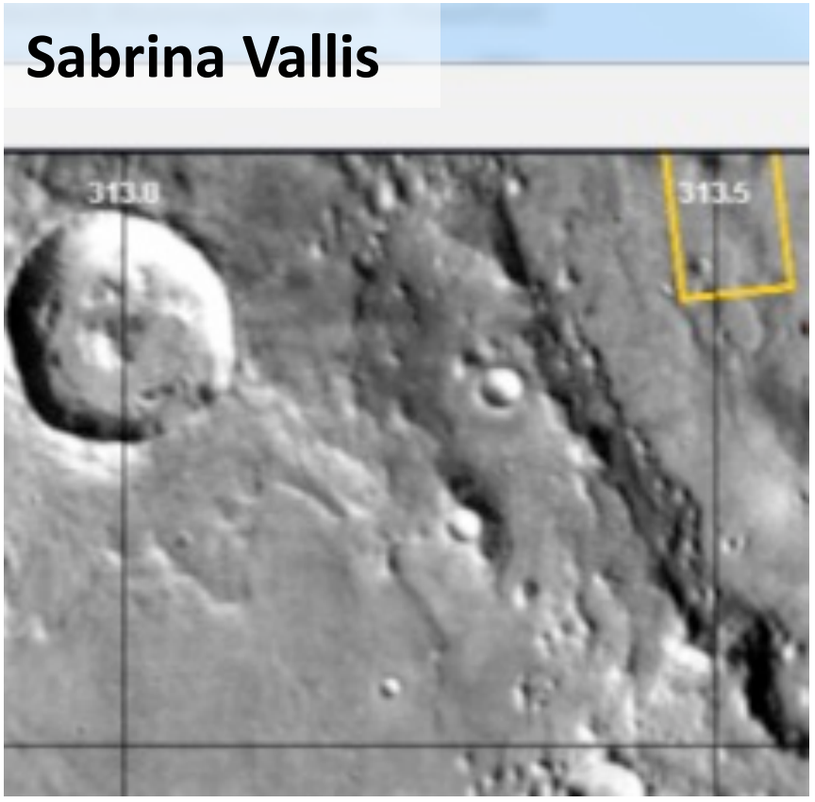
Landing Site	Latitude (°N)	Longitude (°E)	Approx. Elev. (km)
Columbia Hills/Gusev crater	-14.4	175.6	-1.94
Eberswalde crater	-23.0	327.0	-1.4
Holden crater	-26.4	325.1	-2.2
Jezero crater	18.5	77.4	-2.0
Mawrth Vallis	24	341.1	-2.3
NE Syrtis Major	17.8	77.1	-2.0
Nili Fossae trough (N)	21.0	74.5	0.6
SW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

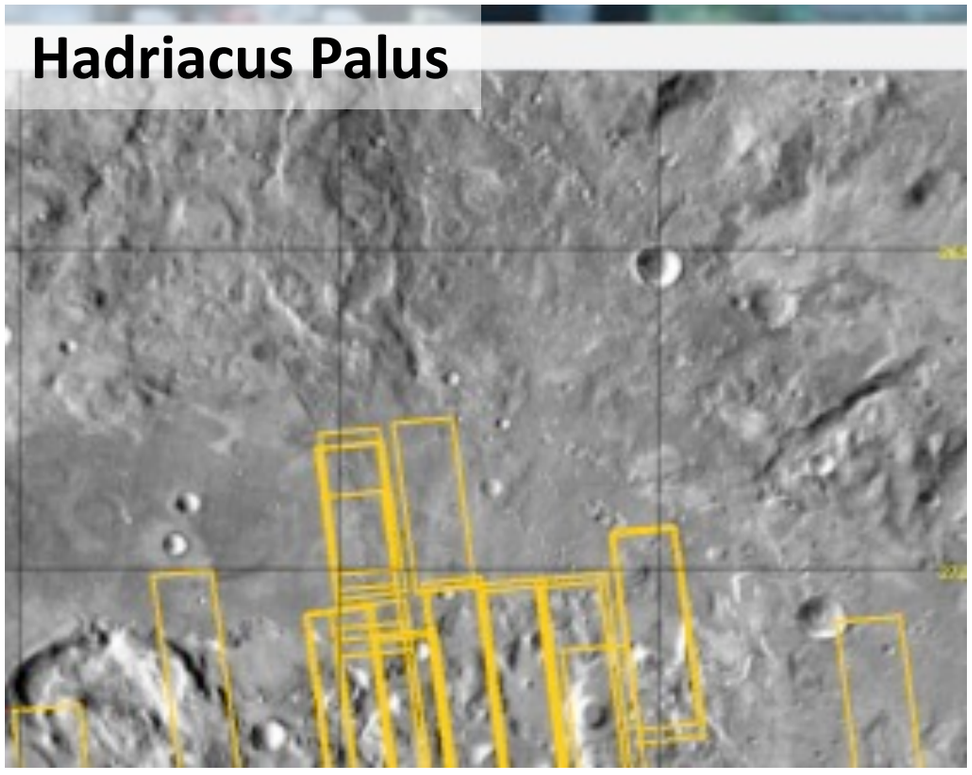
HiRISE Coverage for Select Landing Sites

