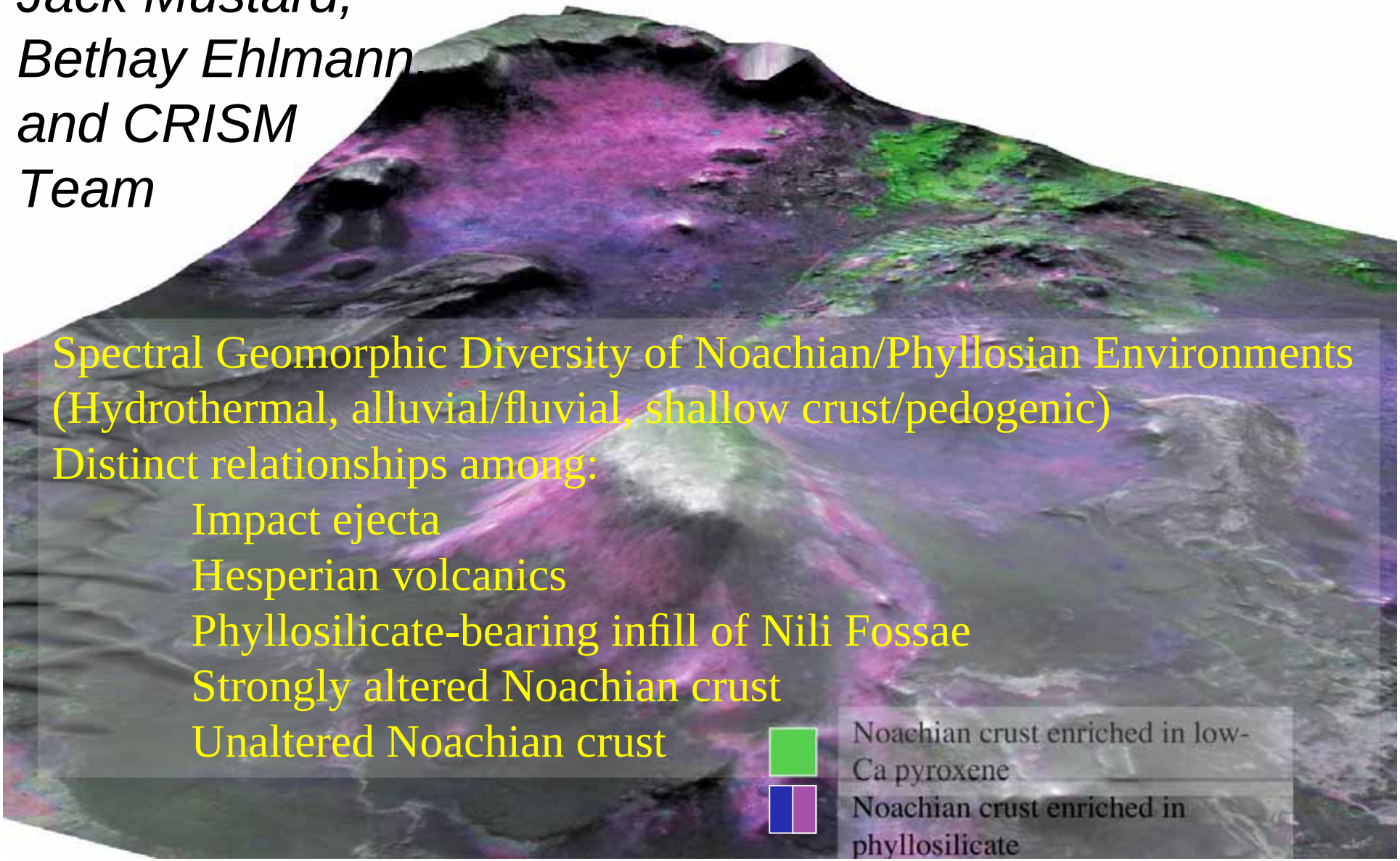
Noachian/Phyllosian Stratigraphy in Nili Fossae

Jack Mustard, Bethay Ehlmann, and CRISM Team



Spectral Geomorphic Diversity of Noachian/Phyllosian Environments (Hydrothermal, alluvial/fluvial, shallow crust/pedogenic)

Distinct relationships among:

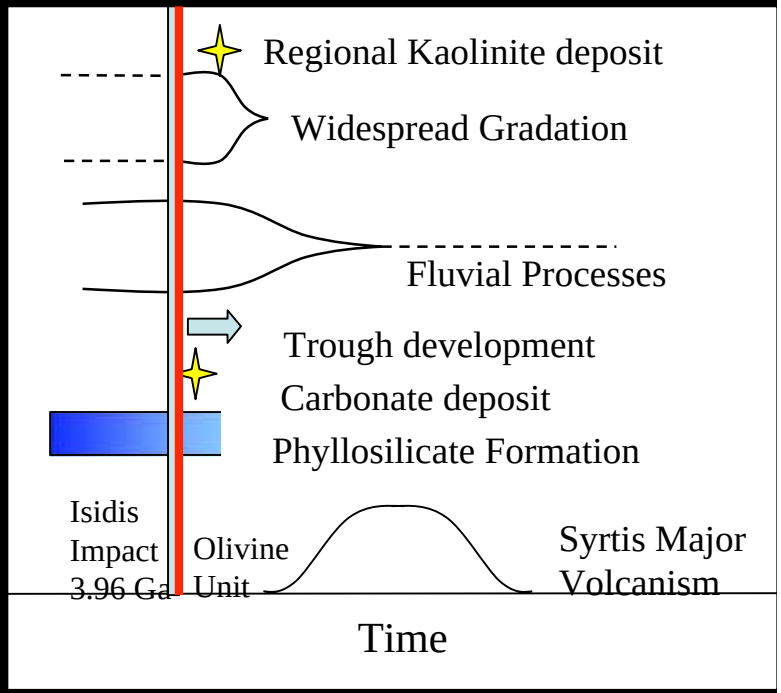
- Impact ejecta
- Hesperian volcanics
- Phyllosilicate-bearing infill of Nili Fossae
- Strongly altered Noachian crust
- Unaltered Noachian crust

Noachian crust enriched in low-Ca pyroxene

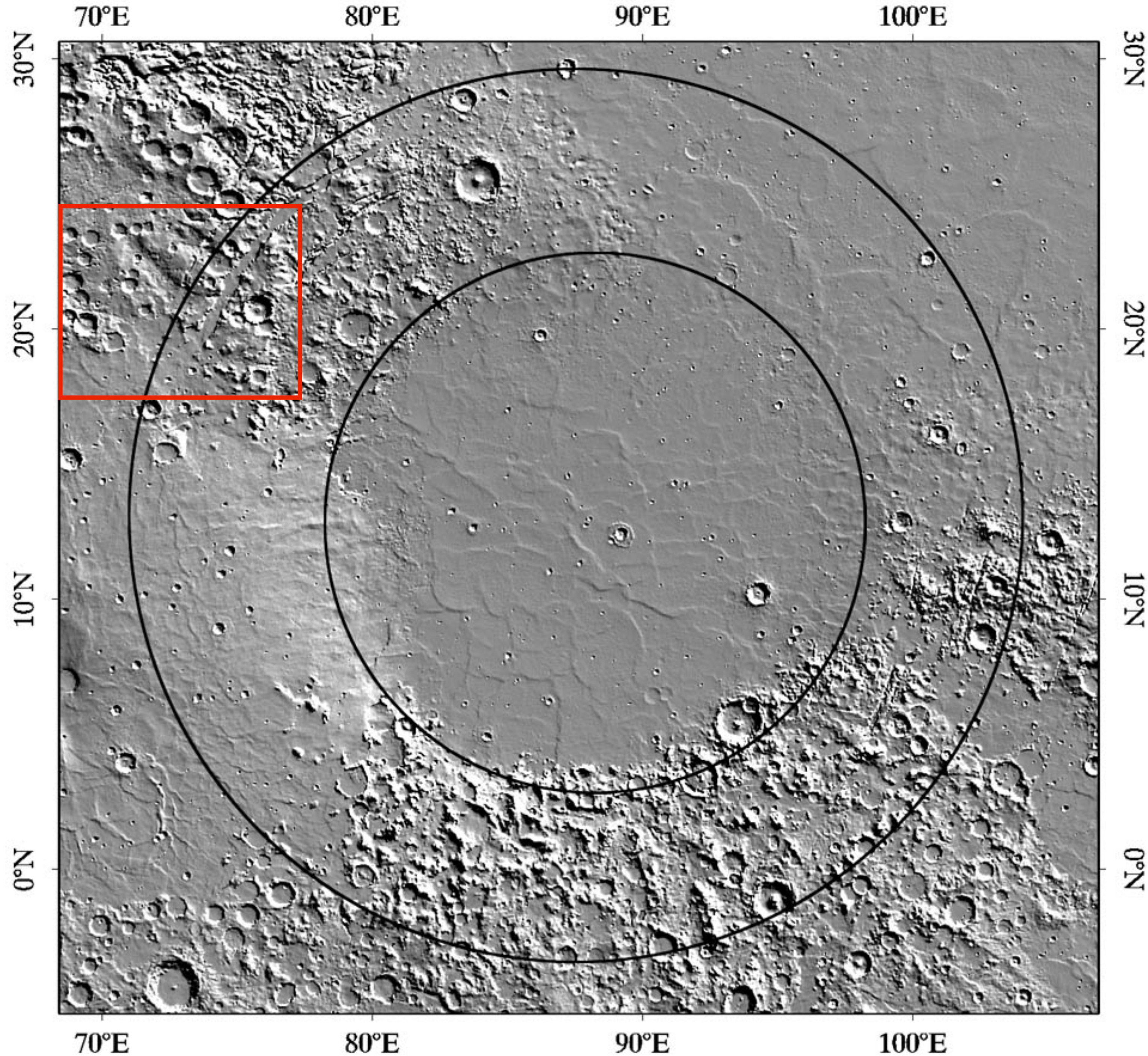
Noachian crust enriched in phyllosilicate

Nili Fossae Geologic Highlights

- Noachian Habitable Environments
  - Ancient crustal and genesis region
  - Fluvially transported sediments
  - Hydrothermal systems
- Impact processes
  - Superbly exposed ejecta from 65 km Hargraves crater
  - Ejecta blocks in a phyllosilicate-bearing matrix
  - Transport, fluidization, alteration



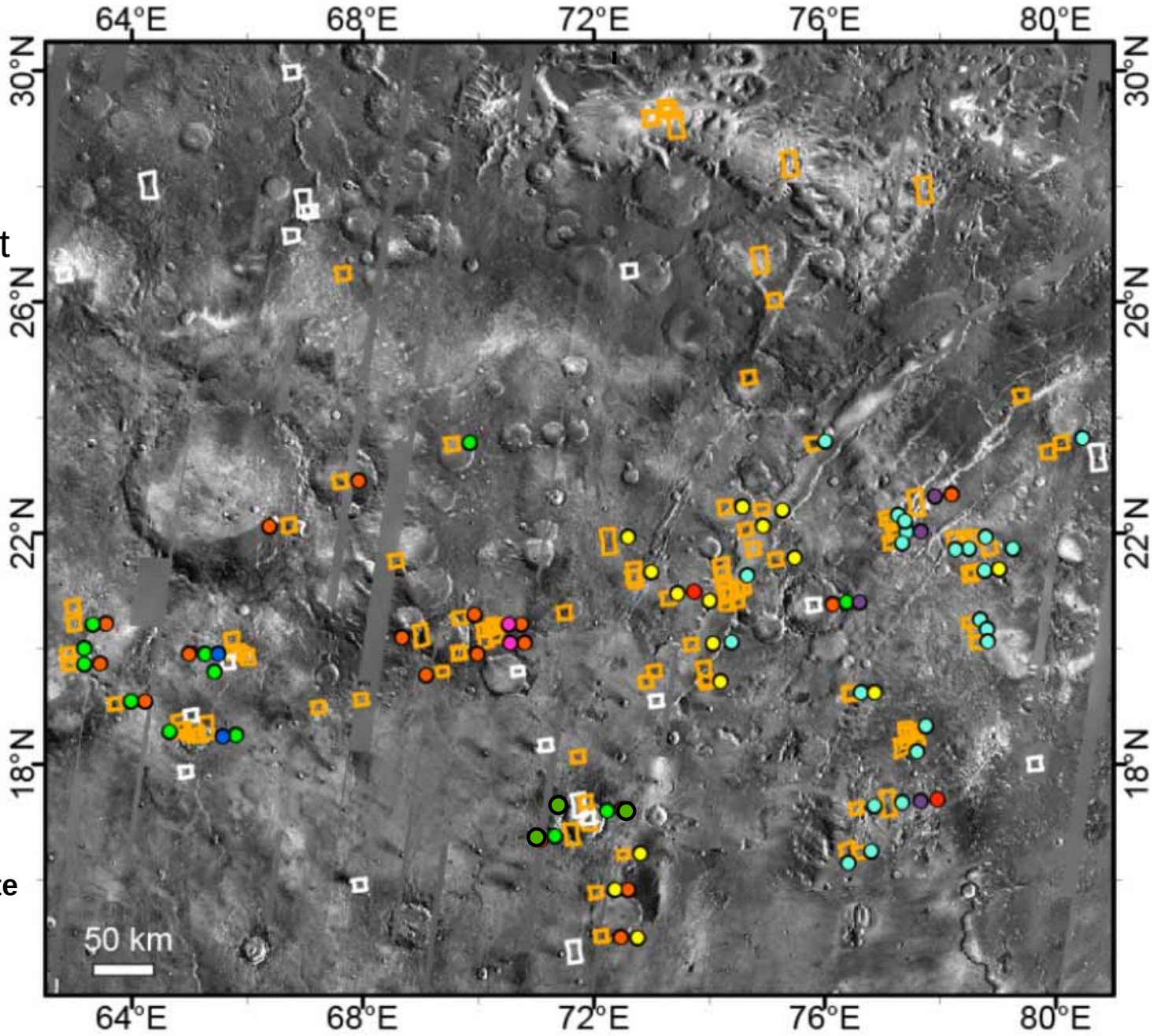
- Composition and character of ancient, unaltered crust
- Composition, mineralogy, and texture of Hesperian Syrtis Major lava
- Traverse the Noachian-Hesperian Boundary

