

Analysis of Phyllosilicate-bearing Outcrops and their Relationship to Olivine- and Pyroxene-bearing Rocks at a Proposed Landing Site at Libya Montes

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**Part of larger study of Libya Montes region including many from CRISM, HiRISE, HRSC and OMEGA teams

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Introduction

- Libya Montes valley networks support aqueous alteration across Noachian-Hesperian-Amazonian periods.
 - Jaumann et al. (2010) EPSL
 - Erkeling et al. (2010) EPSL
- This study presents analyses of mineralogy from CRISM, layered structure from HiRISE and context from stereo HRSC images.
- Hydrated minerals include Fe/Mg-smectite, Fe/Mg-smectite+carbonate, and beidellite.
- Mafic units include olivine- and pyroxene- bearing materials.

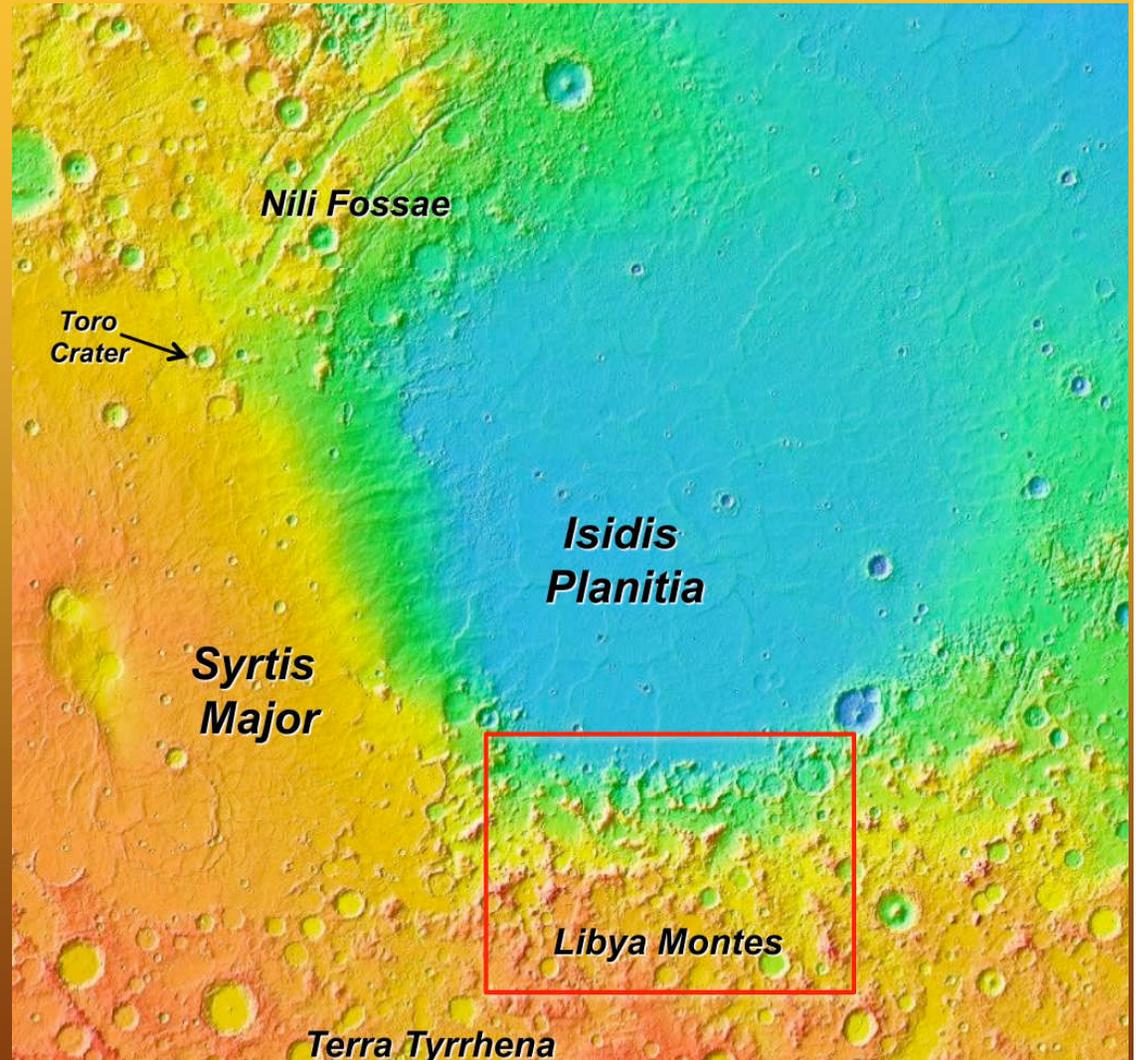
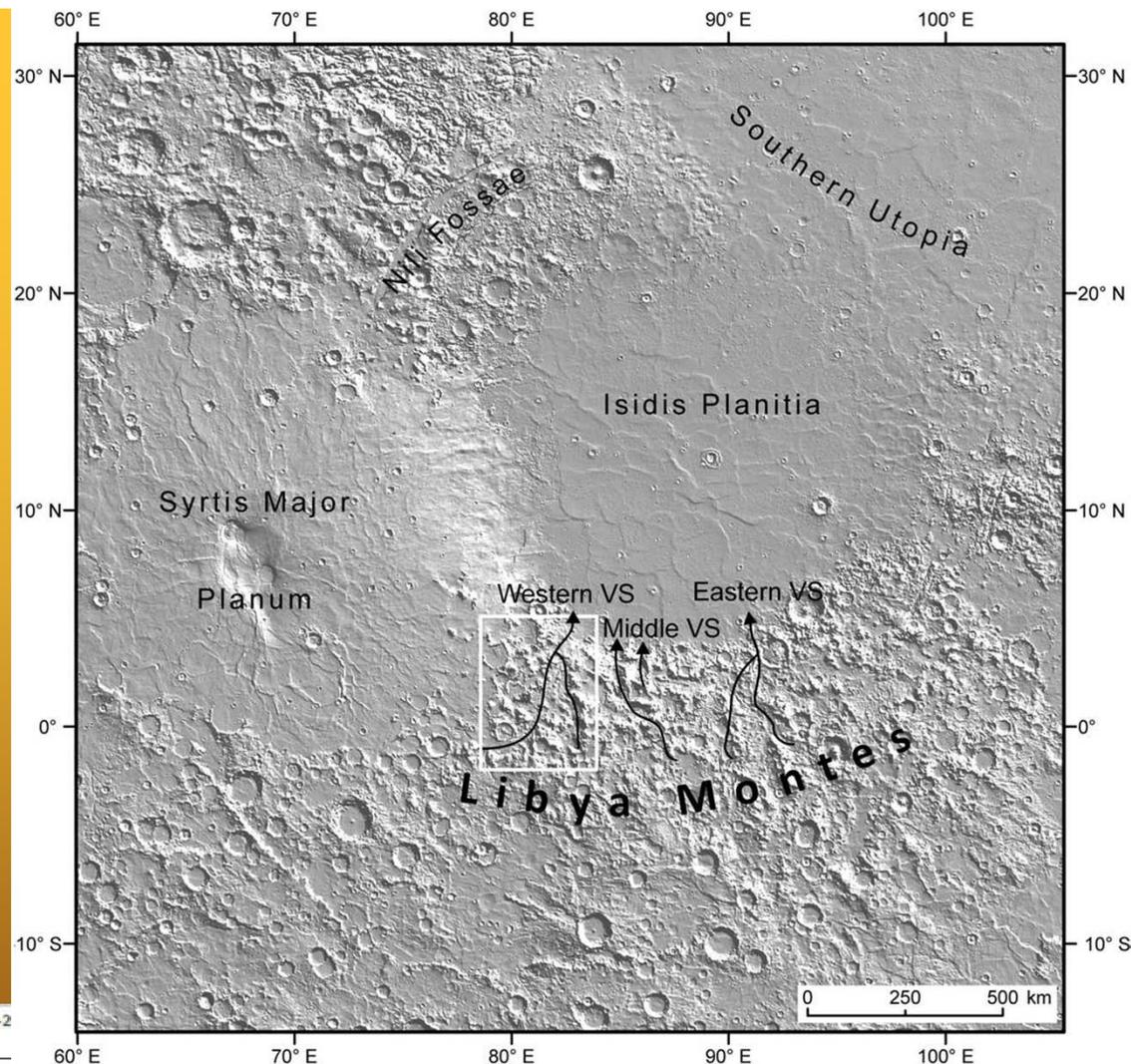


Fig. 1. Regional context of the Libya Montes Region (MOLA shaded relief). The area of investigation is marked by the white box (VS = Valley System).



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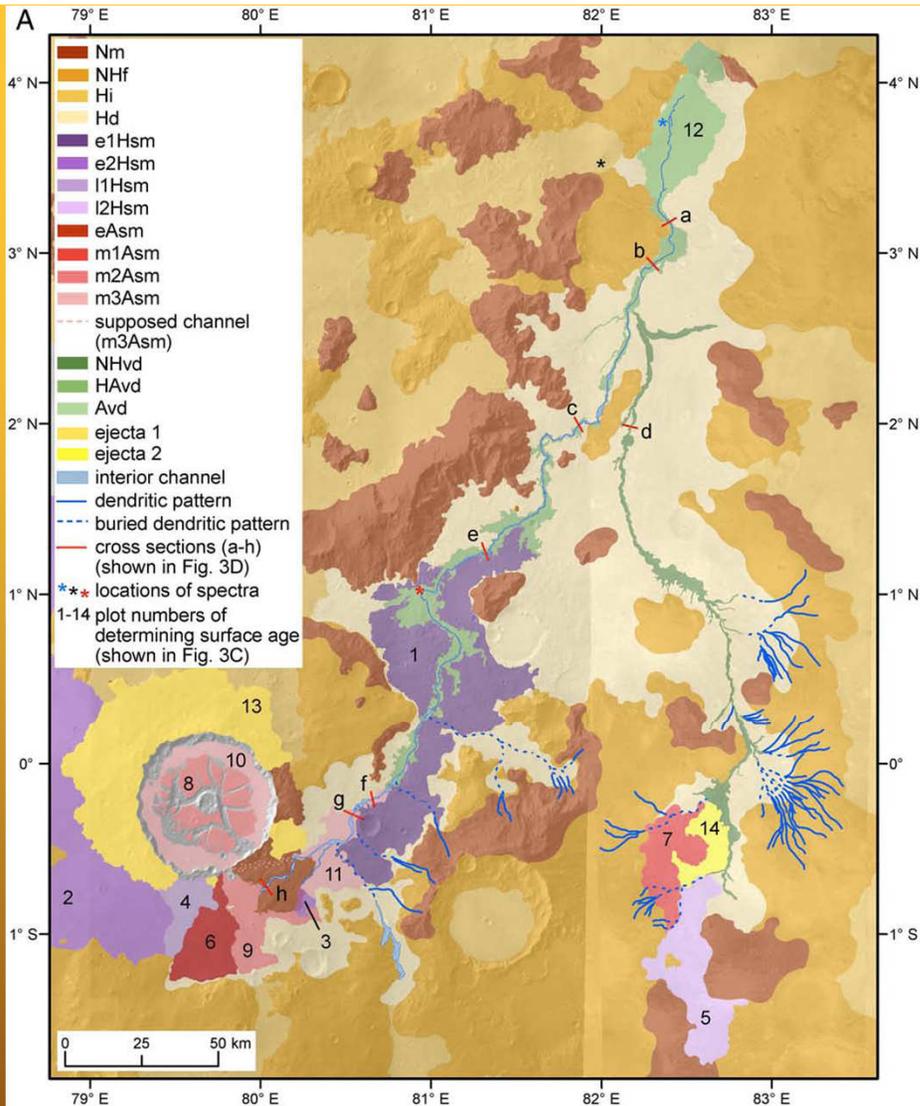
Earth and Planetary Science Letters

journal homepage: www.elsevier.com/locate/epsl



The Western Libya Montes Valley System on Mars: Evidence for episodic and multi-genetic erosion events during the Martian history

R. Jaumann^{a,b,*}, A. Nass^{a,c}, D. Tirsch^a, D. Reiss^d, G. Neukum^b



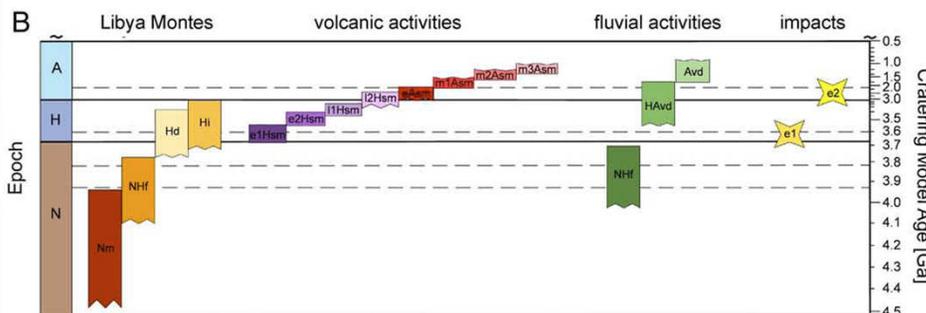
Jaumann et al. (2010) EPSL

Fig. 3. A: Geologic map of the Western Libya Montes Valley System.

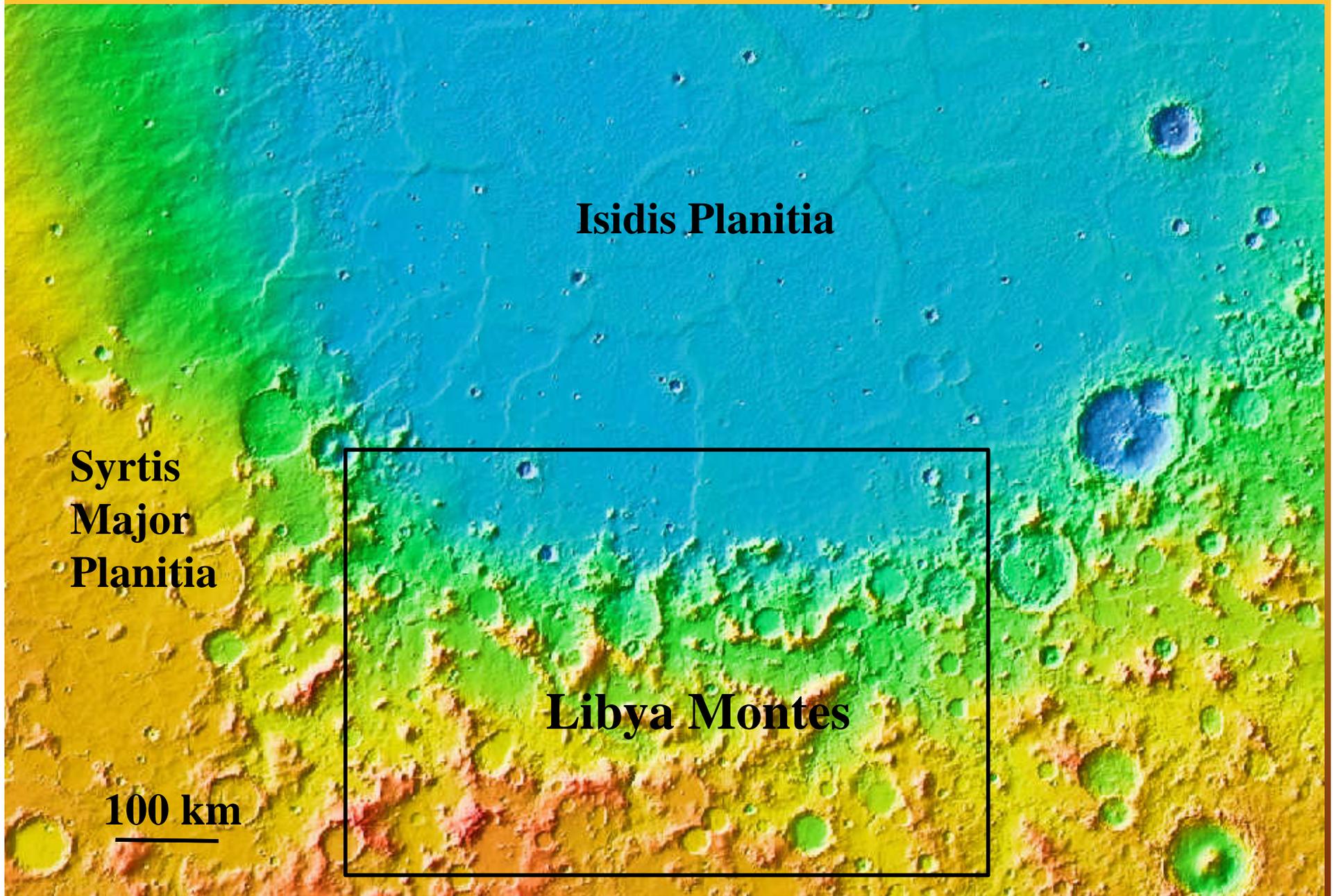
--illustrates fluvial networks and diversity of rock types.

