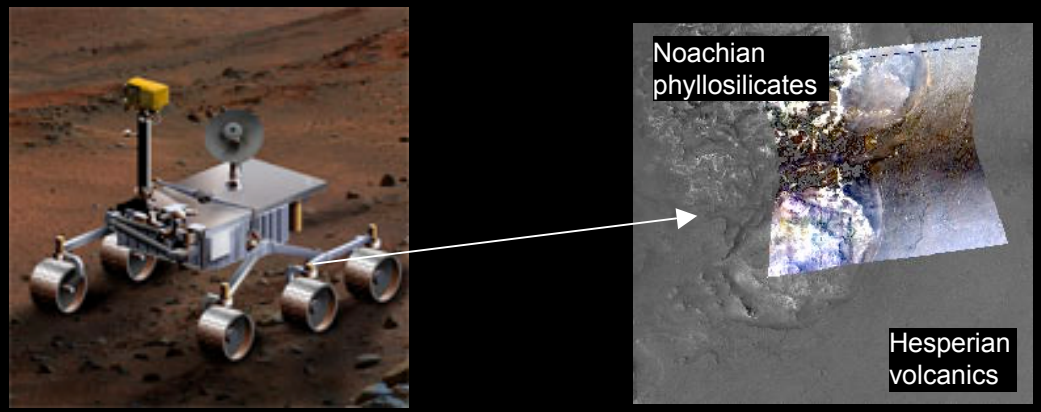
NE Syrtis

Traversing the Noachian-Hesperian contact: Syrtis Major volcanics to diverse Nili Fossae phyllosilicates



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Brown University

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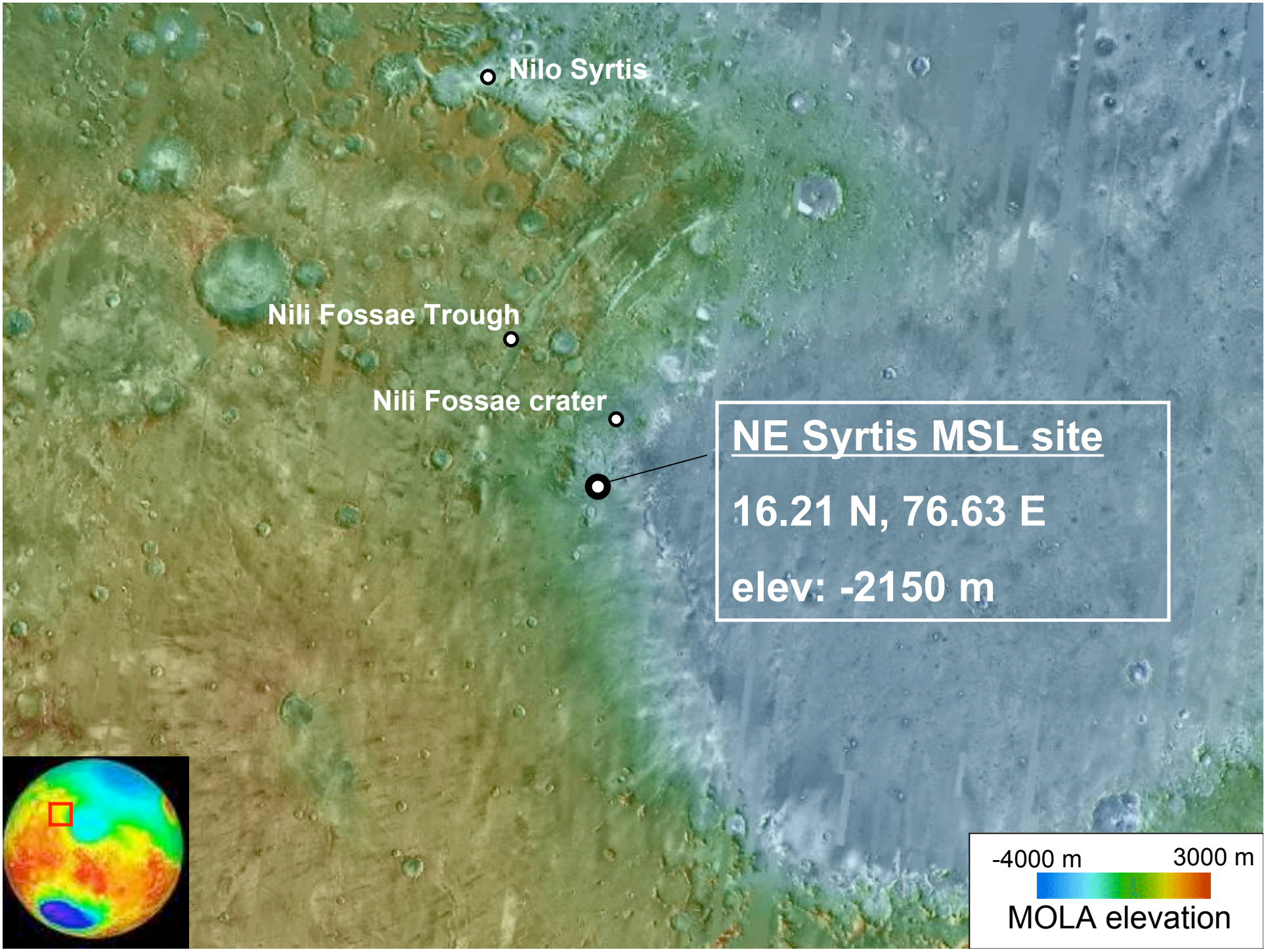
Case Western Reserve University

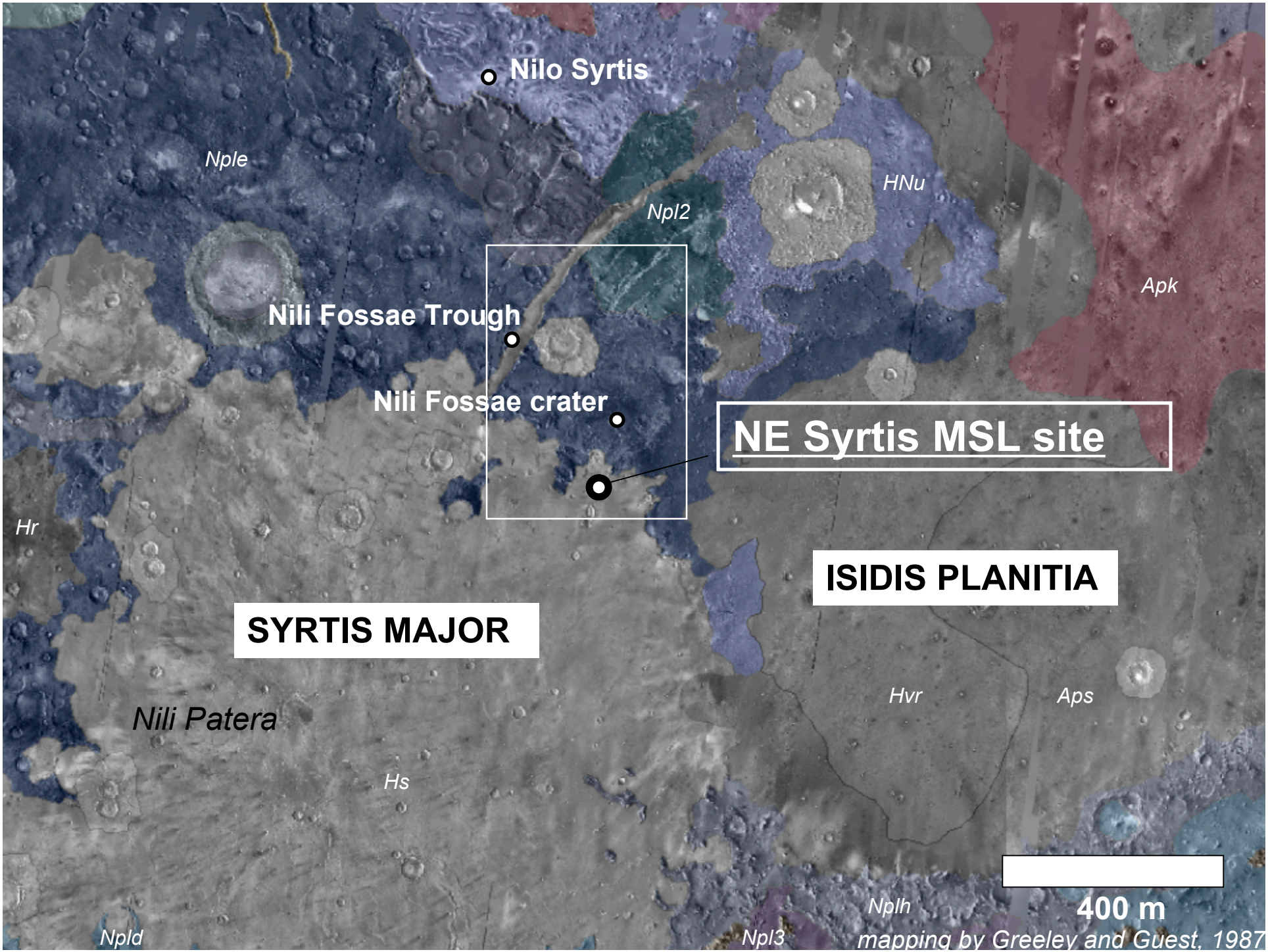
with thanks to the CRISM, HiRISE, CTX, HRSC, OMEGA, MOLA, and THEMIS teams

2nd MSL landing site workshop - 24 October 2007

NE Syrtis MSL landing site

- Outline
  - Tour of the region and site
  - MSL science rationale (a two phase mission)
    - ***Traverse Phase: Martian Large Igneous Provinces***
      mineralogy, geochemistry, and emplacement morphology of the Hesperian Syrtis Major formation
    - ***Outcrop Science Phase: Paleohabitability in the Noachian***
      diverse in-situ layered stack → mineralogy, geochemistry, and facies of hydrated/phyllosilicate rich units typical of the phyllosilicates globally
  - Site safety assessment: safe!
  - A sample mission profile


Nilo Syrtis
Nili Fossae Trough
Nili Fossae crater
NE Syrtis MSL site
16.21 N, 76.63 E
elev: -2150 m
-4000 m
3000 m
MOLA elevation


Nilo Syrtis
Nple
Npl2
HNu
Apk
Nili Fossae Trough
Nili Fossae crater
NE Syrtis MSL site
Hr
ISIDIS PLANITIA
SYRTIS MAJOR
Hvr
Aps
Nili Patera
Hs
Nplh
Npl3
Npld
400 m
mapping by Greeley and Guest, 1987

Mafic Mineral Diversity

Pyroxene

Compositional transition from Npl to Hesperian Syrtis Major formation:

~60% LCP (Noachian)

~60% HCP (Hesperian)

(Mustard et al., 2005; Thollot et al., 2007)

Olivine

Greatest concentration of olivine on the planet

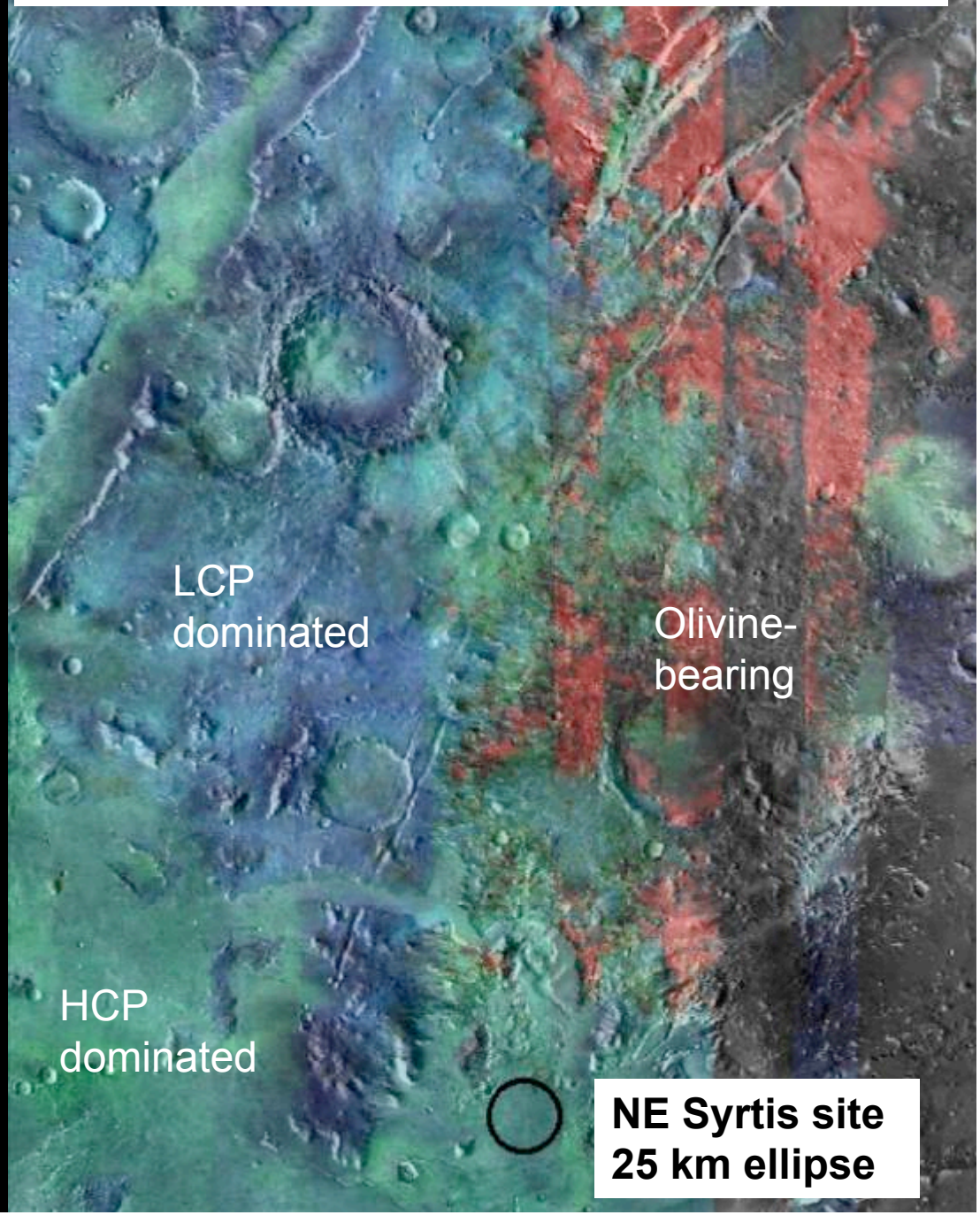
(Hoefen et al., 2003; Hamilton and Christensen, 2005; Mustard et al., 2007)

OLINDEX > 0.015

0.0 1.0

MGM band strength LCP/(LCP + HCP)