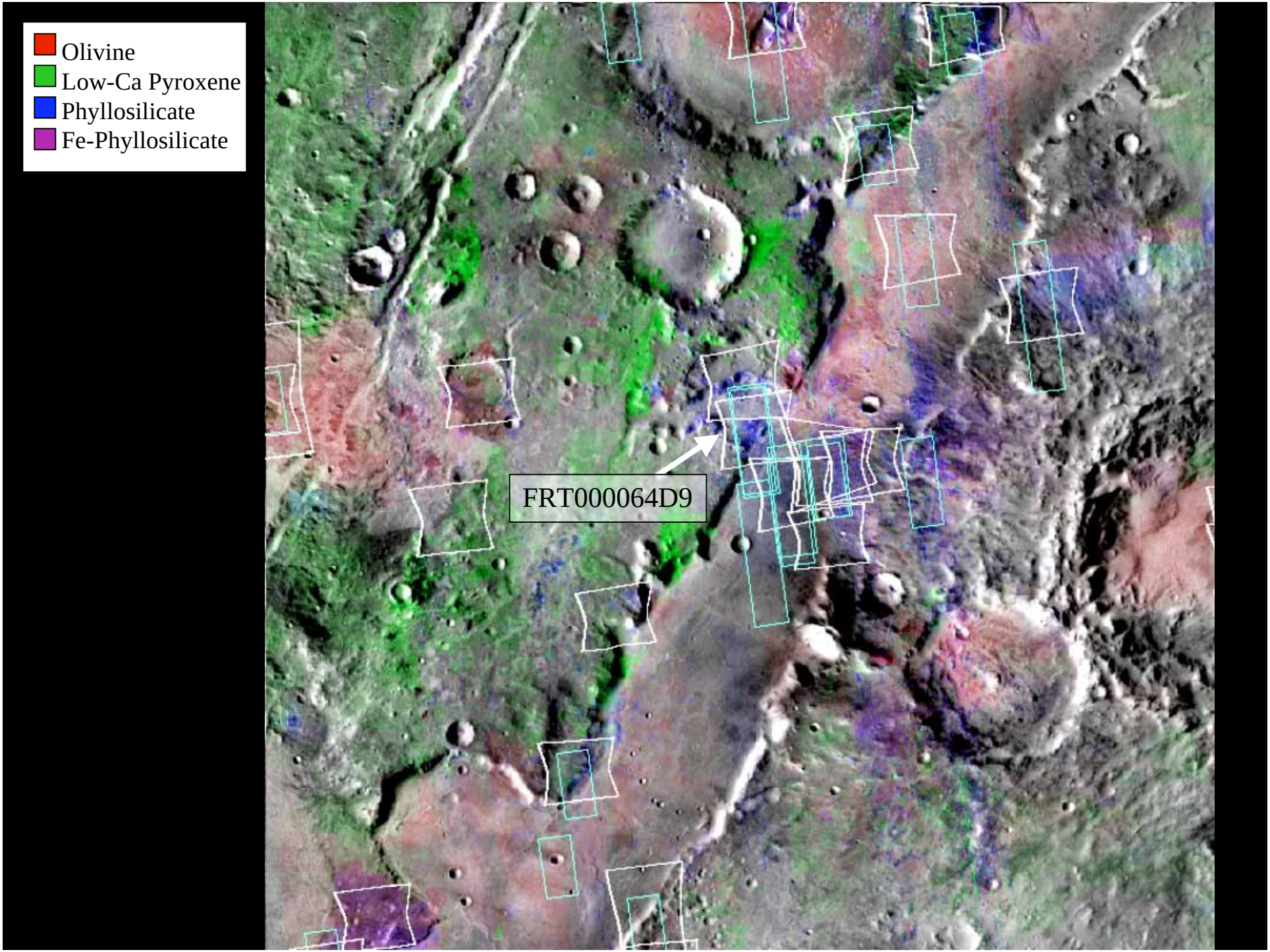

70°E
80°E
90°E
100°E
30°N
20°N
10°N
0°N

Regional Mineral Assemblages, Nili Fossae

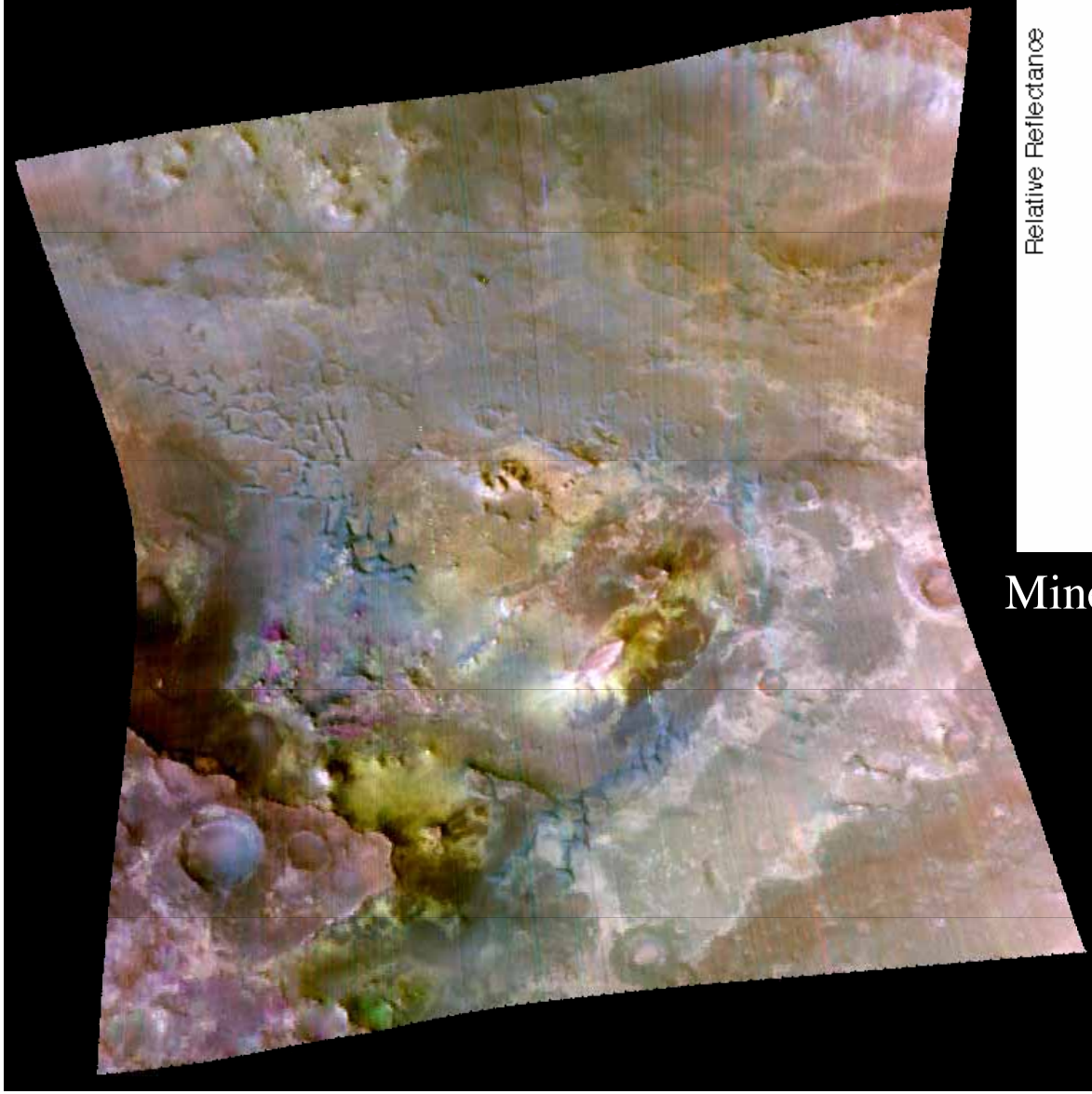
Ehlmann et al., 2008; JGR 2009

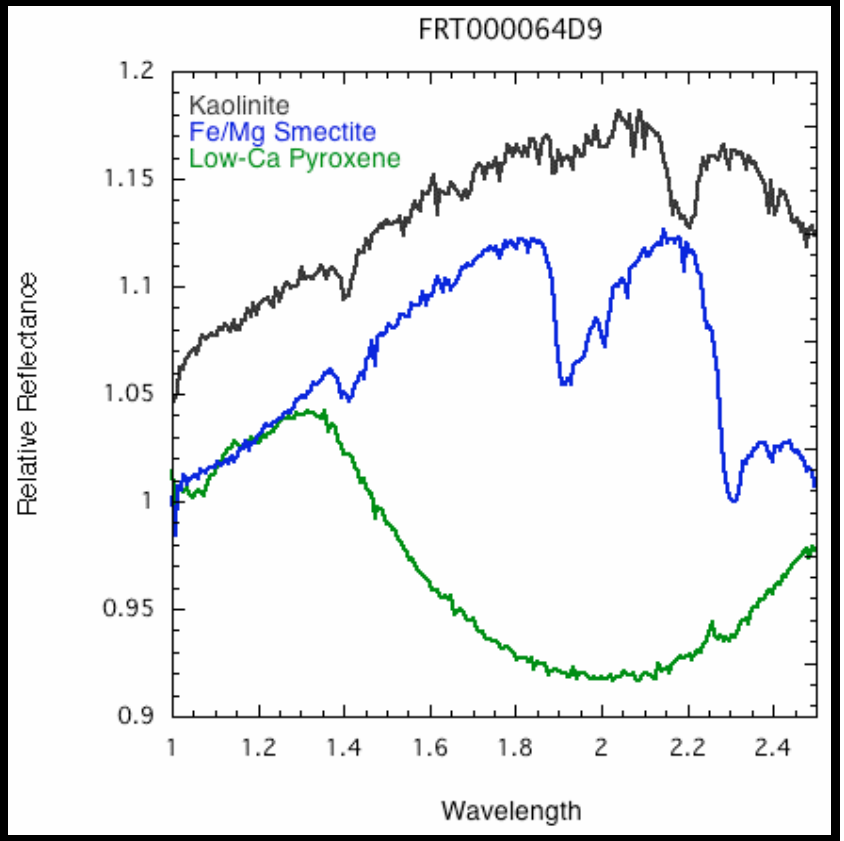
Minerals in context with observation ID's and coordinates




Olivine
Low-Ca Pyroxene
Phyllosilicate
Fe-Phyllosilicate
FRT000064D9

FRT000064D9:
2.4, 1.8, 1.15 μm RGB

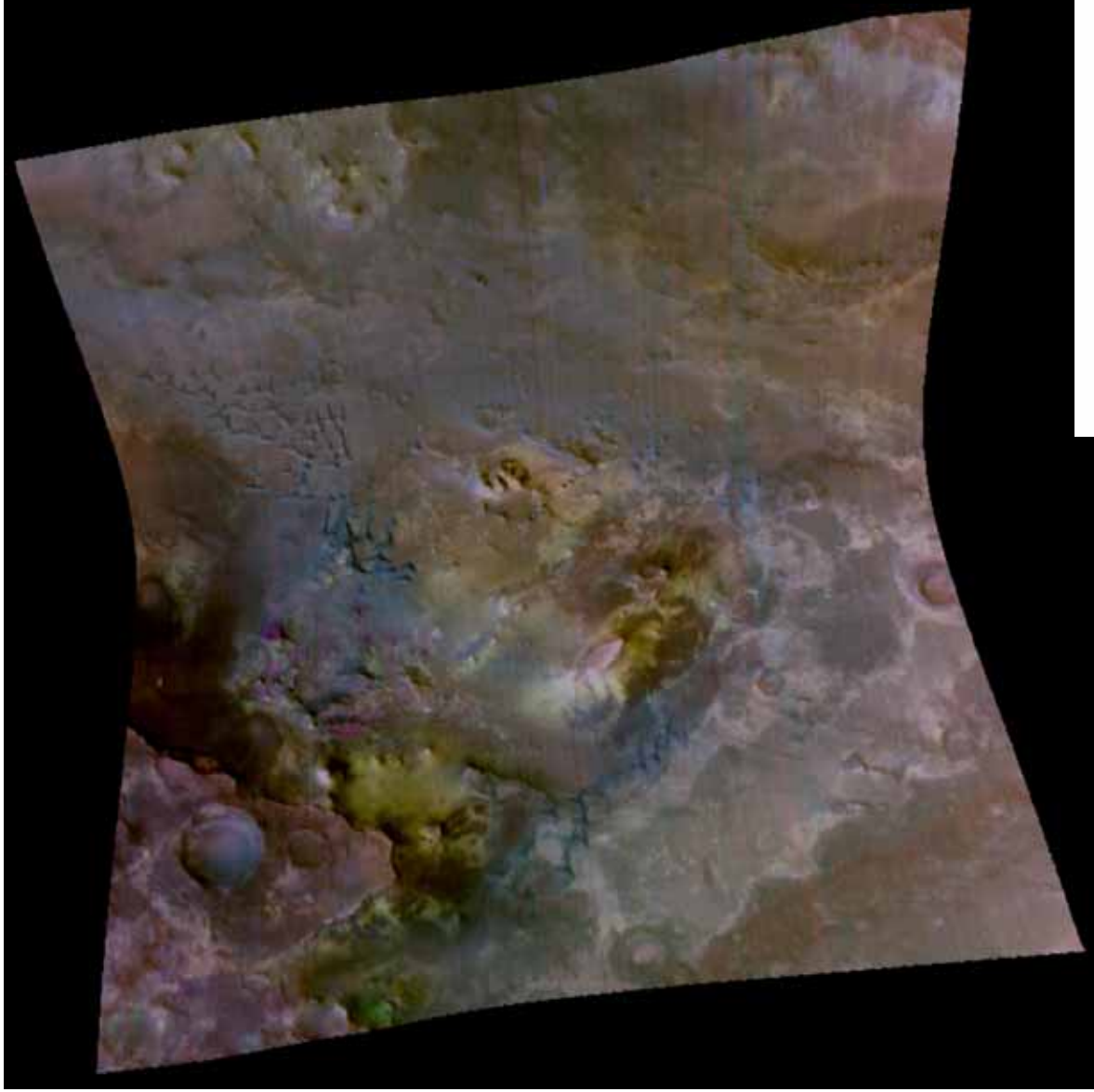


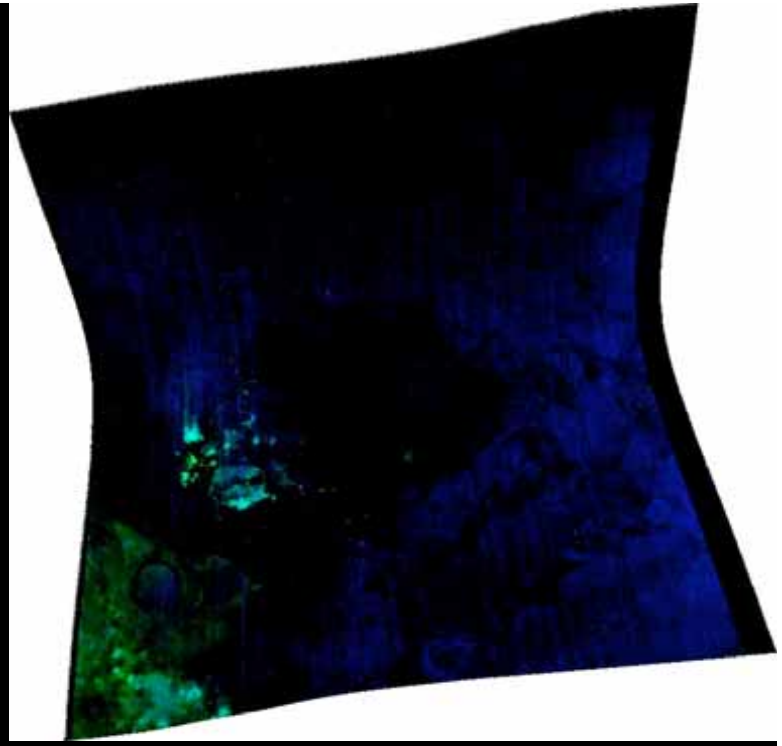


Mineralogy identified

- Fe-oxide and crystalline hematite
- Fe/Mg Smectite with variety of band positions, H_2O content
- Kaolinite
- Carbonate
- Pyroxene (Low and High Ca)
- Olivine