Fig. 3. B: Stratigraphic correlation of map units and geological events in the Western Libya Montes Valley System.

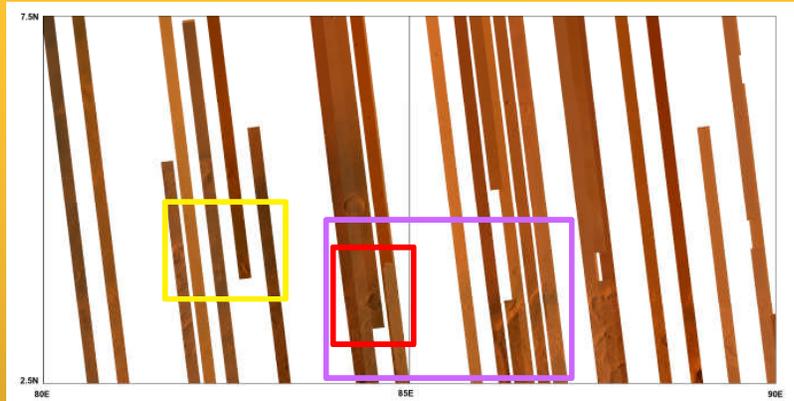
--illustrates wide distribution of ages (Noachian, Hesperian, Amazonian) of geologic features including volcanic, fluvial and impact events.



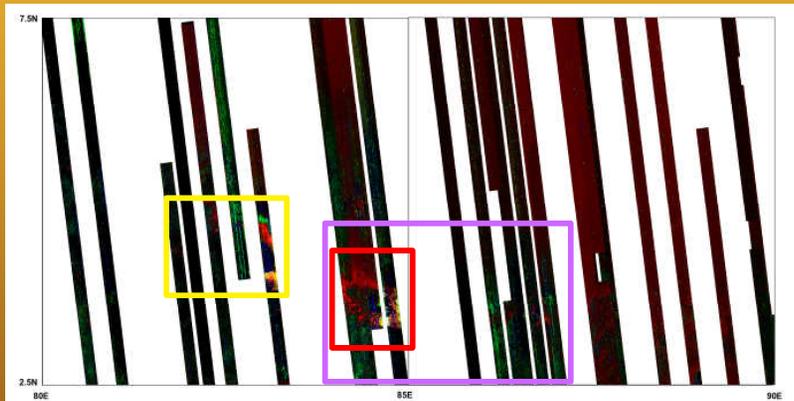
Libya Montes at southern border of Isidis Basin



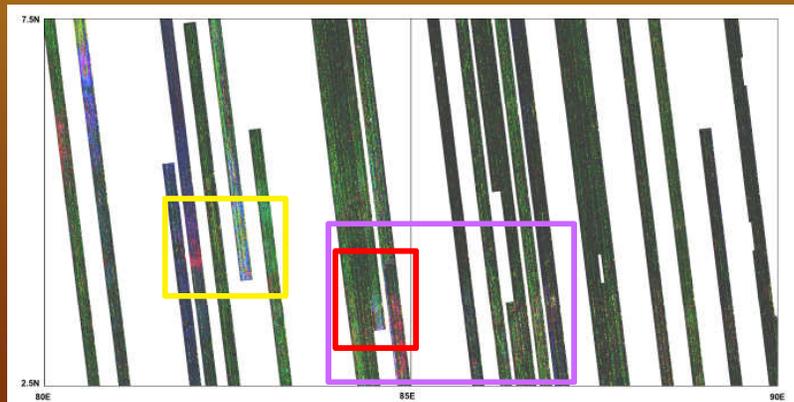
CRISM Map Tiles at Libya Montes, TRR2 - McGuire



R=598 nm
G=533 nm
B=442 nm

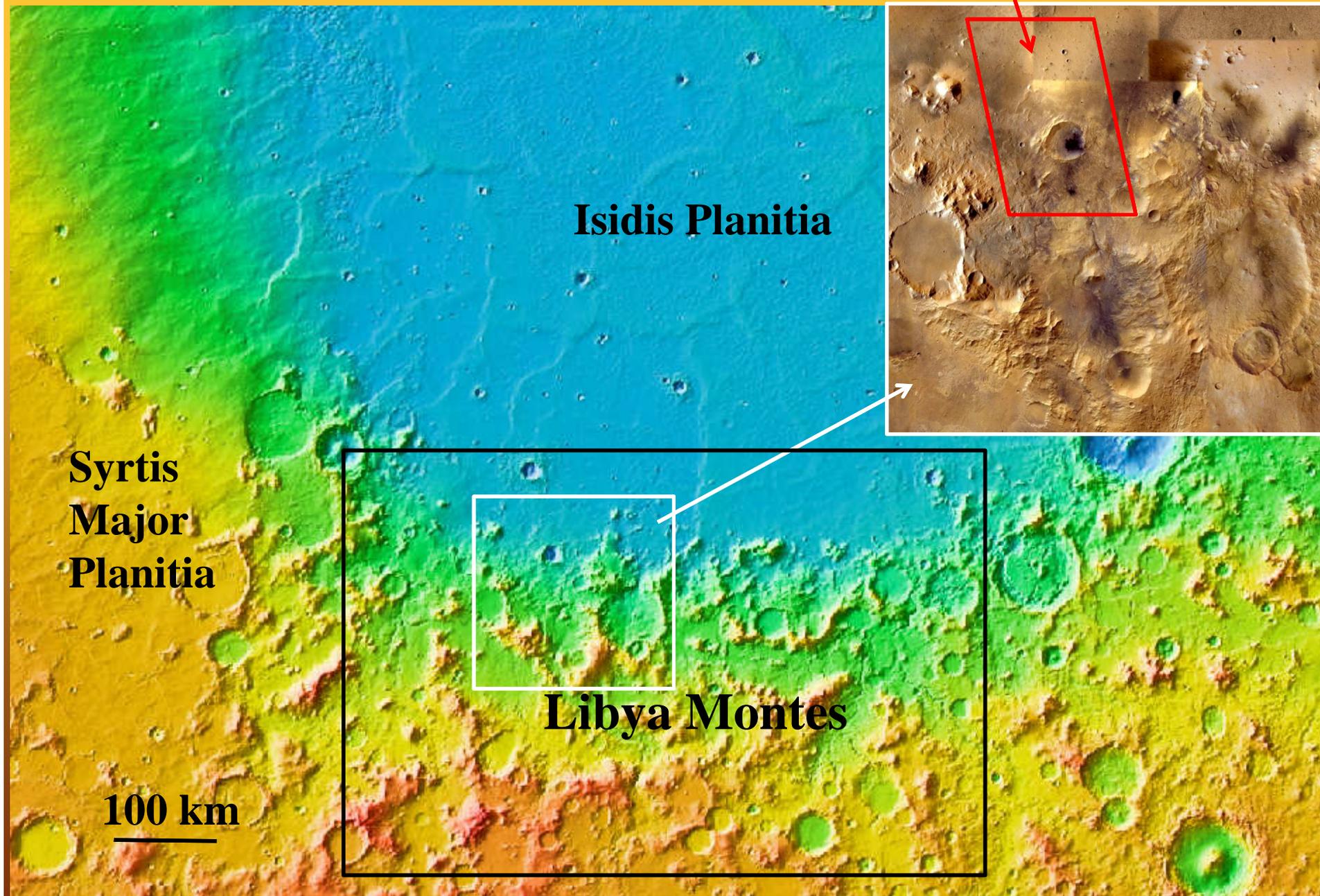


R=OLV
G=LCP
B=HCP



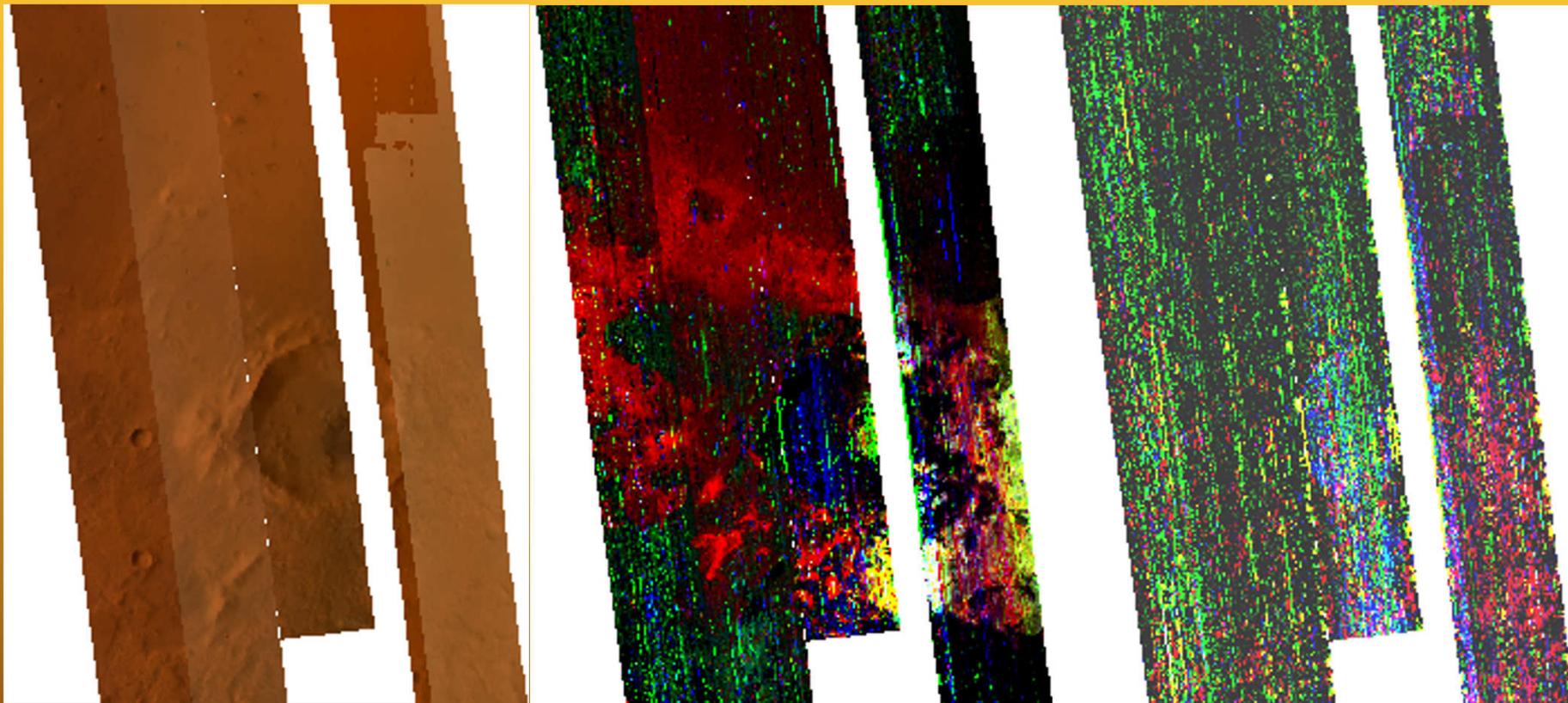
R=D2300
G=BD2210
B=BD1900

Libya Montes at southern border of Isidis Basin



CRISM Map Tiles at Libya Montes (TRR2 cal)

Location on previous slide



R=598 nm

G=533 nm

B=442 nm

R=OLV

G=LCP

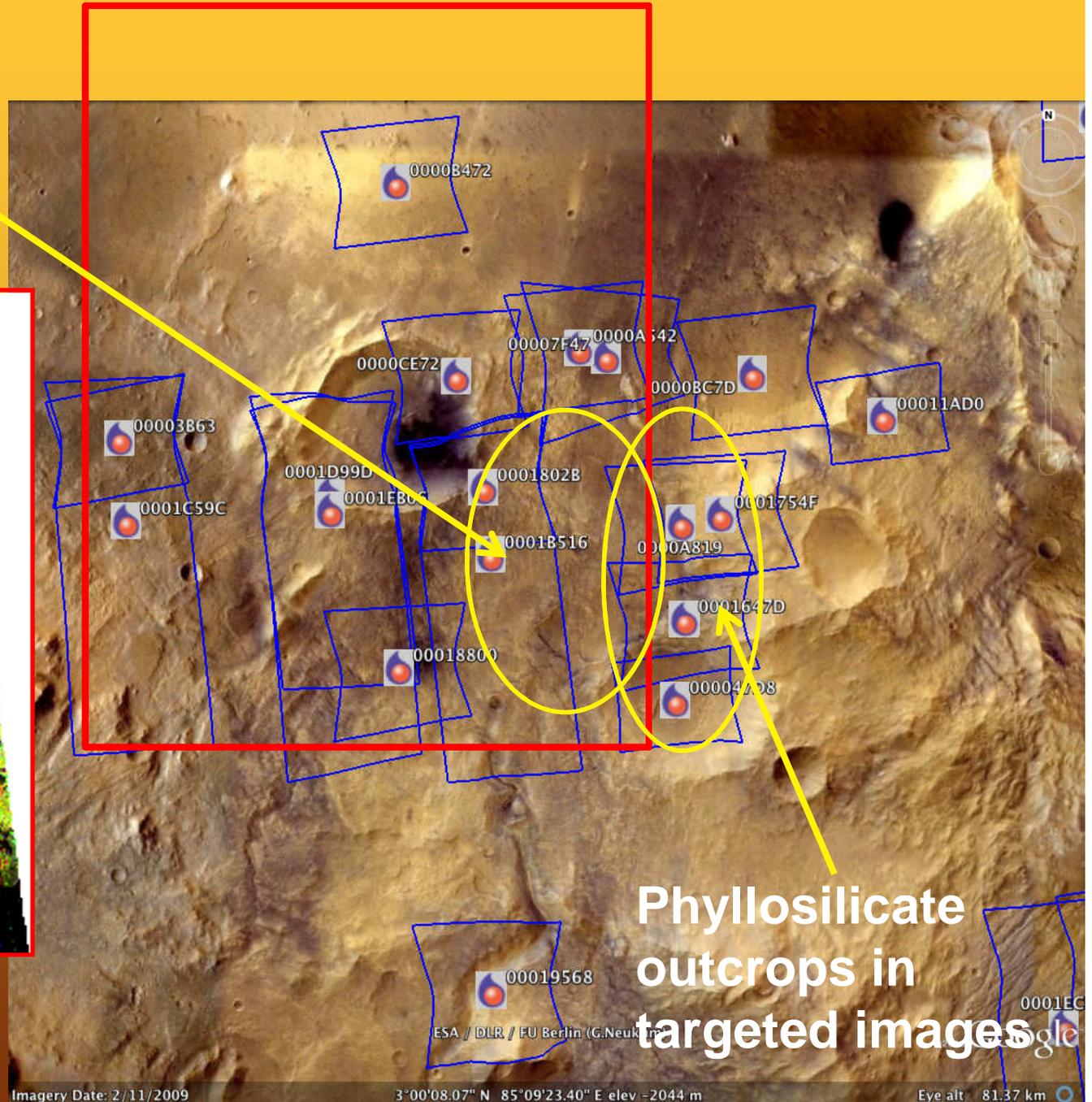
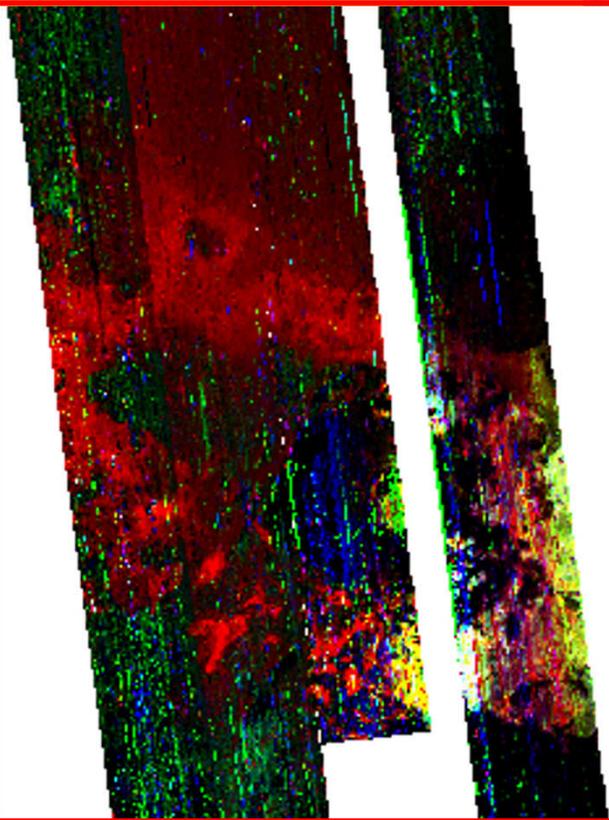
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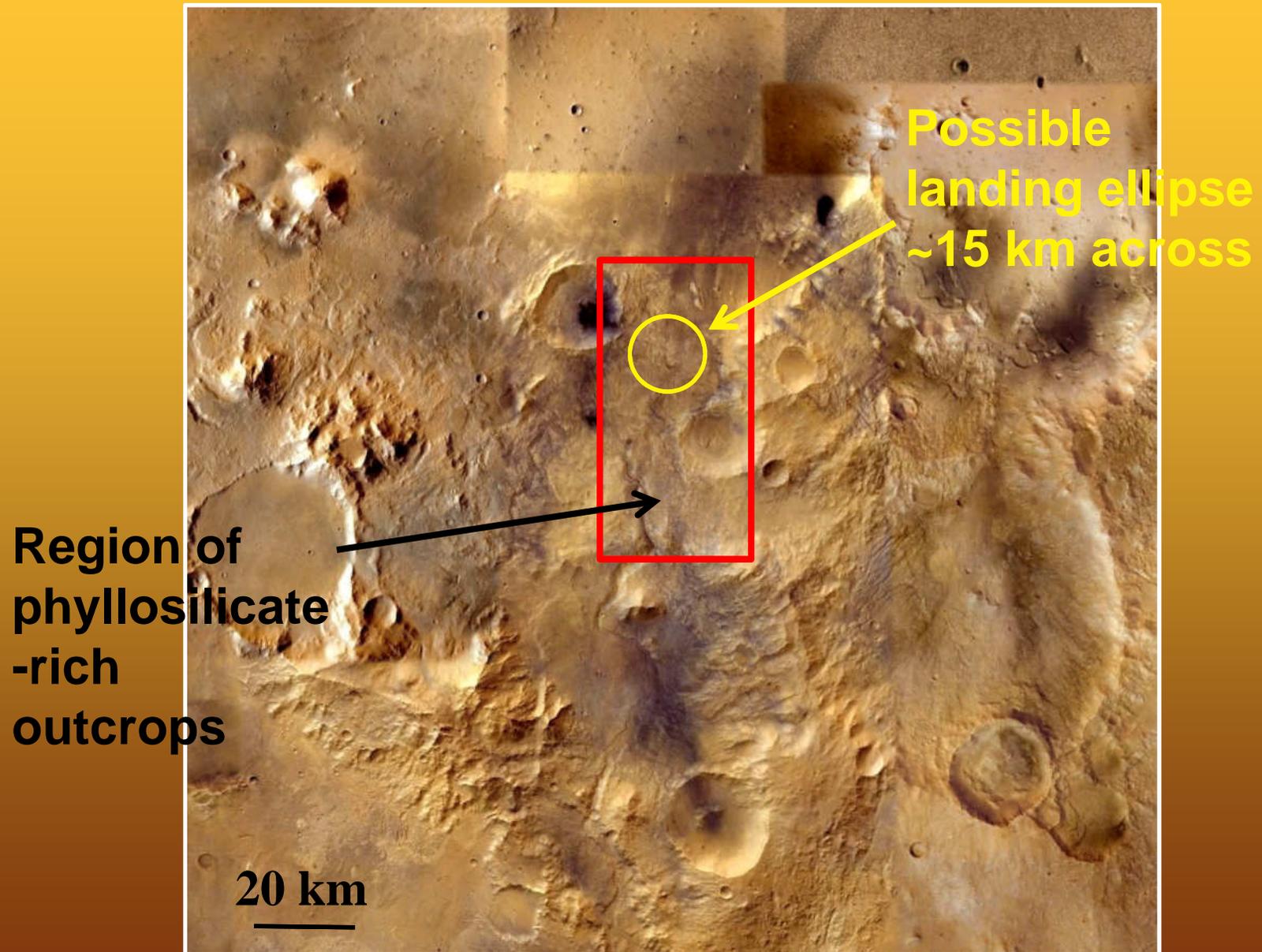
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**Phyllosilicate
outcrops in
map tiles**