OMEGA OLINDEX parameter + MGM NBSR



Phyllosilicate minerals

Iron-Magnesium rich smectite

Clays are spread over >100,000 km^2 in the Nili Fossae Npl terrain

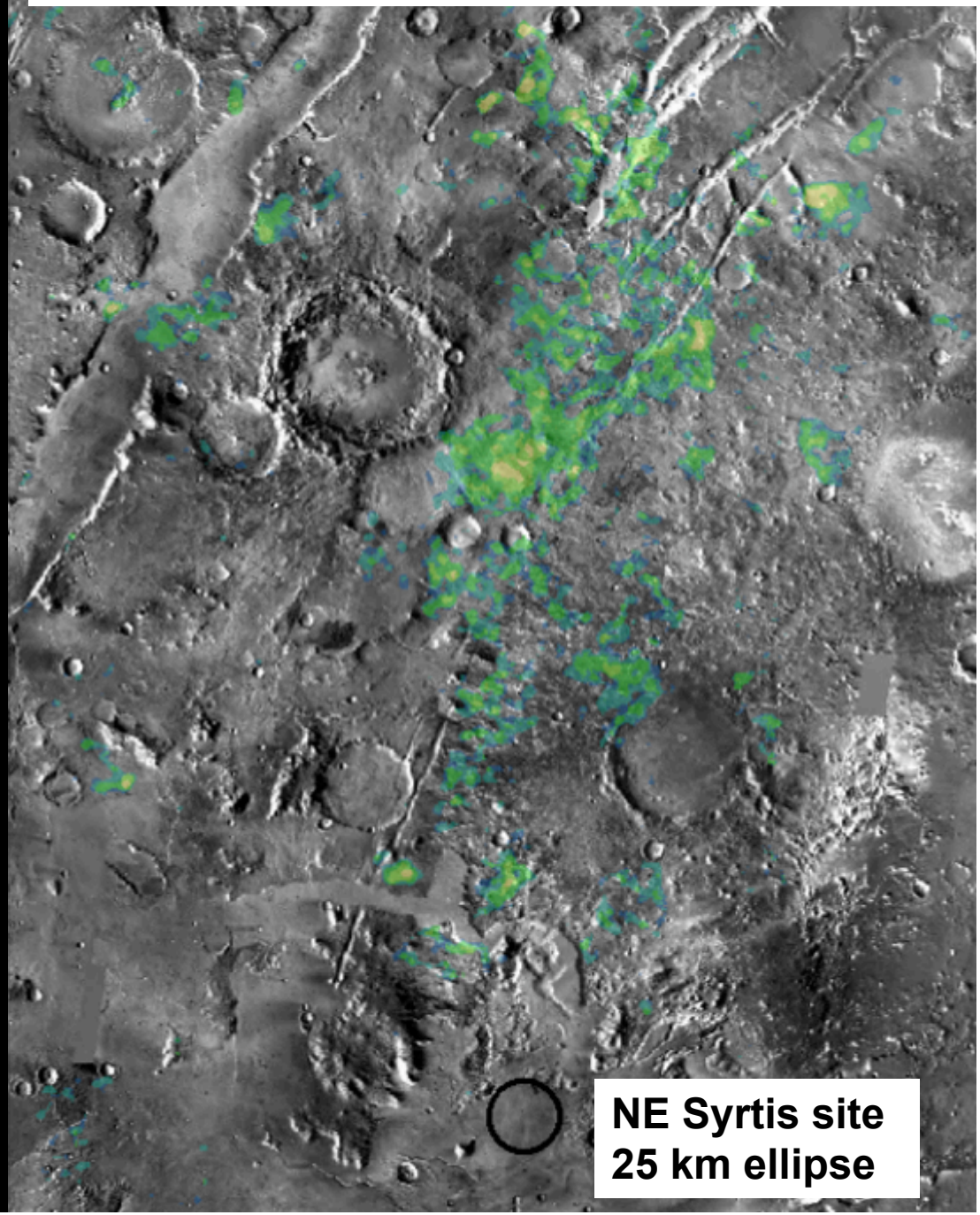
Found in the **lowermost stratigraphic layer**, beneath olivine and LCP mafics and cut by the fossae

(Bibring et al., 2005; Poulet et al., 2005; Bibring et al., 2006; Mangold et al., 2007; Poulet et al., 2007; Mustard et al., 2007)

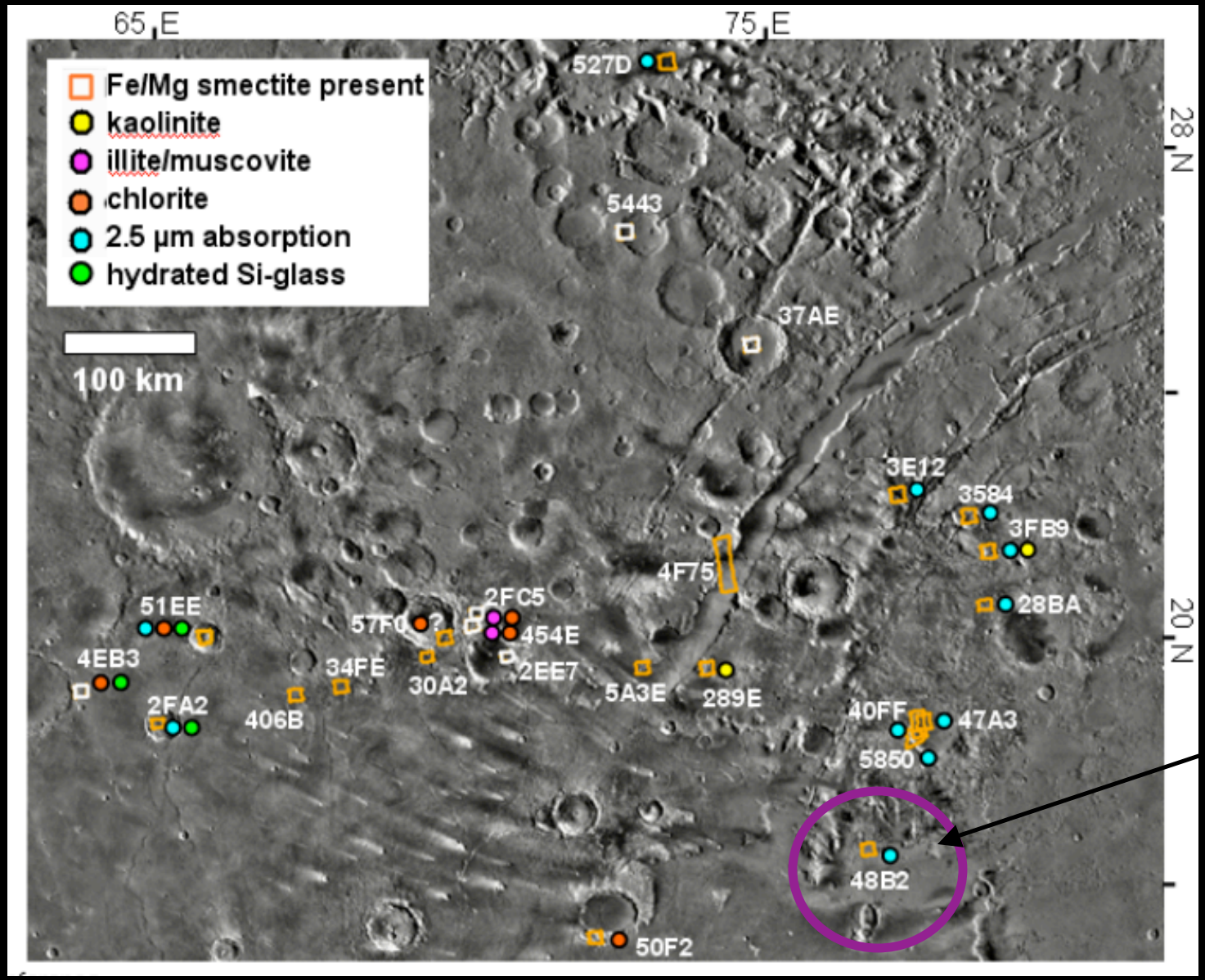
Phyllosilicate band strength

0.01 *D2300* *0.05*

OMEGA D2300 parameter - phyllosilicate

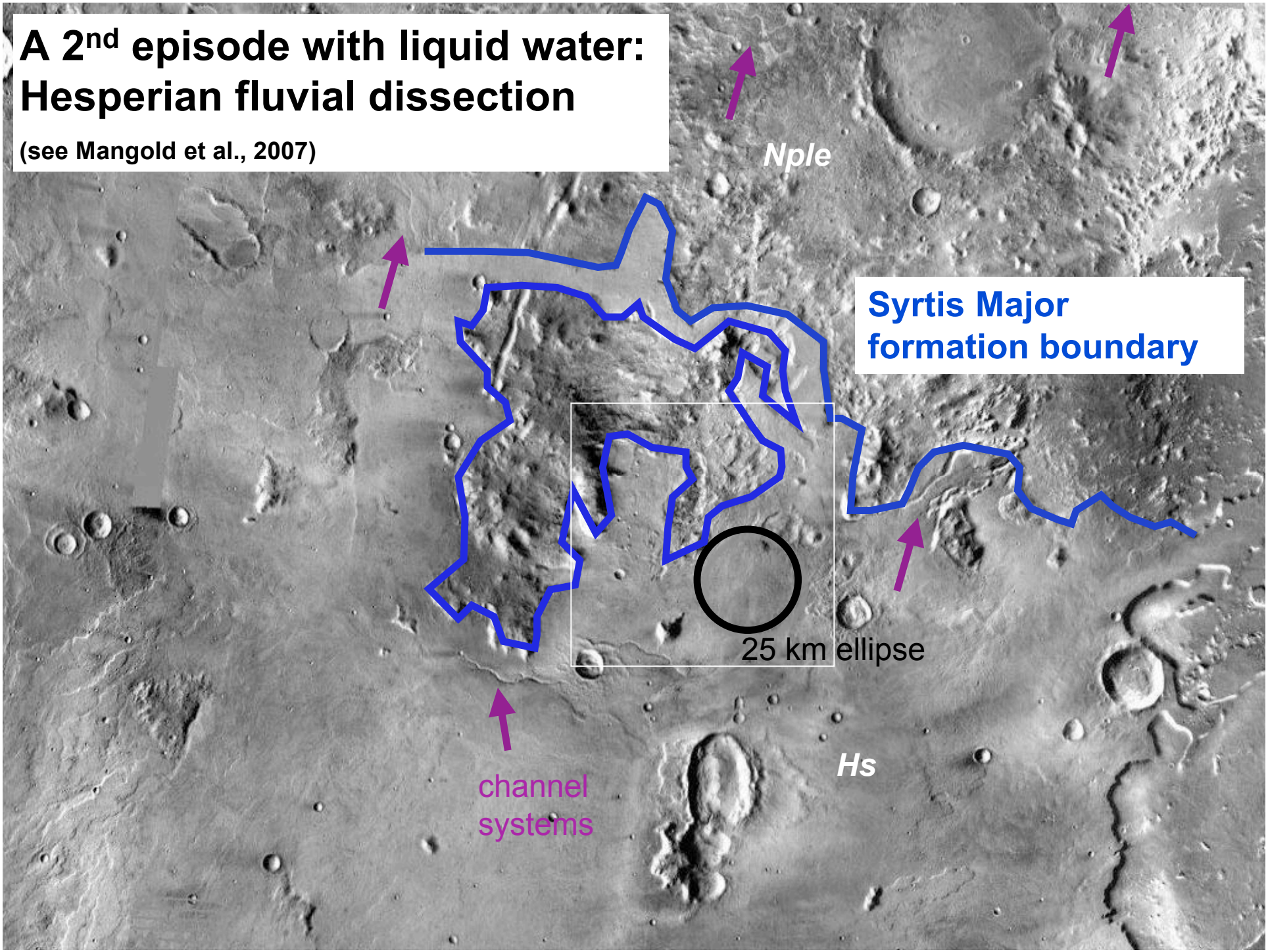


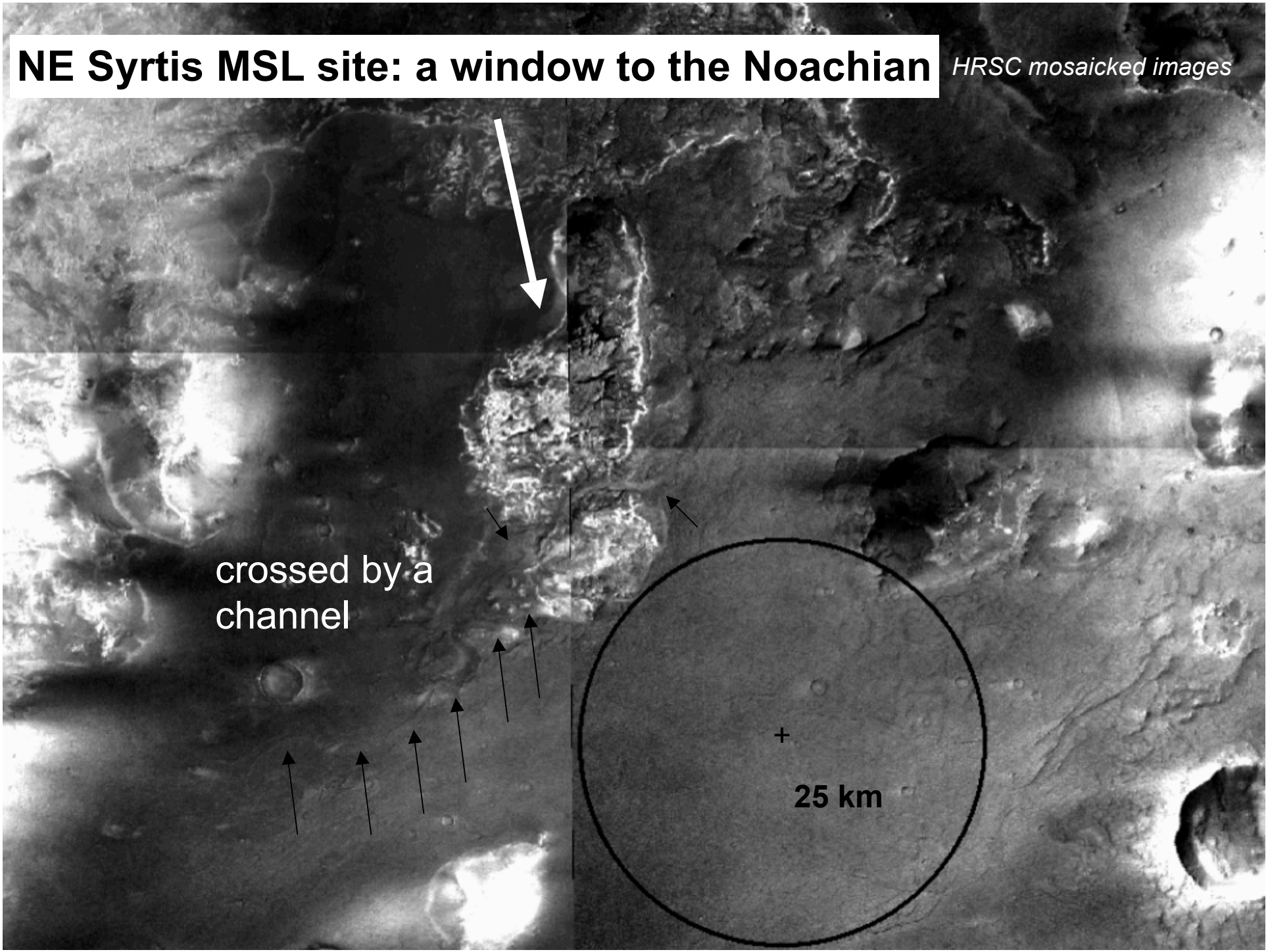
Recalling 7th Mars conf. and regional phyllosilicate mineral diversity…