FRT000064D9:
2.4, 1.8, 1.15 μm RGB

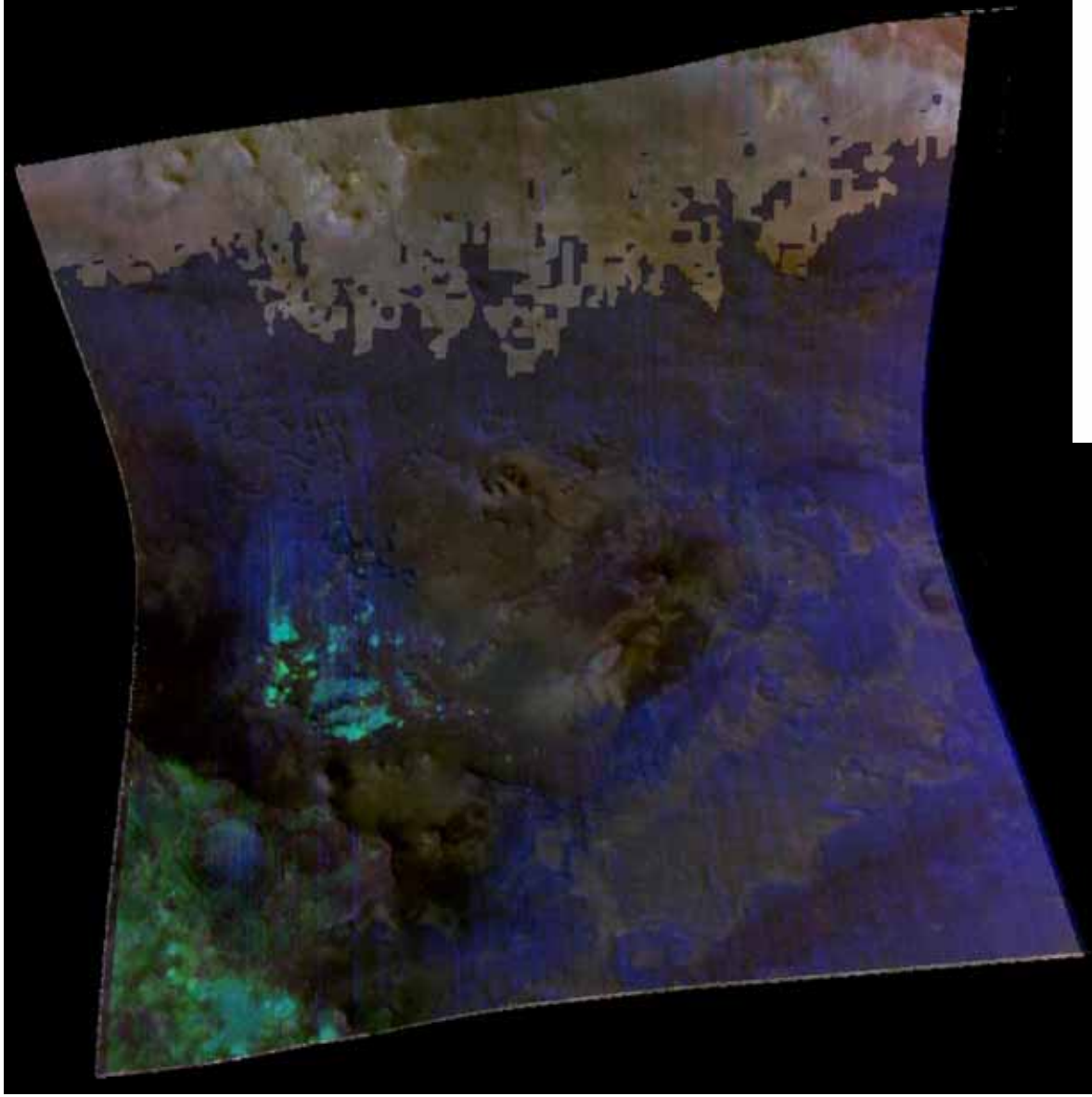


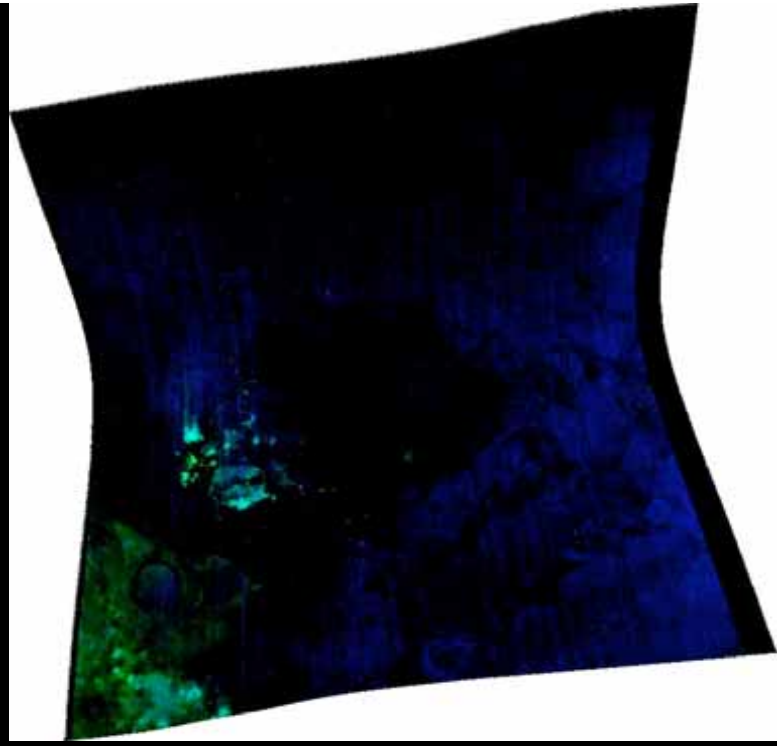


Mafic mineralogy estimated with MGM model.

Blue=High-Ca pyroxene band strength
Green= Low-Ca pyroxene band strength
Both stretched 0.02-0.12

FRT000064D9:
2.4, 1.8, 1.15 μm RGB





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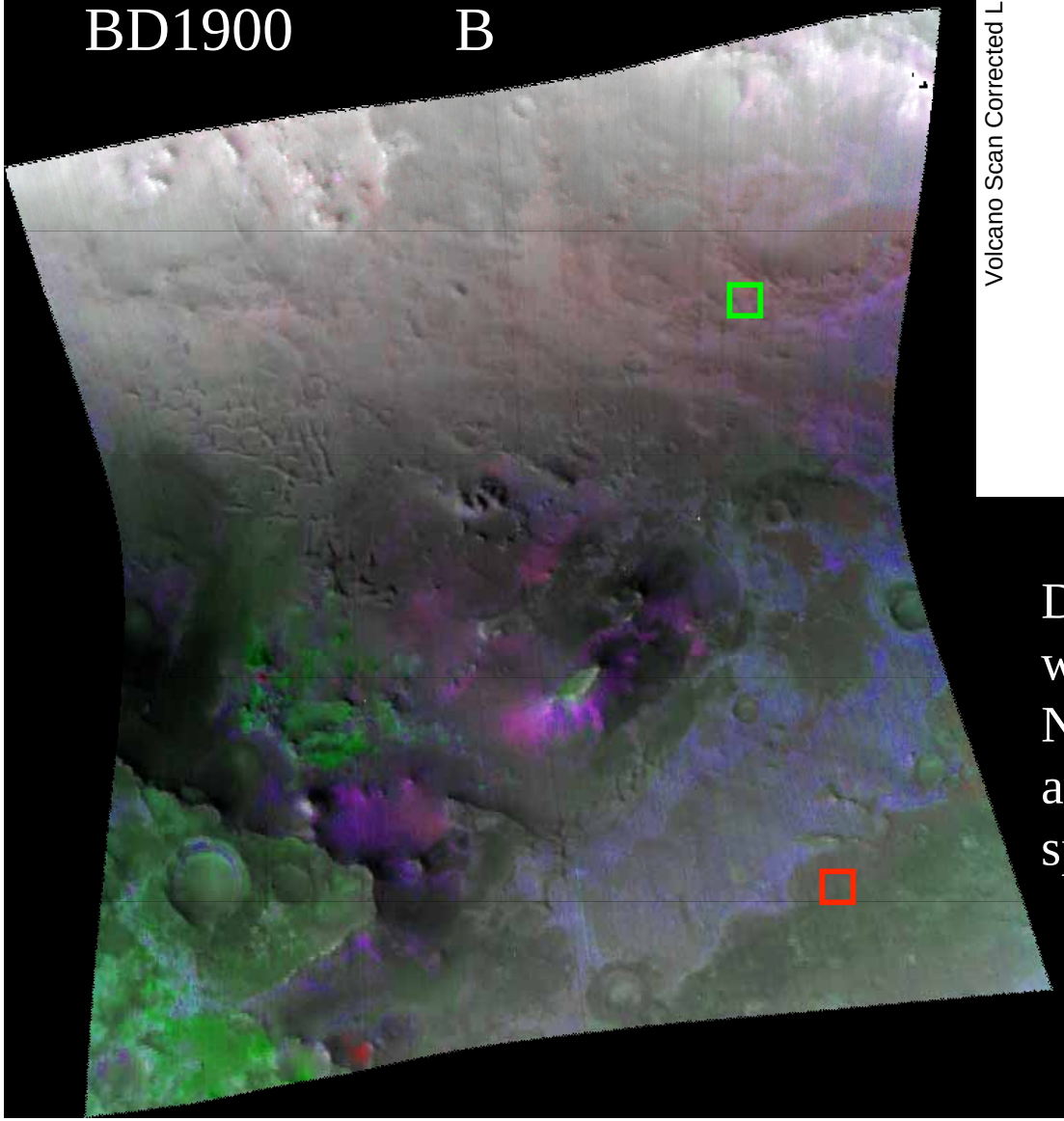
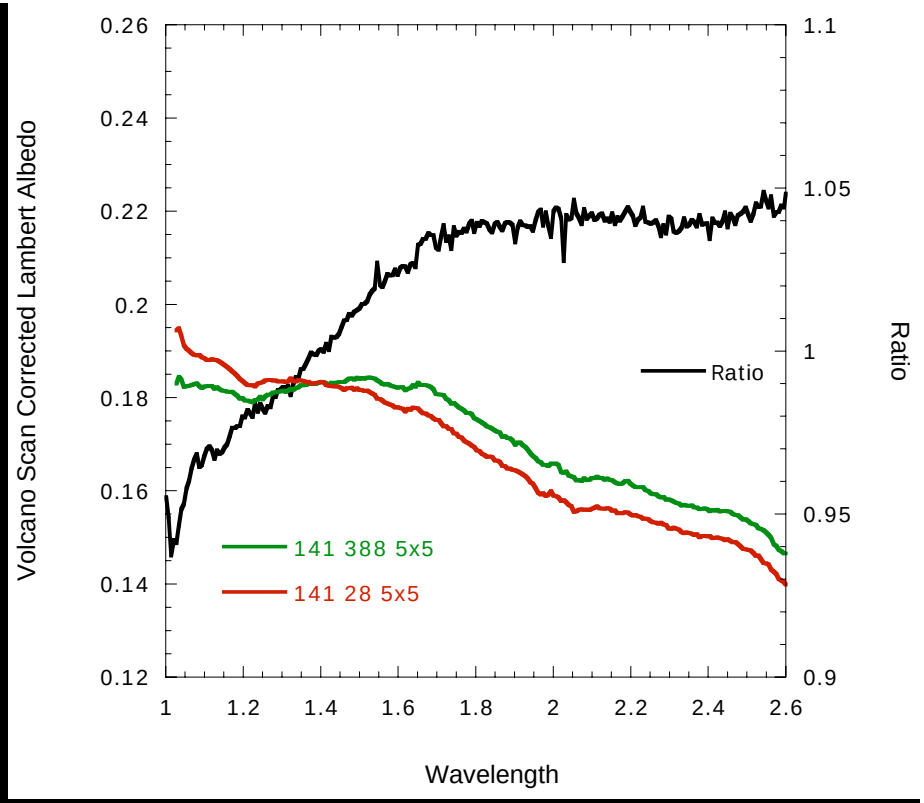
Both stretched 0.02-0.12

