Astrobiology Relevant Hypotheses for the Origin of Quartz-bearing Materials in Eos Chasma: Tests for MSL

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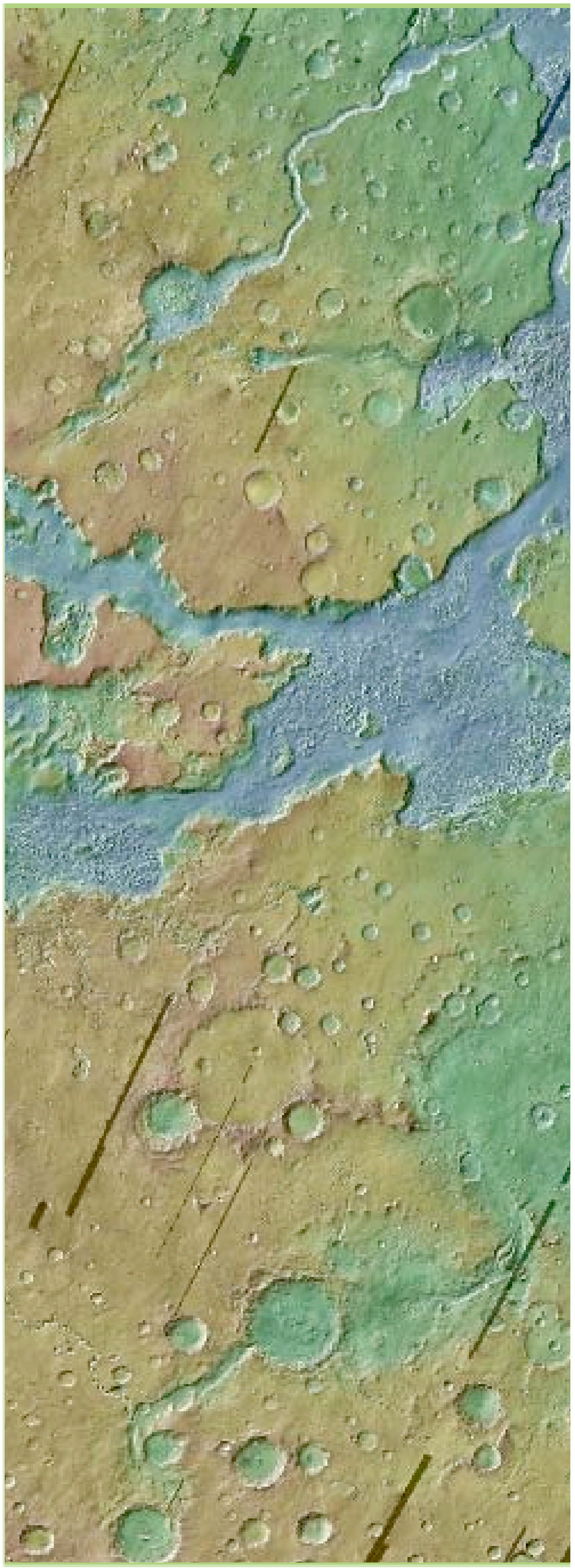
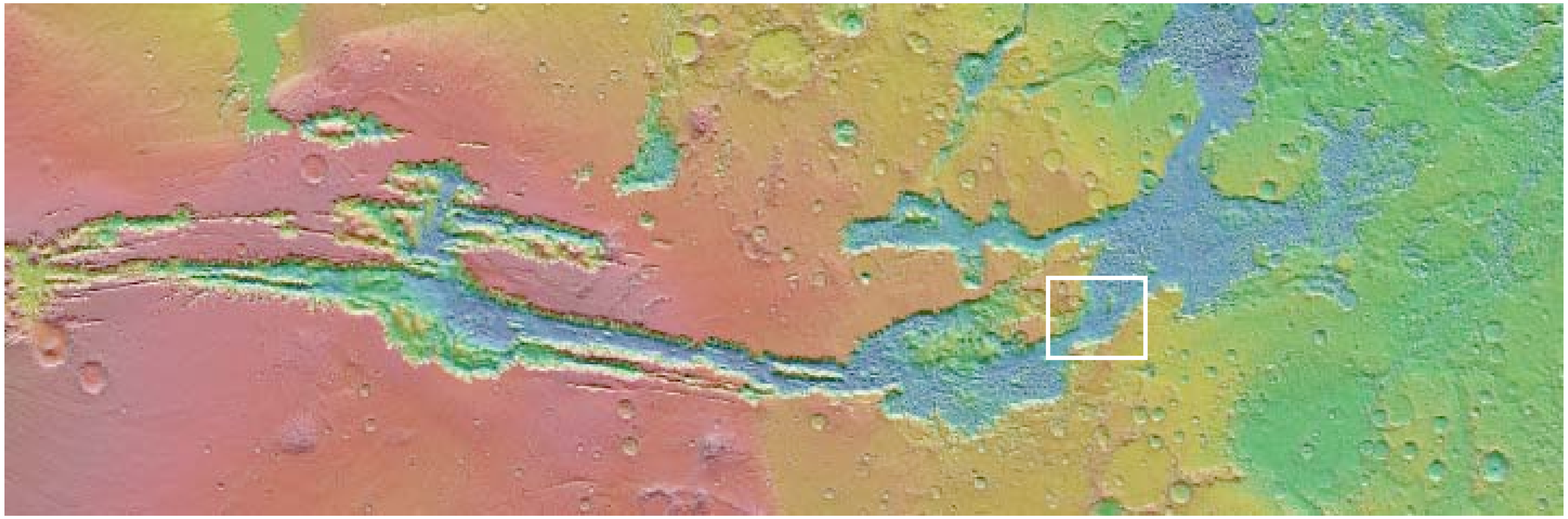
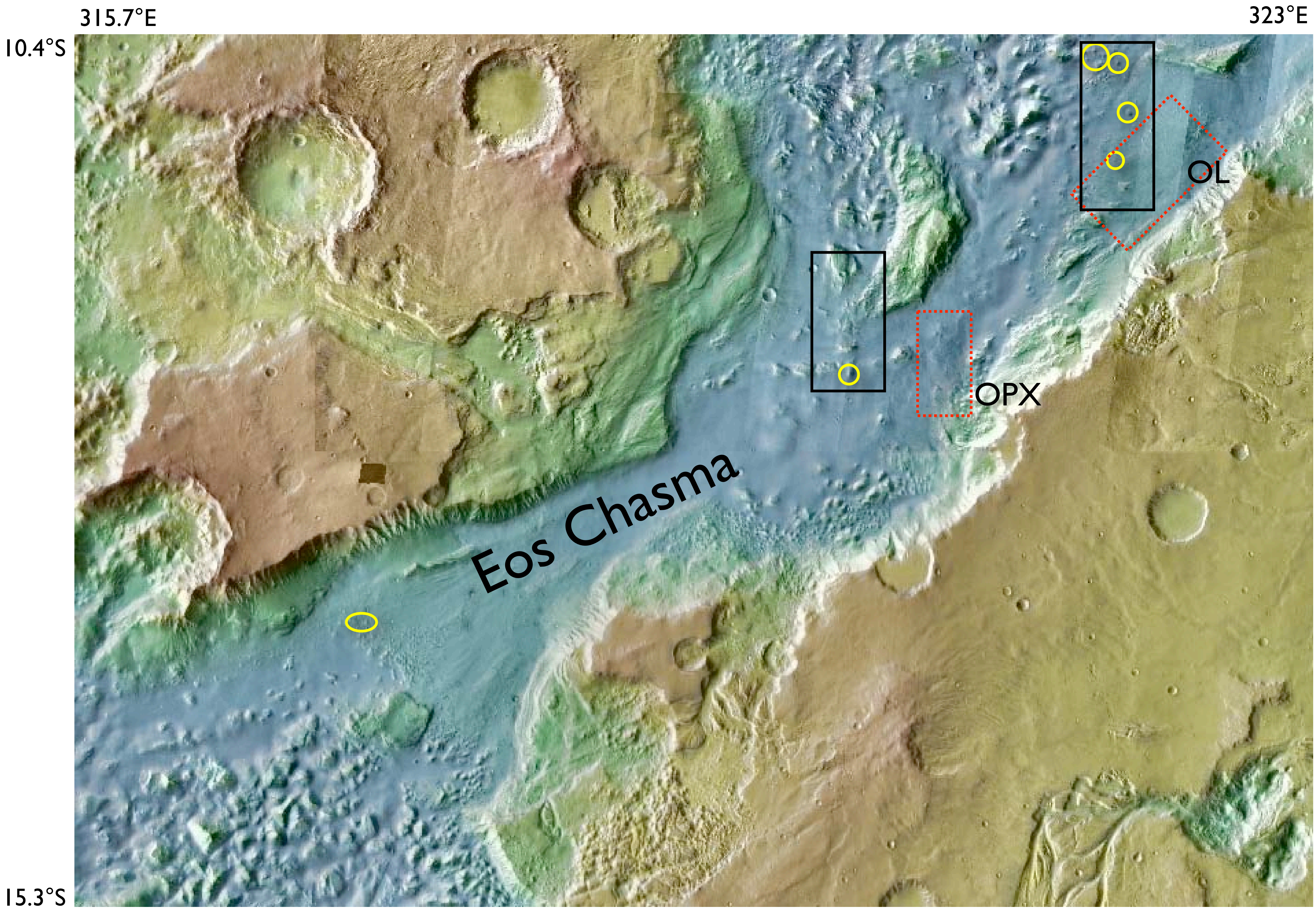