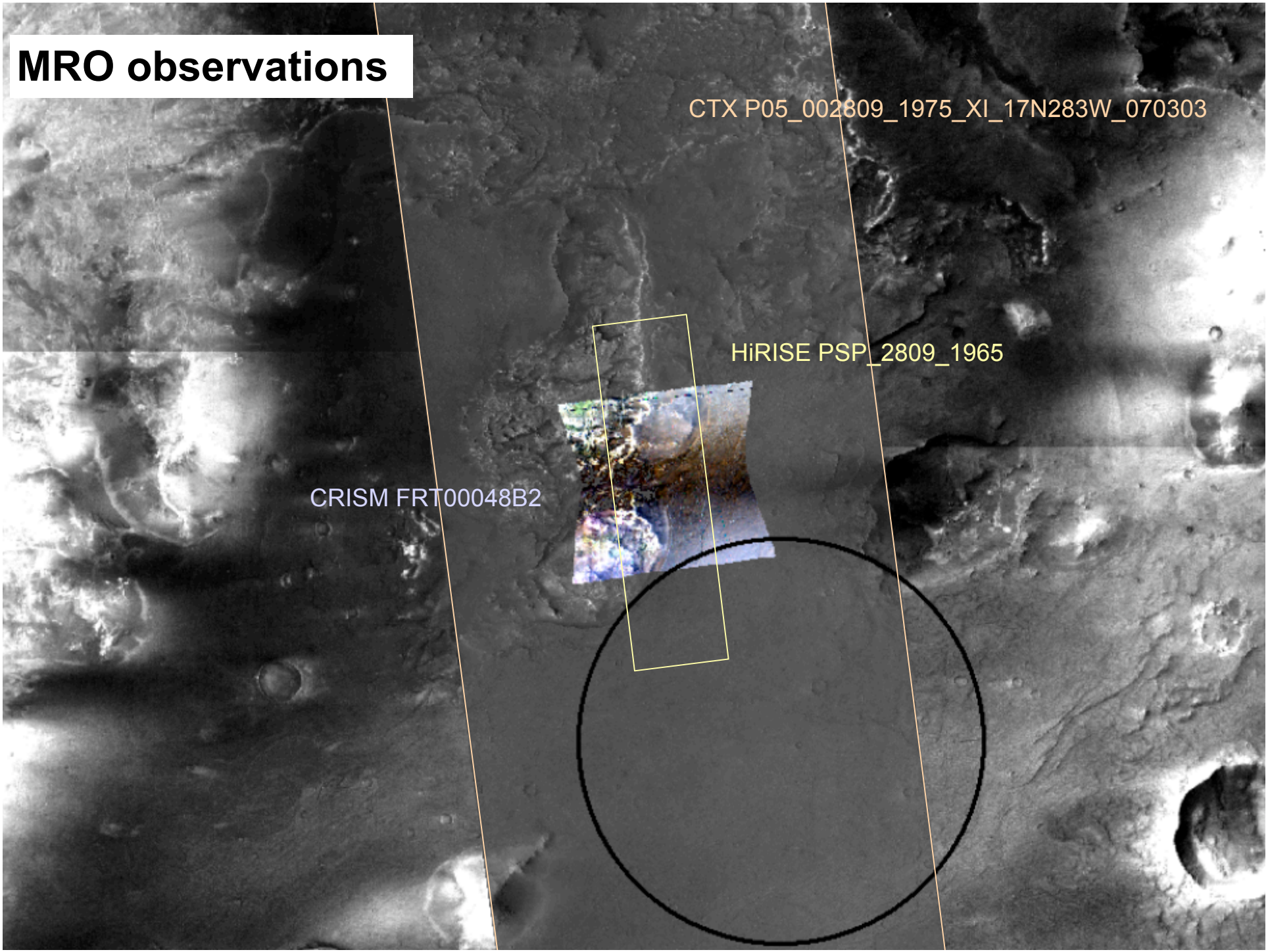


Ehlmann et al., 2007

NE Syrtis: typical "Eastern assemblage"


A 2nd episode with liquid water:
Hesperian fluvial dissection
(see Mangold et al., 2007)
Nple
Syrtis Major
formation boundary
25 km ellipse
channel
systems
Hs


NE Syrtis MSL site: a window to the Noachian
HRSC mosaicked images
crossed by a channel
25 km


MRO observations
CTX P05_002809_1975_XI_17N283W_070303
HiRISE PSP_2809_1965
CRISM FRT00048B2

CRISM spectra show surface compositional diversity

CRISM data show

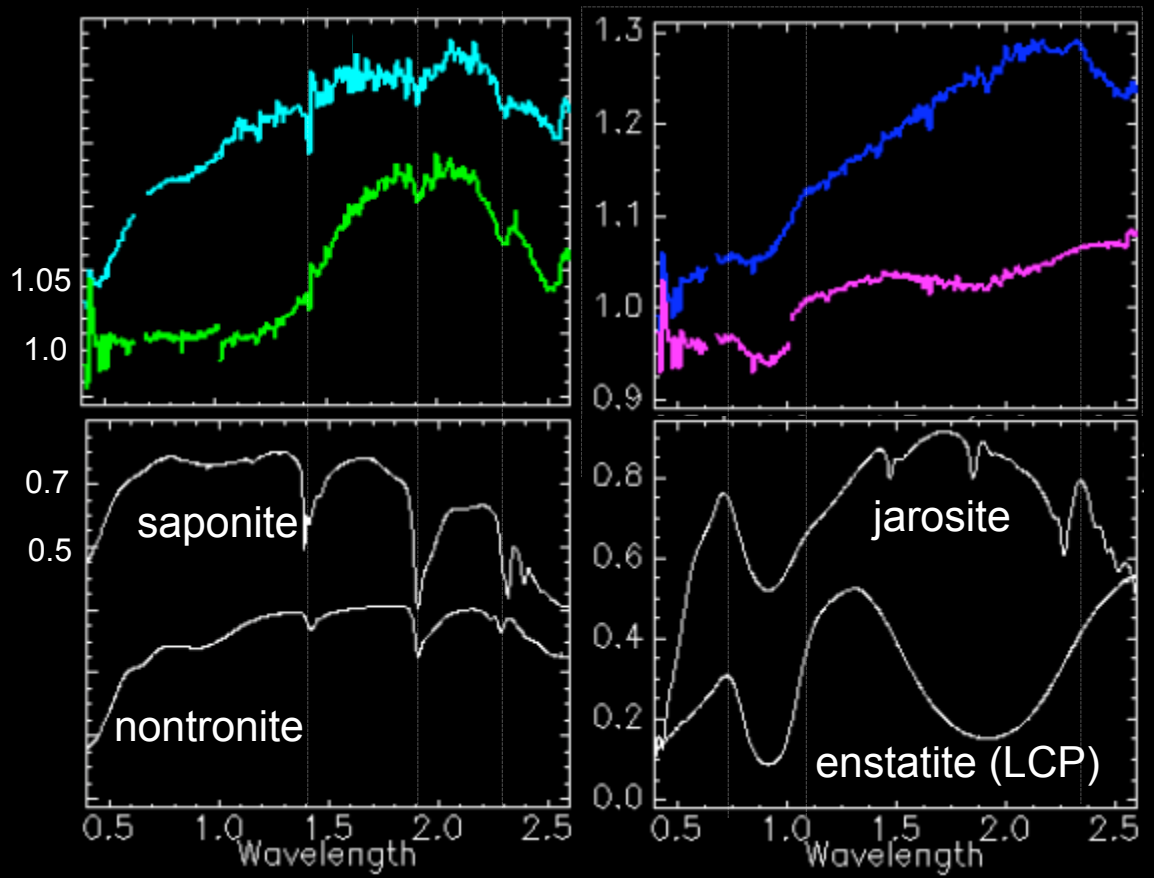
- **Fe/Mg smectites**, e.g. nontronite and saponite
- Low calcium pyroxene
- Variation is also seen in parameters which pick up hydration, iron composition: jarosite? iron oxides + a hydrated phase?

FRT000048B2

10 km across

R: 2.38, G: 1.80, B: 1.15 microns

CRISM spectra (colored)



library spectra

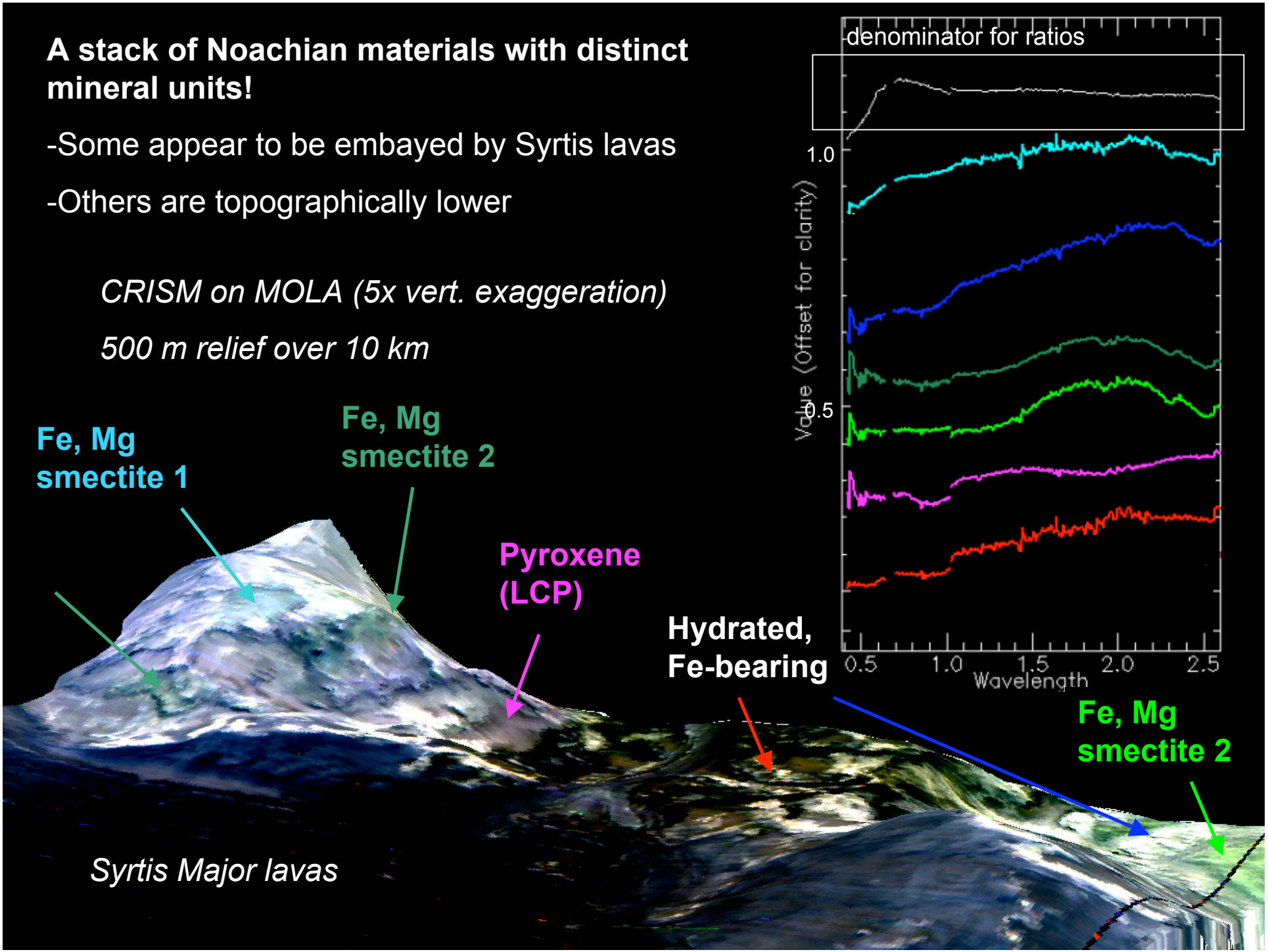
A stack of Noachian materials with distinct mineral units!

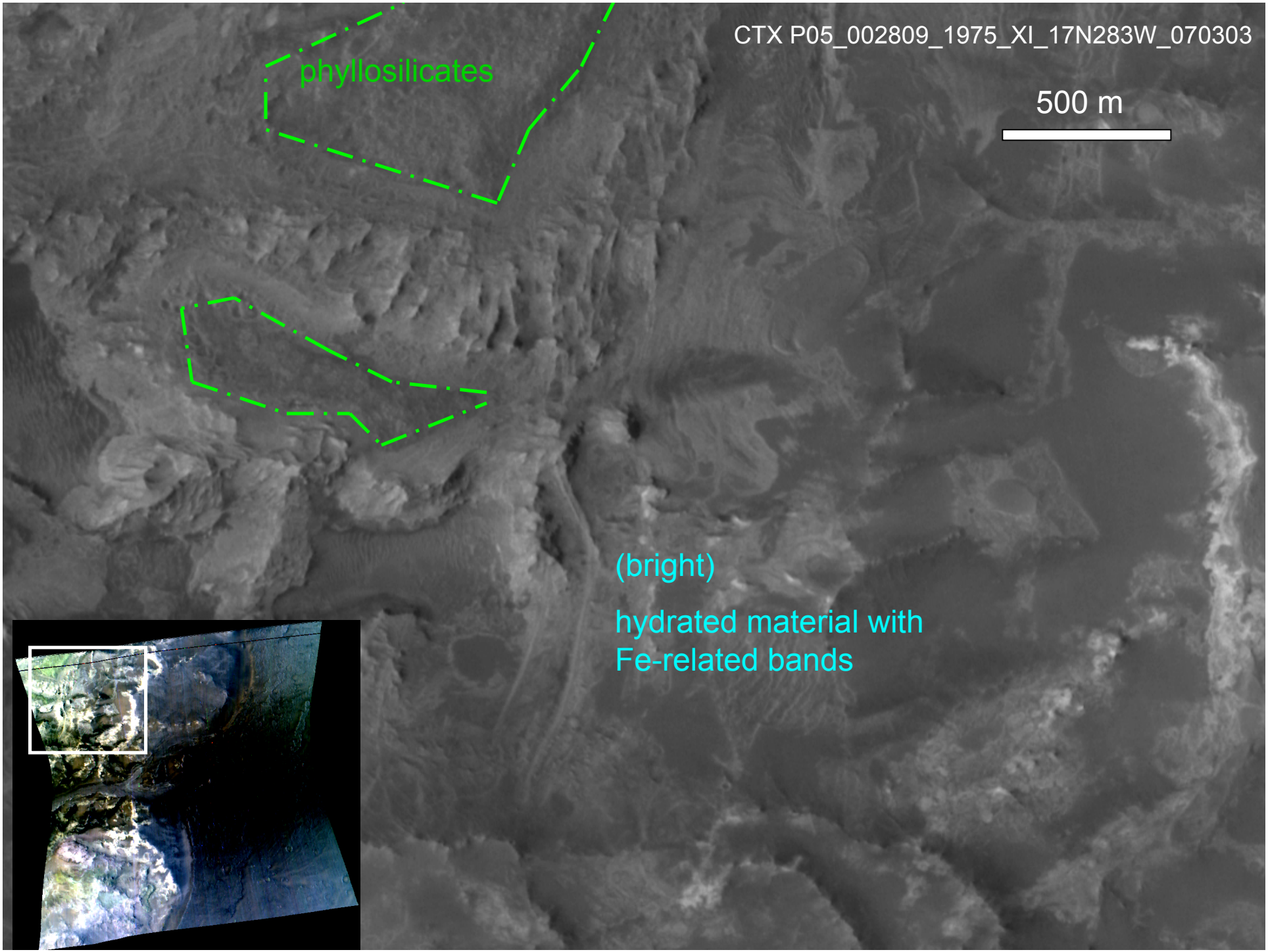
-Some appear to be embayed by Syrtis lavas