FRT000064D9:
OLINDEX-2 R
LCP-mgm G
BD1900 B

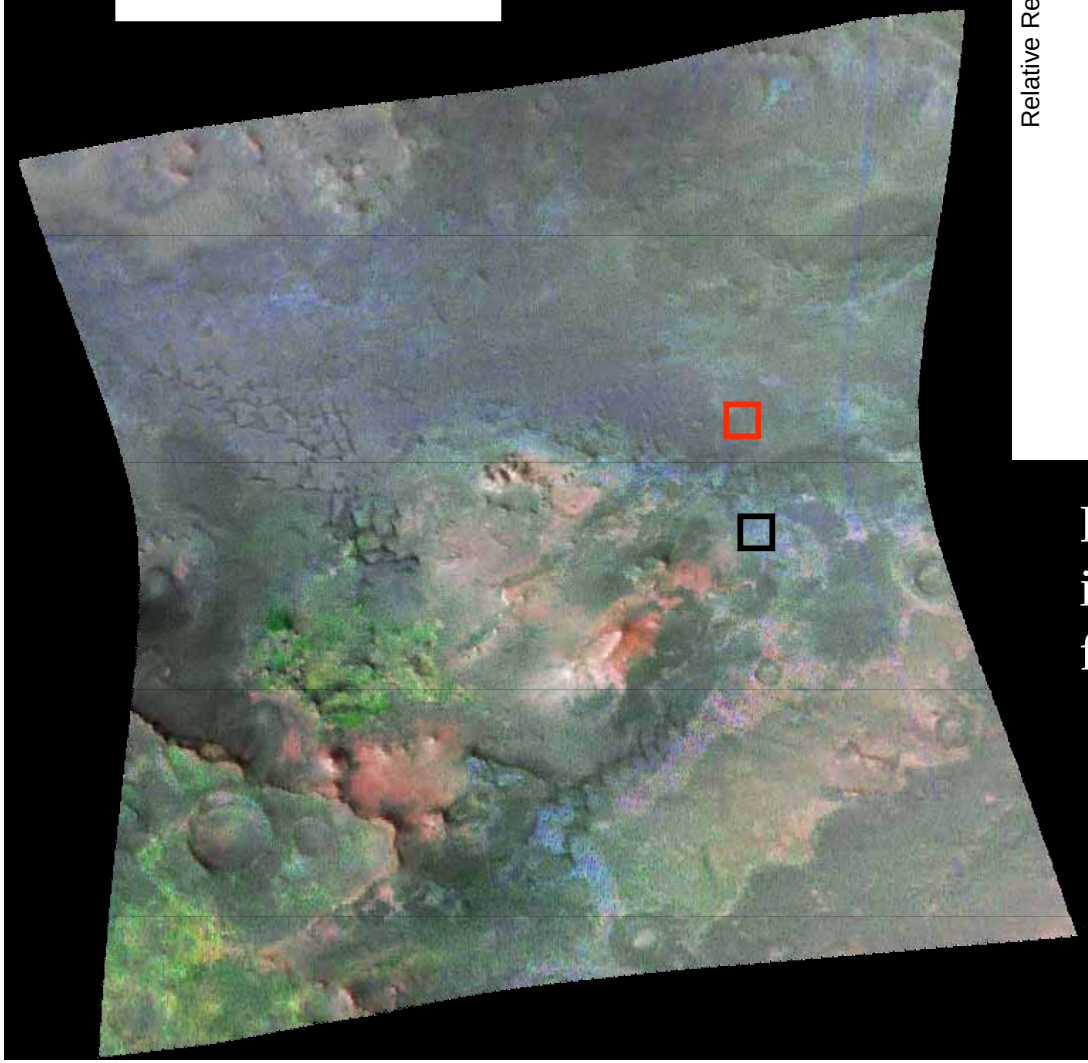
Low-Ca Pyroxene
Phyllosilicate
Fe-Phyllosilicate

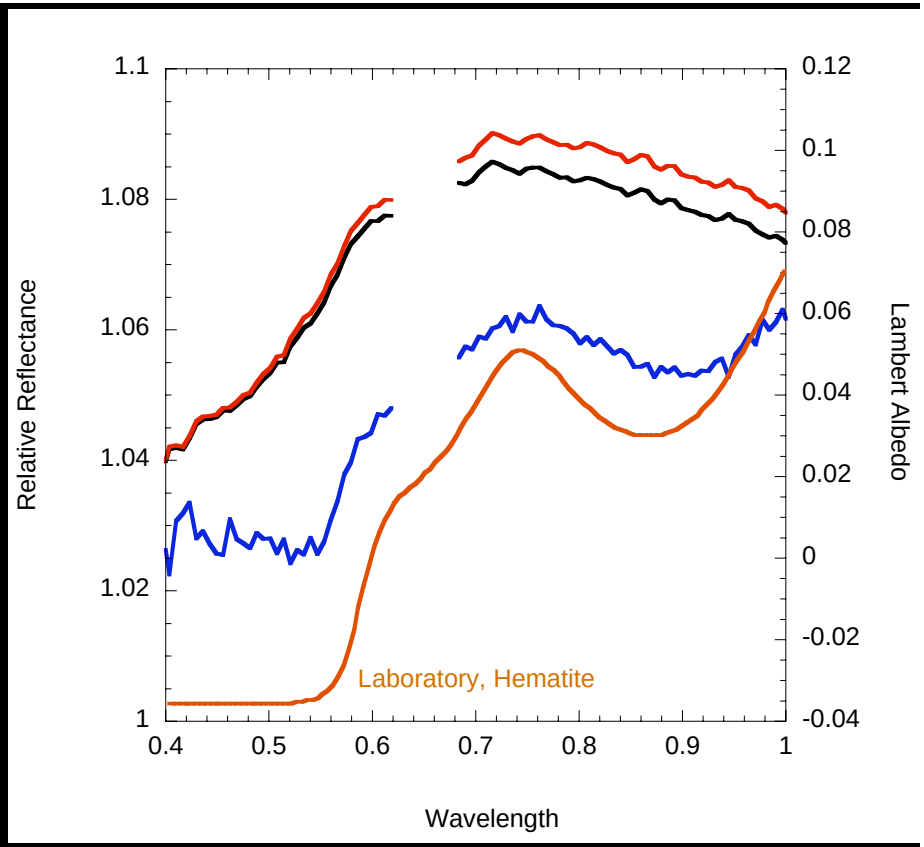




Dune fields show evidence for a weak olivine absorption
Note that pyroxene bands are apparent in the Lambert albedo spectra

FRT000064D9:

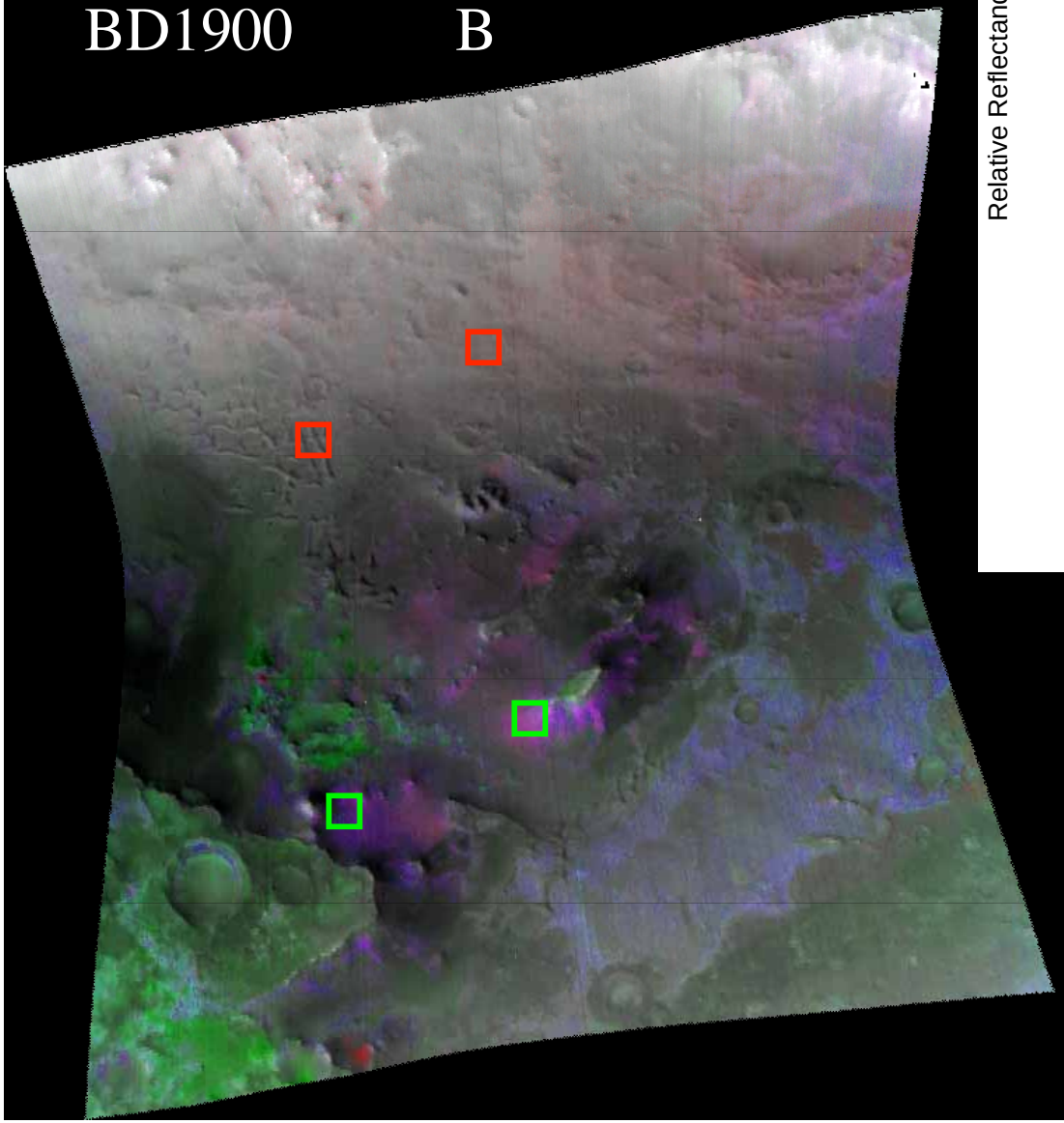


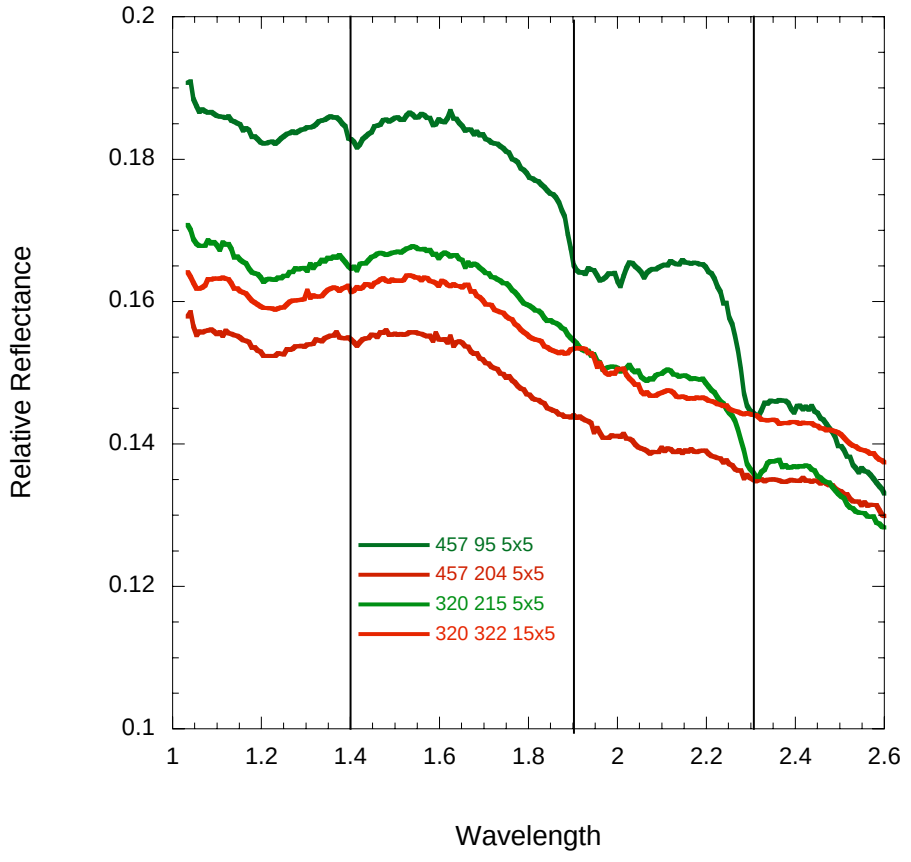


Red crystalline hematite is observed in discrete regions of the material filling the trough floor