**Phyllosilicate
outcrops in
targeted images**

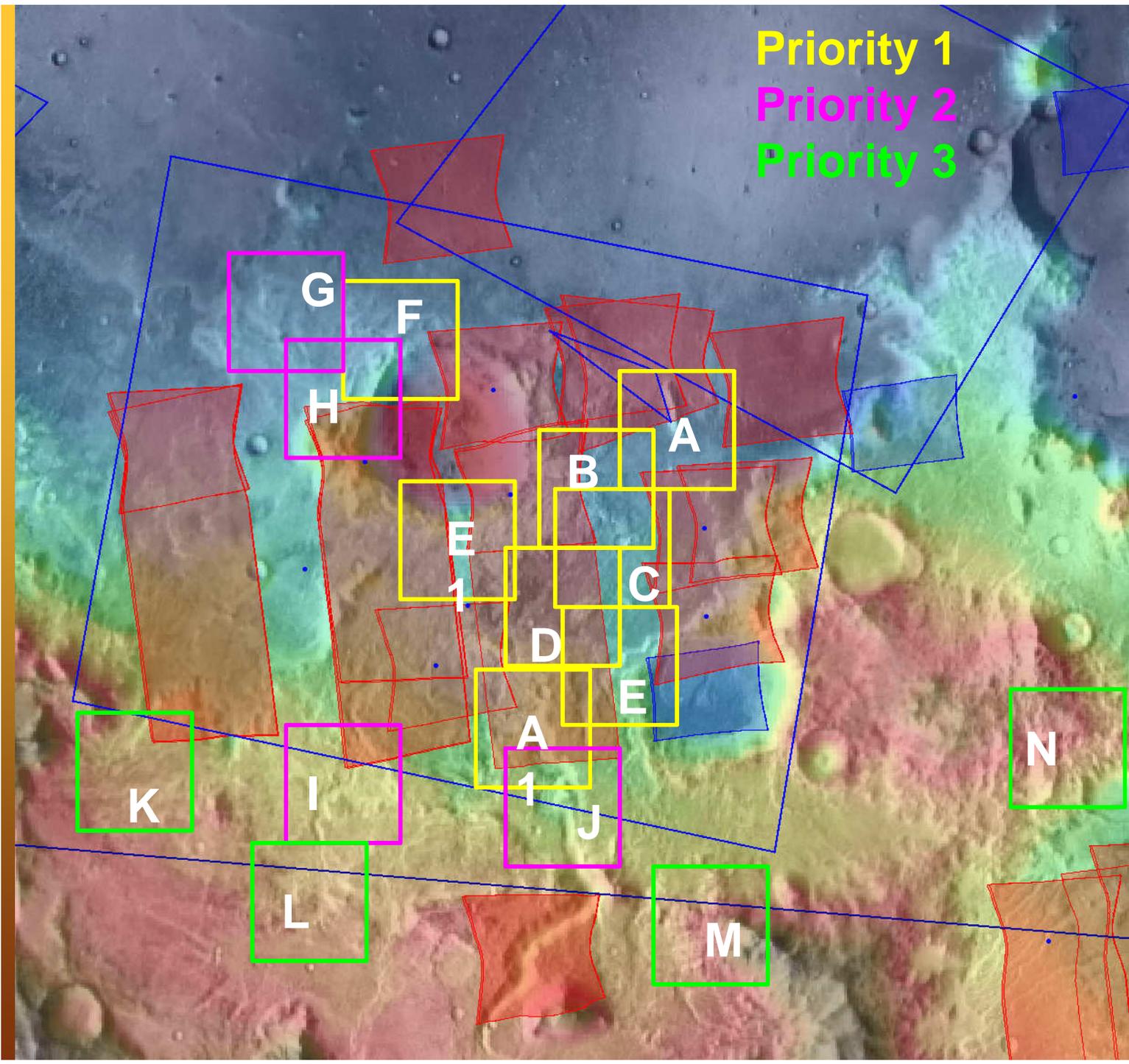
Possible landing site ellipses at Libya Montes

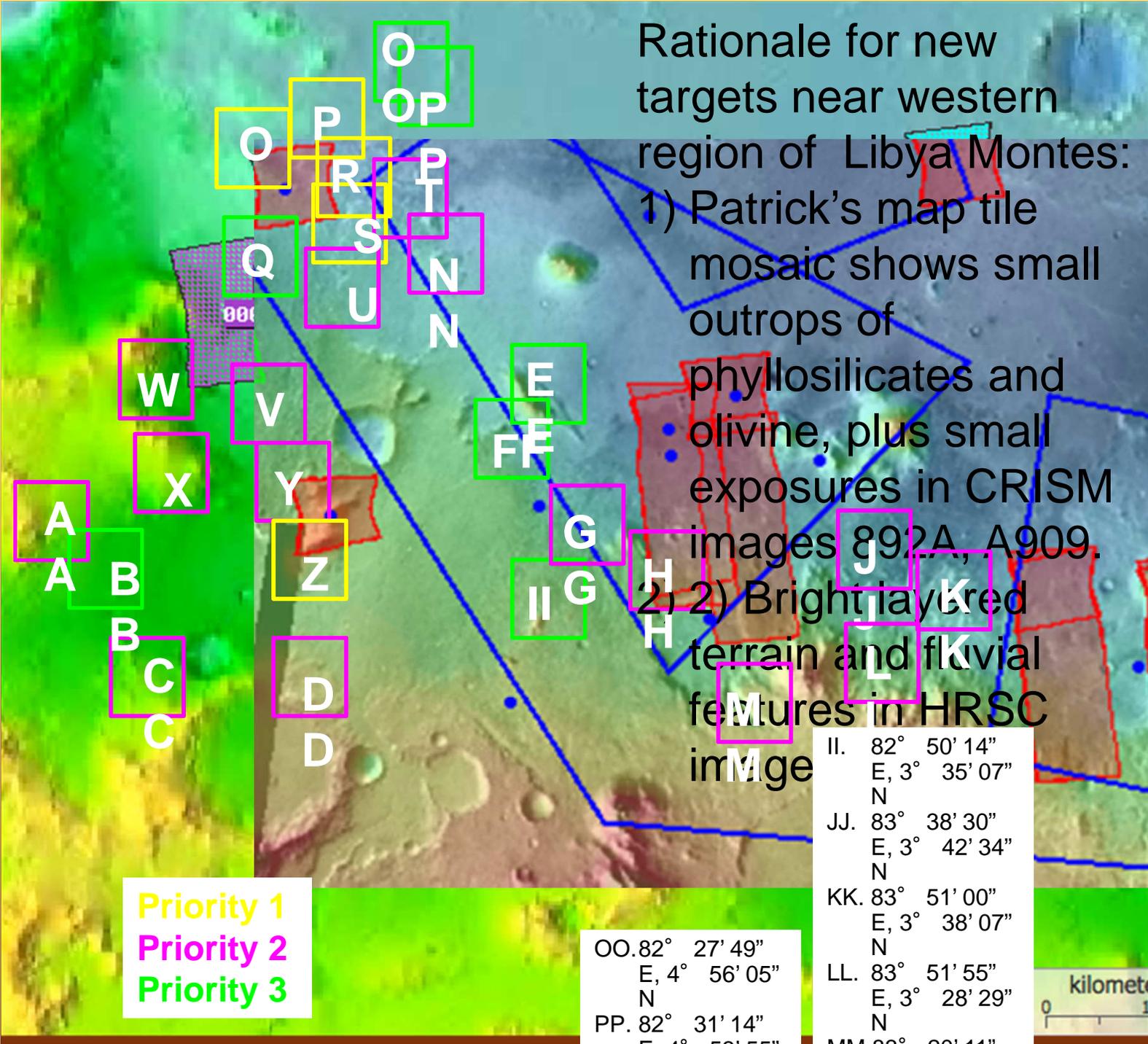


Priority 1
 Priority 2
 Priority 3

Libya Montes
 Lat, lon for new targets:

A.	84° 54' 33"	E, 3° 36' 04"	N
B.	84° 51' 17"	E, 3° 31' 33"	N
C.	84° 52' 56"	E, 3° 24' 43"	N
D.	84° 46' 43"	E, 3° 18' 20"	N
E.	84° 51' 44"	E, 3° 13' 08"	N
F.	84° 25' 18"	E, 3° 45' 26"	N
G.	84° 17' 50"	E, 3° 45' 07"	N
H.	84° 22' 17"	E, 3° 40' 35"	N
I.	84° 23' 07"	E, 3° 02' 47"	N
J.	84° 45' 50"	E, 3° 00' 45"	N
K.	84° 01' 11"	E, 3° 01' 29"	N





Rationale for new targets near western region of Libya Montes:

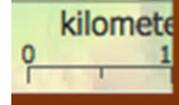
- 1) Patrick's map tile mosaic shows small outcrops of phyllosilicates and olivine, plus small exposures in CRISM images 892A, A909.
- 2) Bright layered terrain and fluvial features in HRSC image

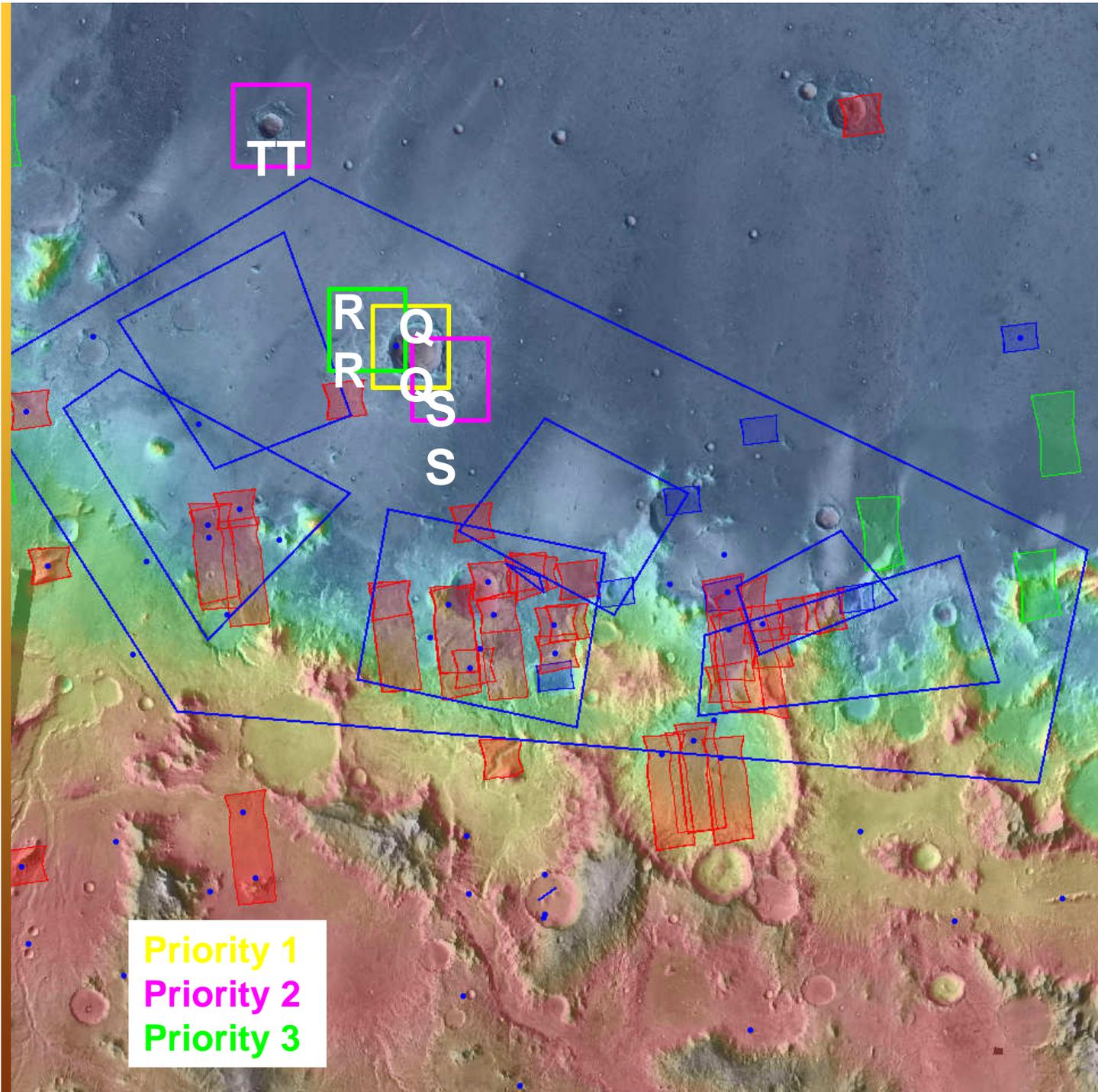
Priority 1
Priority 2
Priority 3

OO. 82° 27' 49"
 E, 4° 56' 05"
 N
 PP. 82° 31' 14"
 E, 4° 50' 55"
 N

II. 82° 50' 14"
 E, 3° 35' 07"
 N
 JJ. 83° 38' 30"
 E, 3° 42' 34"
 N
 KK. 83° 51' 00"
 E, 3° 38' 07"
 N
 LL. 83° 51' 55"
 E, 3° 28' 29"
 N
 MM. 83° 30' 11"
 E, 3° 30' 11"
 N