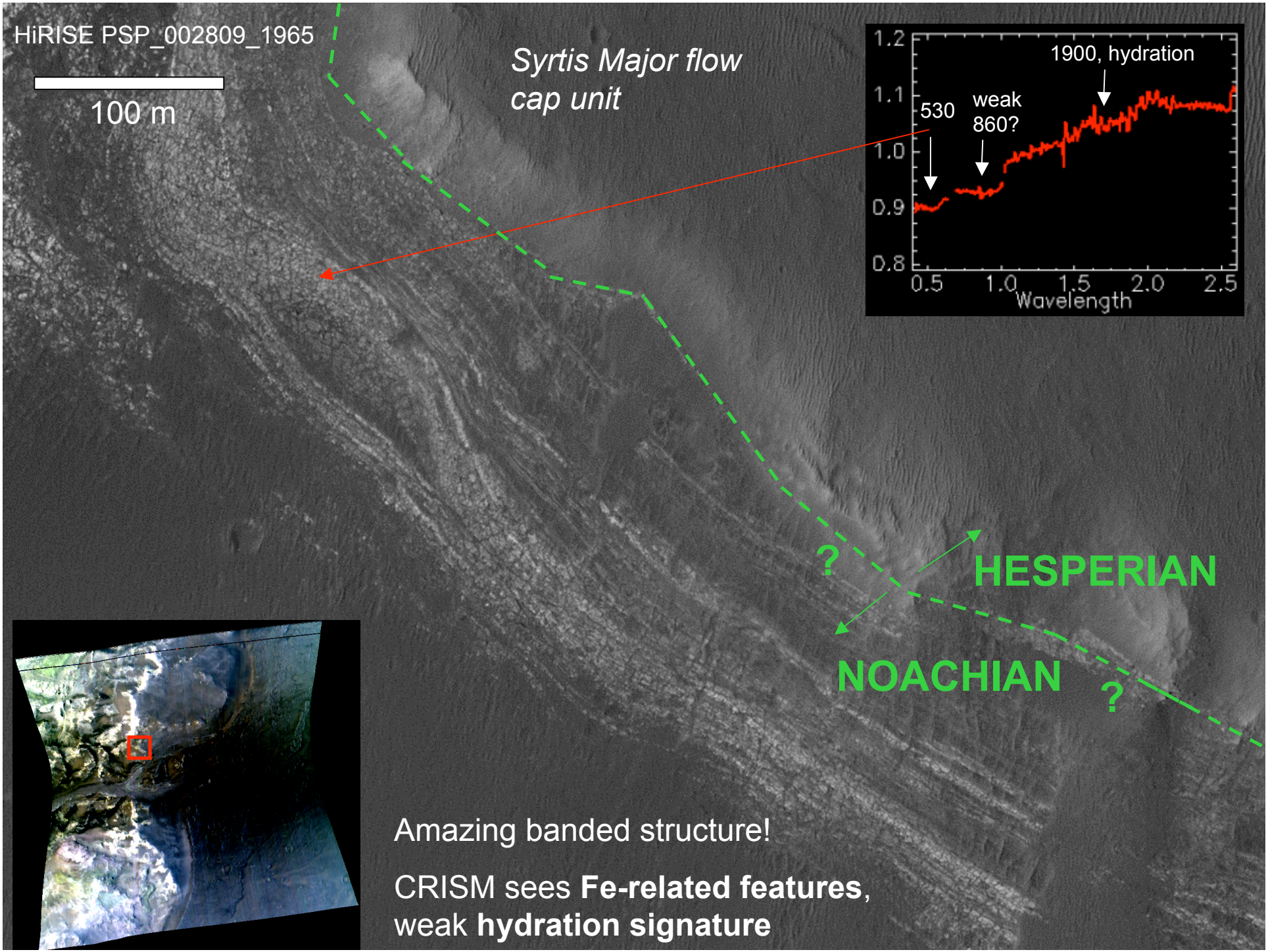
-Others are topographically lower

CRISM on MOLA (5x vert. exaggeration)

500 m relief over 10 km

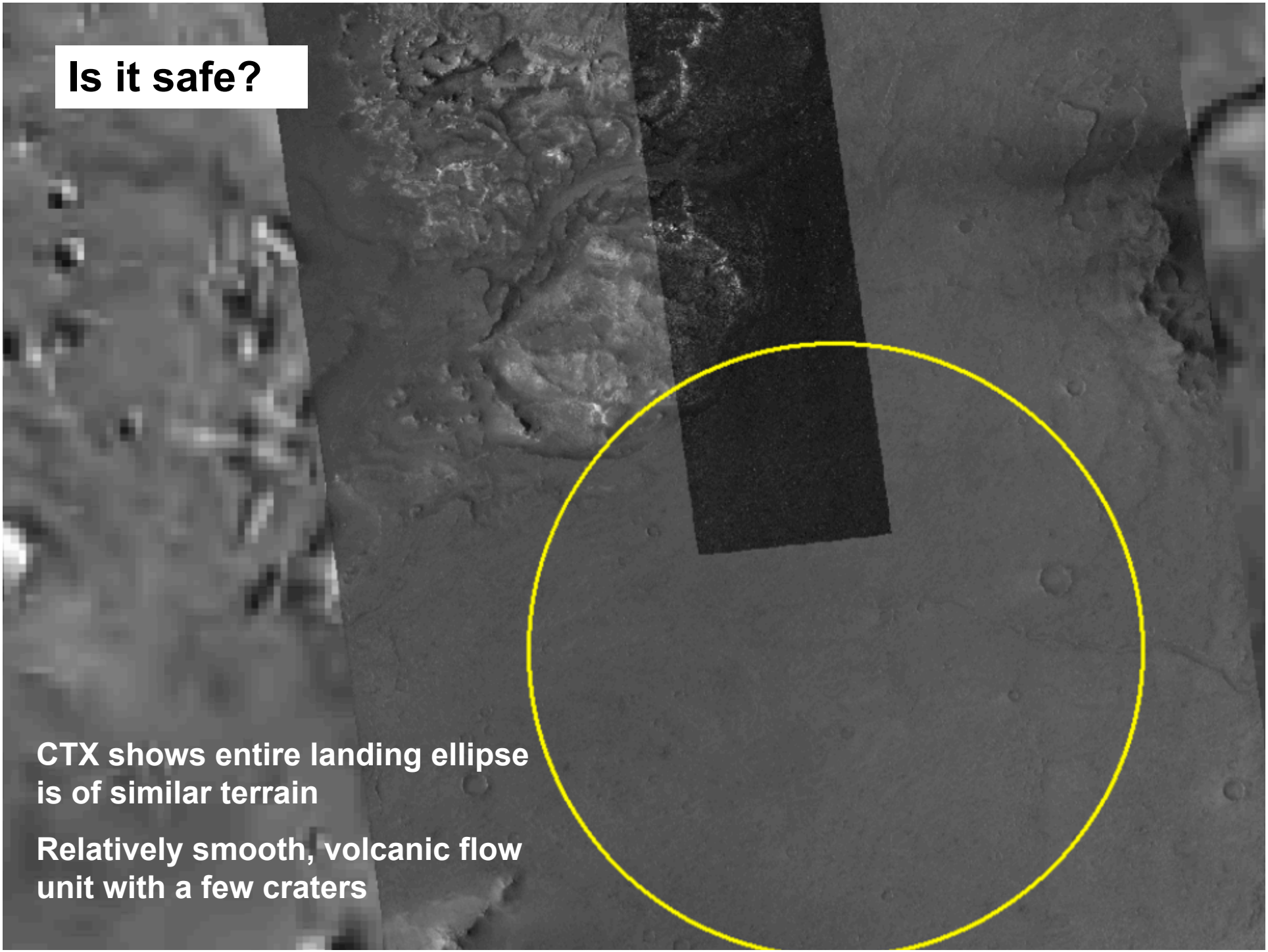


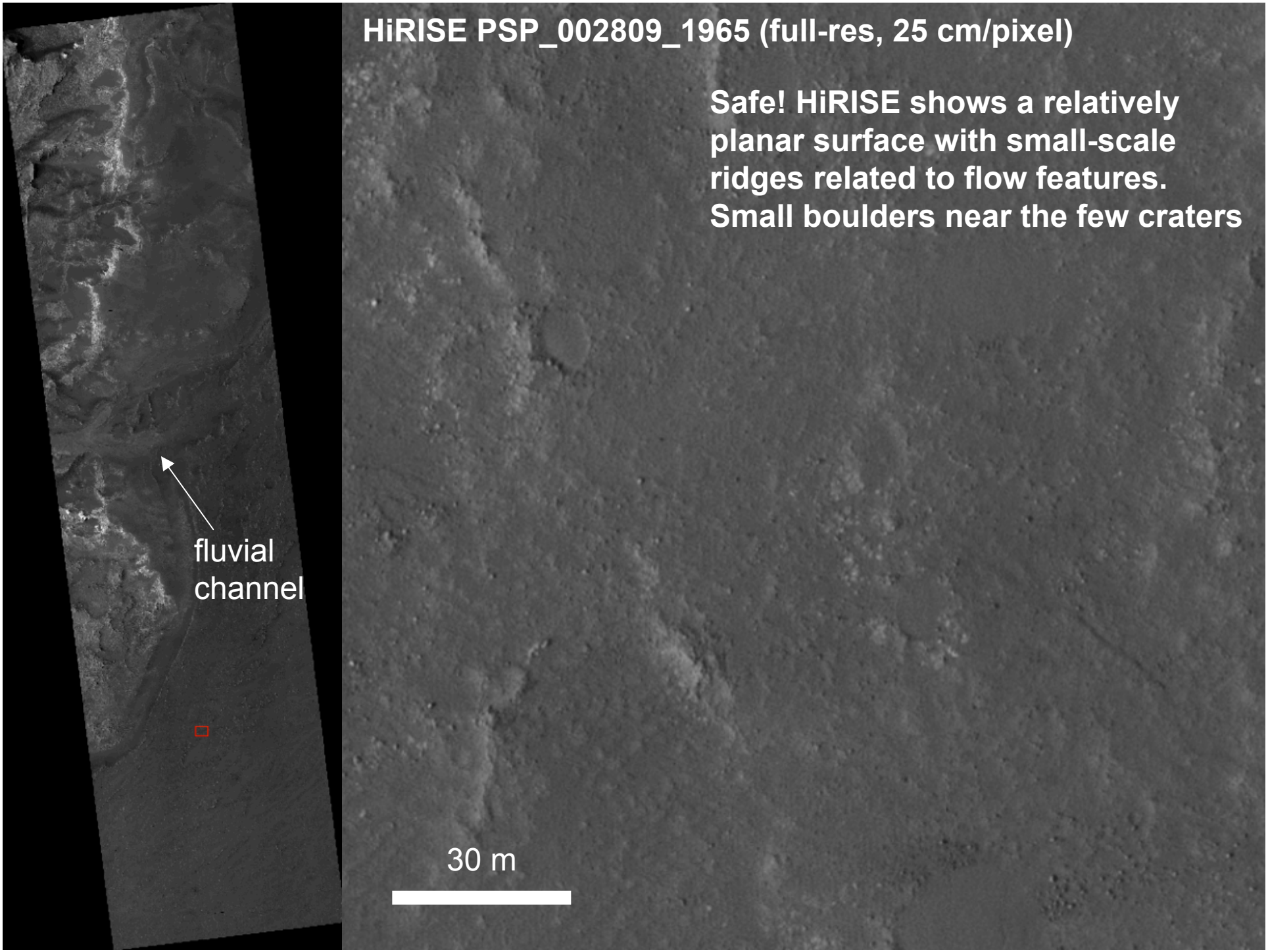

CTX P05_002809_1975_XI_17N283W_070303
phyllosilicates
500 m
(bright)
hydrated material with
Fe-related bands


HiRISE PSP_002809_1965
100 m
Syrtis Major flow
cap unit
1.2
1.1
1.0
0.9
0.8
530
weak
860?
1900, hydration
0.5
1.0
1.5
2.0
2.5
Wavelength
?
HESPERIAN
NOACHIAN
?
Amazing banded structure!
CRISM sees **Fe-related features**,
weak **hydration signature**

MSL science rationale

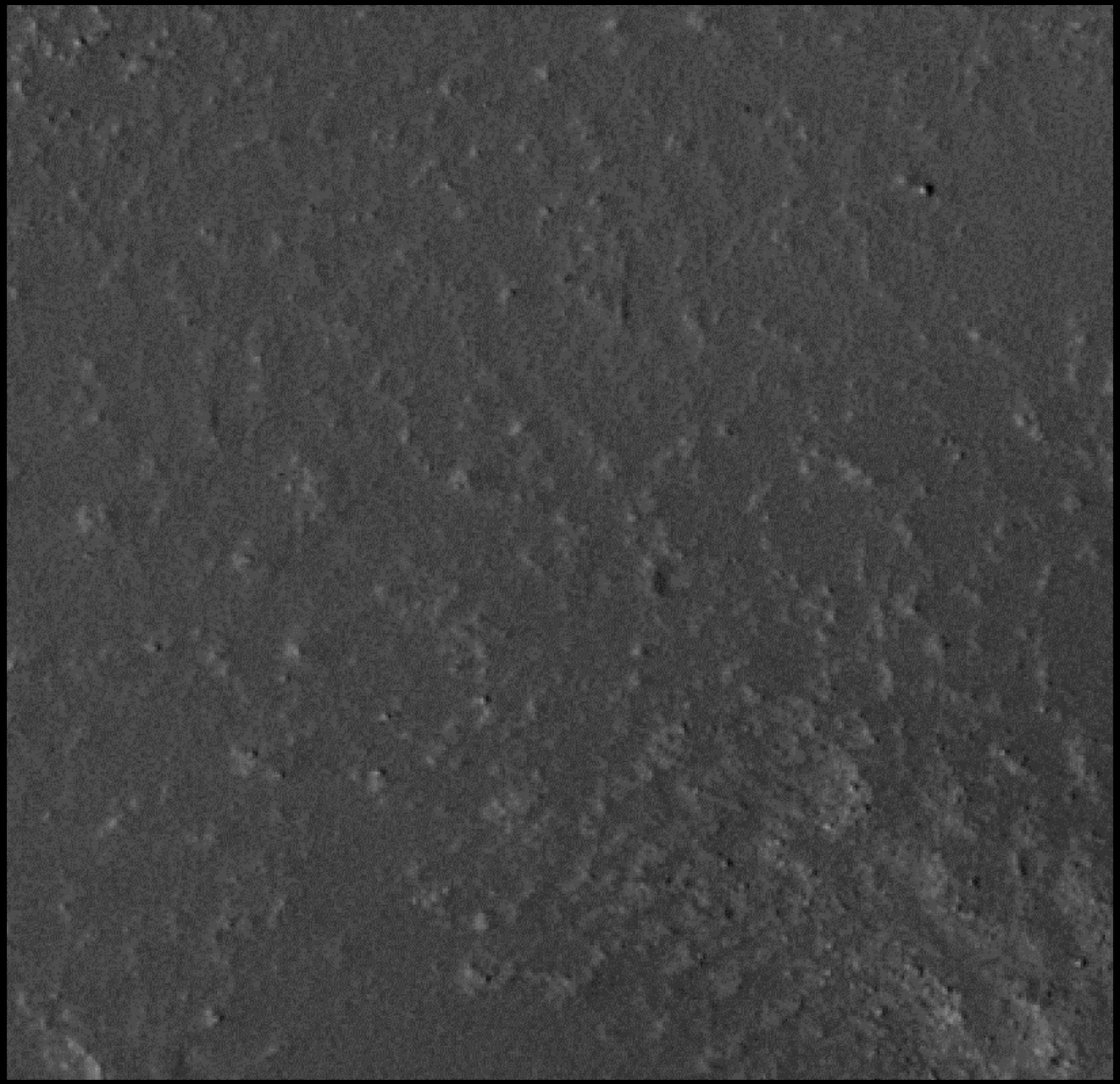
- **Crossing the major time stratigraphic boundary in Mars history**
- **Investigating a major large igneous province, well-constrained in time (Hesperian Syrtis Major formation)**
  - Composition provides insight into igneous processes driving crustal evolution
  - MSL payload ideal for establishing elemental abundances and modal mineralogy
  - Compare to composition at other landing sites, meteorites
  - Great unit to collect a sample for absolute dating
- **Investigating diverse Noachian hydrated/phyllosilicate deposits critical to understanding Mars' biological potential**
  - Important for determining the habitability environment of Mars >3.5 Ga, around the time of the first organisms on Earth
  - Smectite interlayers are ideal sites for sorption of organic matter circulating in pore fluids (Kennedy et al., *Science*, 2002)
  - Testing hypotheses: hydrothermal (near surface or deep), pedogenesis, lacustrine?
  - Provides the opportunity to characterize Noachian habitable environments through in-situ stratigraphy