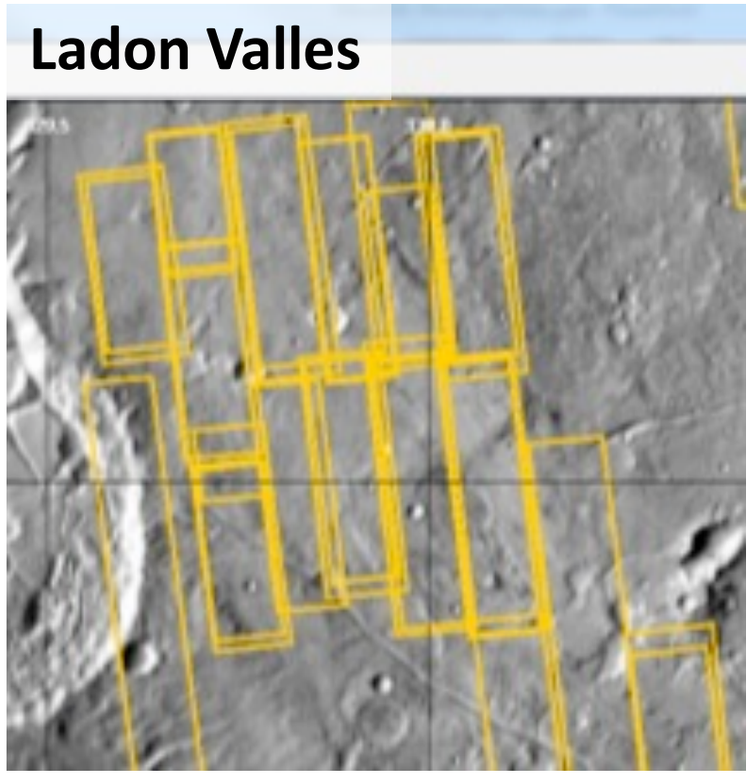












Mars 2020

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			
Eberswalde			
Holden			Likely to exceed the prime mission duration to accomplish science objectives
Jezero			
Mawrth			
NE Syrtis			
Nili Fossae			
SW Melas			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

3rd 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

3rd 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.

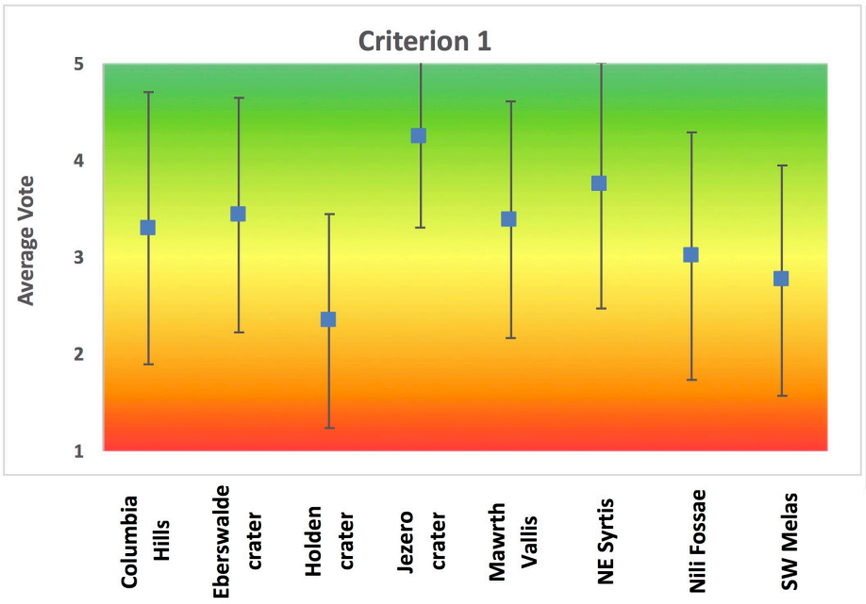
The site has high potential for significant water resources that may be of use for future exploration—whether in the form of water-rich hydrated minerals, ice/ice regolith or subsurface ice. (scoring: 1=lowest potential, 5=highest potential)