Label	Lat	Lon
O.	82° 02' 10"	E, 4° 42' 44" N
P.	82° 13' 12"	E, 4° 47' 59" N
Q.	82° 04' 29"	E, 4° 25' 11" N
R.	82° 20' 05"	E, 4° 38' 41" N
S.	82° 18' 02"	E, 4° 32' 29" N
T.	82° 27' 37"	E, 4° 33' 47" N
U.	82° 18' 54"	E, 4° 22' 33" N
V.	82° 10' 03"	E, 4° 01' 35" N
W.	81° 48' 52"	E, 4° 05' 27" N
X.	81° 49' 31"	E, 3° 50' 11" N
Y.	82° 05' 56"	E, 3° 51' 36" N
Z.	82° 11' 28"	E, 3° 39' 26" N
AA.	81° 31' 07"	E, 3° 44' 29" N
BB.	81° 37' 56"	E, 3° 37' 56" N





South Isidis Basin region

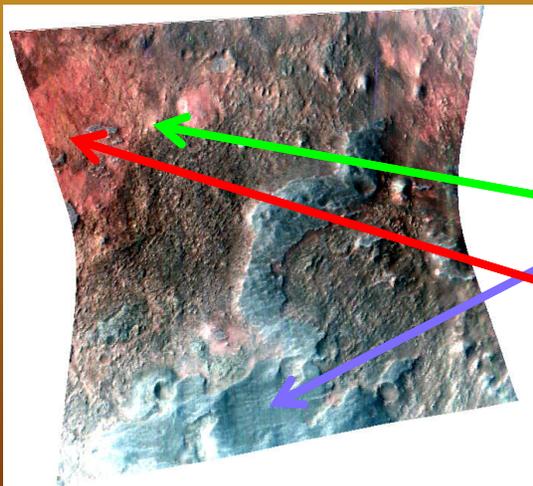
Lat, lon for new targets:

- QQ. 84° 14' 10"
E, 4° 55' 30"
N
- RR. 84° 01' 55"
E, 5° 00' 22"
N
- SS. 84° 24' 48"
E, 4° 49' 13"
N
- TT. 83° 26' 34"
E, 6° 07' 47"
N

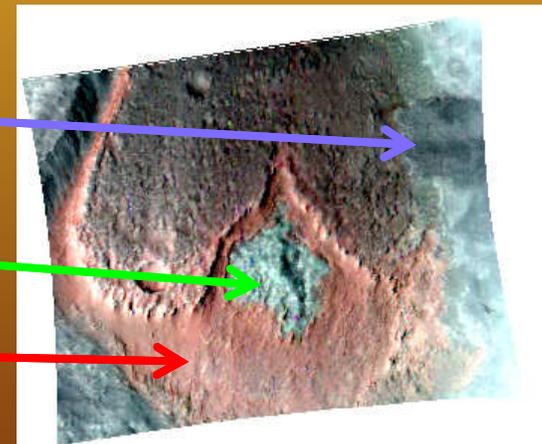
Priority 1
Priority 2
Priority 3

Libya Montes rim/terrace complex of the Isidis Basin

- Phyllosilicates present in oldest lithologies, exposed in central uplift portion of Hashir crater and other locations of ancient rocks.
- Olivine-rich units represented morphologically as
 - blocky layered materials (old lava flows from Syrtis or impact melt) and
 - more recent lag deposit present in lower lying topography.
- Pyroxene-rich unit is most recent and is likely an evolved or fractionated lava from Syrtis Major.

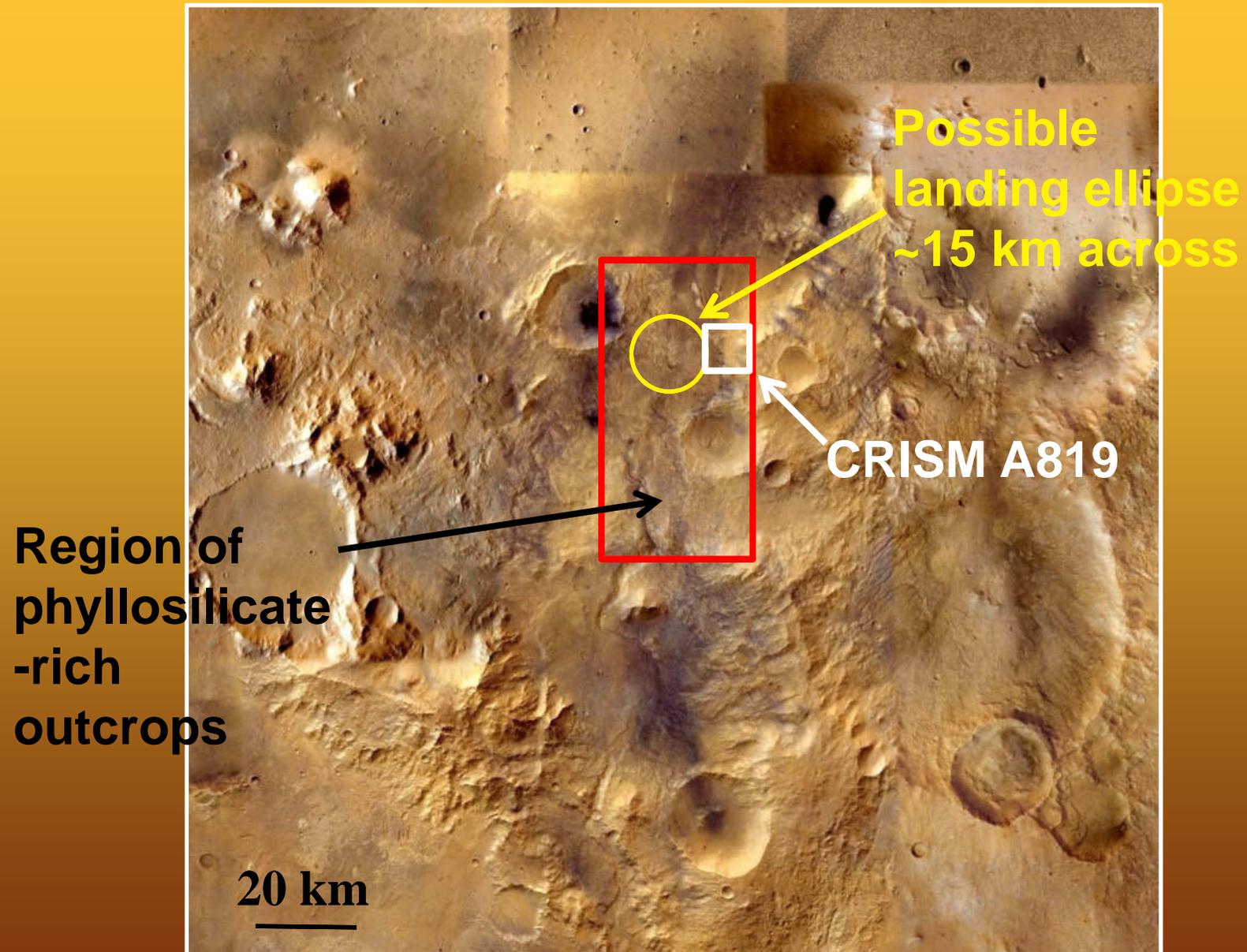


CRISM image FRT00003B63_07
(R 2500 nm, G 1500 nm, B 1200 nm)
Libya Montes region: olivine in red



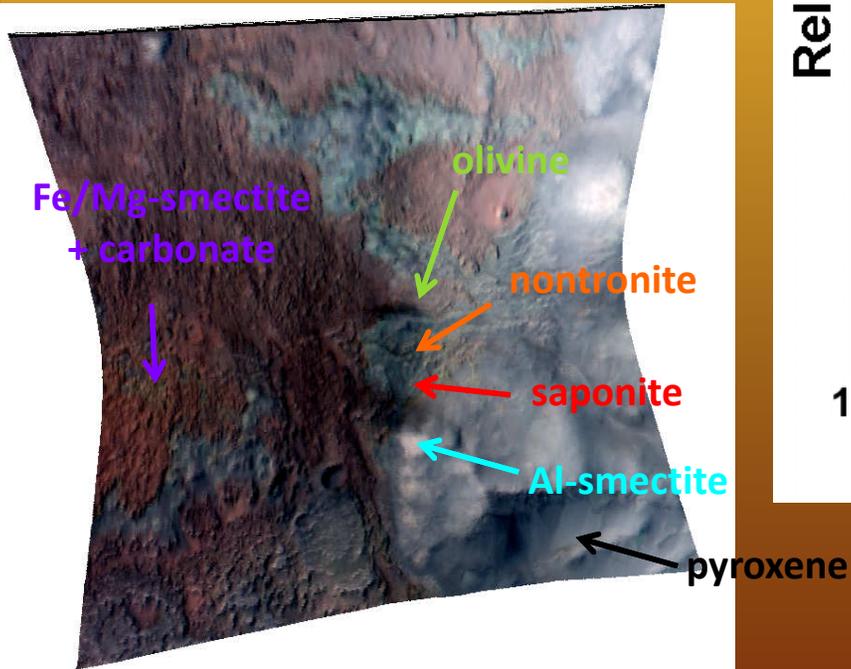
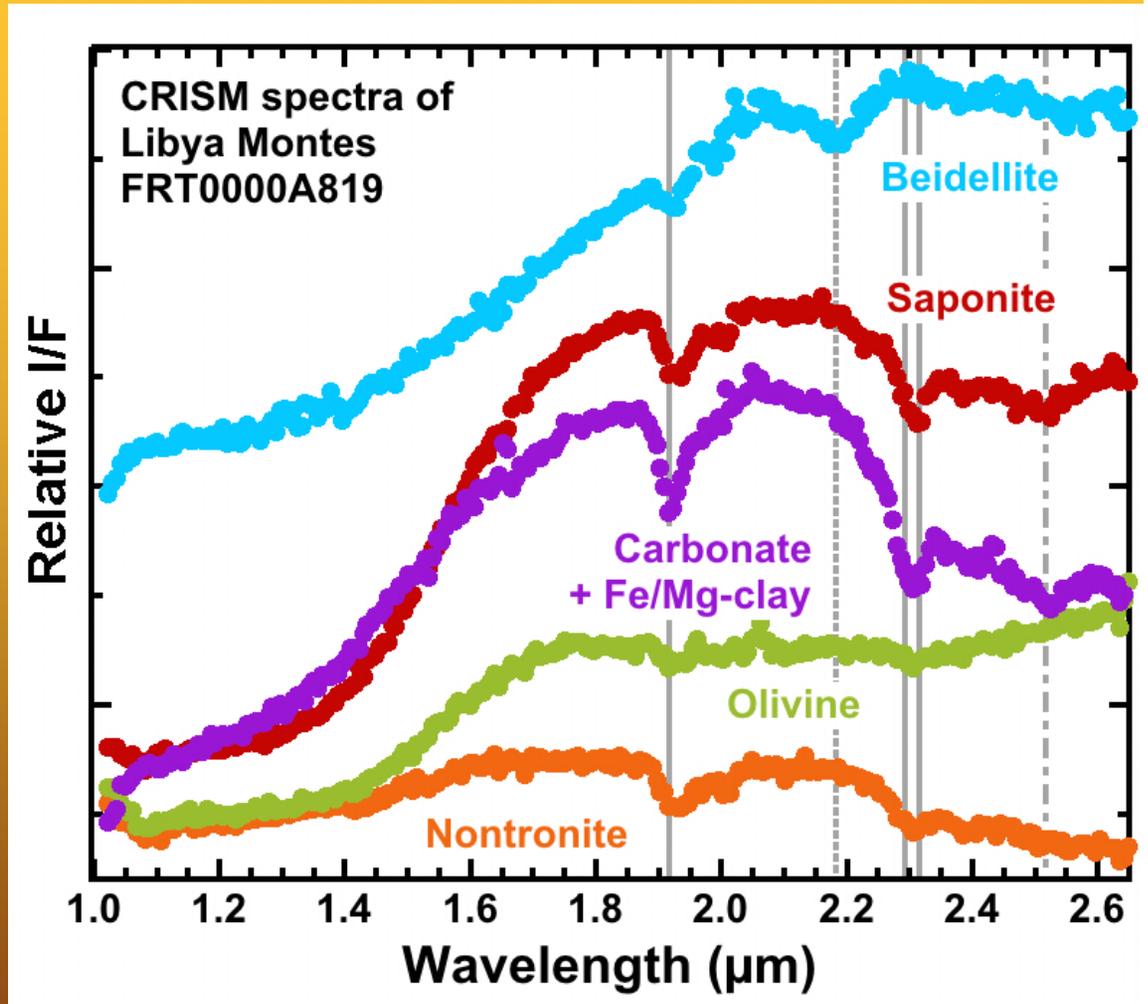
CRISM image HRS000047D8_07
(R 2500 nm, G 1500 nm, B 1200 nm)
Hashir crater: olivine in red, phyllosilicates in green-blue and pyroxene in dark blue/grey.