Overview

- Geographic orientation
- Identification of quartz- and/or silica-bearing materials
- Quartz/Silica-forming processes
- Relevance to & tests for MSL
- Engineering requirements for candidate landing ellipses, and prioritization of sites

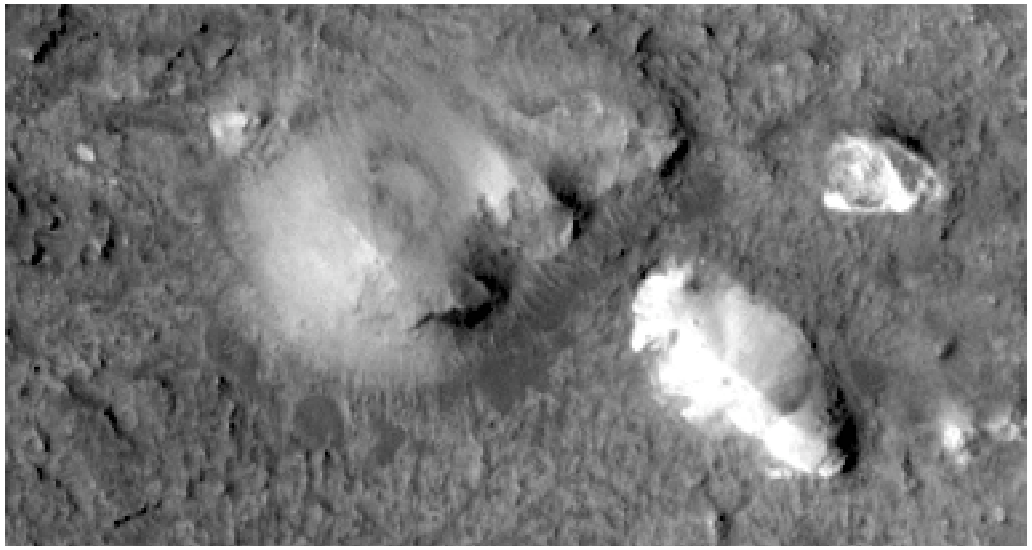




Colorized MOLA elevation over THEMIS IR

Quartz-bearing Materials - Eos Chasma

- Identified in THEMIS color infrared images [*Hamilton & Christensen*, 2005]
- Spectral data indicate a composition with anywhere from ~35 ≤ 100% quartz/chert, or amorphous silica
  - NOT consistent with dominant phase as tridymite, cristobalite, or coesite; does not mean these phases cannot be present
- Olivine- and orthopyroxene-rich igneous materials nearby; silica phase may be an alteration product of these
- Whereas olivine-rich materials form mesas, quartz-bearing features dominantly are light-toned, rounded knobs
  - may be (or be contained in) weak, erodable materials



MOC NA R0301554
~2 km wide

Quartz- and Silica-forming Processes

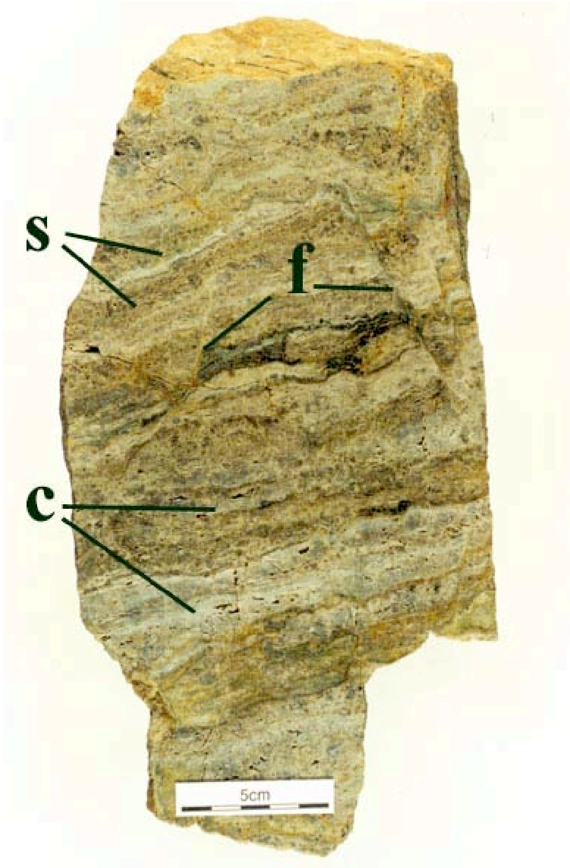
- Much like hematite, a variety of processes produce quartz, and many of these processes involve aqueous activity:
  - Evolved igneous activity producing crystalline quartz
  - Metamorphism producing crystalline quartz
  - *Precipitation from hydrothermal fluids producing vein quartz*
  - *Precipitation from ambient fluids producing quartz "cement" in sediments*
  - *Alteration of primary igneous lithologies producing silica*
  - *Replacement of evaporites/carbonates producing chert*
  - *Diagenesis of abiotically precipitated opaline silica producing chert*
  - *Diagenesis of biotically precipitated opaline silica producing chert*
    - Italics denote processes/conditions favorable to biology/biomarker preservation

Example: Macroscopic Chert Textures

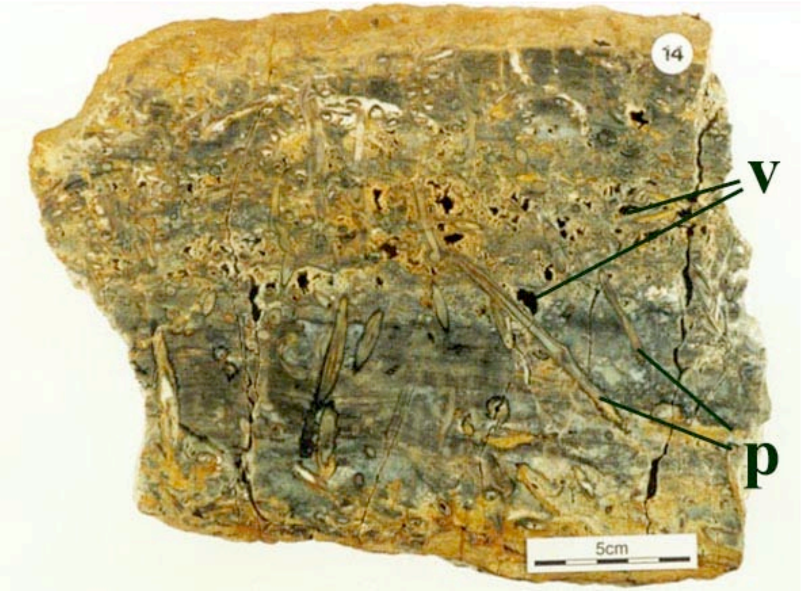
Valley of Watermelons, Egypt

McBride et al. [1999]