Community Evaluation:

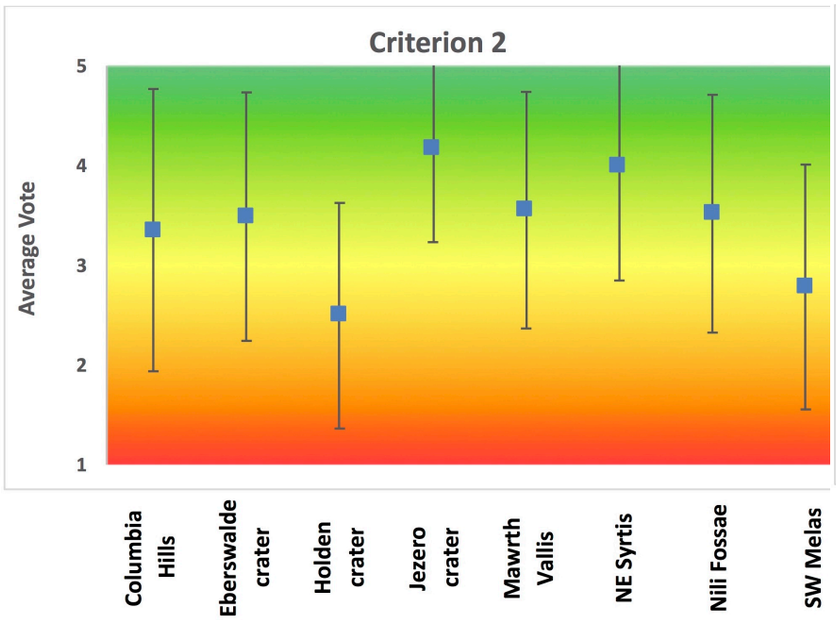
- Science community assesses the merits of the 8 candidate sites.
- Workshop attendees voted on 5 criteria
  - Used Online Voting for those in attendance – More expedient and private
- Provide a list of top 3-4 sites to Project for further consideration:
  - Rank the candidate sites as green, yellow, 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