FRT000064D9:
OLINDEX-2 R
LCP-mgm G
BD1900 B

Low-Ca Pyroxene
Phyllosilicate
Fe-Phyllosilicate



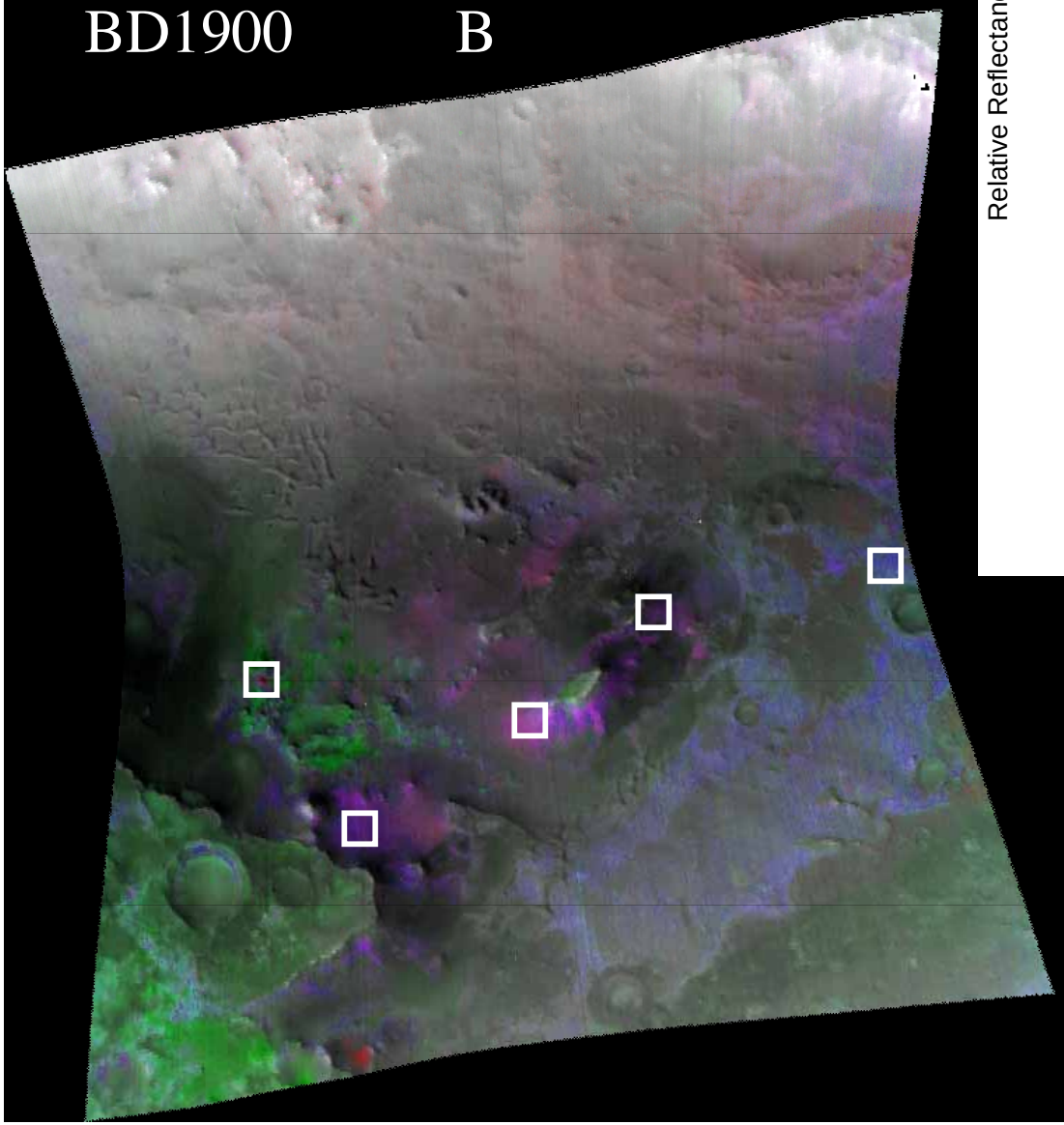


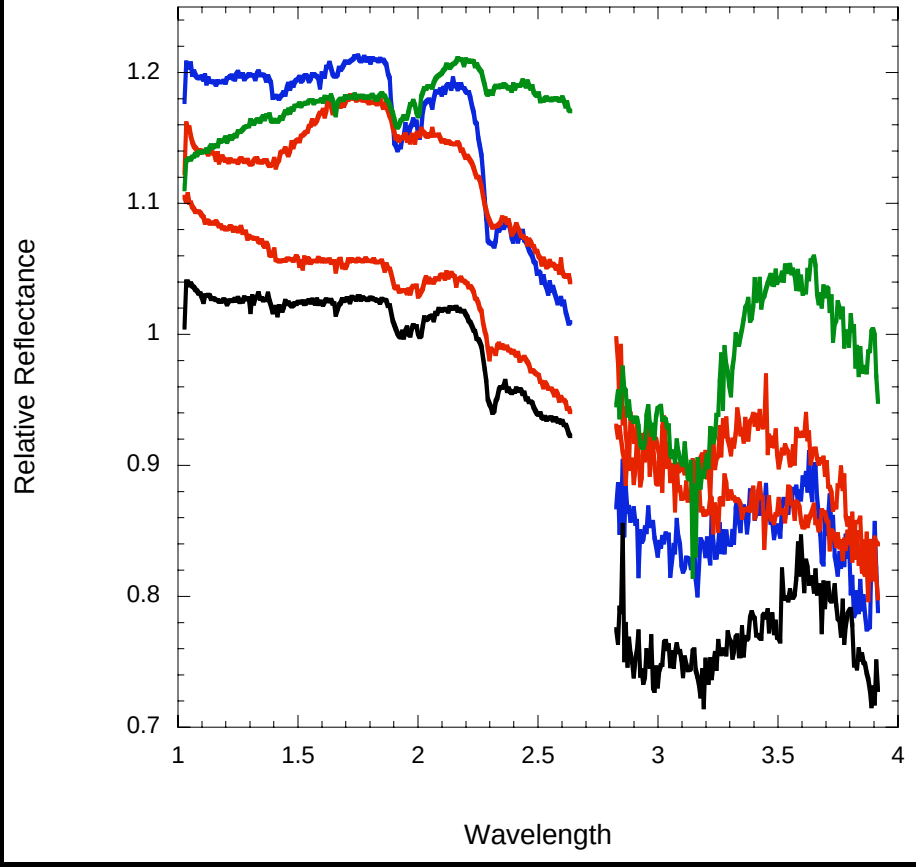
Fe-Mg phyllosilicate indicated by absorptions near 2.3, 1.91, and 1.41 μm

Spectra ratioed to brown-colored dunes

FRT000064D9:
OLINDEX-2 R
LCP-mgm G
BD1900 B

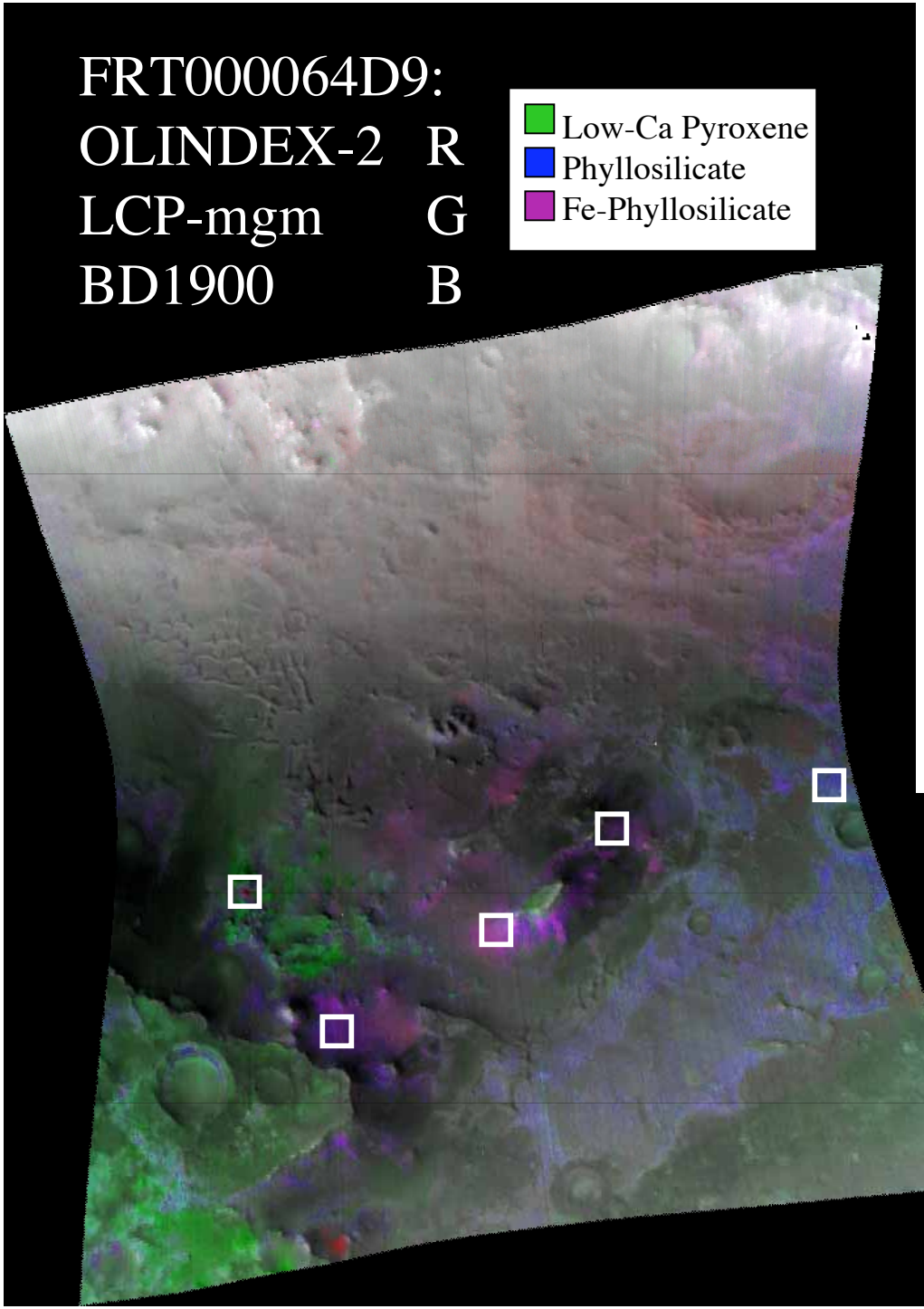
Low-Ca Pyroxene
Phyllosilicate
Fe-Phyllosilicate