Is it safe?
CTX shows entire landing ellipse is of similar terrain
Relatively smooth, volcanic flow unit with a few craters


HiRISE PSP_002809_1965 (full-res, 25 cm/pixel)
Safe! HiRISE shows a relatively planar surface with small-scale ridges related to flow features. Small boulders near the few craters
fluvial channel
30 m

HiRISE

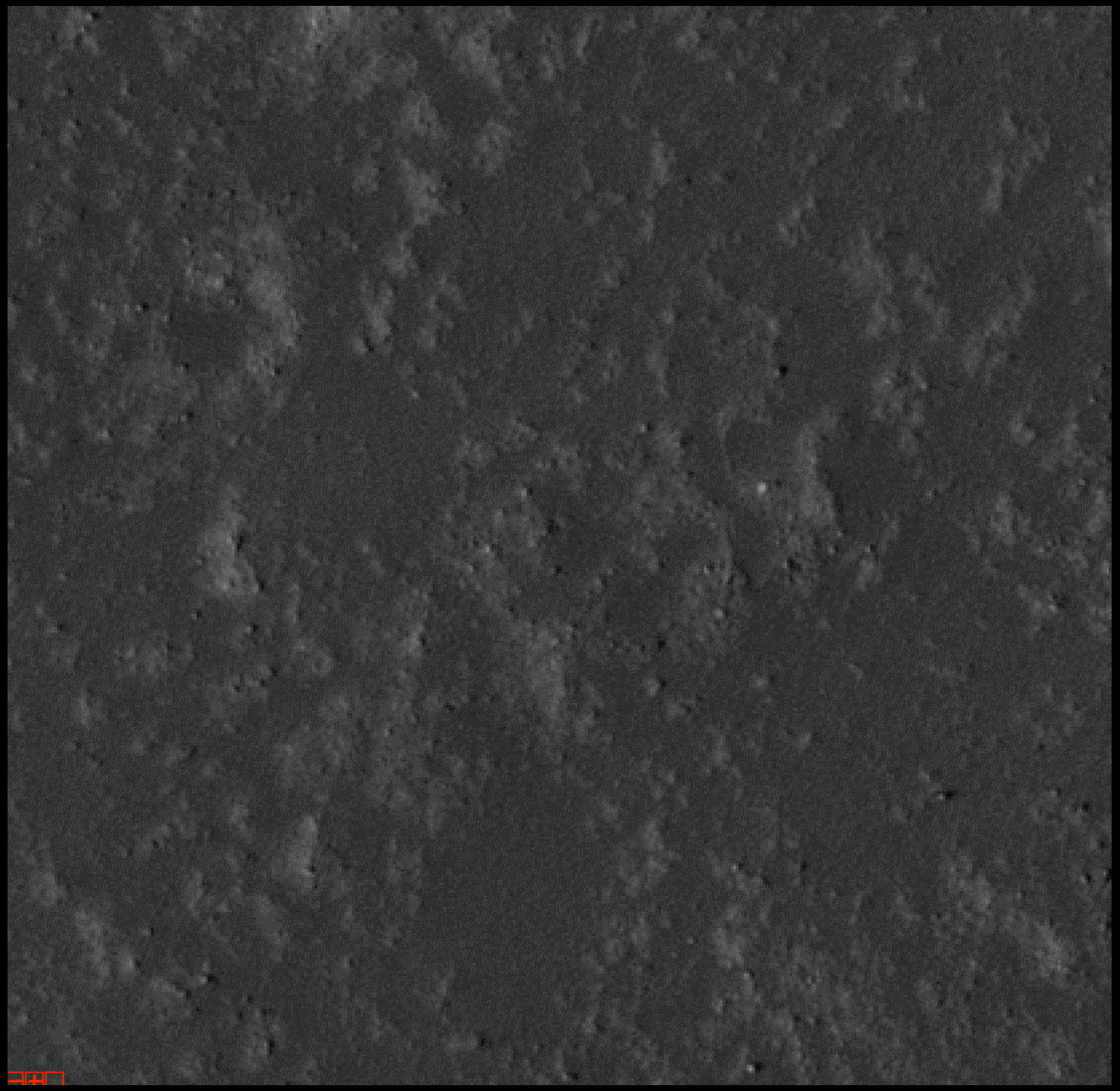
boulders?



100 m across

HiRISE

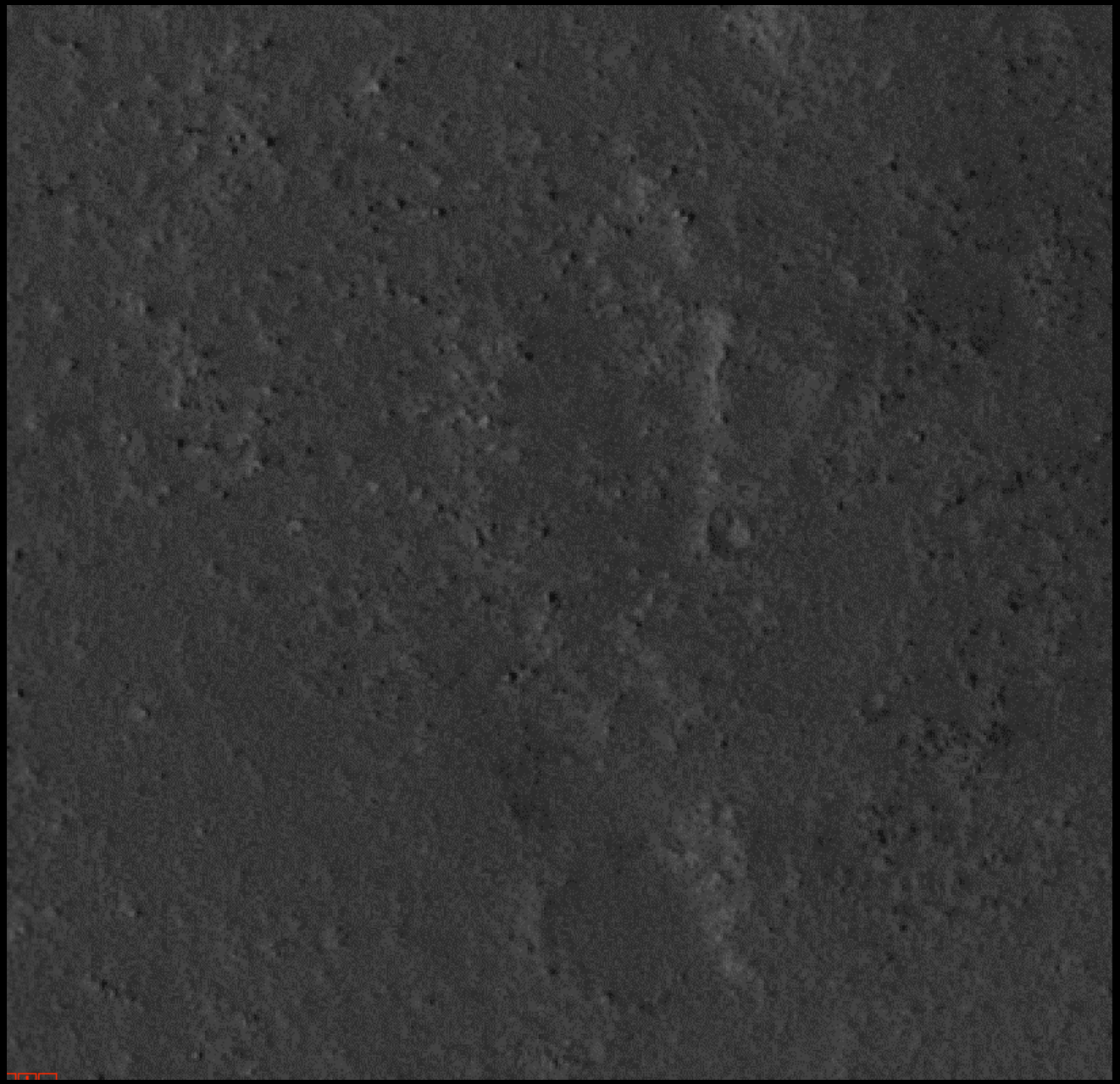
boulders?



100 m across

HiRISE

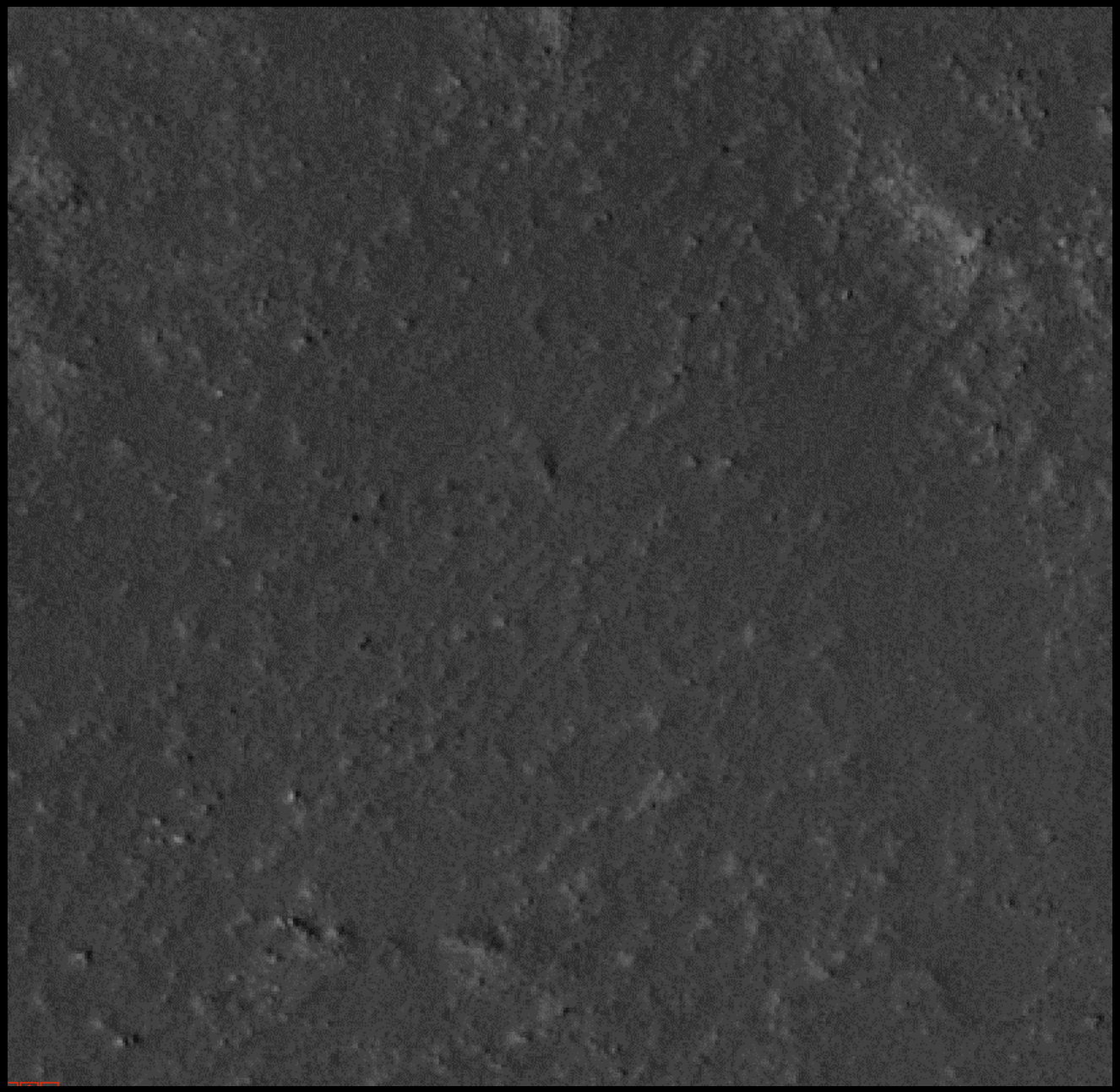
boulders?



100 m across

HiRISE

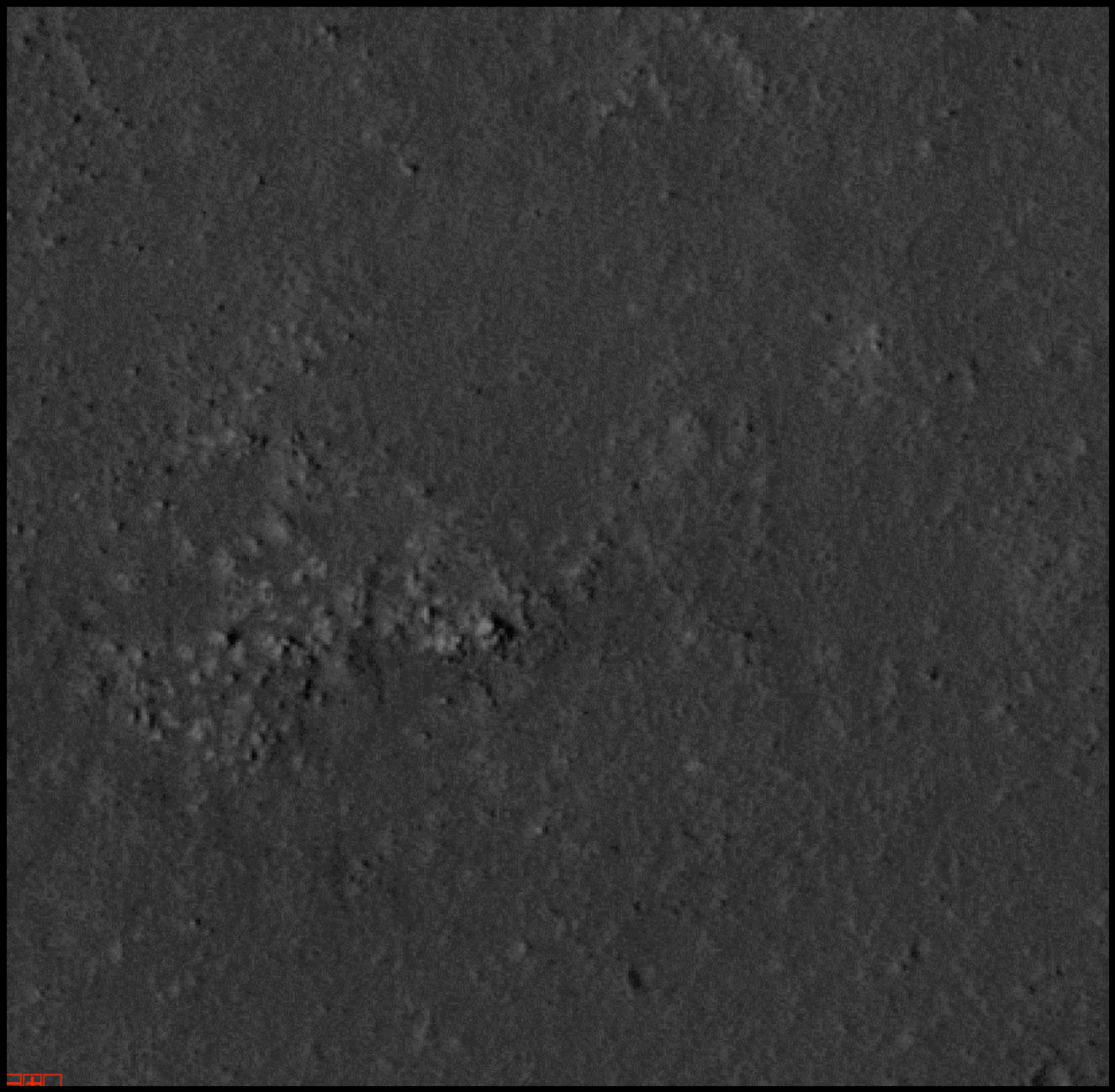
boulders?