Possible landing site ellipses at Libya Montes

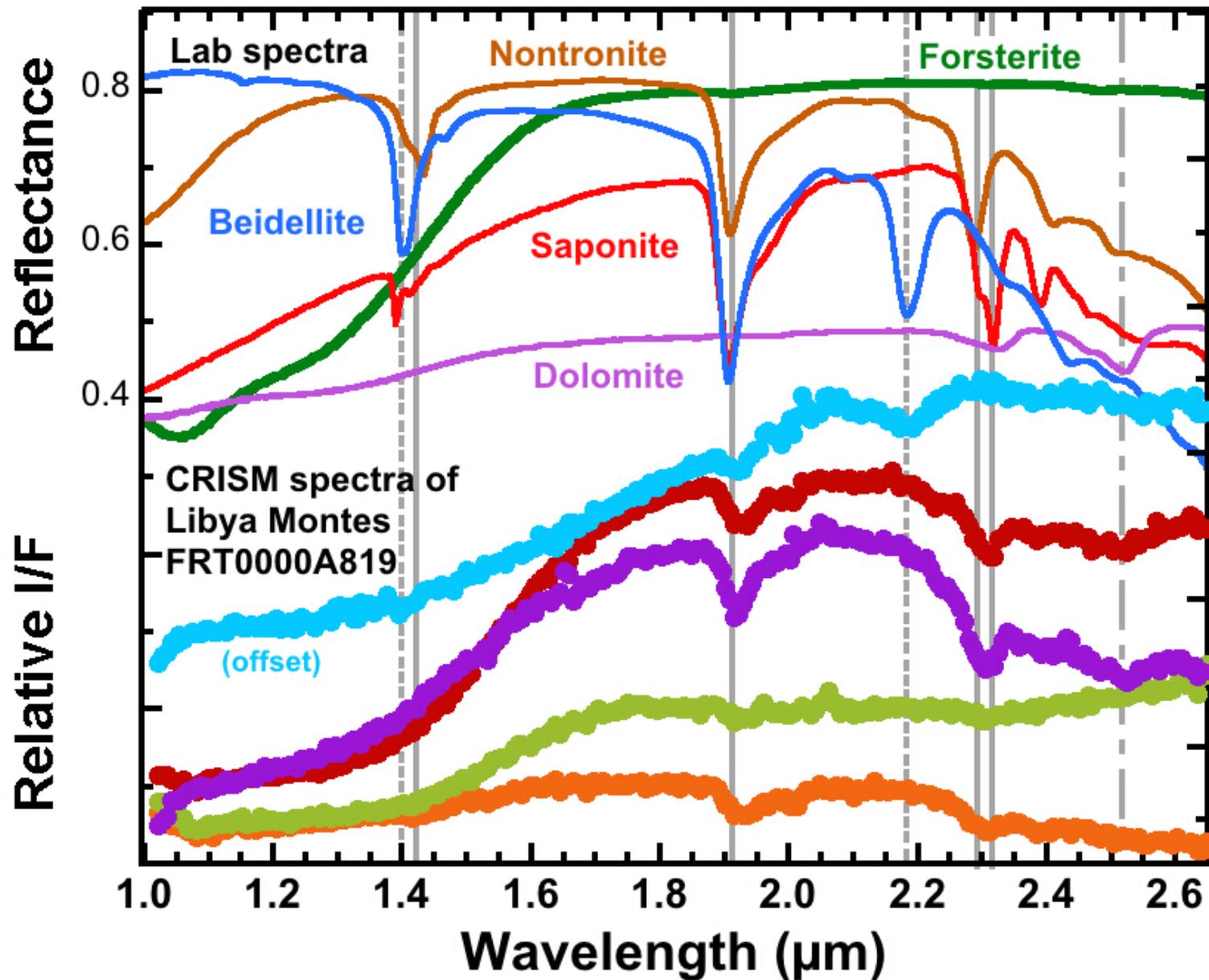


Compositional Units in FRT0000A819

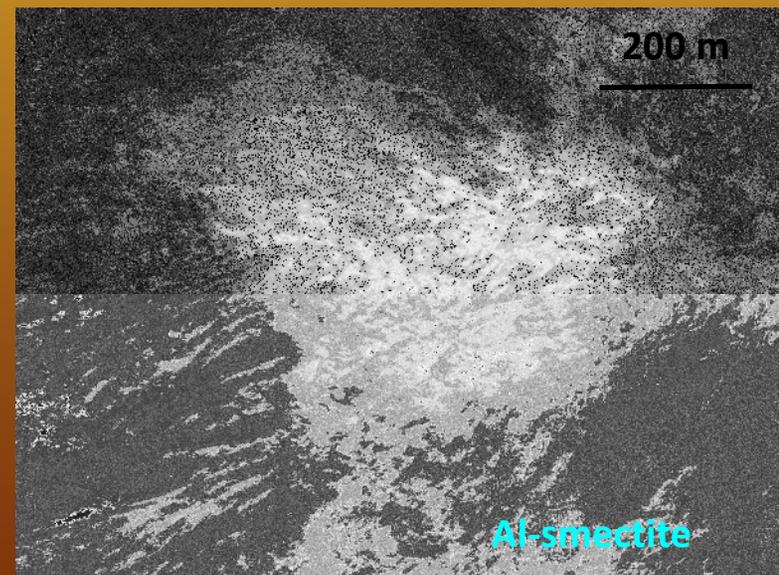
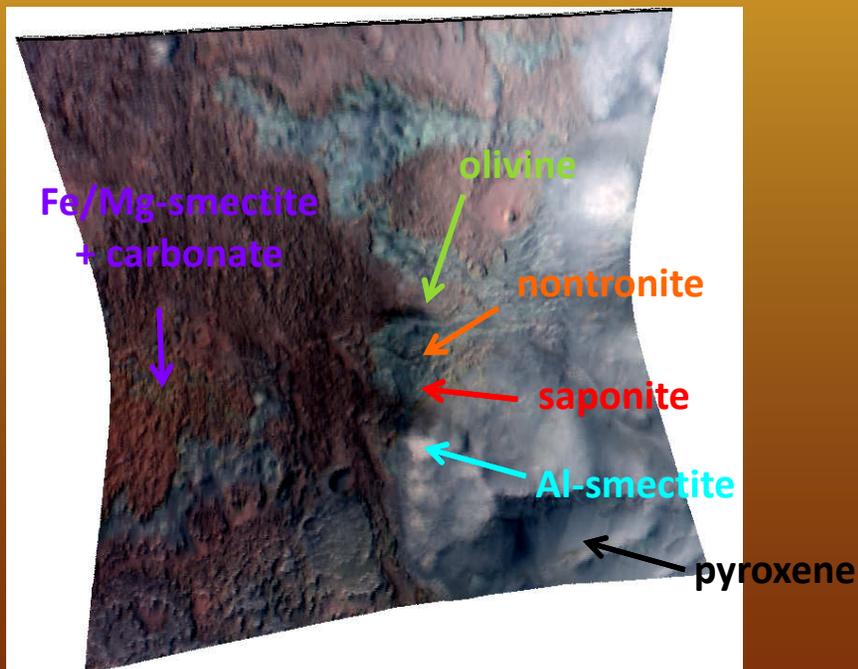
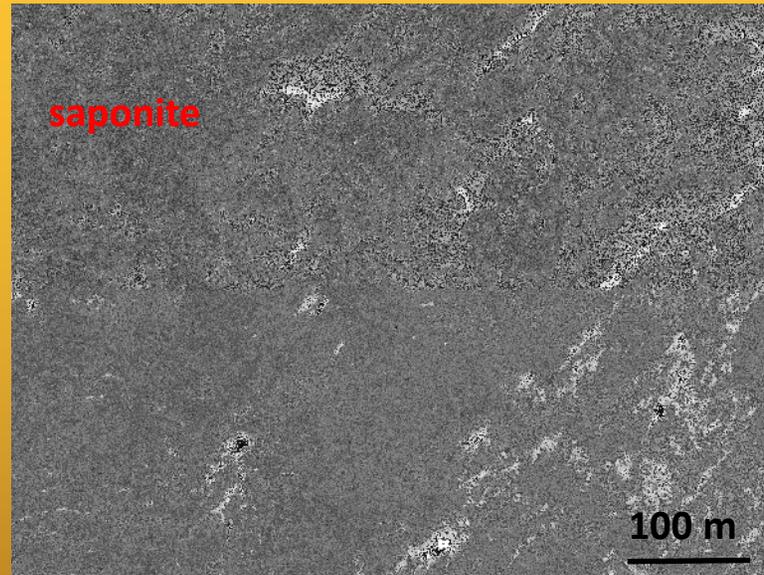
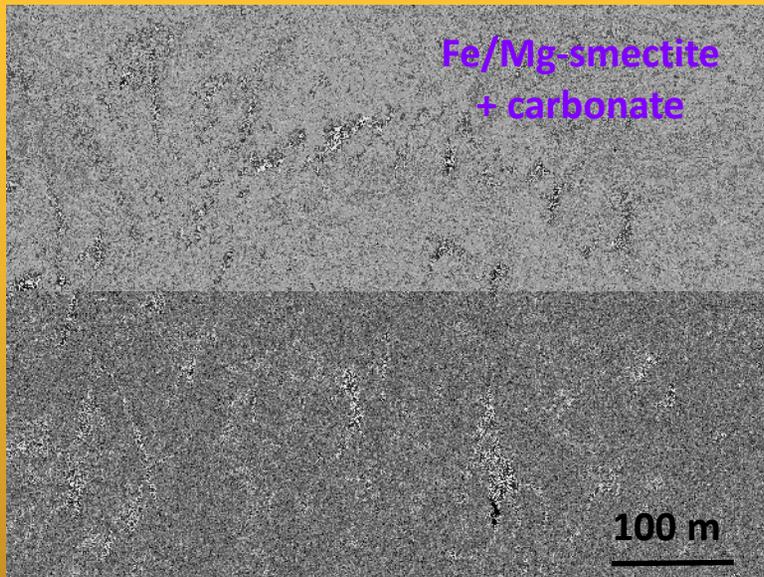
(TRR3 cal)



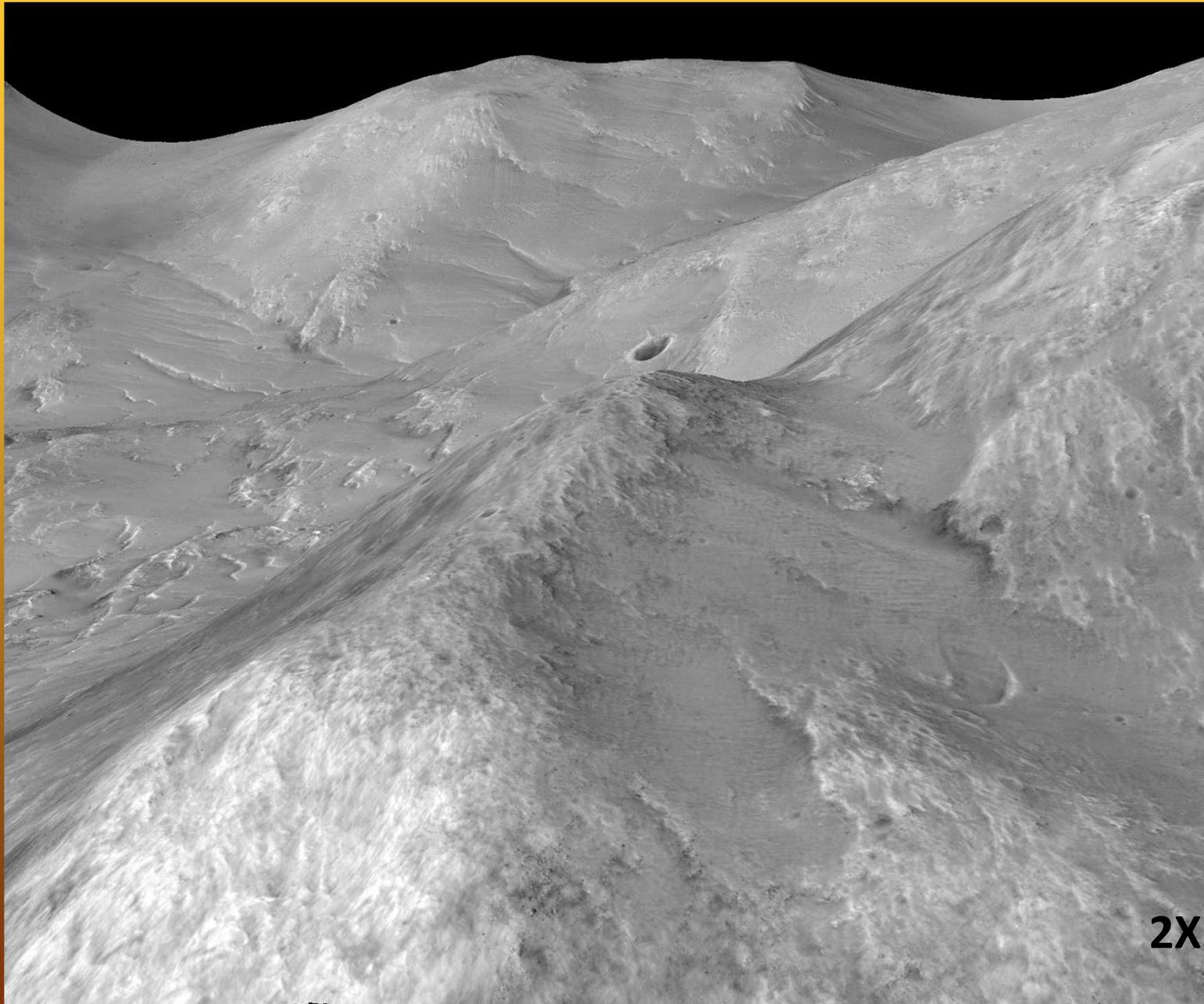
CRISM Spectra Compared to Mineral Spectra



Compositional Units in FRT0000A819

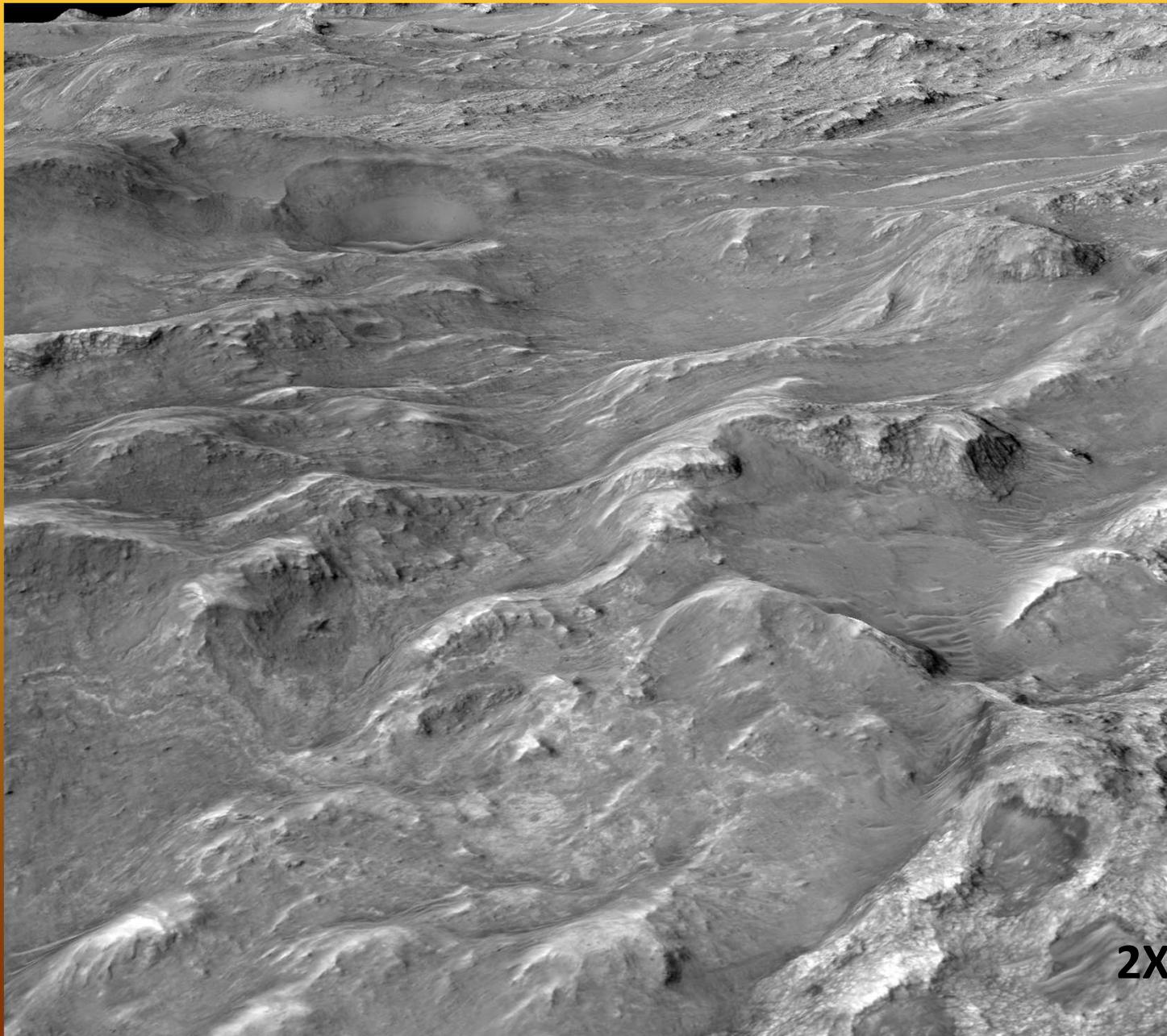


Al-smectite unit in FRT0000A819



2X vertical

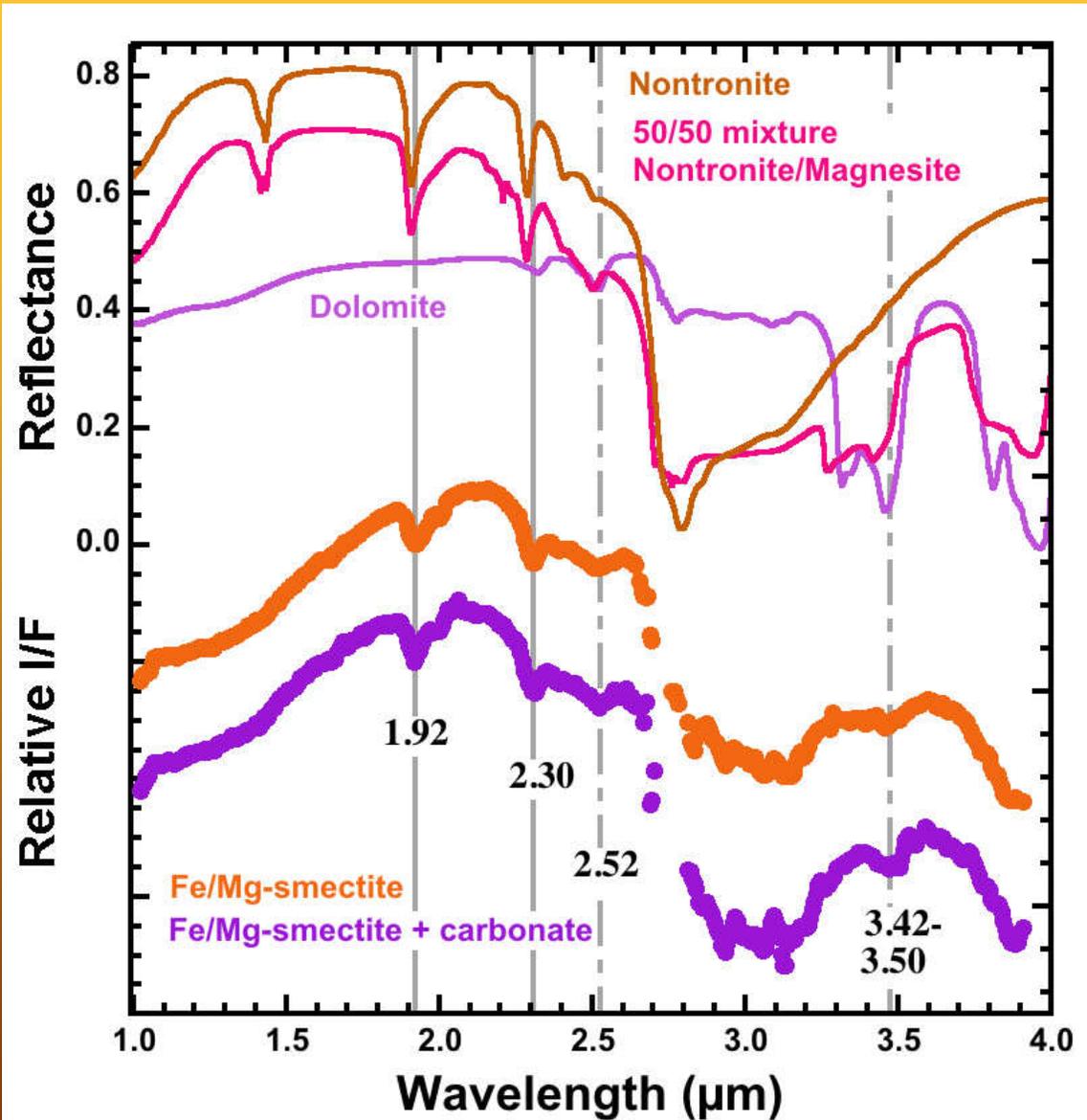
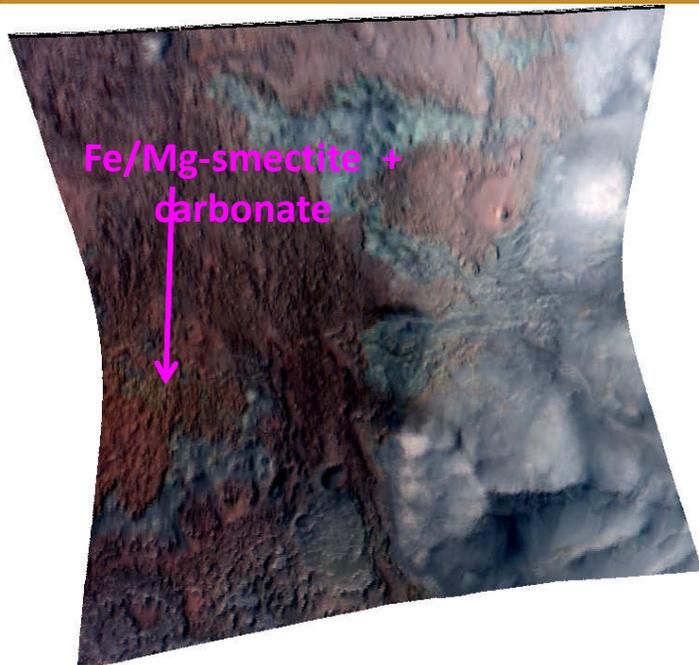
Saponite unit in FRT0000A819