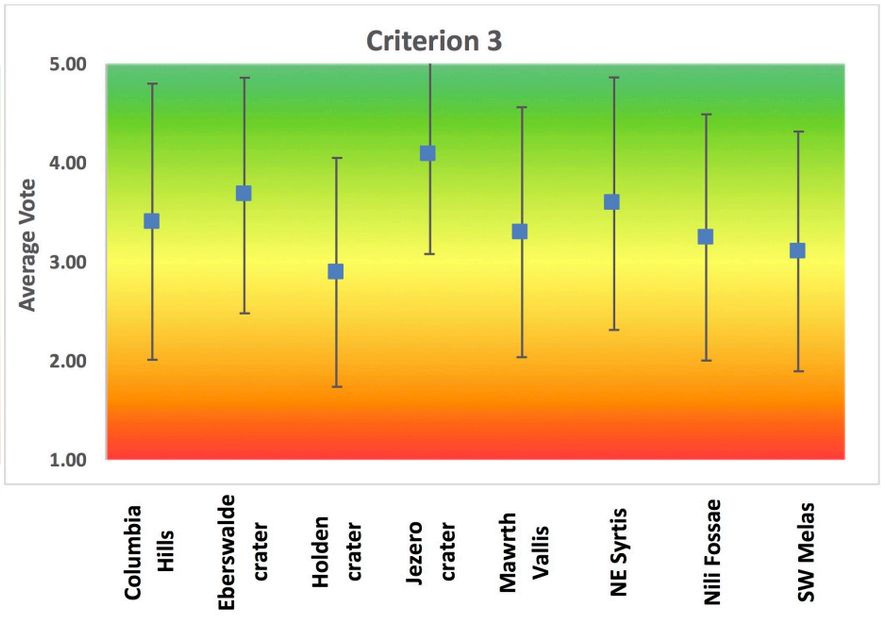
Bio Rel Geo Div

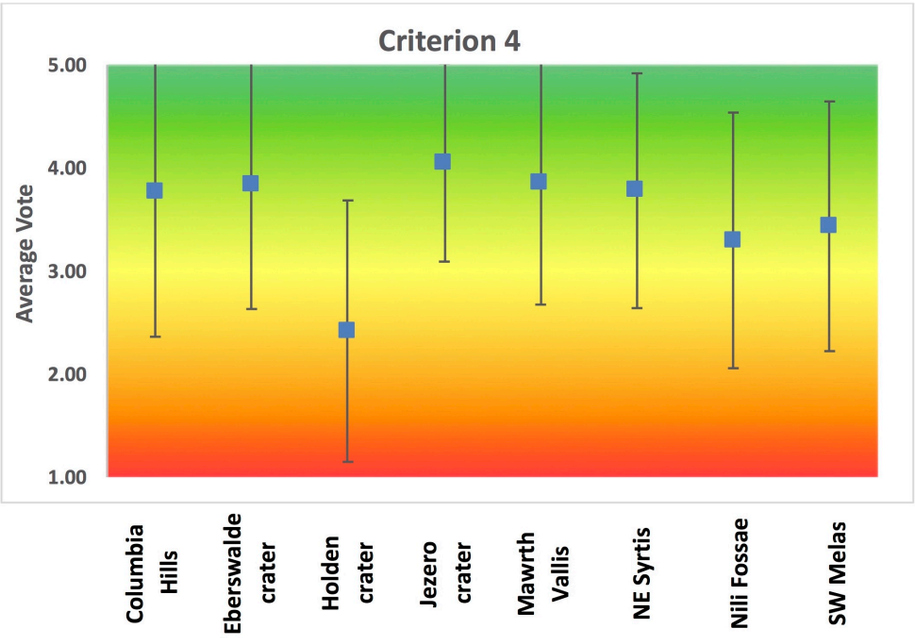


Ret Samples

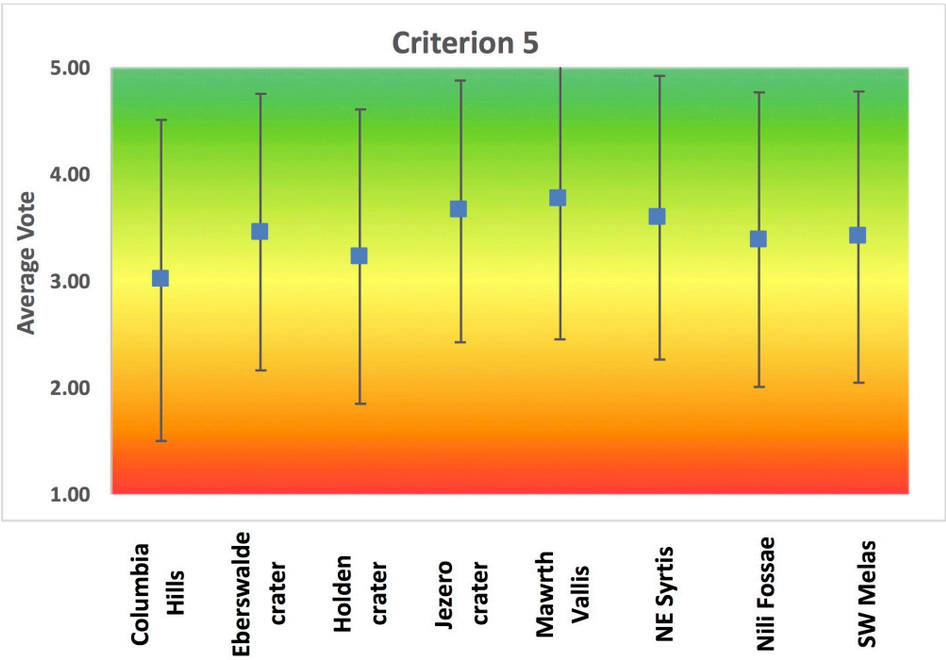


Hi Conf





ROI Nom Mission



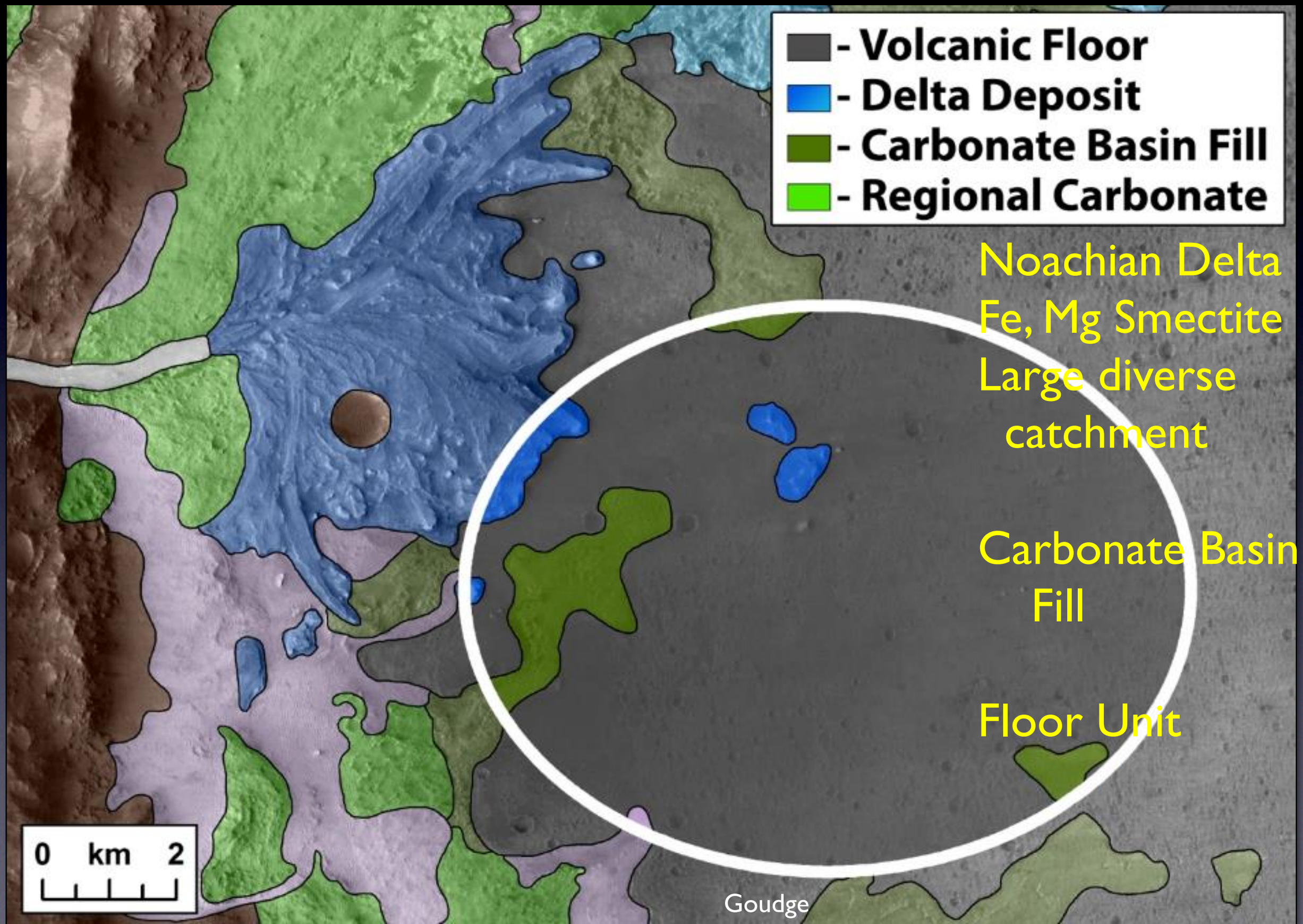
Water Resources

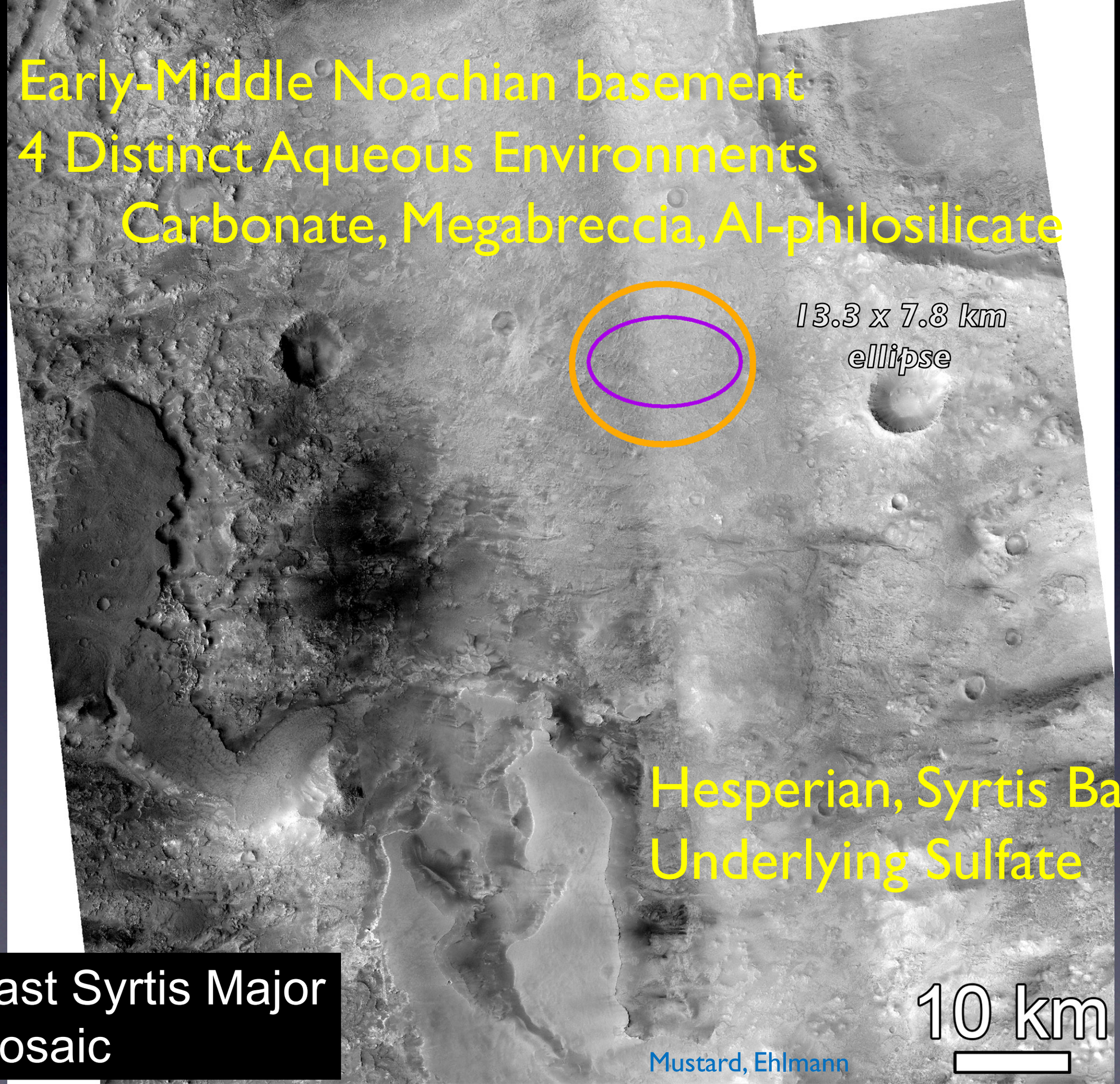
Mean & SD

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





Northeast Syrtis Major
CTX mosaic

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	• Preliminary engineering constraints	
5/14	LSW 1	• Sites prioritized into thirds by science merit • Top 3rd to be characterized for safety and TRN need by LSW 2	~28
6/15	LSW 2	• Identify 8 selectable sites – Are there enough non-TRN sites of sufficient science merit? – If not, is TRN required? Define TRN attributes needed	8
2/17	LSW 3	• ~Middle of Phase C	3-4
~8/18	LSW 4	• Final planned workshop	1-2
TBD	Site selection	• Decision dependent on number of high priority sites, clustering of sites, programmatic factors	
7/20	Launch		

Modified from Al Chen