100 m across

HiRISE

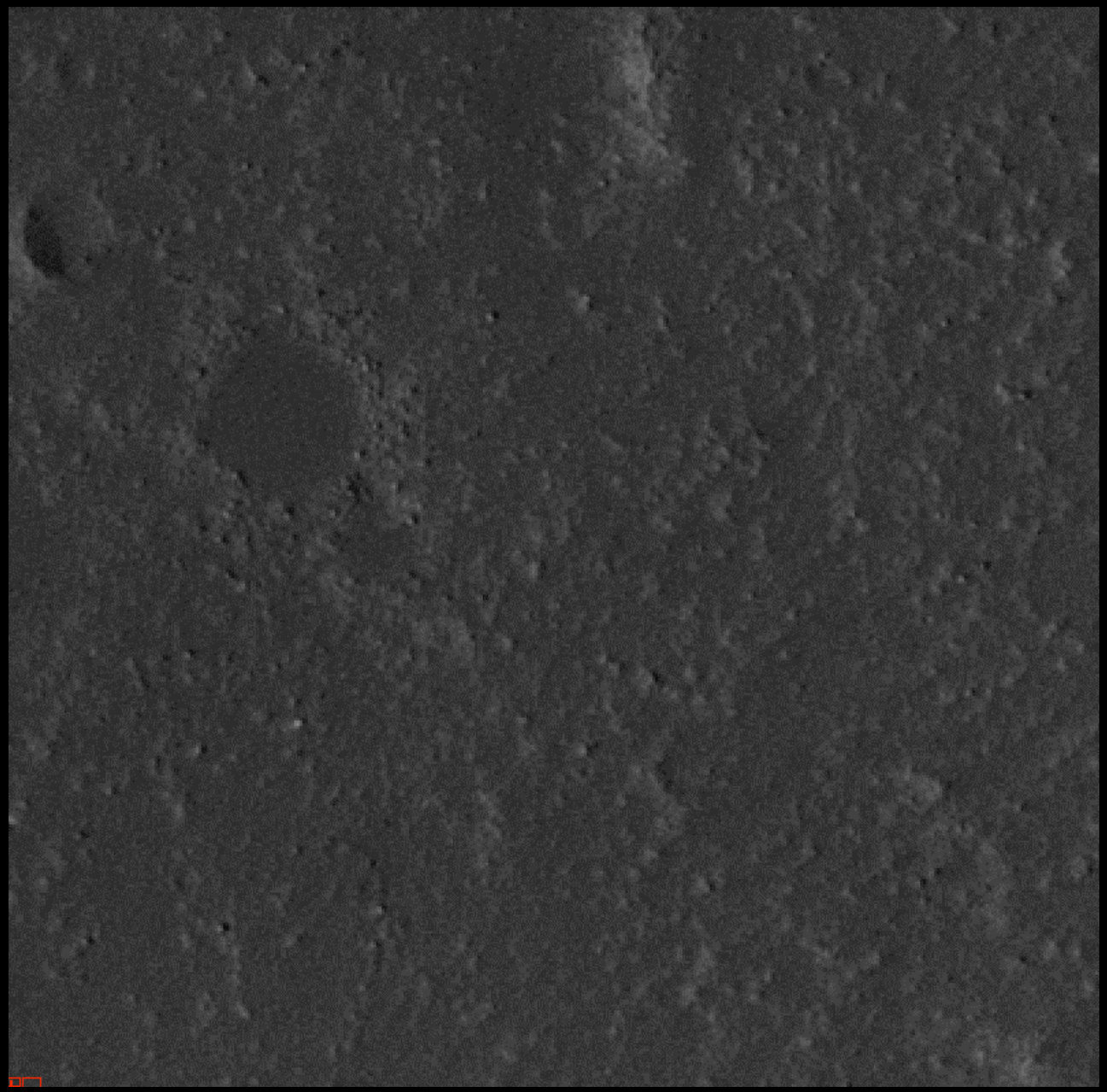
boulders?



100 m across

HiRISE

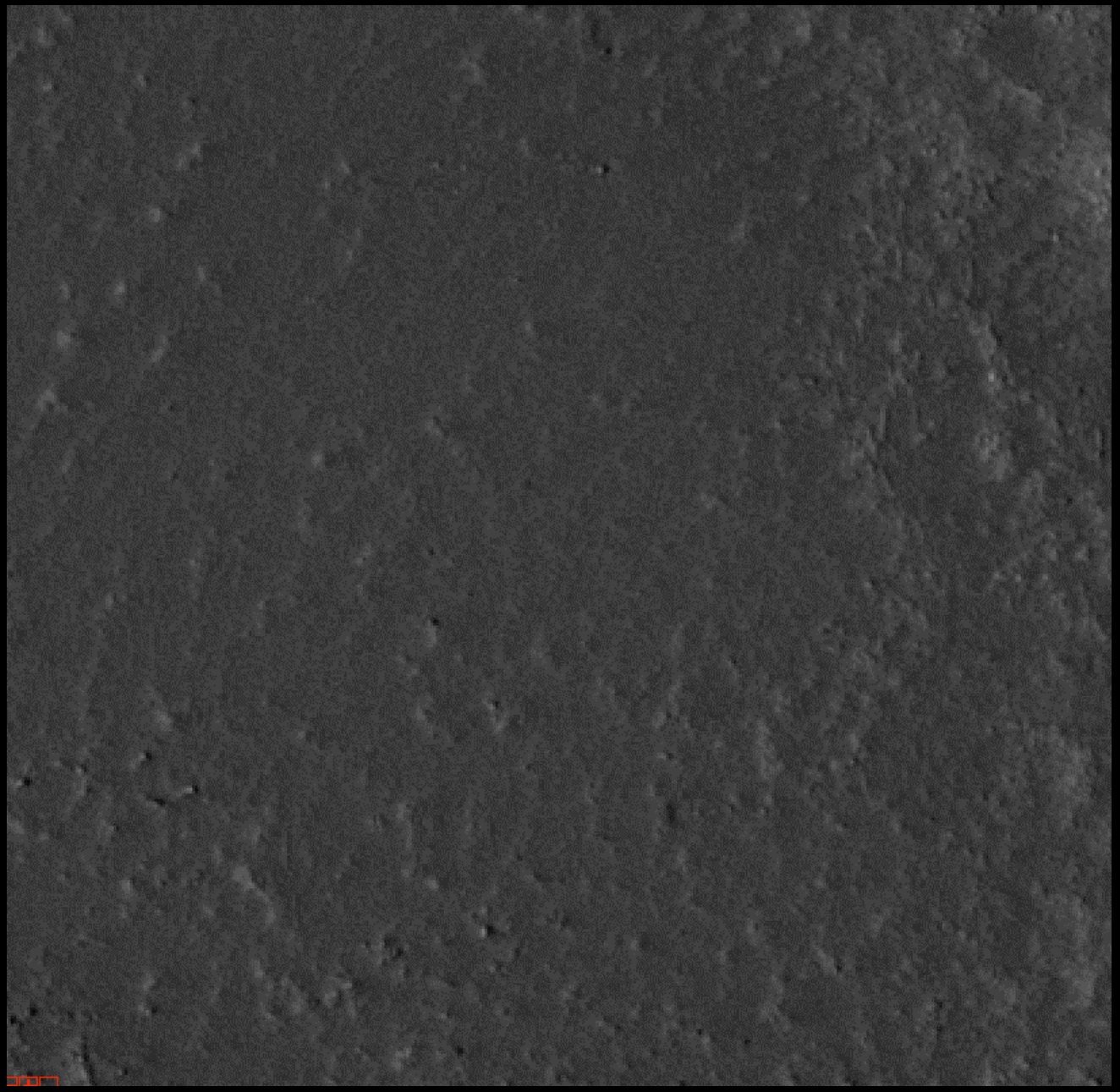
boulders?



100 m across

HiRISE

boulders?



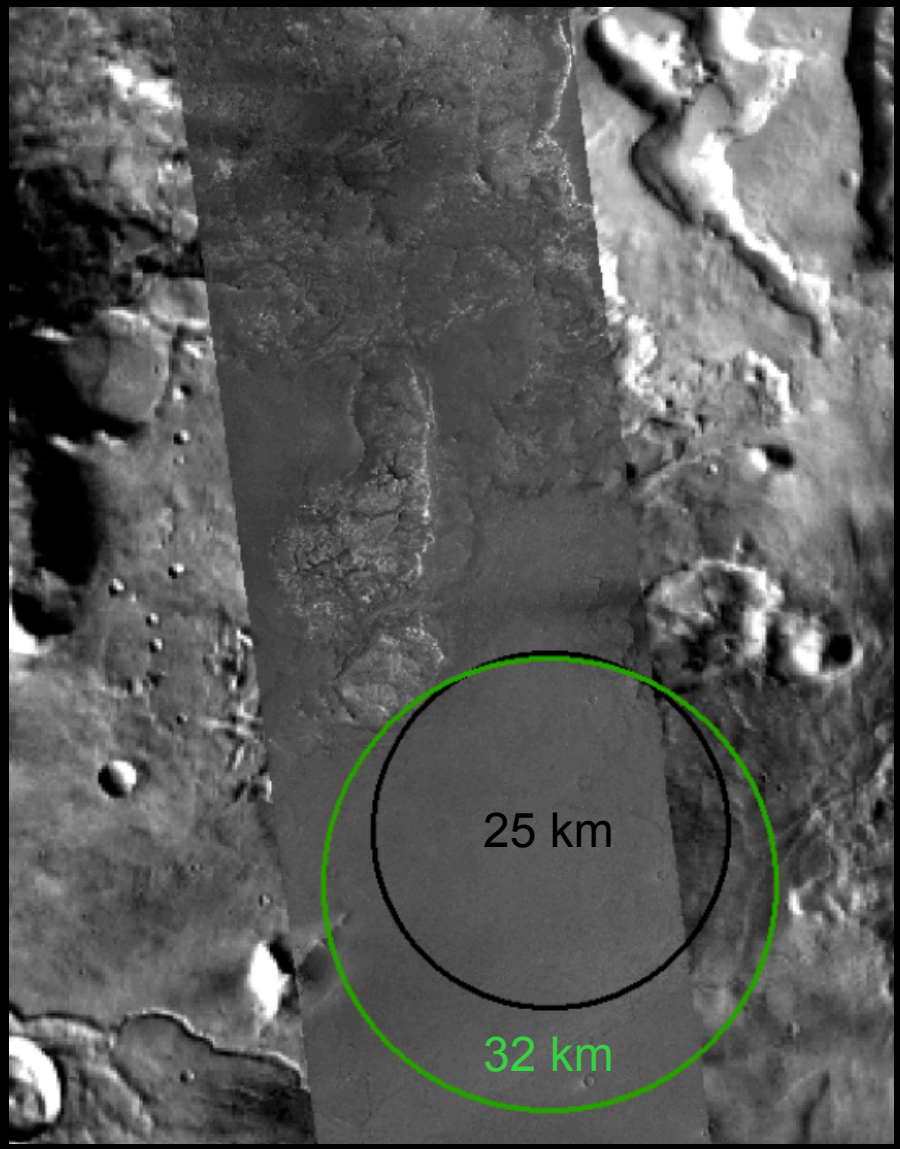
100 m across

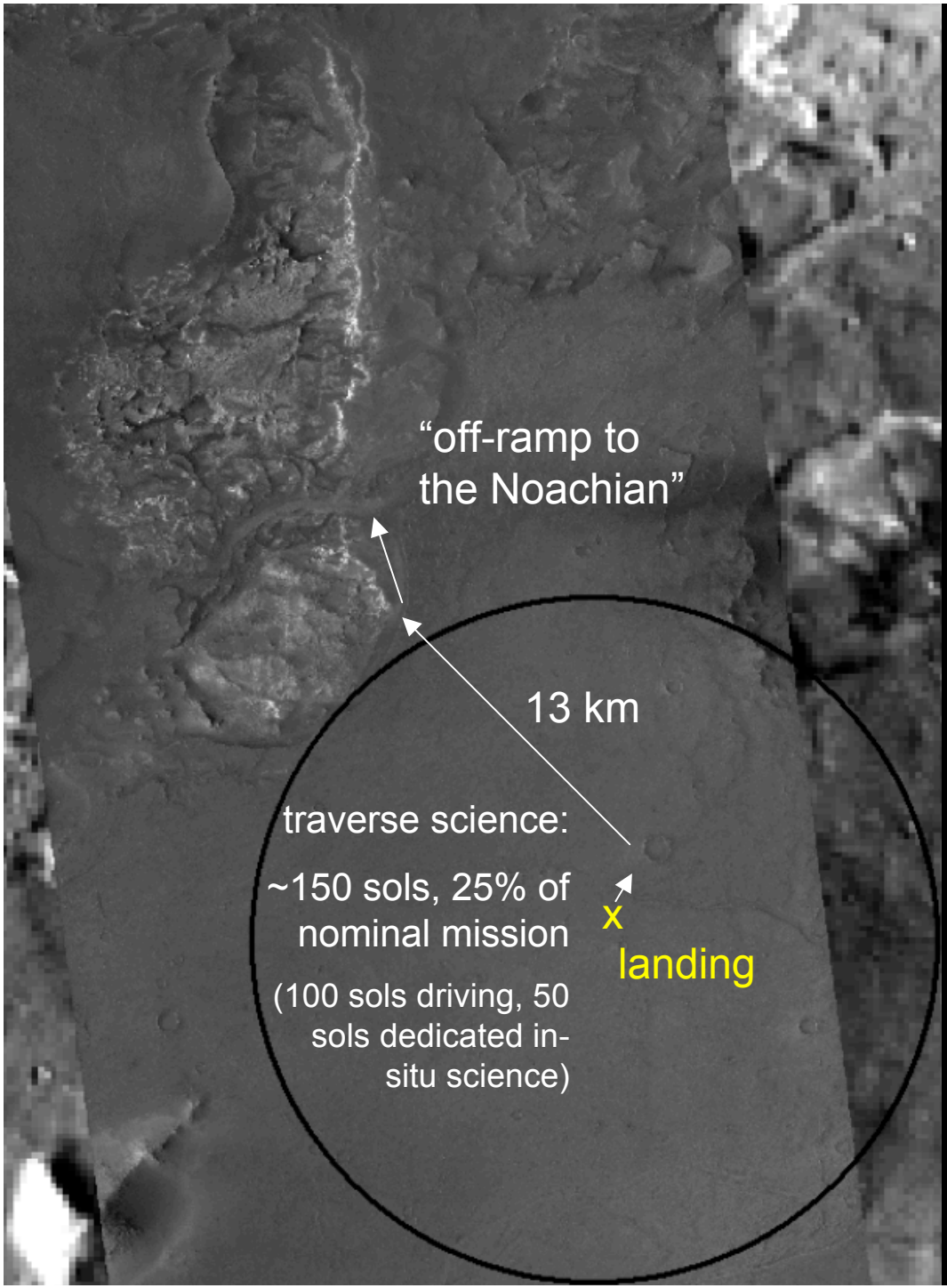
A safe site …

Site latitude/temperature	★	In the 0-22 N lat band window for optimal thermal conditions for full rover performance
Surface and warning track slopes	★	963 m slopes << 2° over ellipse (Eldar provided slope map) CTX/HiRISE → not problematic Syrtis Major flow is a uniform, smooth unit
Flexibility ellipse placement	★	Yes, can expand or can be moved northward toward the phyllosilicates or southward
Safe haven	★	Fits all engineering criteria for safe haven
Rock abundance <0.05% probability of >0.5 m boulder per 4m^2	★	<0.01% chance of a half meter boulder per 4m^2 (sample counts, HiRISE image)
Load Bearing Surface	★	**no problems here!**
Dust		
Cold Temperatures		
Trafficability		
Atmospherically challenging		