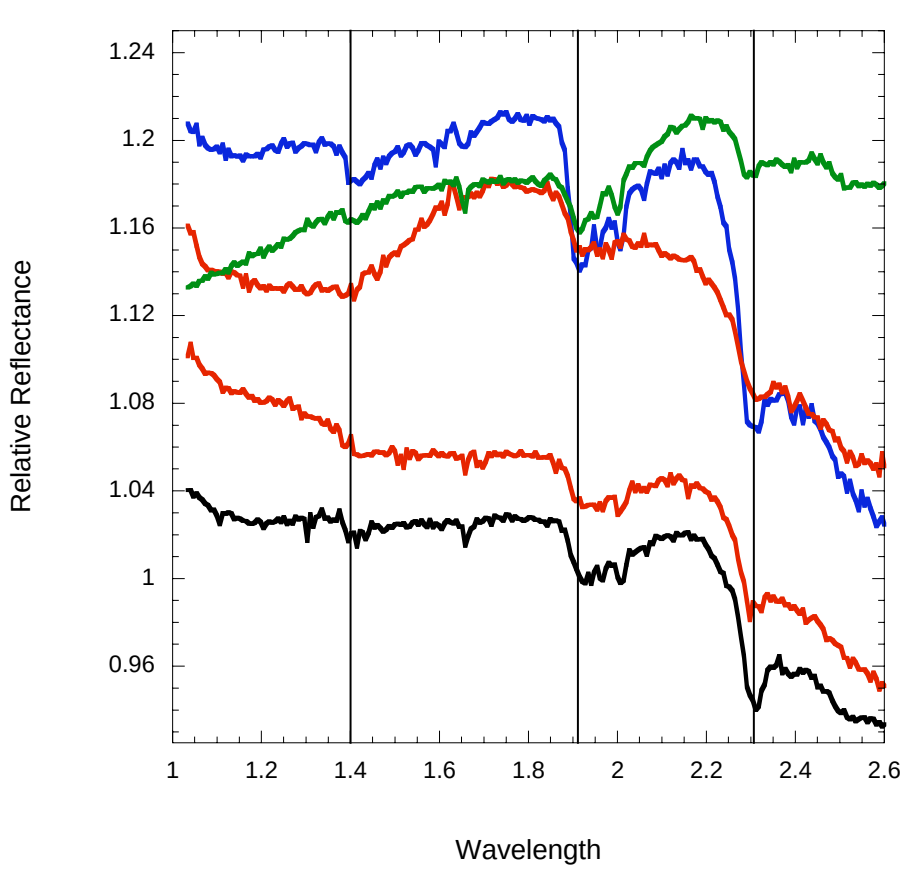




Fe-Mg phyllosilicate indicated by absorptions near 2.3, 1.91, and 1.41 μm

Possible absorption near 3 μm due to H_2O



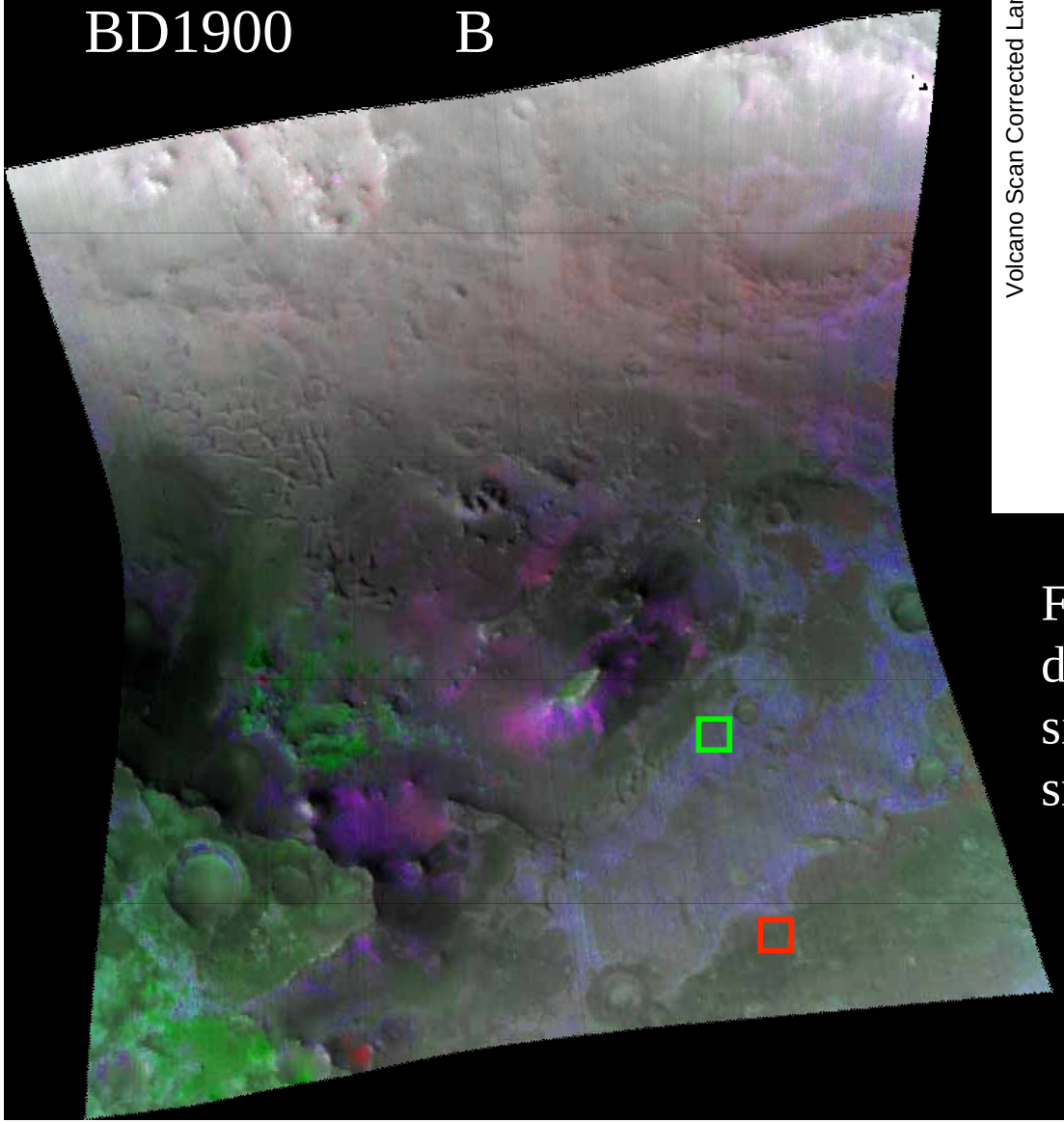


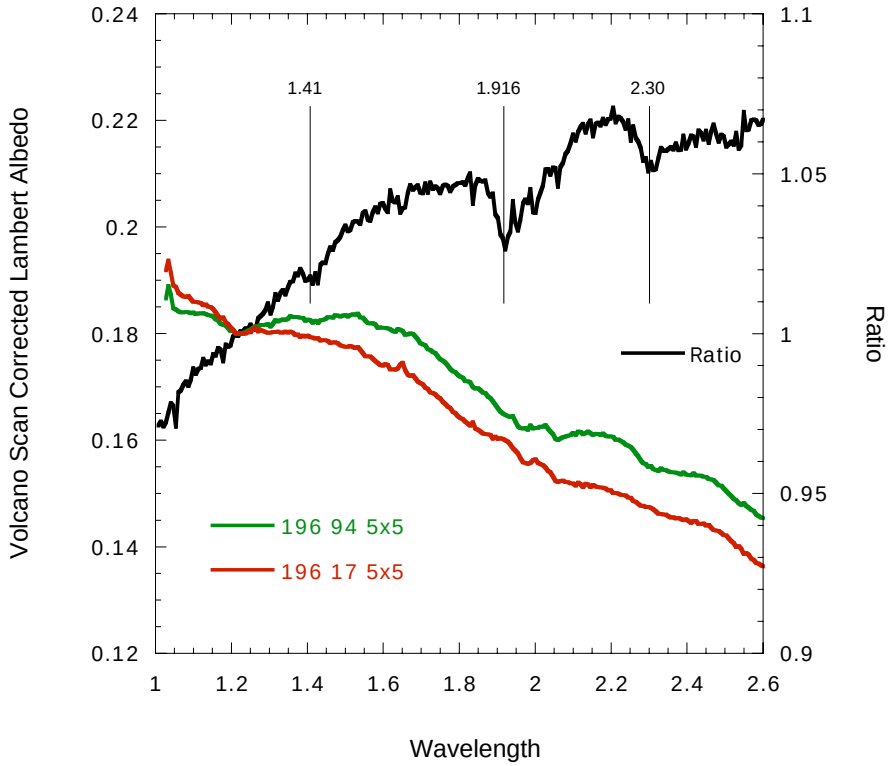
Fe-Mg phyllosilicate indicated by absorptions near 2.3, 1.91, and 1.41 μm

The spectral properties of Fe/Mg phyllosilicates is relatively consistent across scene but with small variance in the 1.9 μm H_2O band

FRT000064D9:
OLINDEX-2 R
LCP-mgm G
BD1900 B

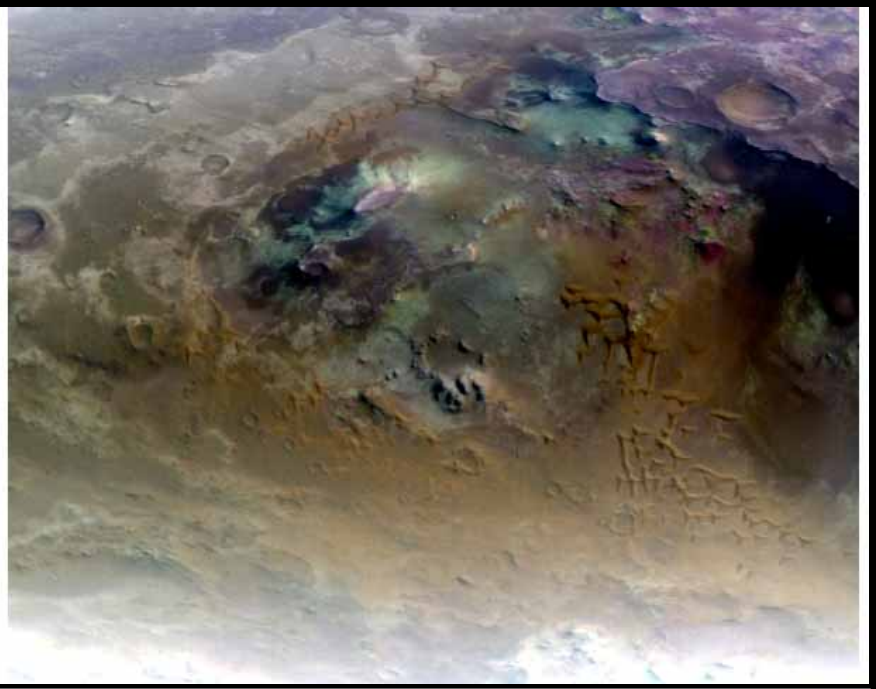
Low-Ca Pyroxene
Phyllosilicate
Fe-Phyllosilicate

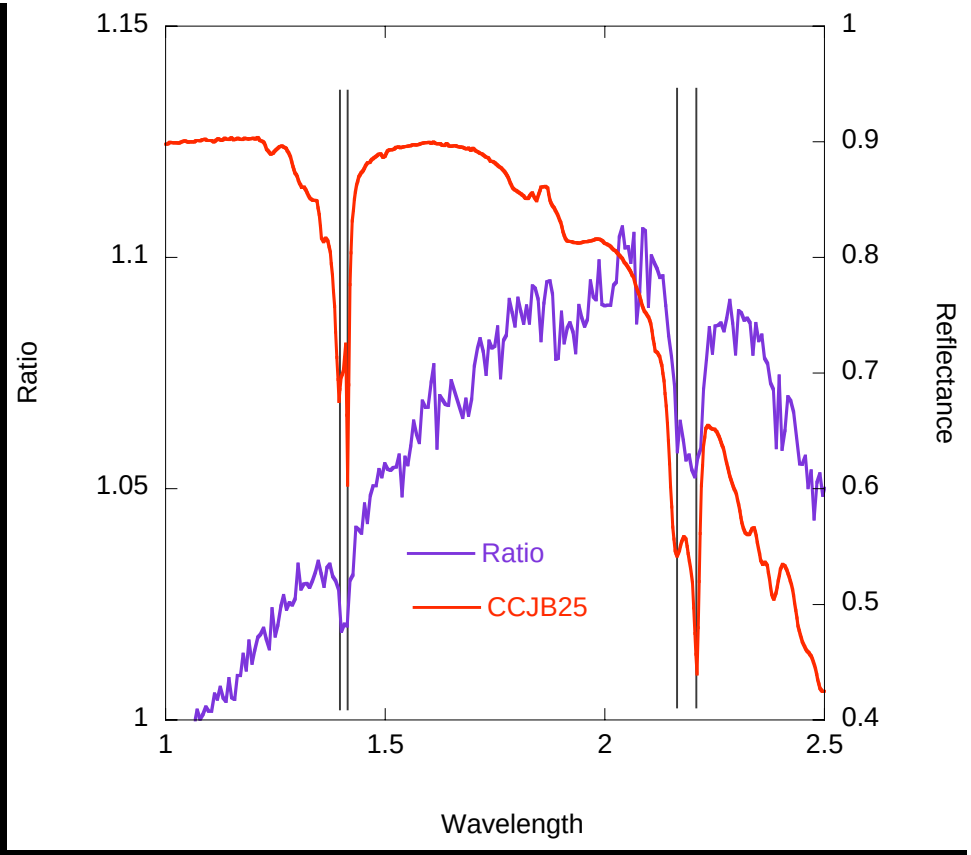




Fill of Nili Fossae floor shows definitive absorptions for hydrated silicate, consistent with Fe/Mg smectite clay