Bedding plane that has been case hardened by a layer of chert a few millimeters thick.



s - sandstone
f - fractures
c - chert

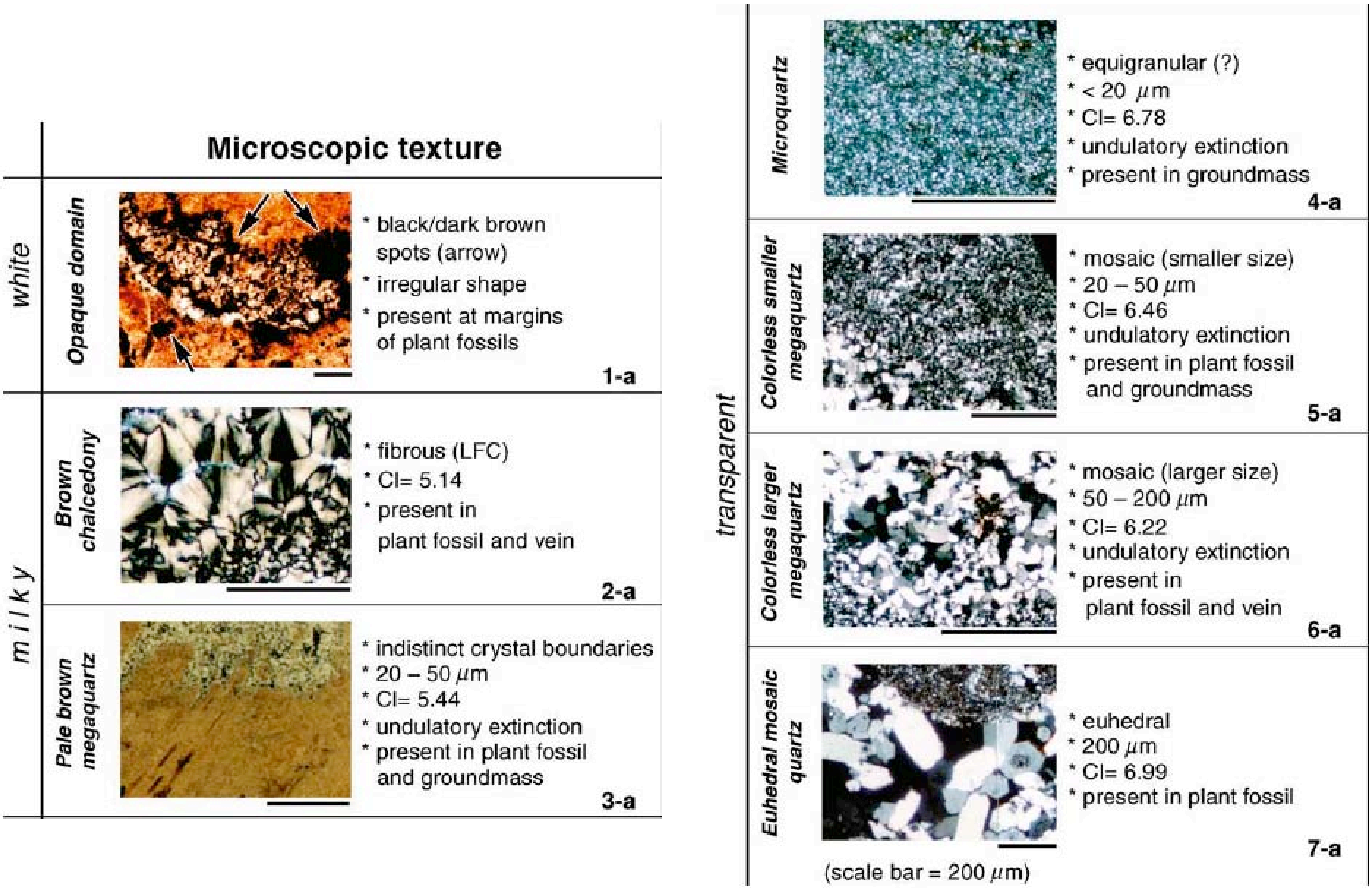


v - vugs
p - plant stems

n - nodular chert
b - brecciated chert

Trewin et al. (http://www.abdn.ac.uk/rhynie/texture.htm)

Example: Microscopic Chert Textures



Umeda [2003]