Fits safe haven engineering criteria

- The landing ellipse can easily be expanded to 32 km
- Elevation (< -2km), lat/lon, and rock abundance (<0.01%) are all consistent with safe haven criteria
- Ideal thermal environment at ~16 N





NE Syrtis mission profile:

Traverse phase (25%) - the Syrtis Major flows:

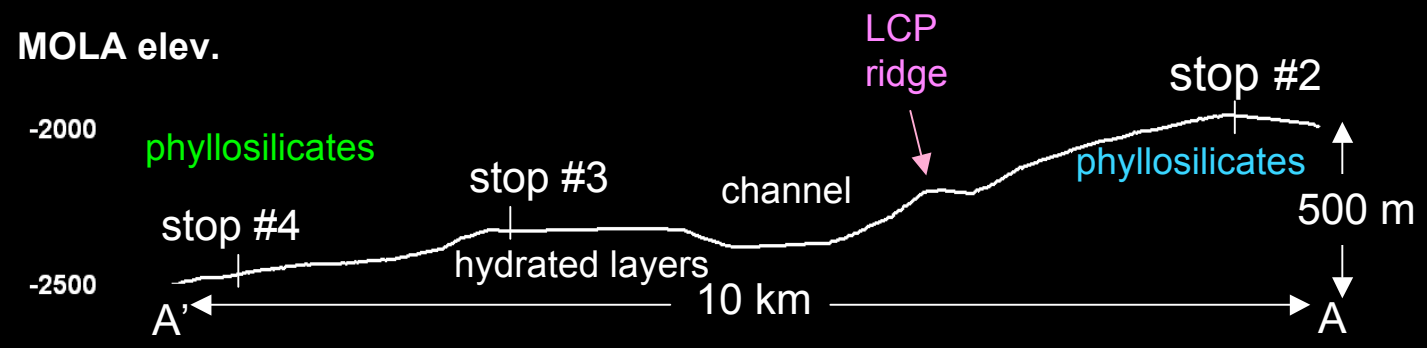
-Elemental abundance, mineralogy

-Alteration from fluvial activity?

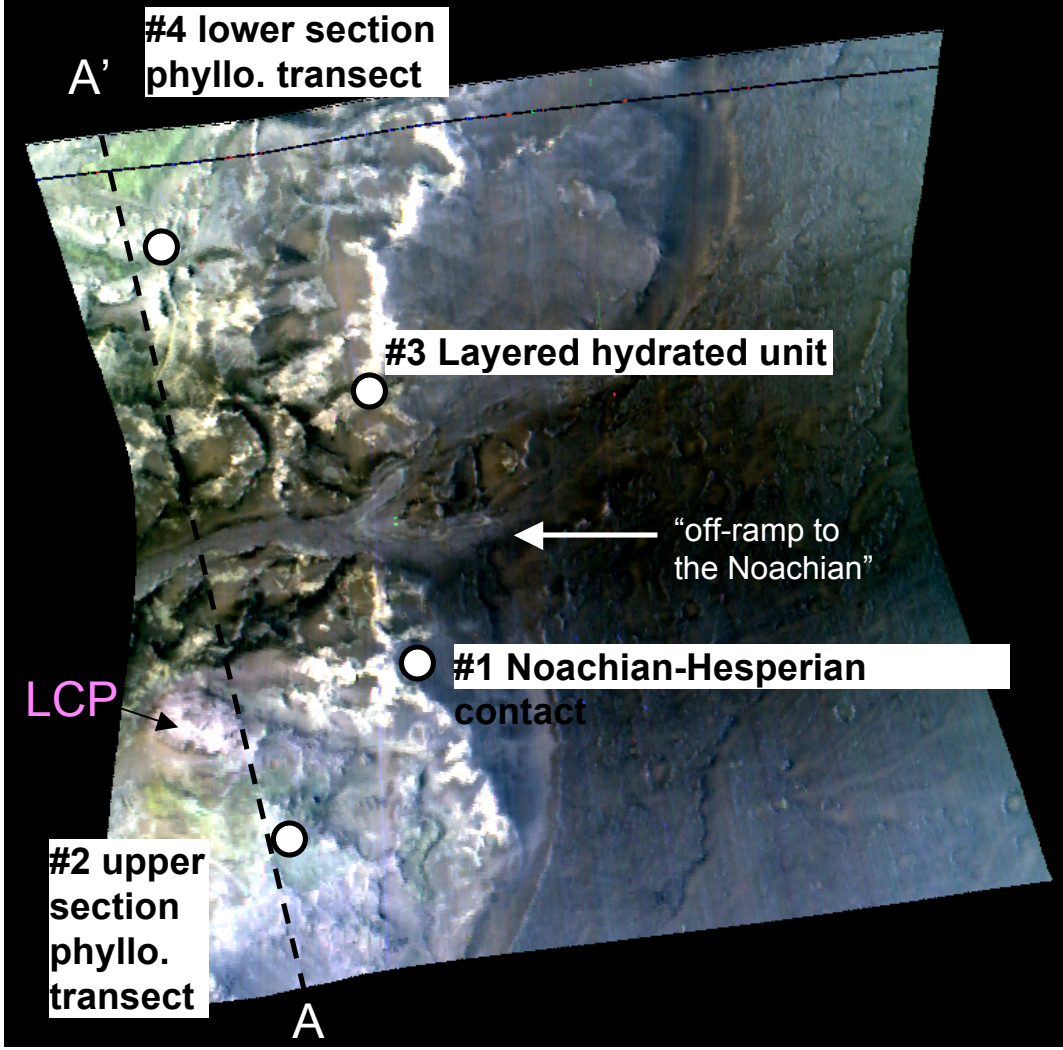
-Assess whether streams are fluvial or lava drainage

-Assess thickness of uppermost flow

→ Hesperian igneous processes



stop #1: Hesperian-Noachian contact! Dry Mars-Wet Mars



NE Syrtis mission profile:

Outcrop science phase (75%):

-Stratigraphic mapping of contacts between unaltered, hydrated units

-Nature of the Noachian-Hesperian contact: unconformable? any low grade-metamorphism?

-Determine mineral assemblages, esp. of alteration minerals

-Examine deposit facies, strike-dip

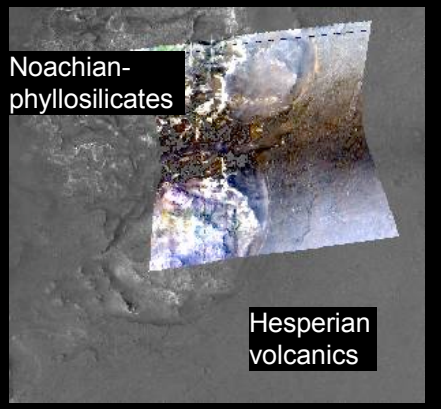
→Nature of Noachian phyllosilicate formation

→Organics in Noachian units?

Why NE Syrtis?

planetary.brown.edu/pdfs/nesyrtis.pdf

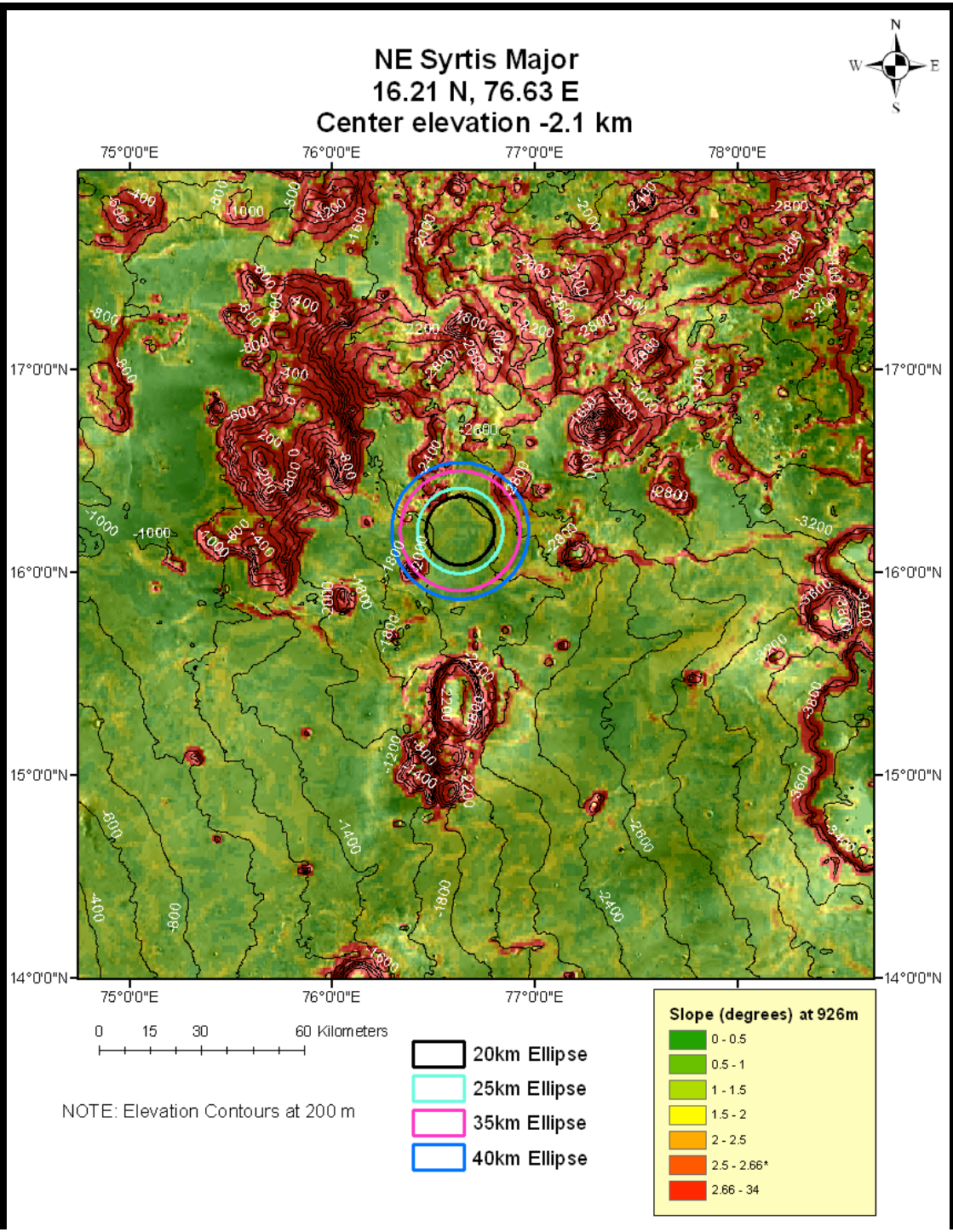
- *Characterize the geologic setting:*
  - Traverse Hesperian-Noachian boundary
  - Noachian eroded, layered, phyllosilicate outcrop
  - A major Mars volcanic province
- *Evidence for habitable environment*
  - DIVERSE phyllosilicates preserve evidence of water-rich Noachian from gradients in energy, T, P
  - Disequilibrium between unaltered (LCP) and altered materials in the stack
  - Assess whether lacustrine, near-surface, hydrothermal
- *Preservation of biosignatures*
  - Smectite ideal (interlayer sites) for capturing and sequestering organic molecules
- *MSL payload use in assessing biosignatures*
  - Fully exercise all payload science instruments
  - Exciting science throughout mission
  - Thermally favorable, 16 N
  - optimal safety → a fabulous site!