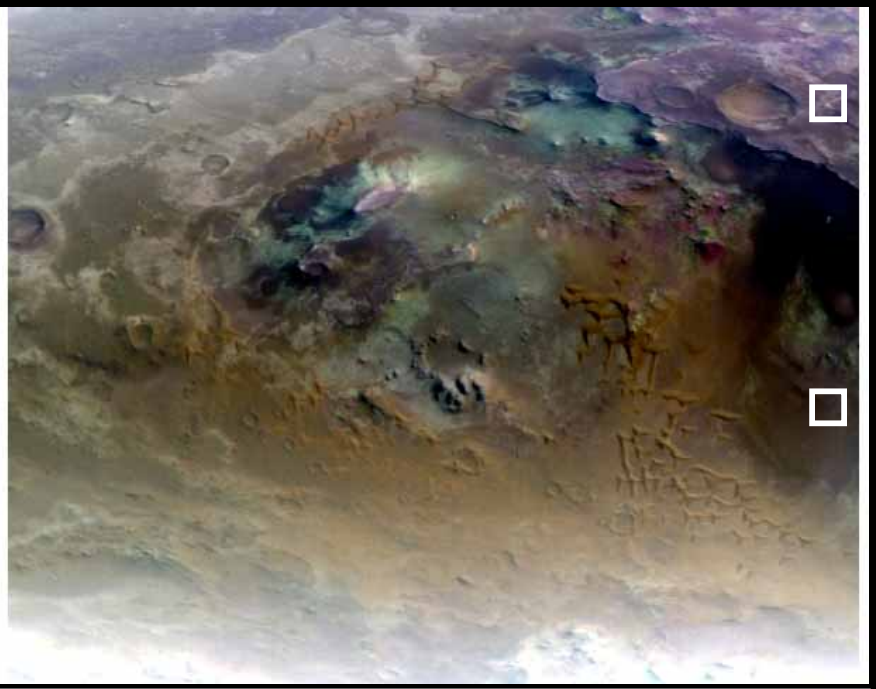
FRT000064D9: R=2.4 G=1.8 B=1.08 μm

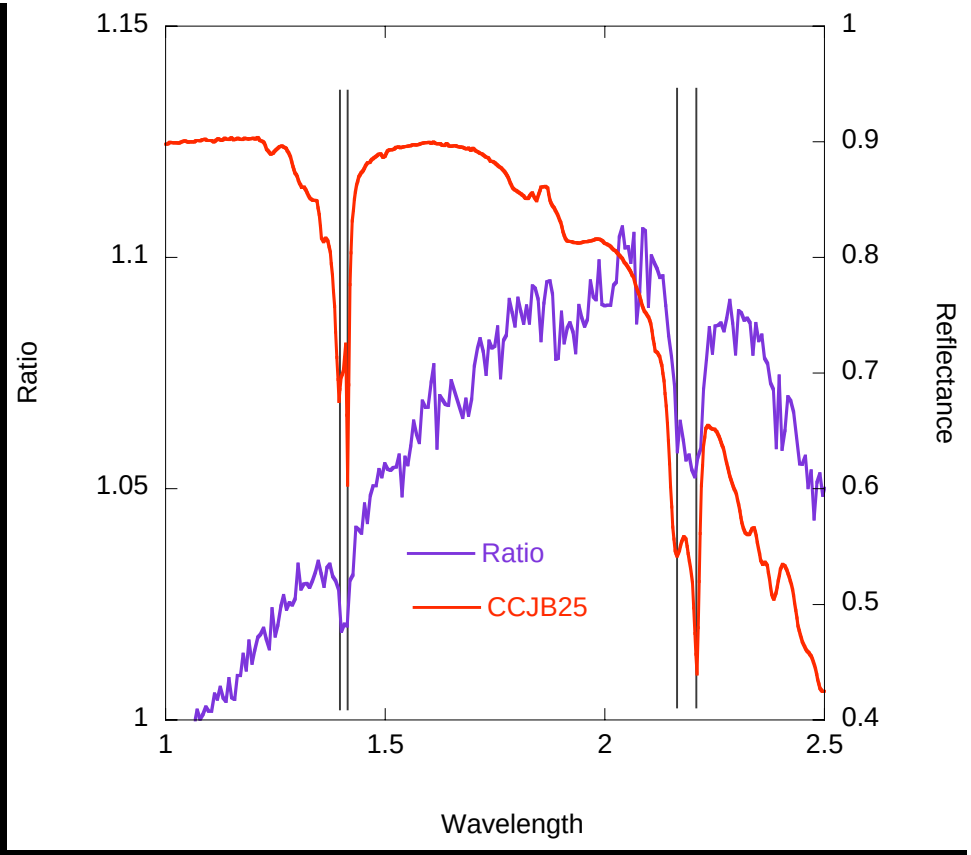




Small outcrops on the plateau show distinct absorptions diagnostic of kaolinite

FRT000064D9: R=2.4 G=1.8 B=1.08 μm





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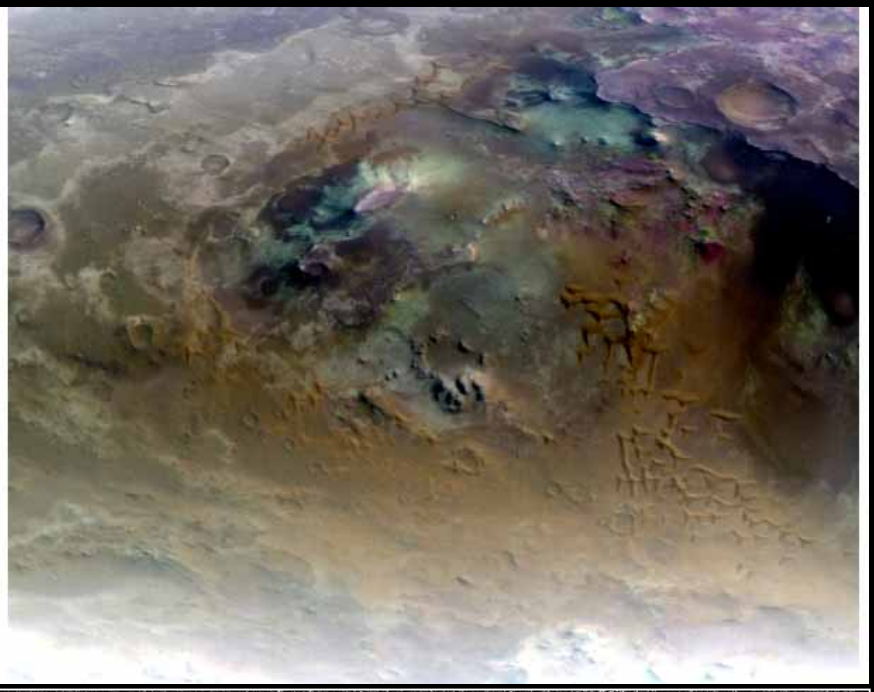
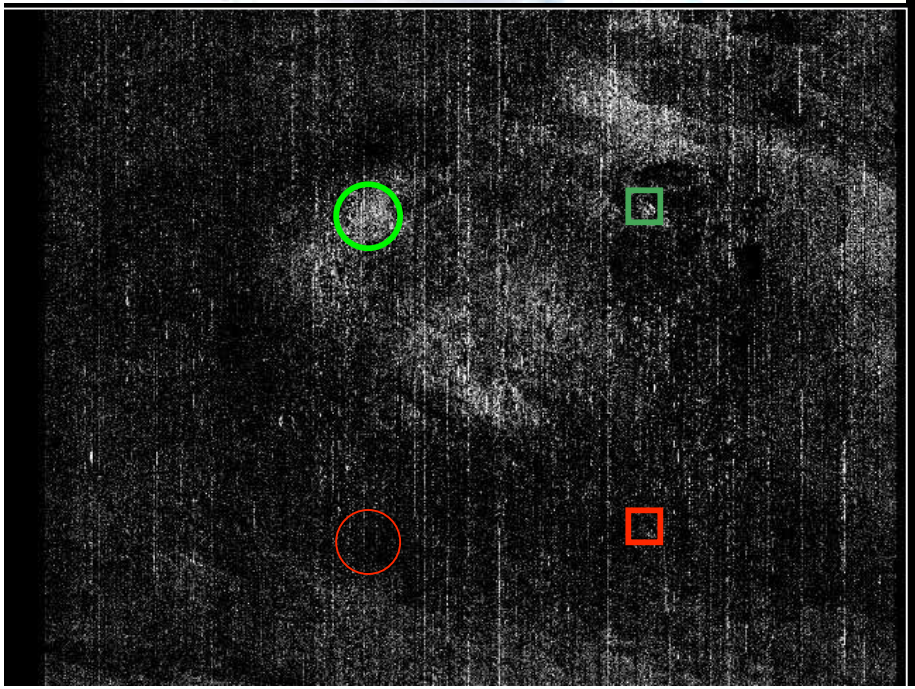
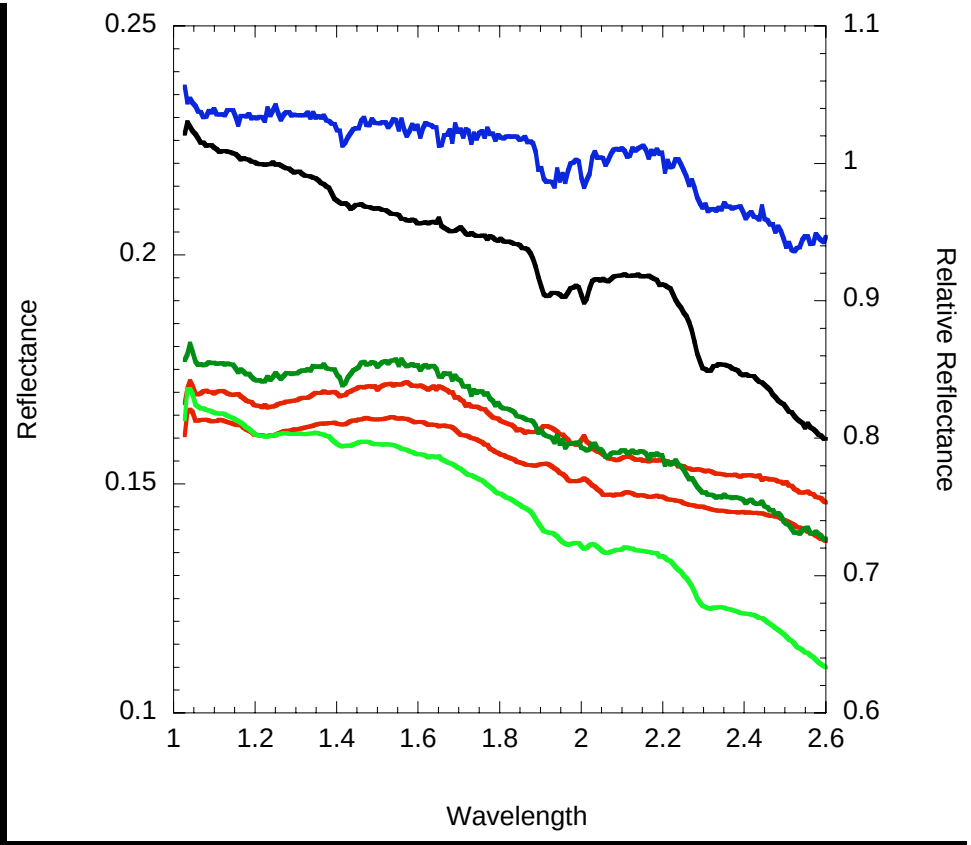




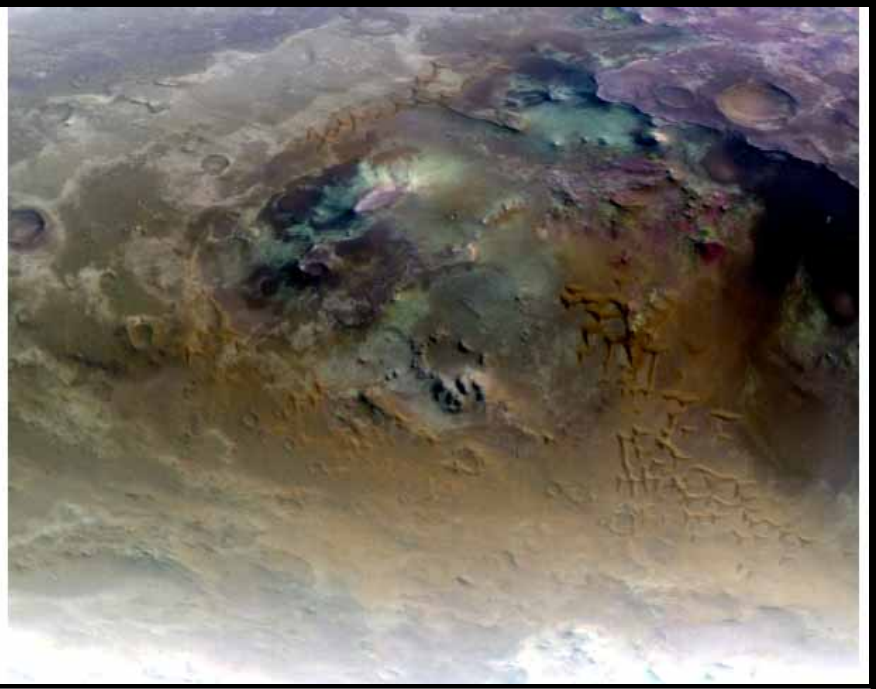


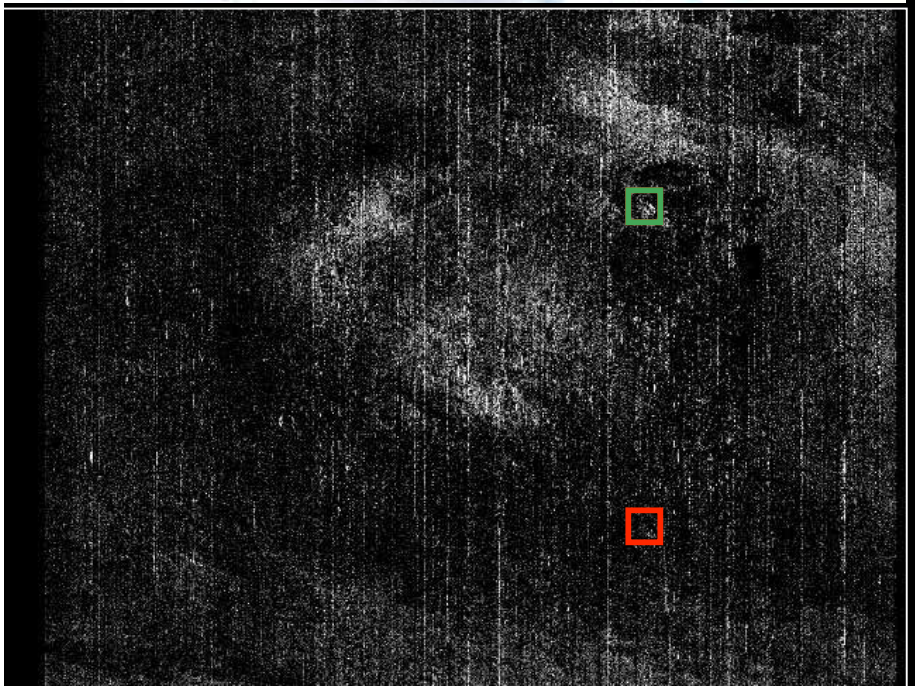
2500 nm Band, may be indicative of carbonate but careful analysis required

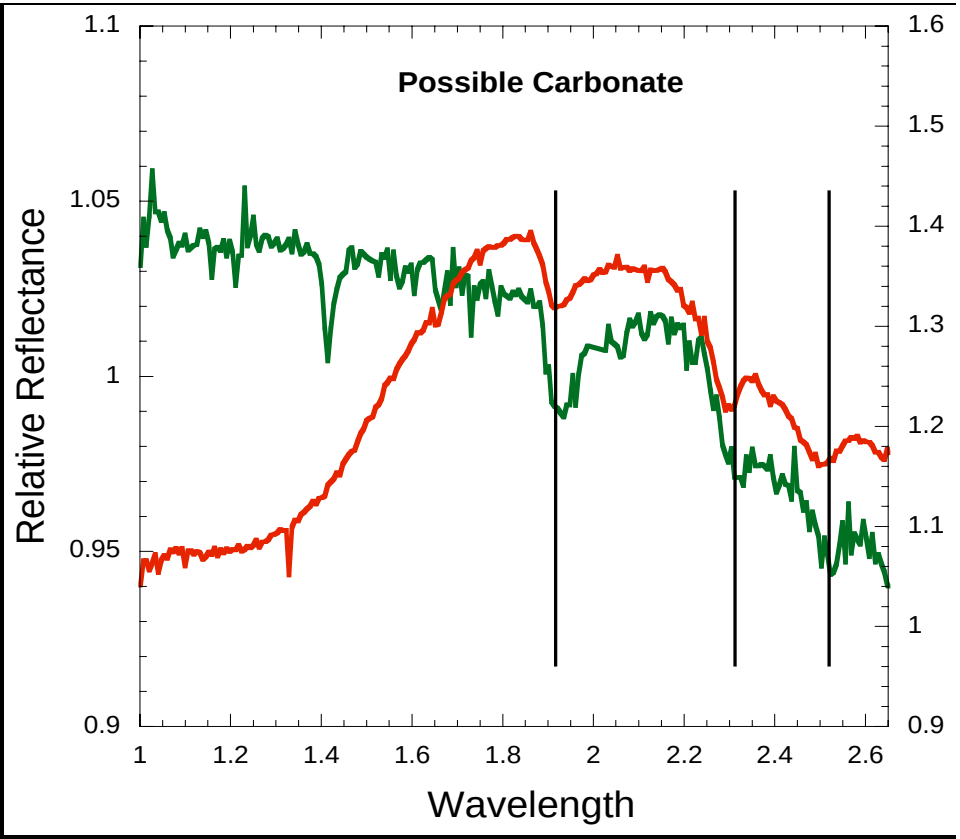
Small blocks show possible carbonate (Blue ratio spectrum)

Larger region is not consistent with carbonate (black ratio spectrum)