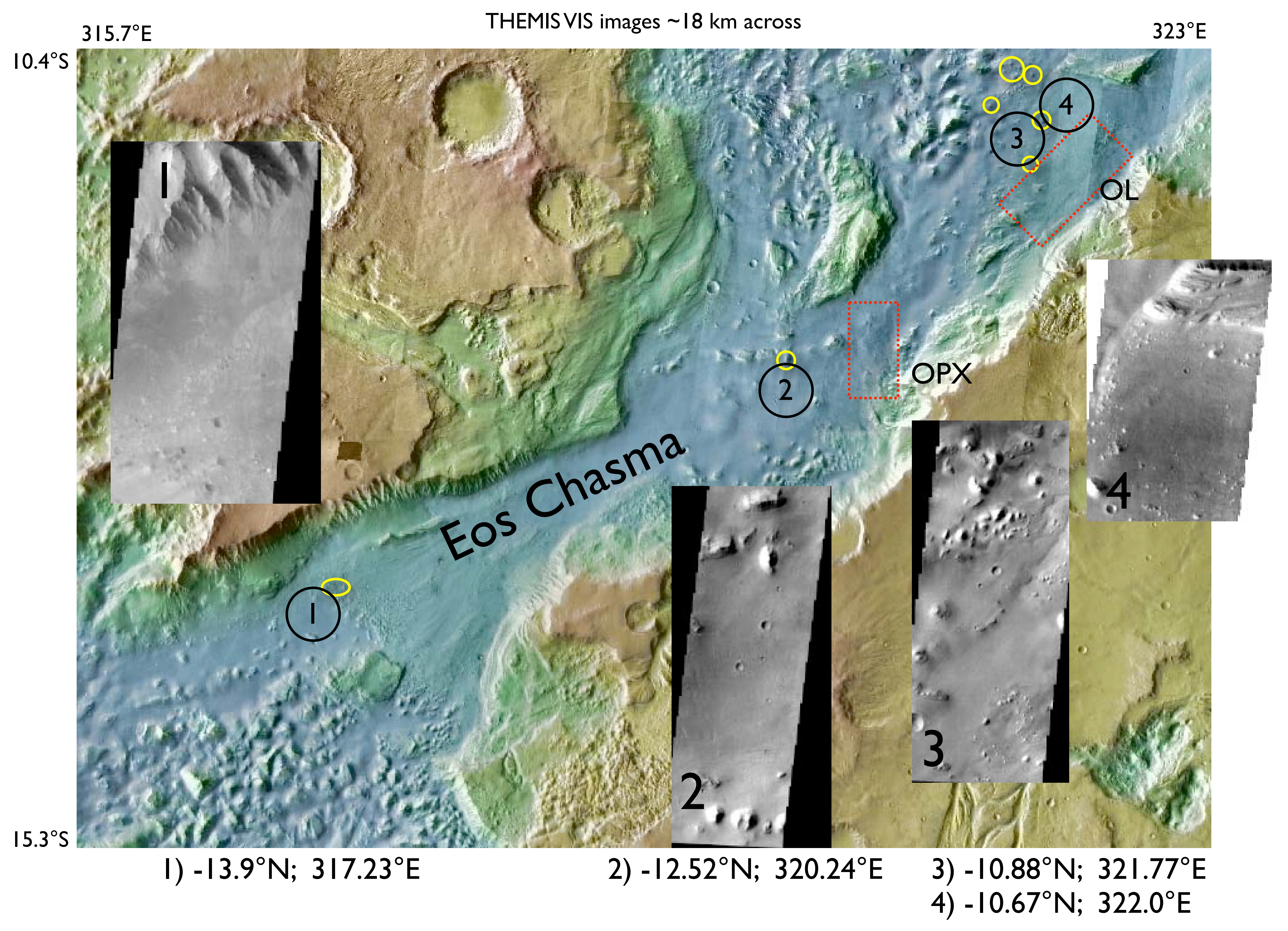
Relevance to the Mars Science Laboratory