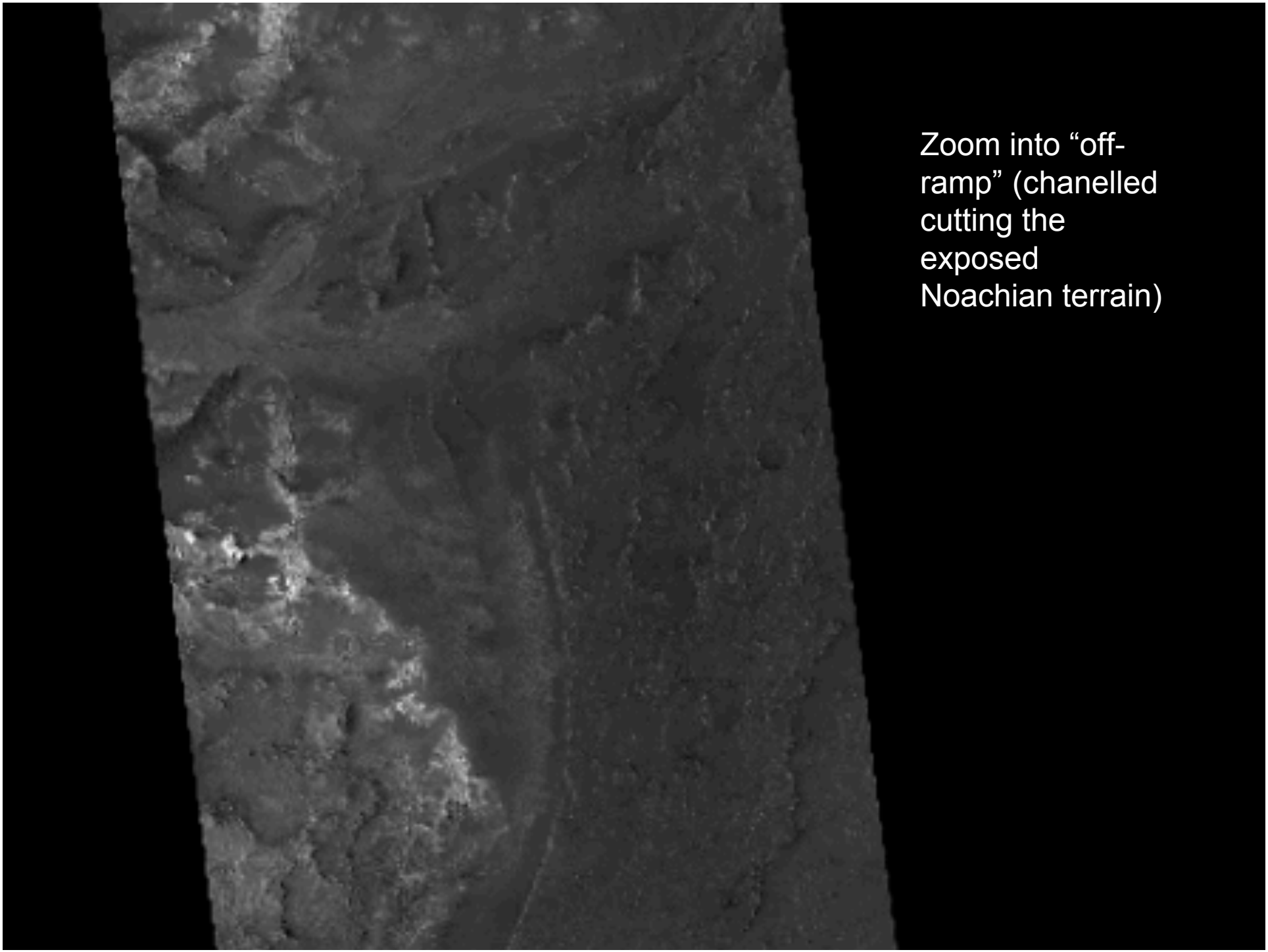
Additional slides

Science criteria

- Biological potential: Noachian habitability assessment with MSL payload
- Evidence for habitable: disequilibrium in altered/unaltered
- Preservation of biosignatures: smectite interlayer sites!
- Ability to characterize geology, geochem, strat. setting – very well-constatined stratigraphy, crossing major boundary

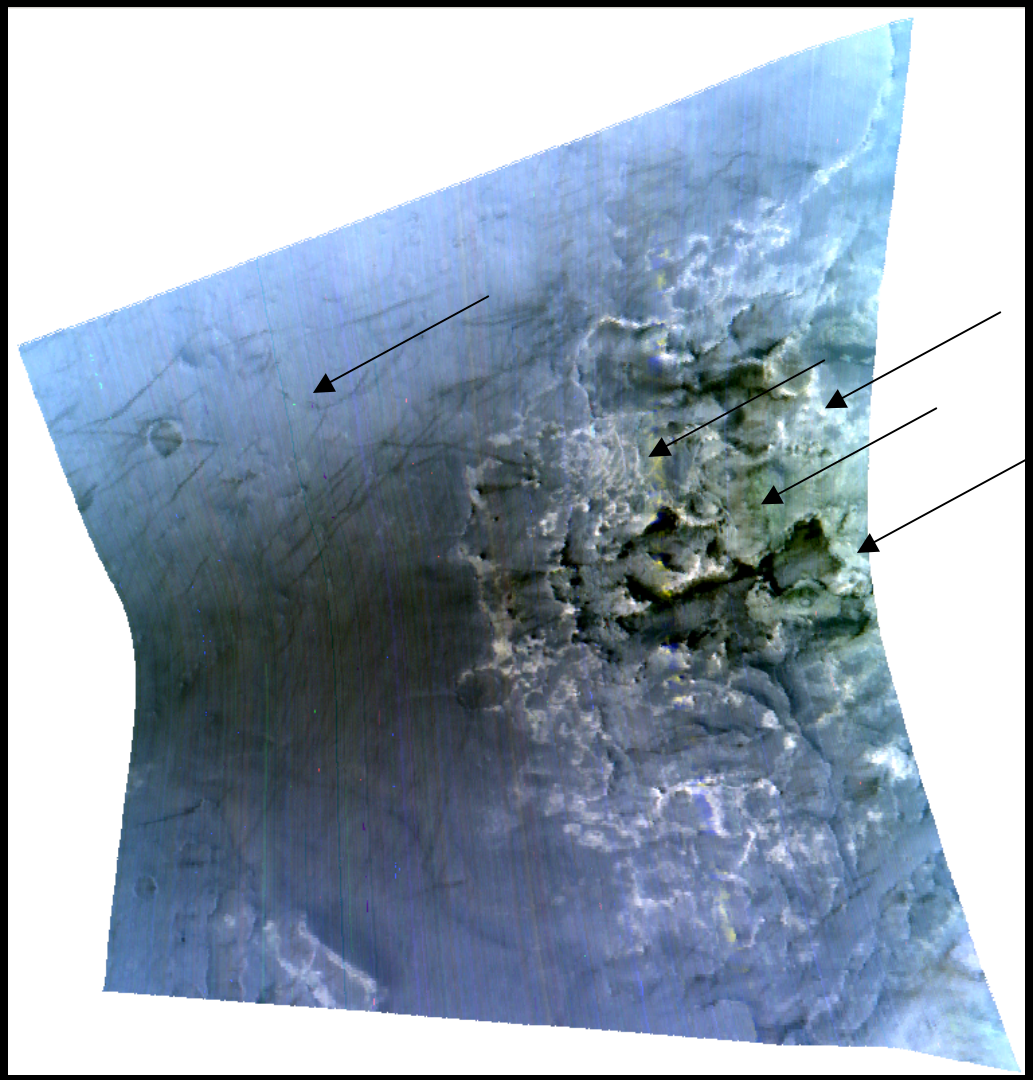


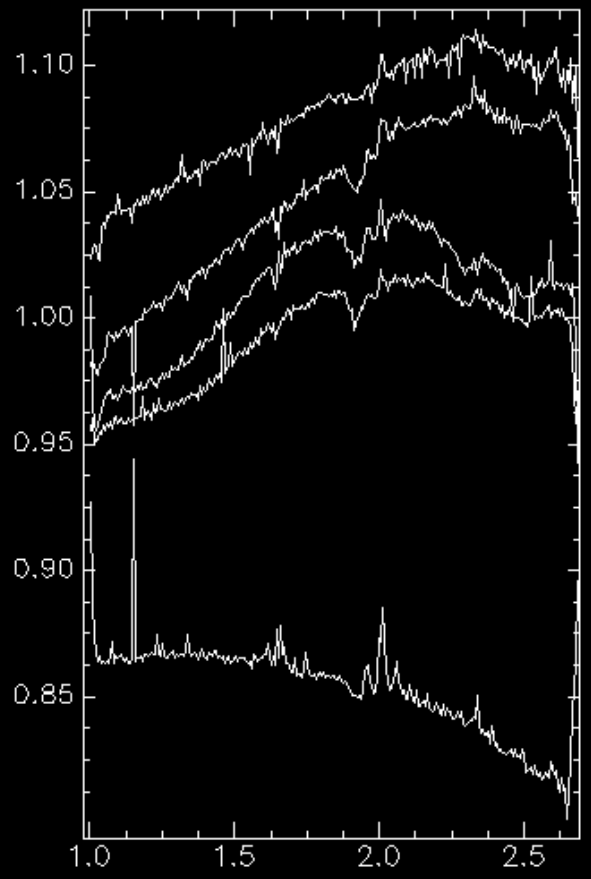
Courtesy E. Noe Dobrea

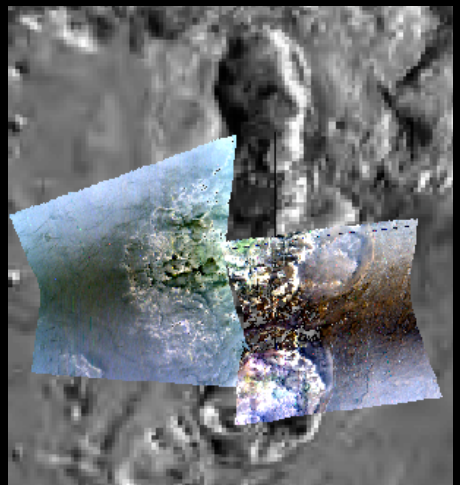


Zoom into “off-ramp” (chanelled cutting the exposed Noachian terrain)

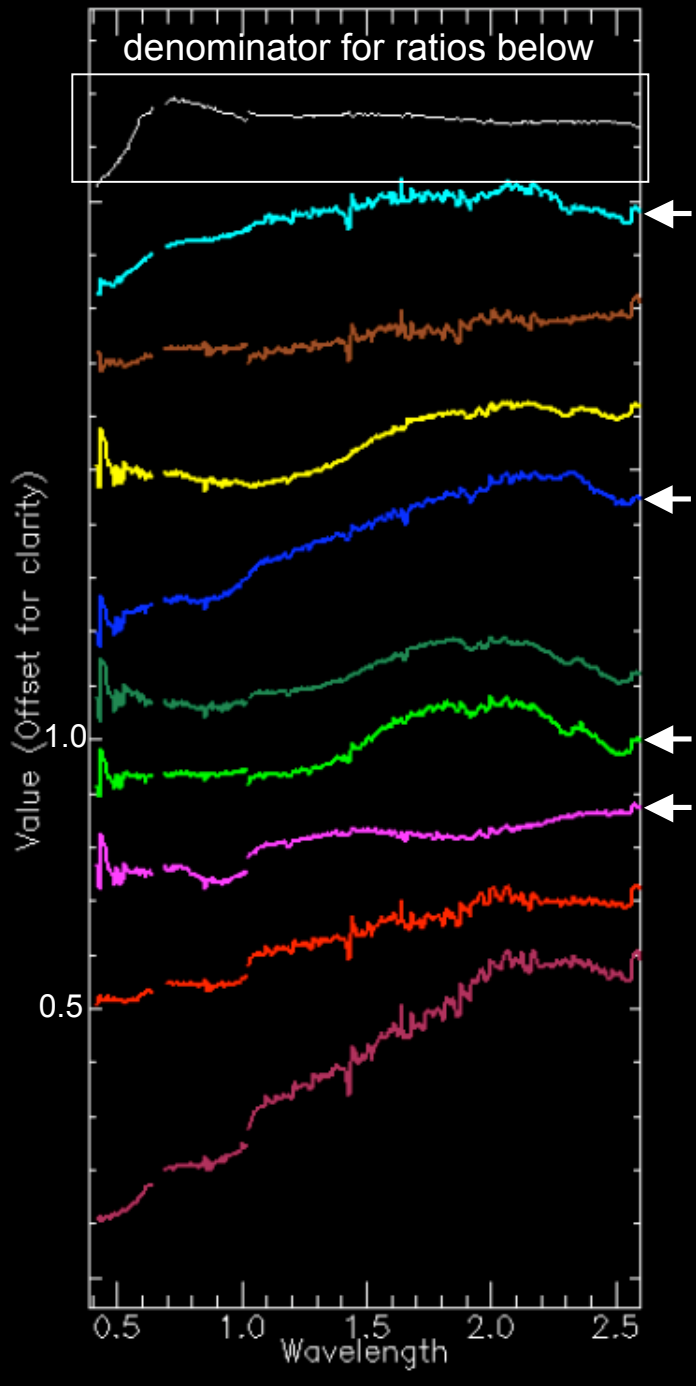
FRT0000821F

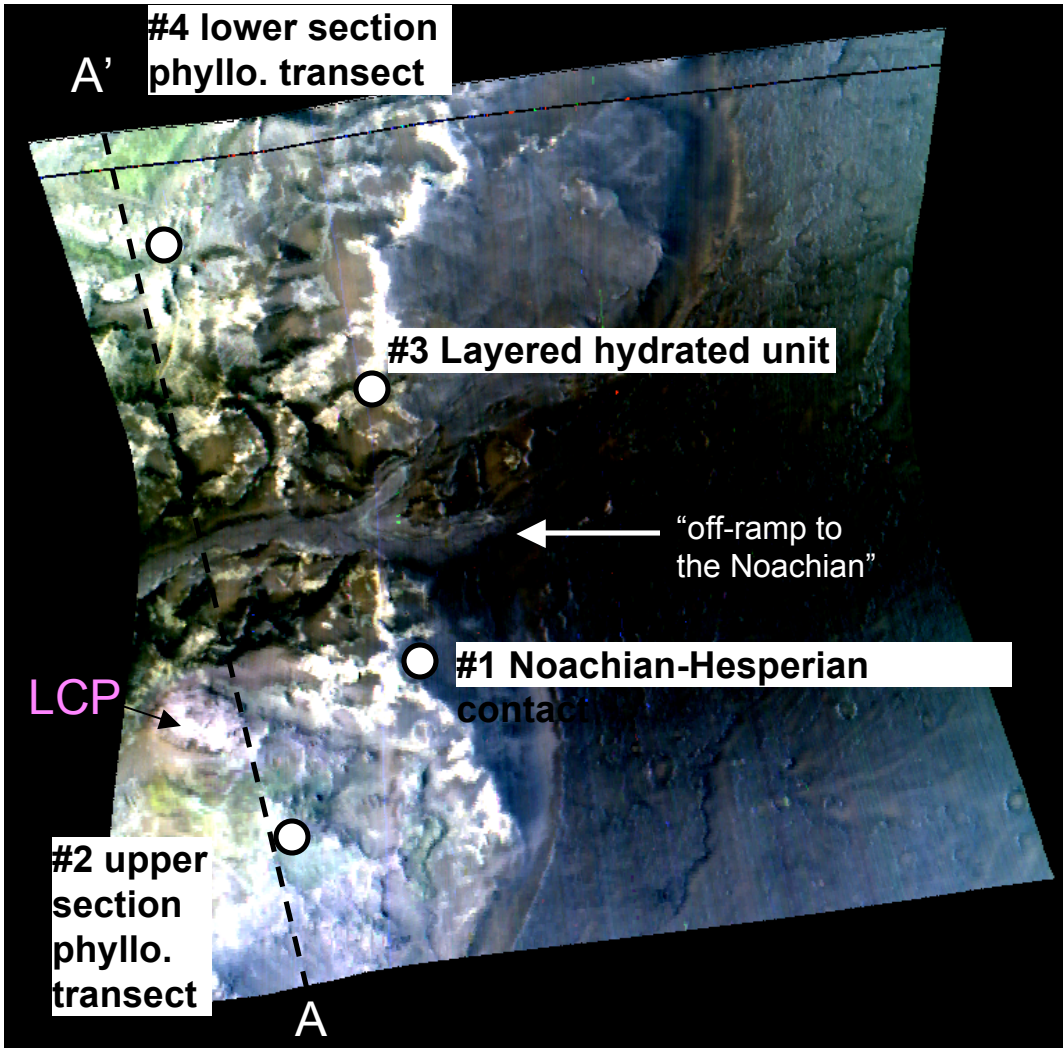







Surface of Syrtis
Major flows
R: 2.38, G: 1.80, B: 1.15 microns


denominator for ratios below
Value (Offset for clarity)
1.0
0.5
0.5
1.0
1.5
2.0
2.5
Wavelength



NE Syrtis mission profile:

Outcrop science phase:

-Stratigraphic mapping of lava flows, hydrated units, and contacts

-Nature of the Noachian-Hesperian contact: unconformable? any low grade-metamorphism?

Determine mineral assemblages, esp. of alteration minerals

-Examine deposit facies, strike-dip

→Nature of Noachian phyllosilicate formation

→Organics in Noachian units?