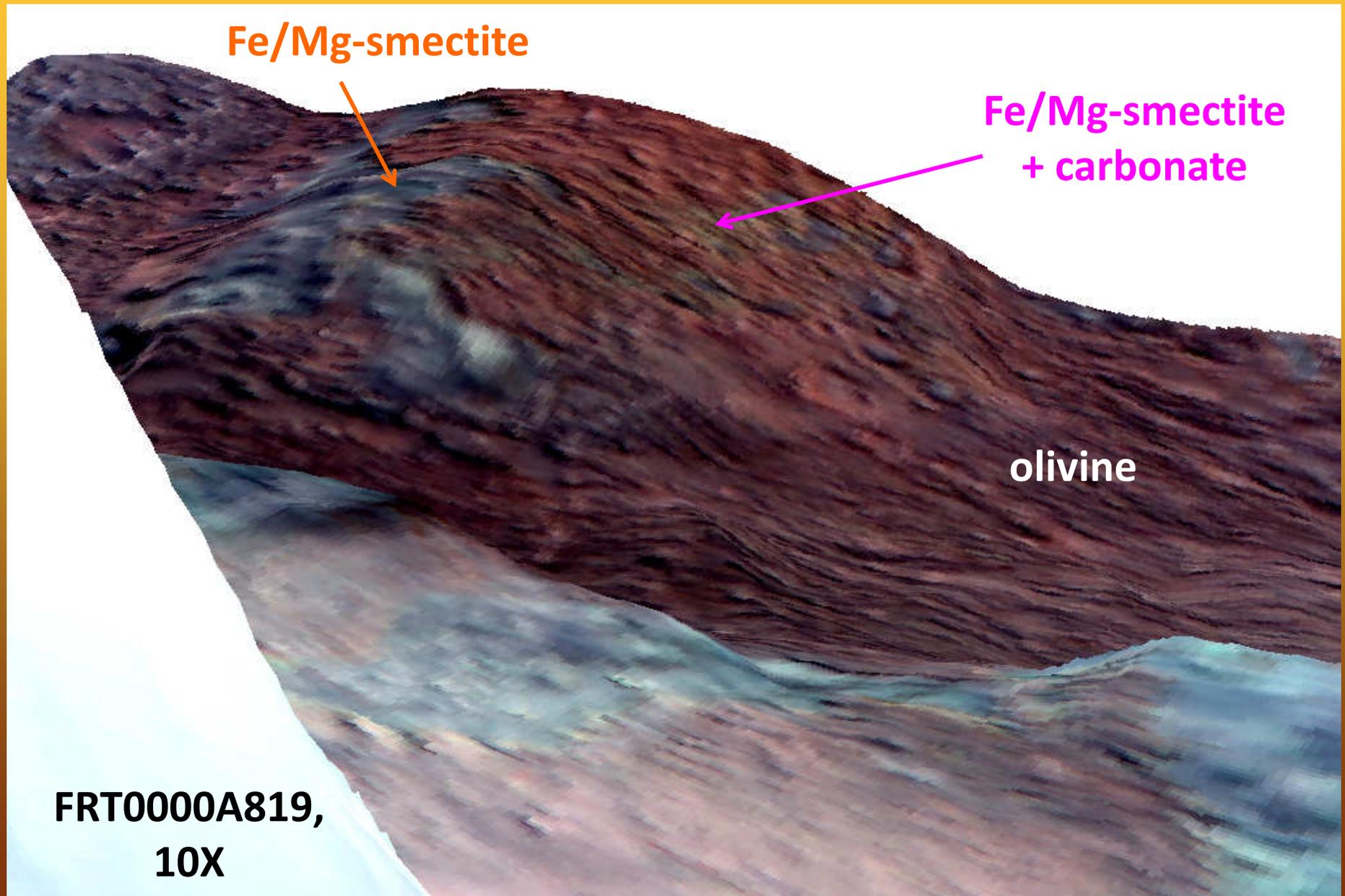
2X vertical

Carbonate-bearing Unit

- Material exposed below olivine exhibits strongest carbonate signatures and extensive layering and polygonally fractured texture.
- Carbonate features consistent with dolomite, but could be other carbonate due to mixture.
- All carbonate occurrences are mixed with Fe/Mg-smectite.

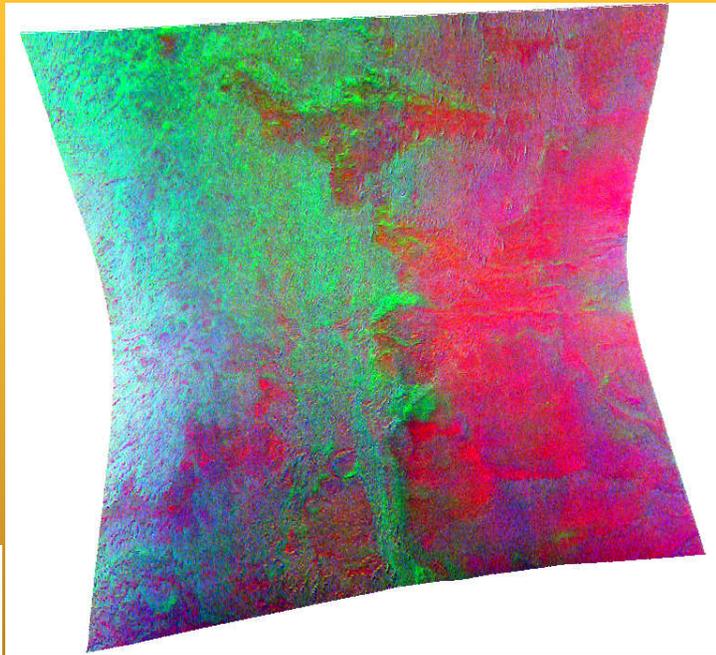


Carbonate-bearing Spectral Unit

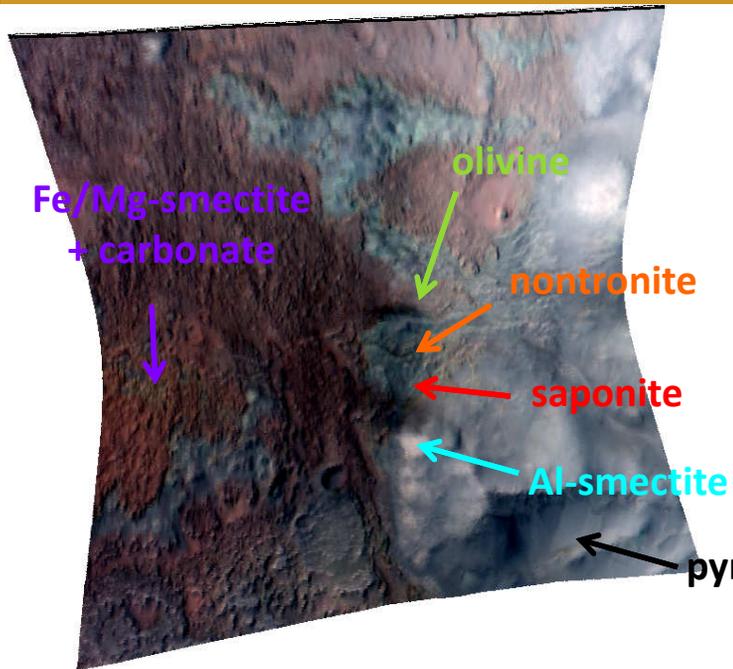


Compositional Units in FRT0000A819

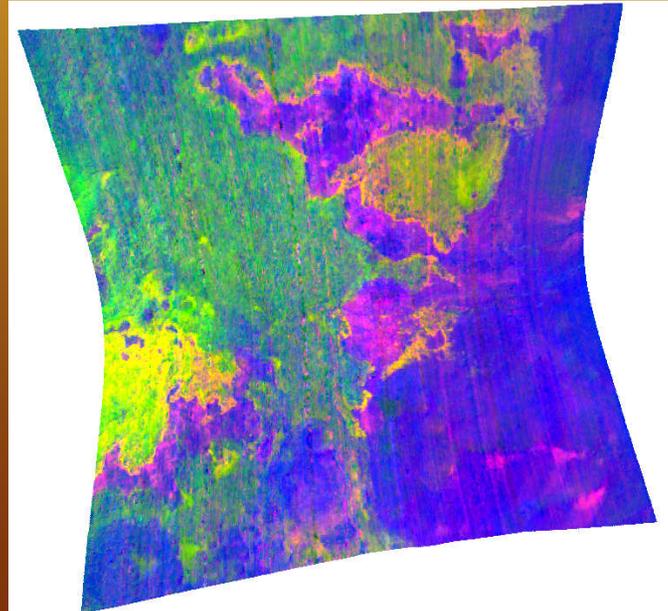
(TRR3 cal)



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G=bd1000vis
B=sh600



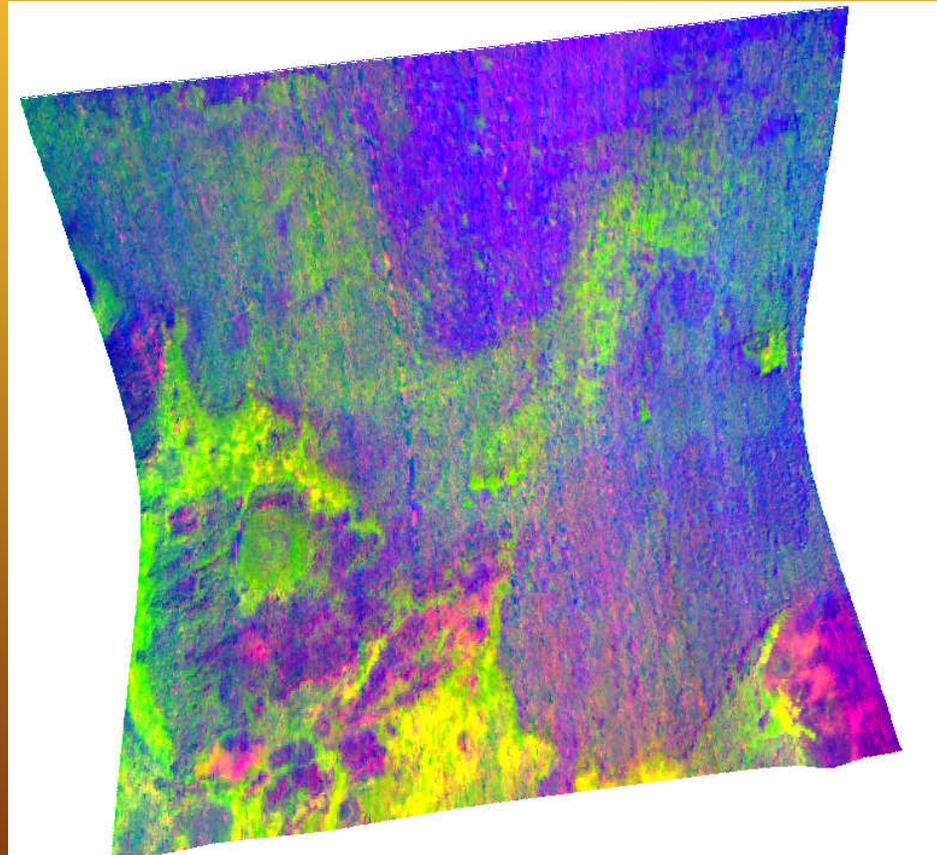
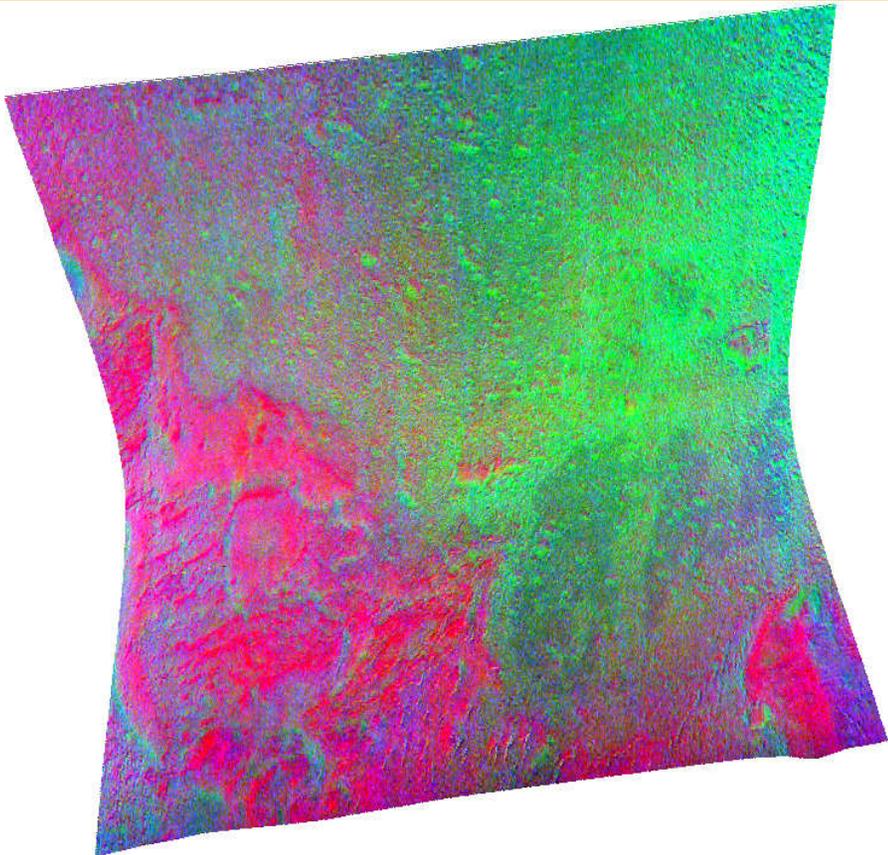
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G=OLV
B=HCP