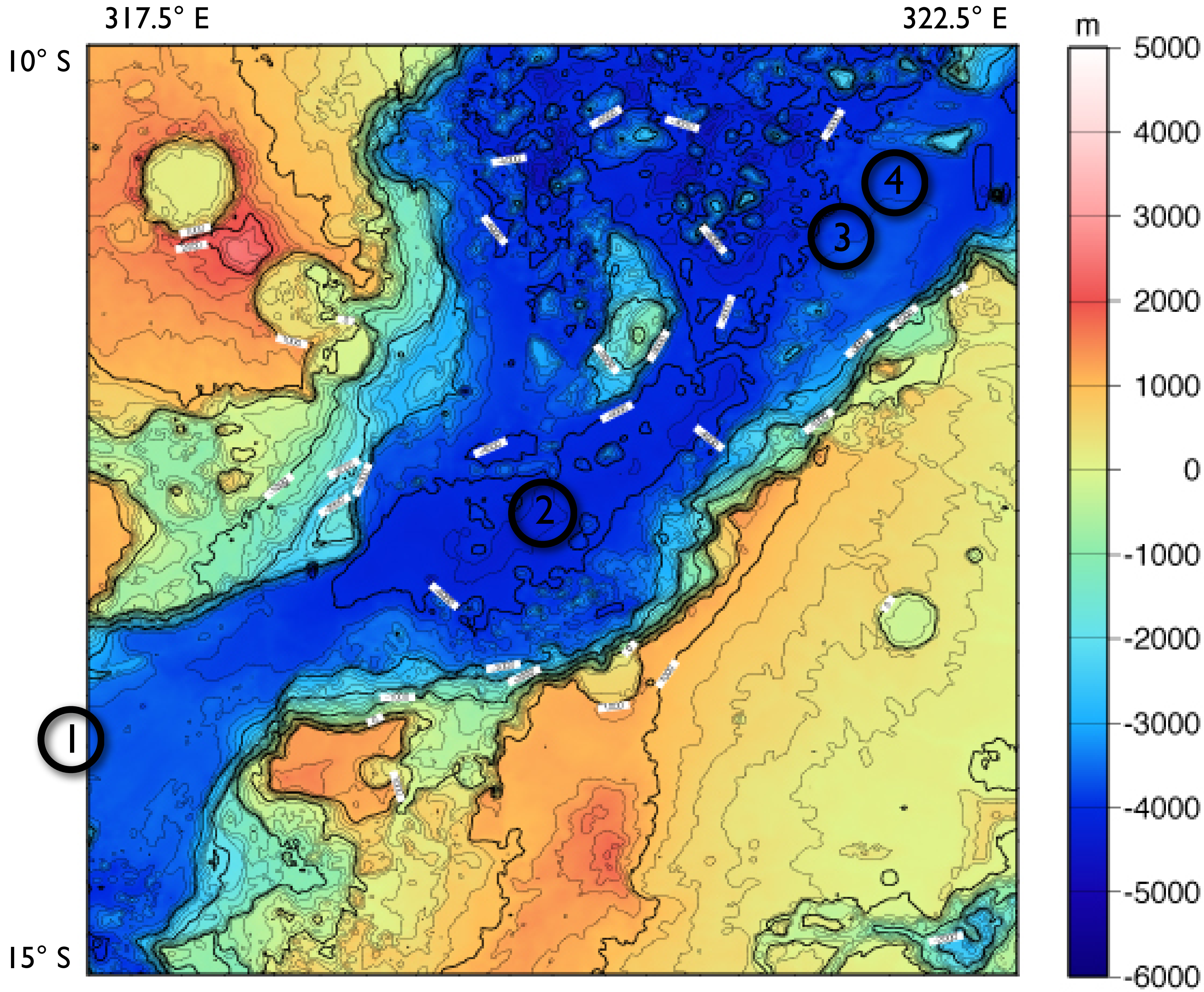
- Goals of the 2009 Mars Science Laboratory (partial listing):
  - Assess the biological potential of the landing site;
  - characterize the geology and geochemistry of that environment;
  - investigate processes of relevance to past habitability, including the role of water.

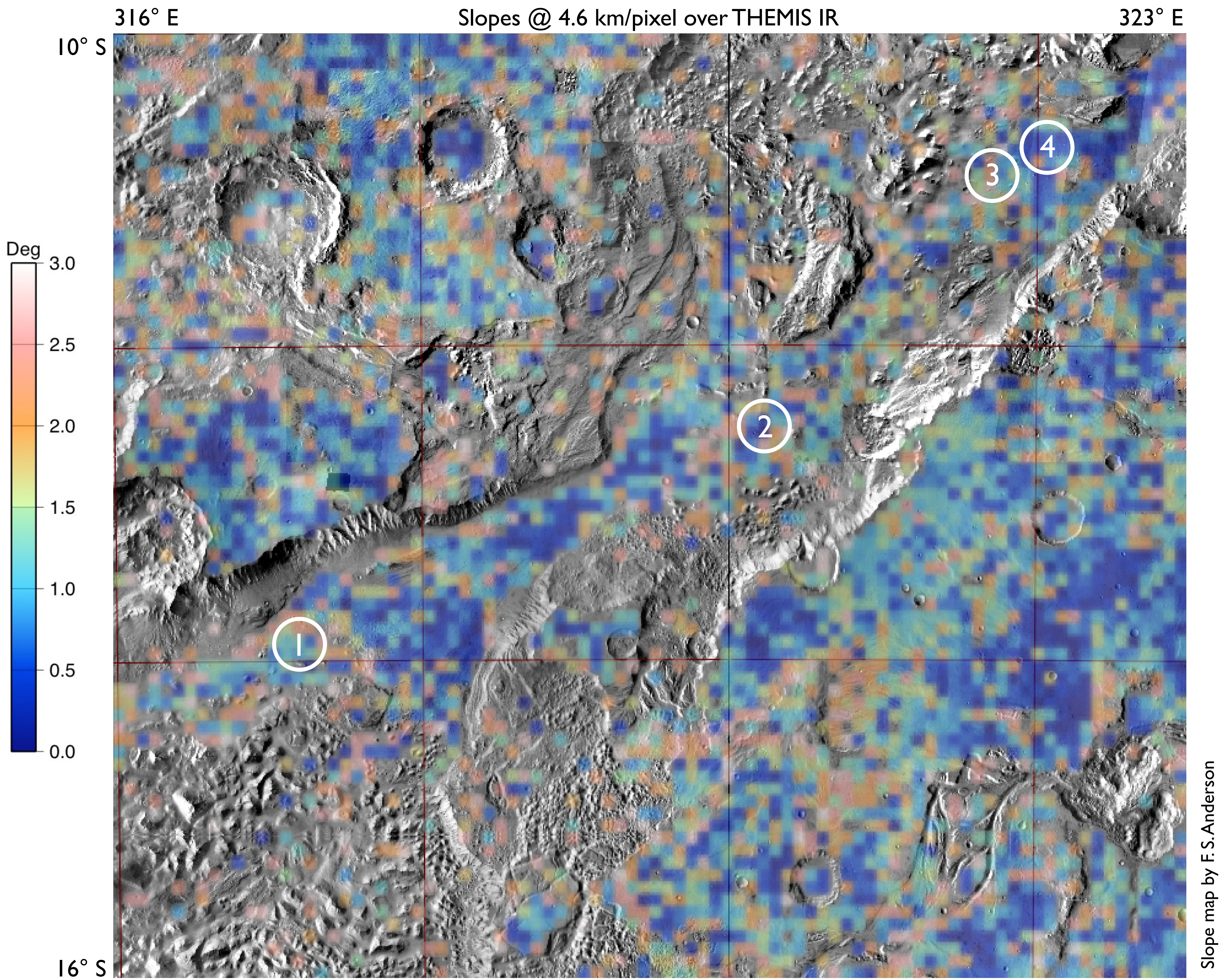
- Selection of a site with <u>abundant</u> mineralogy having connections to water offers *best* chance of fulfilling goals