FRT000064D9: R=2.4 G=1.8 B=1.08 μm







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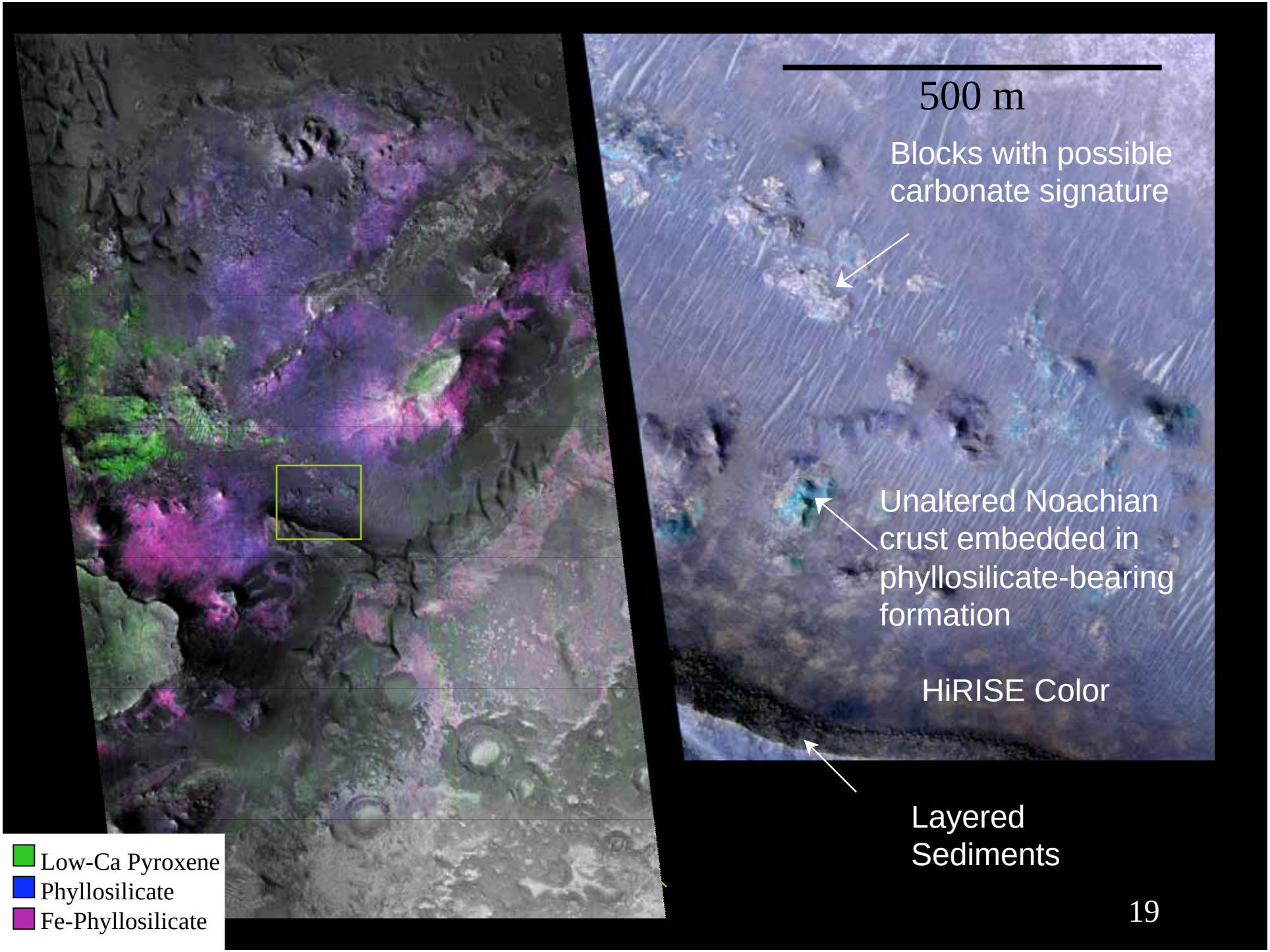
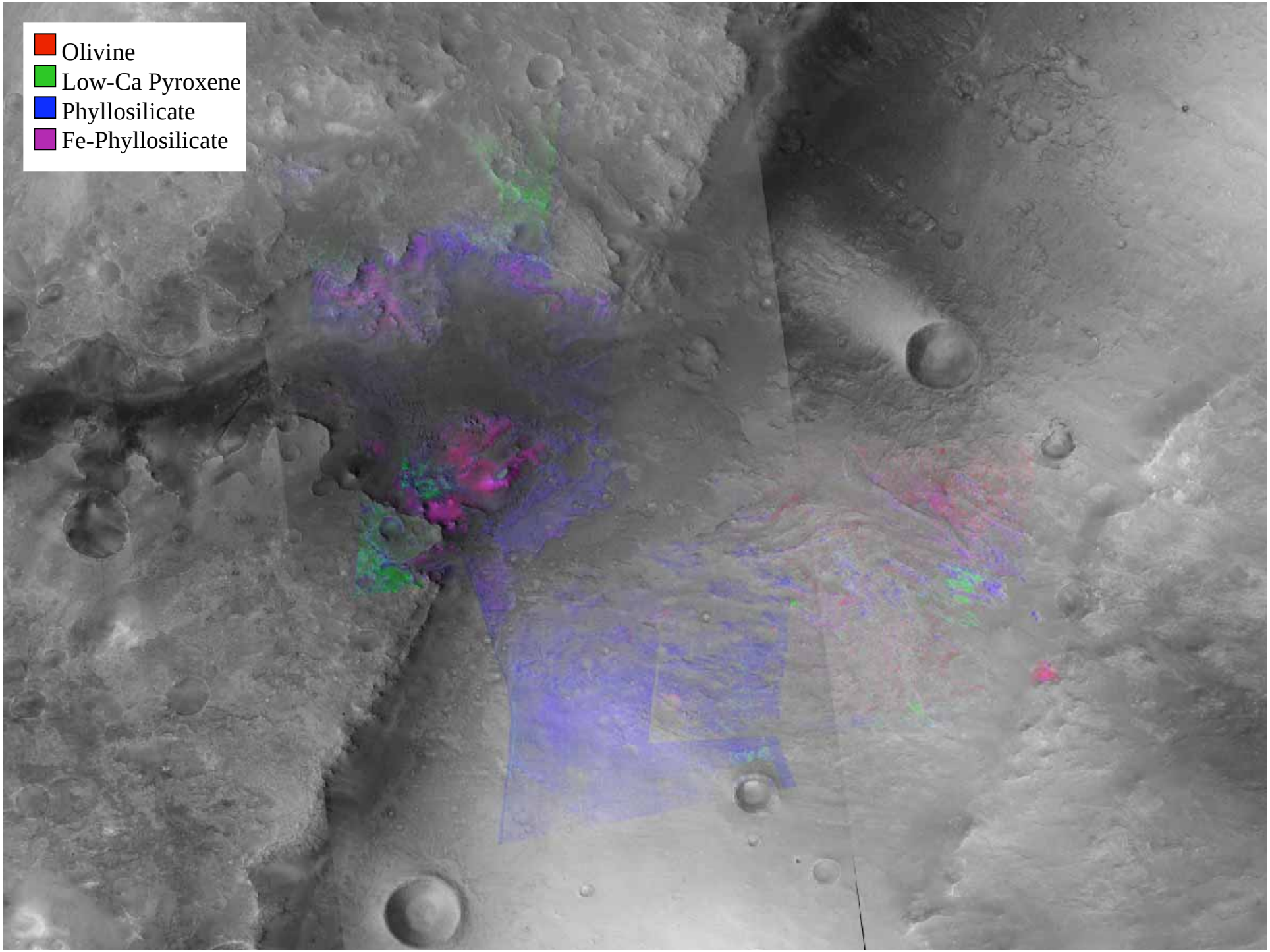

500 m
Blocks with possible carbonate signature
Unaltered Noachian crust embedded in phyllosilicate-bearing formation
HiRISE Color
Layered Sediments
Low-Ca Pyroxene
Phyllosilicate
Fe-Phyllosilicate


Olivine
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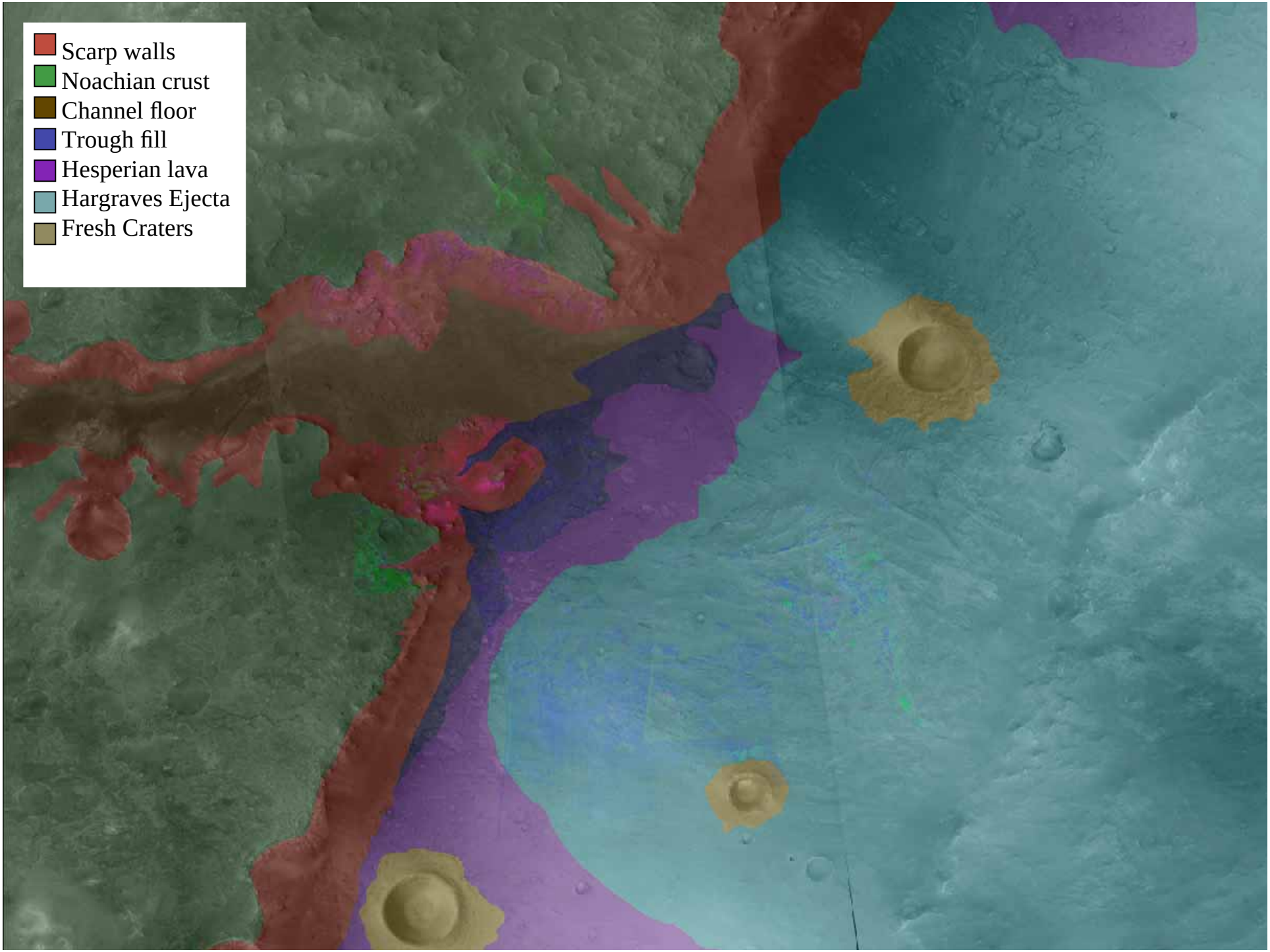
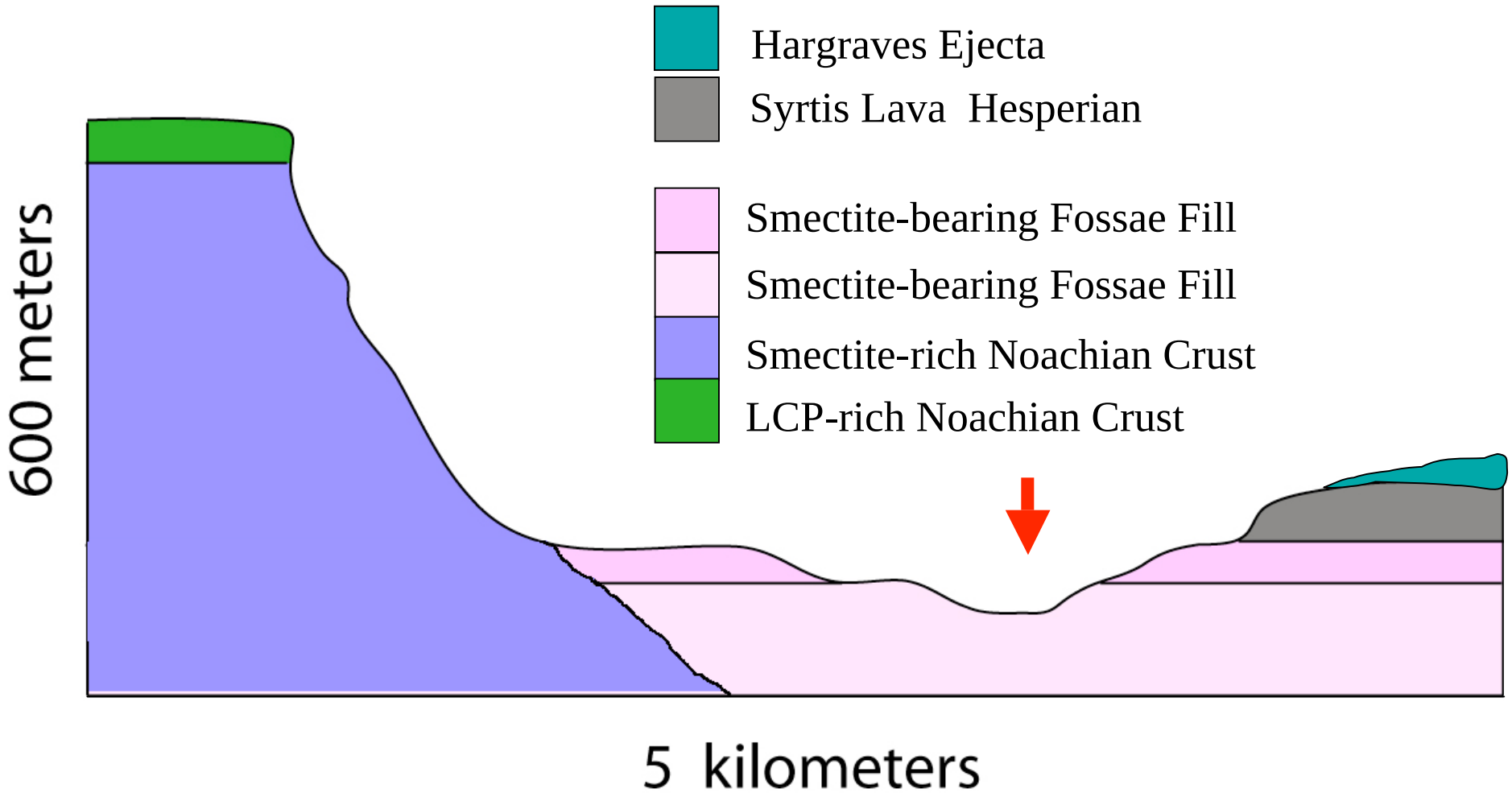

Scarp walls
Noachian crust
Channel floor
Trough fill
Hesperian lava
Hargraves Ejecta
Fresh Craters



(Representative vertical and horizontal distances, not to scale)

Nili Fossae Trough

- Distinct morphologic units with broad mineralogic diversity
- Careful analysis of mineral indicators through spectral analysis required for validation and verification
- Can be validated to the level of a few pixels (e.g. breccia blocks)
- Regional geology indicates sustained interaction of water with the crust over an extended period as a consequence of multiple episodes of distinct character
  - Fe/Mg Phyllosilicates with variation in band position, strength of water absorption
  - Smectite clay transported and deposited in fluvial systems
  - Regional episode of kaolinite formation
  - Carbonate formation in association with olivine
  - Chlorite, zeolite, and hydrated silicate in association with impacts
- Hesperian volcanics show no evidence for extensive alteration