R=bd530
G=bd1000vis
B=sh600

FRT0000A542

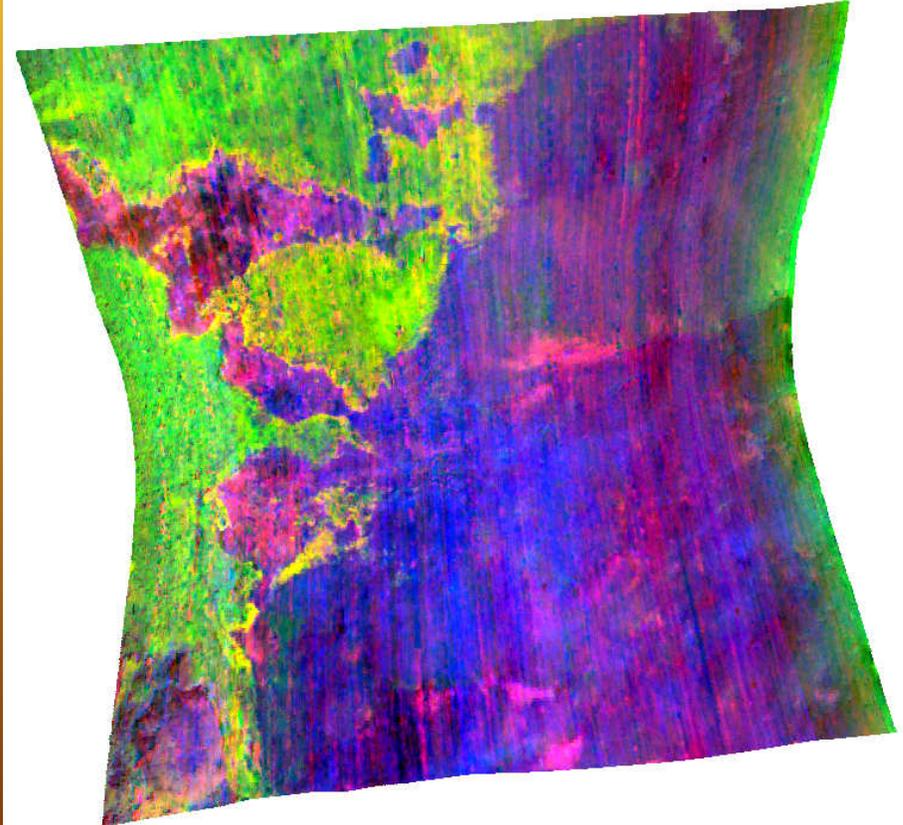
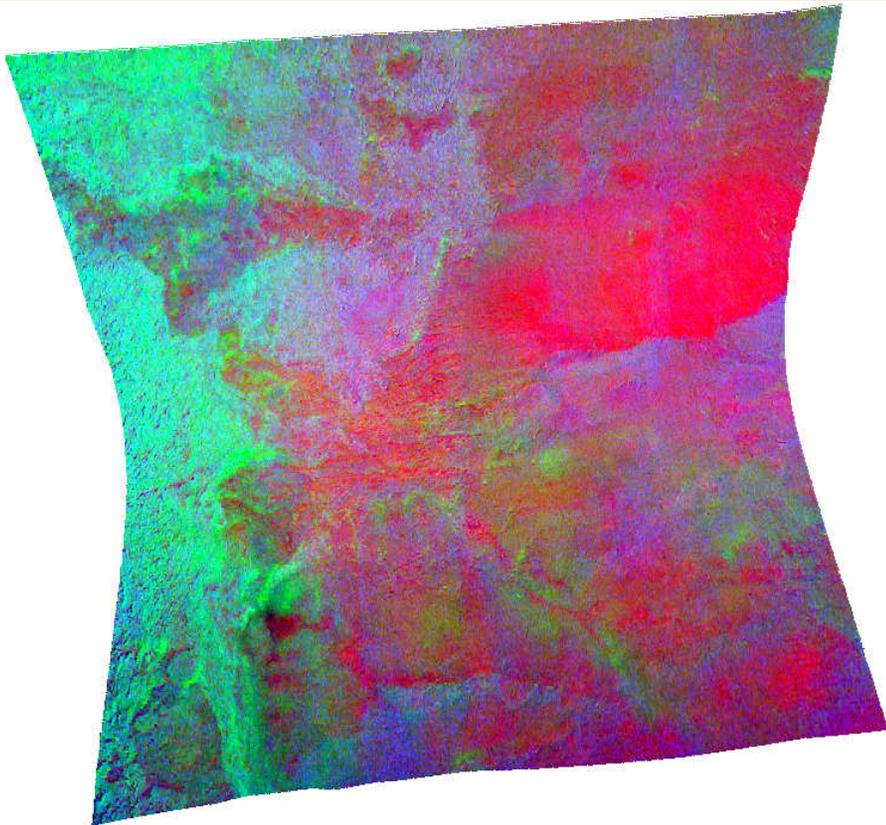
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B=HCP



R=bd530
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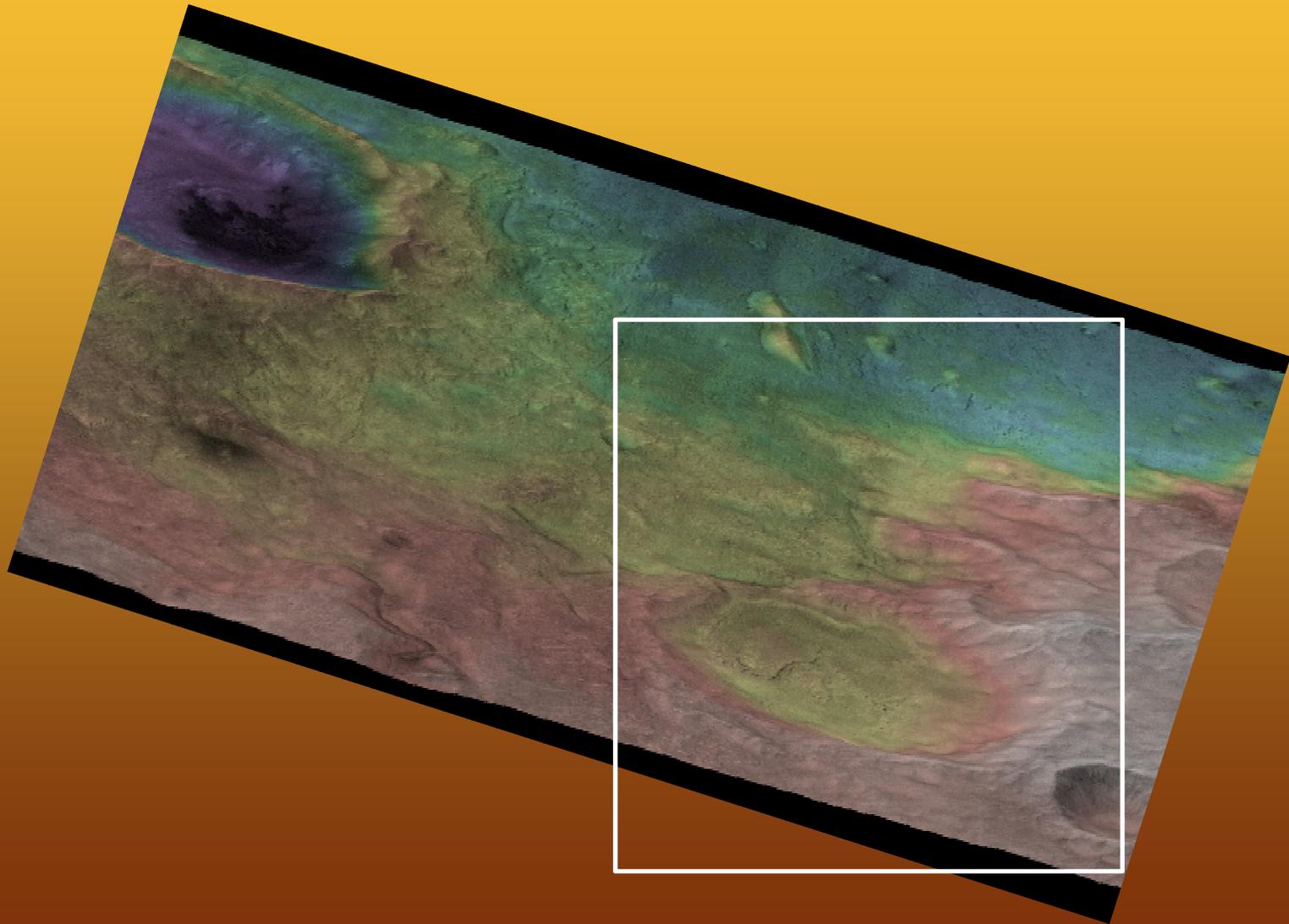
FRT0001754F

R=d2300
G=OLV
B=HCP



HRSC perspective at 25 m resolution

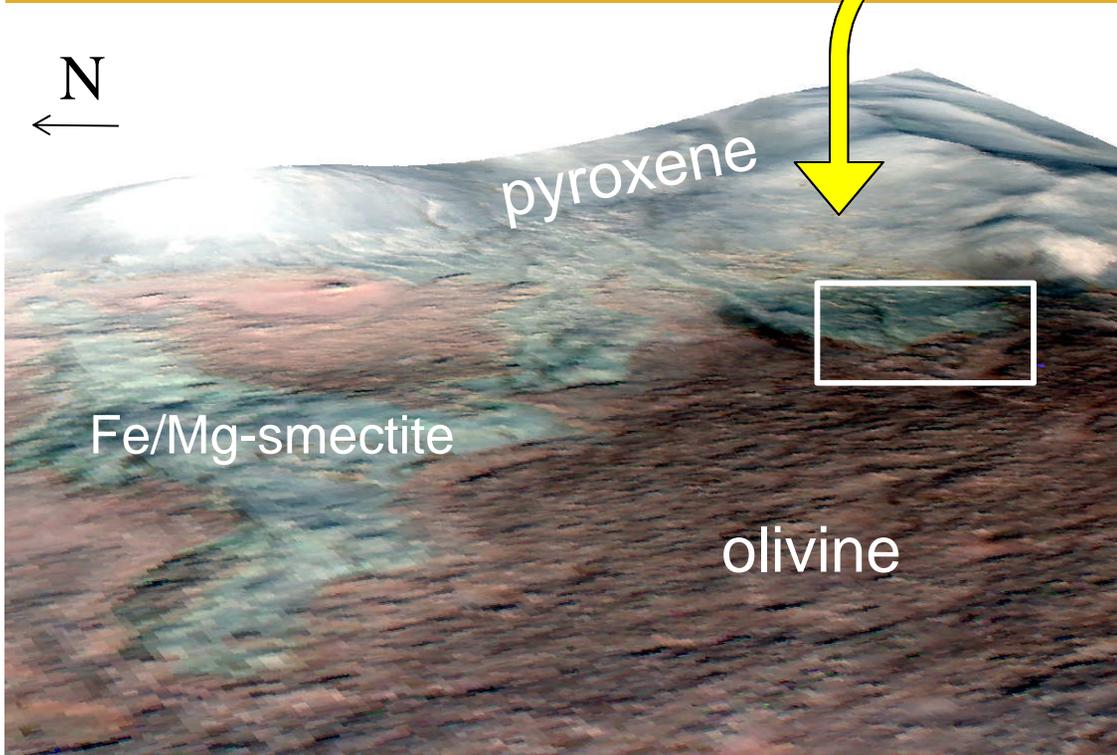
Based on the CRISM mineralogy from the map tiles and FRTs it appears that the higher elevation (red/pink) regions along the bottom and right side are the pyroxene caprock, the yellow elevation is olivine and the clay/carbonate unit. The map tile shows extensive olivine excavation from the crater on the NW corner of the image.



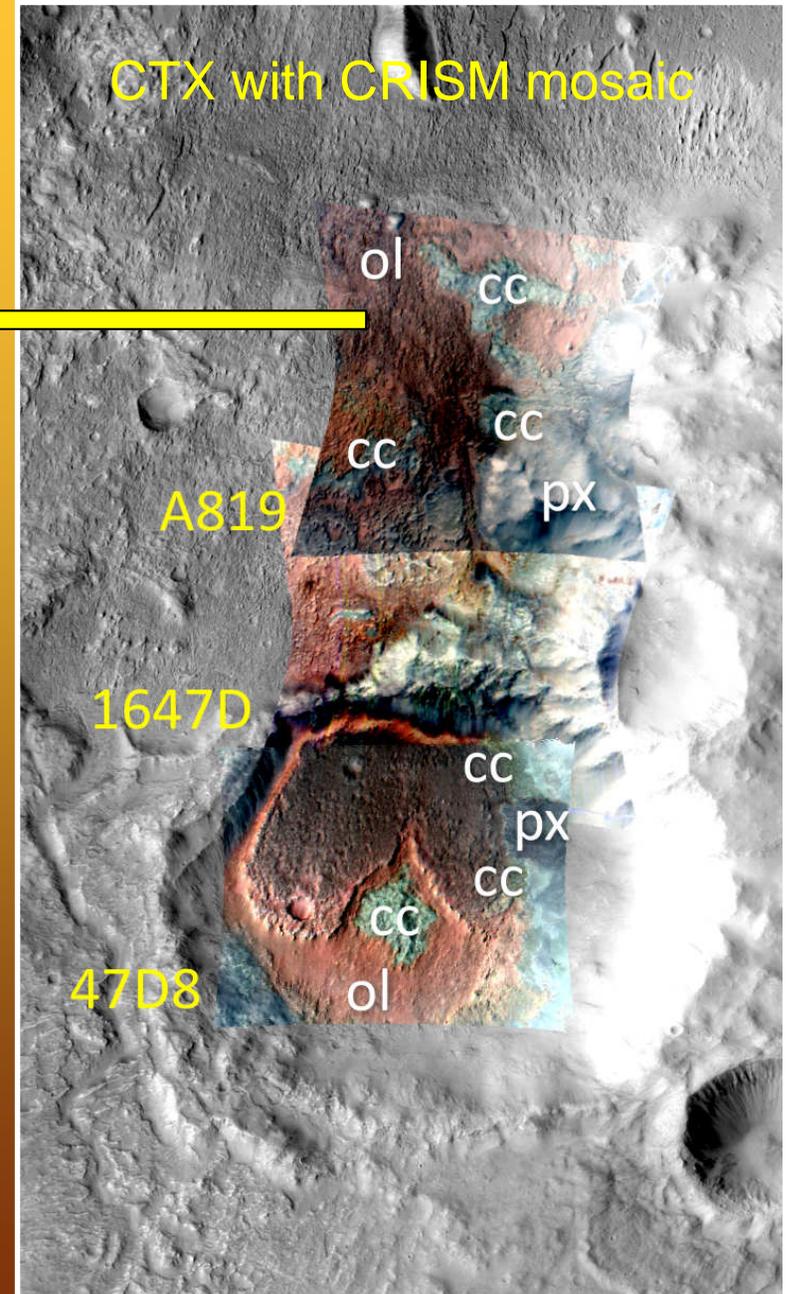
Mineralogy at Main Phyllosilicate Outcrop