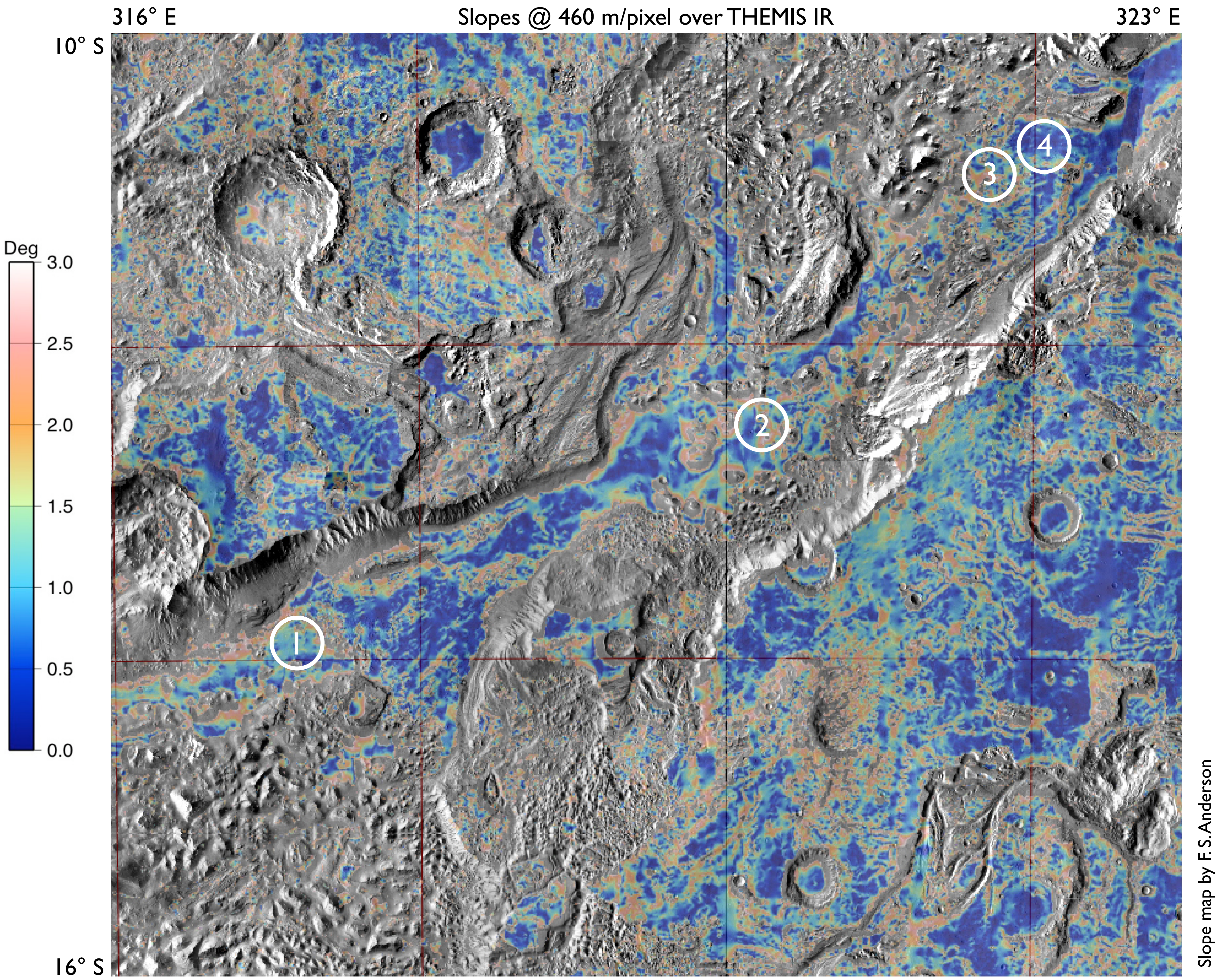
Tests for the Mars Science Laboratory

- The MSL payload can assess habitability of this site, it's potential to preserve chemical or morphological biosignatures, and test hypotheses for the origin of quartz and/or silica (sub-bullets denote MSL instruments that could be applied to each question):
  - *What is the distribution of the silica phase in relation to macroscopic textural features of the host rock?*
    - MastCam, MAHLI, ChemCam
  - *What is the structure and/or chemistry of the silica phase?*
    - CheMin, APXS, ChemCam
  - *What other minerals are present?*
    - CheMin
  - *Are precursor opaline phases present?*
    - CheMin
  - *Are organics present?*
    - SAM
  - *What is the isotopic signature of the silica phase relative to coexisting phases?*
    - SAM


THEMIS VIS images ~18 km across
315.7°E
323°E
10.4°S
15.3°S
Eos Chasma
OPX
OL
1
2
3
4
1) -13.9°N; 317.23°E
2) -12.52°N; 320.24°E
3) -10.88°N; 321.77°E
4) -10.67°N; 322.0°E


317.5° E
322.5° E
10° S
15° S
1
2
3
4
m
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000


316° E
Slopes @ 4.6 km/pixel over THEMIS IR
323° E
10° S
16° S
Deg
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1
2
3
4
Slope map by F. S. Anderson



316° E
Slopes @ 460 m/pixel over THEMIS IR
323° E
10° S
16° S
Deg
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1
2
3
4
Slope map by F. S. Anderson

Engineering Requirements

Parameter	Requirement	Actual
Latitude	60°N to 60°S	All 10 - 14°S; (H_2O/L_s not an issue)
Elevation	≤2 km	All -3.8 km or lower
Slopes	2-5 km: ≤3 degrees	All ≤3 degrees
	200-500 m: ≤5 degrees	All ≤3 degrees
	5 m and 20-40 m: ≤15 degrees	TBD
Rock Abundance	"low to moderate"	IRTM blocks: 8-9% (15% @ site 1)

Engineering Requirements

Parameter	Requirement	Actual
Winds (0-10 km)	Steady State Horizontal: ≤ 30 m/s	30-40 m/s*
	Steady State Vertical: ≤10 m/s	TBD
Wind gusts (0-10 km)	case-by-case	TBD
Radar Reflectivity	Ka band reflective (> -20 db)	value unknown, not likely to be a problem
Load Bearing Surface	TI >100 SI units	TES TI range: 345 - 480 SI units
	Albedo: <0.25	Albedo range: 0.11 - 0.12

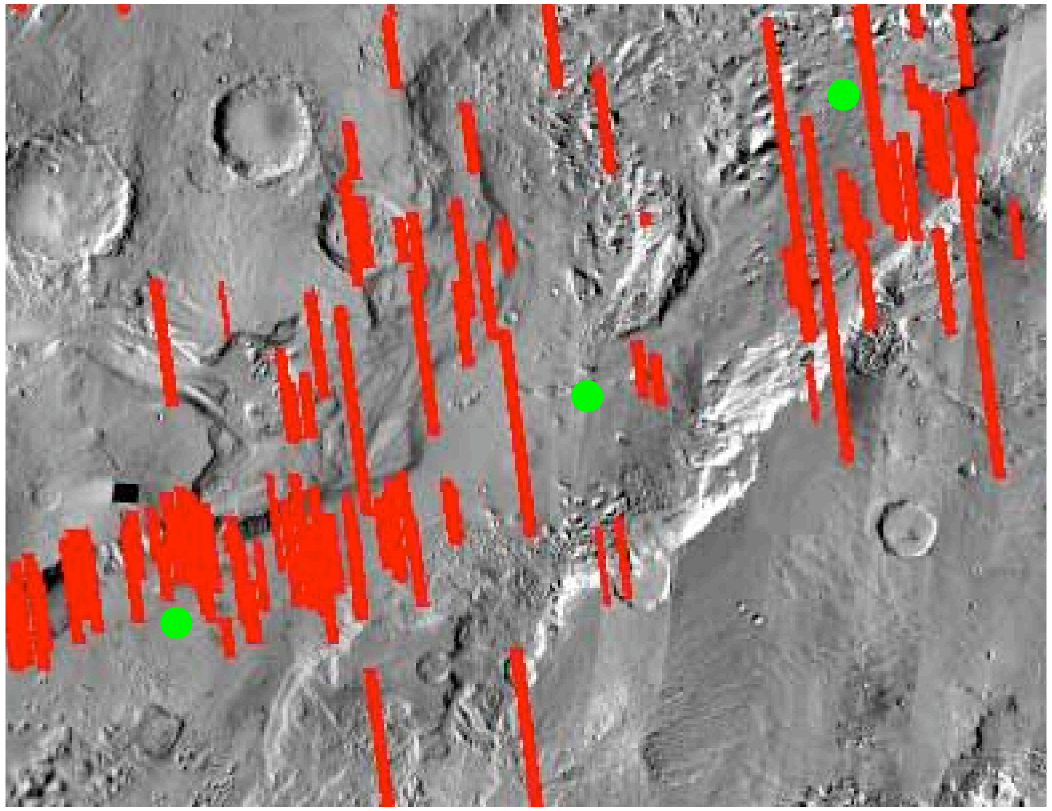
*Rafkin and Michaels, this mtg.

Summary (1 of 2)

- Quartz or silica-bearing materials identified in Eos Chasma; hypotheses of formation offer a wide range of tests ideally suited to MSL payload
  - Many processes of formation involve water
    - Some mechanisms of formation involve biological processes
      - These mechanisms commonly preserve biomarkers

Summary (2 of 2)

- Four candidate ellipses identified
  - Eos sites offer operational benefits
  - Majority of engineering requirements assessed; current priority is: 4, 2, 3, 1
- Eos Chasma exhibits geomorphic evidence of aqueous activity
  - Contingency: Eos offers "grab bag" potential



current MOC coverage

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