N ↑

CTX image from white box
on HRSC view



CRISM FRT0000A819 over MOLA

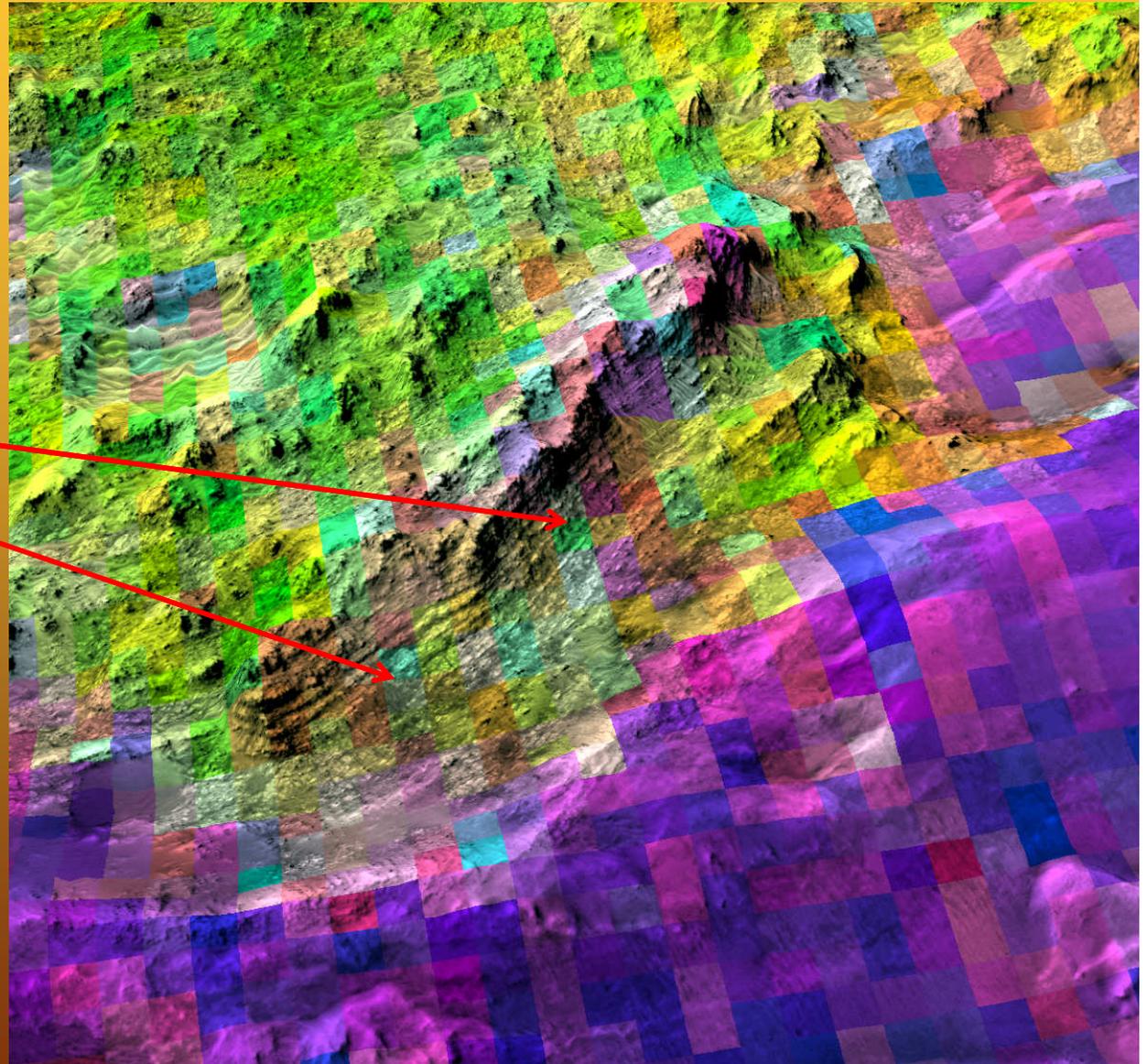


HiRISE DEM with Color from CRISM

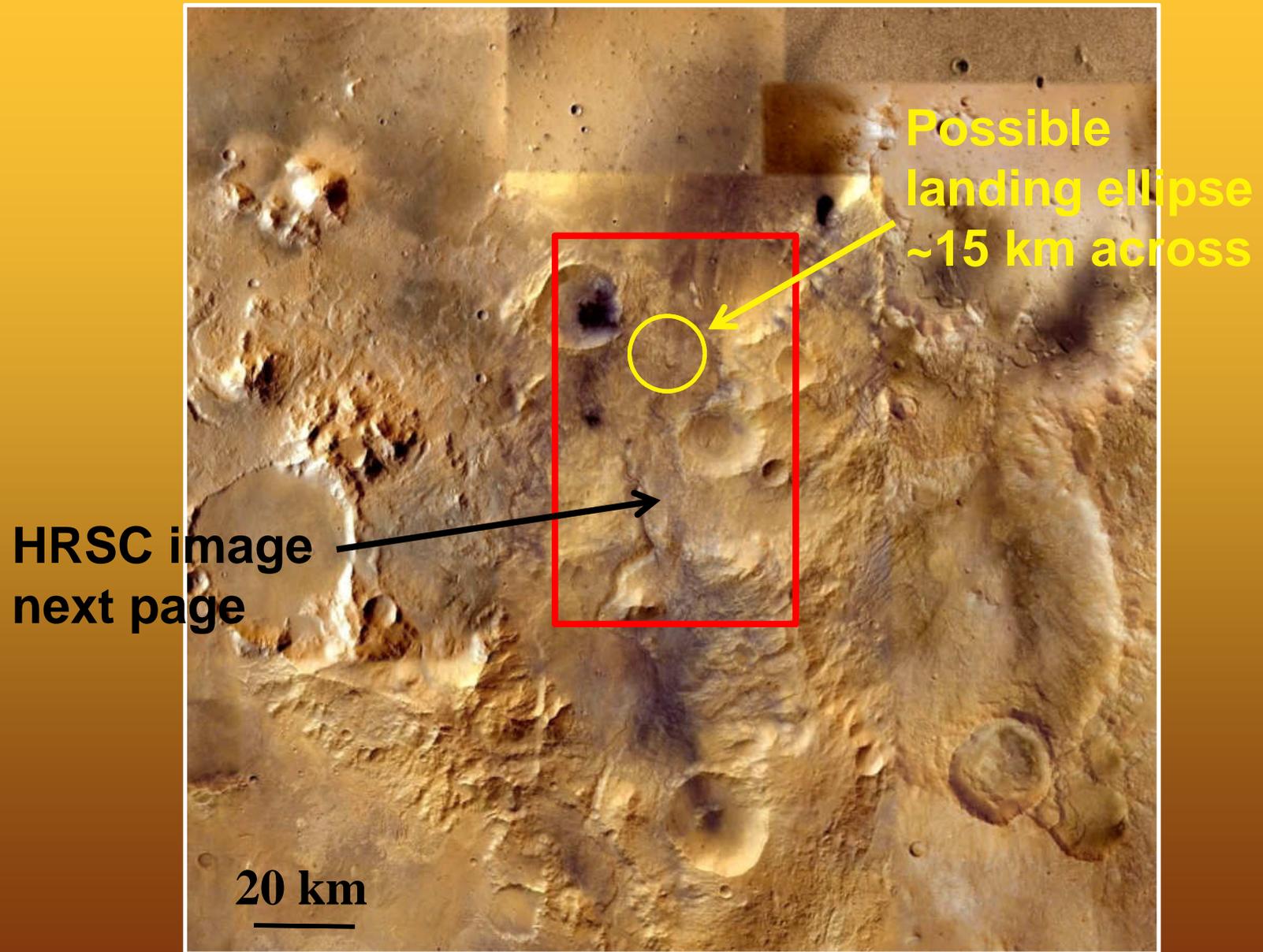
N ↑

Fe/Mg-smectite unit at base of **olivine** where **caprock** eroded back.

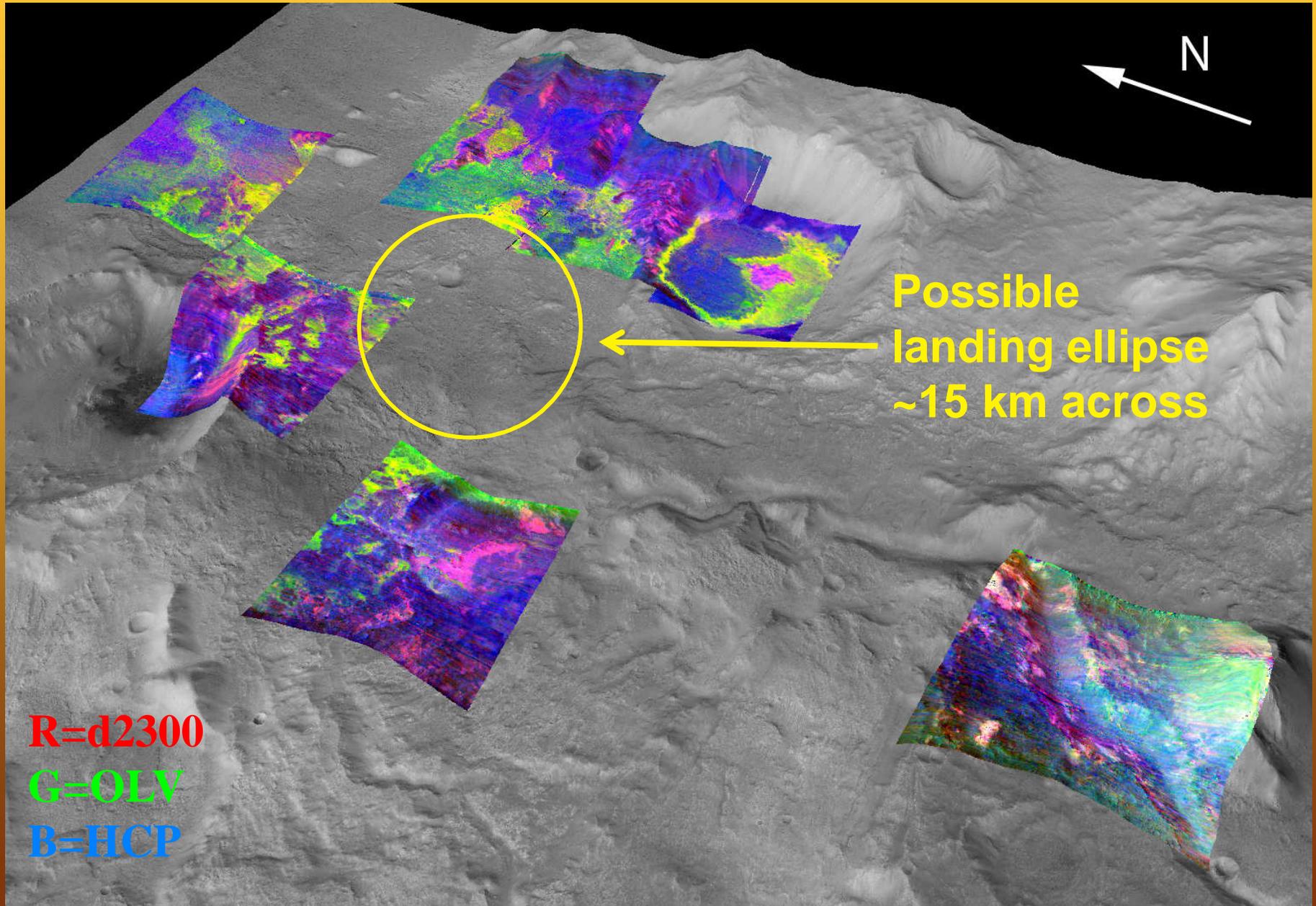
CRISM parameters show Fe/Mg-smectite unit as clearly distinct from olv and pyx units, but spectral features only show up well at slopes of olivine unit. HiRISE shows dust along flat surfaces of Fe/Mg-smectite unit.



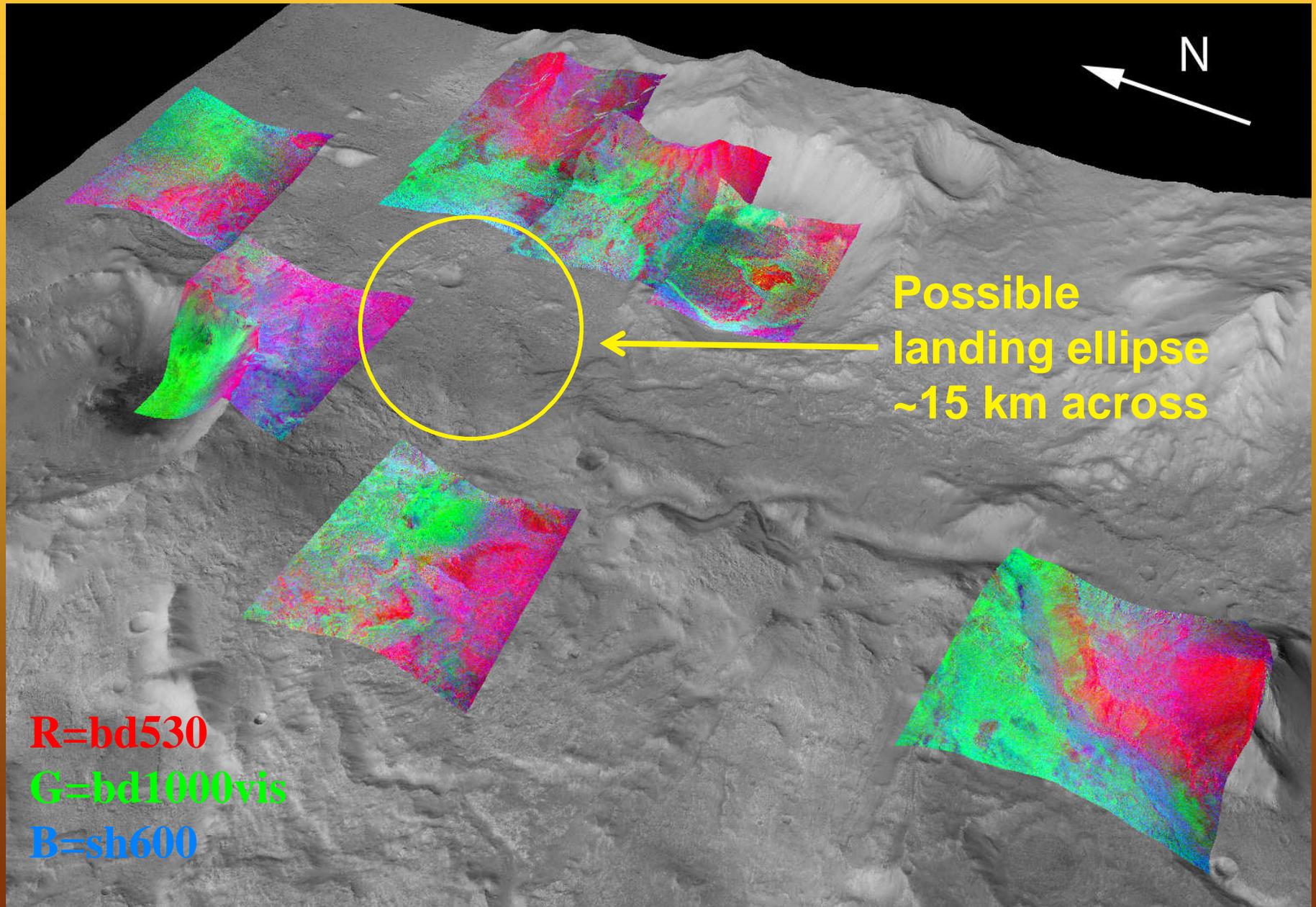
Possible landing site ellipses at Libya Montes



CRISM on CTX over HRSC DTM



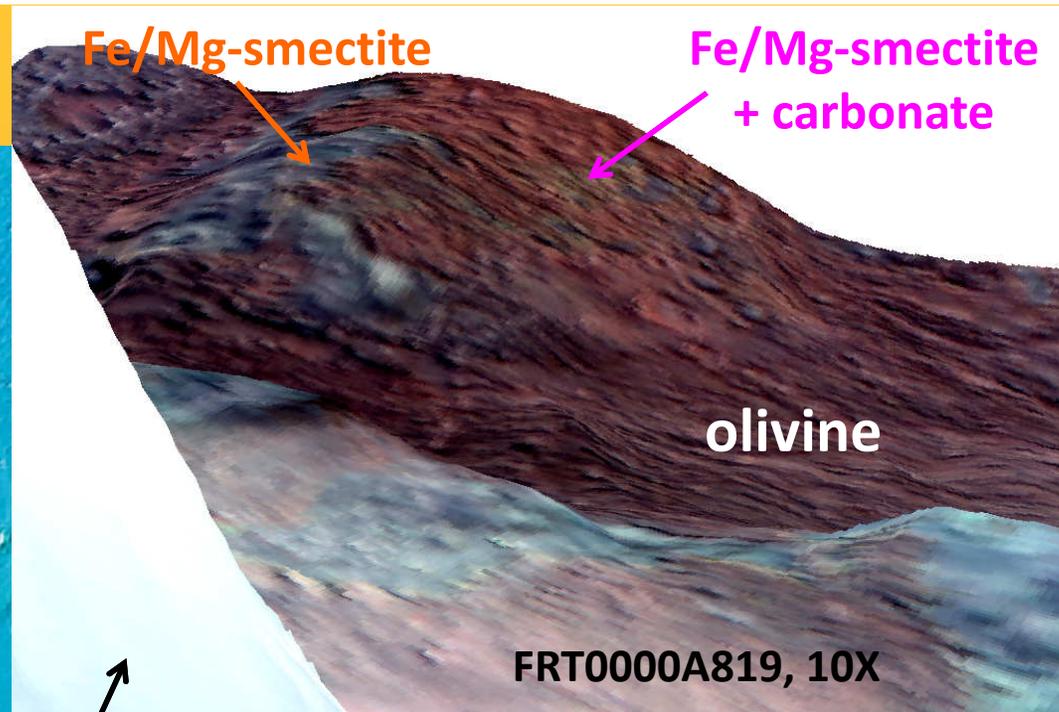
CRISM on CTX over HRSC DTM



Mineralogy of the Libya Montes rim/terrace complex

- Pyroxene-bearing mountains from most recent Syrtis flow.
- Olivine-rich rocks from older Syrtis flow and/or impact melt.
- Fe/Mg-smectite units in the ancient terrains where exposed.
 - Some variation in spectral features near 2.29-2.31 and 2.38-2.41 μm indicating variation in Fe and Mg in octahedral layers from nontronite to saponite (small amounts of serpentine or chlorite may also be mixed in some places).
- Carbonate occurs together with Fe/Mg-smectite in a few regions.
 - Carbonate plus Fe/Mg-smectite unit exhibits most beautiful layered and fractured terrain in HiRISE views (could be that more weathered ancient surfaces have lost carbonate due to alteration).
- Al-smectites (beidellite) in a few bright outcrops; appear to be more recent than Fe/Mg-smectites.
 - Beidellite is formed at mildly elevated temperatures (<200 ° C) compared to montmorillonite and could indicate hydrothermal processes or diagenetic processing.

Primary Fe/Mg-smectite outcrops in ancient rocks exposed under olivine, with some occurrences of carbonate.



Isidis

Syrtis Major

Possible landing ellipse
~15 km across

100 km

Libya Montes

