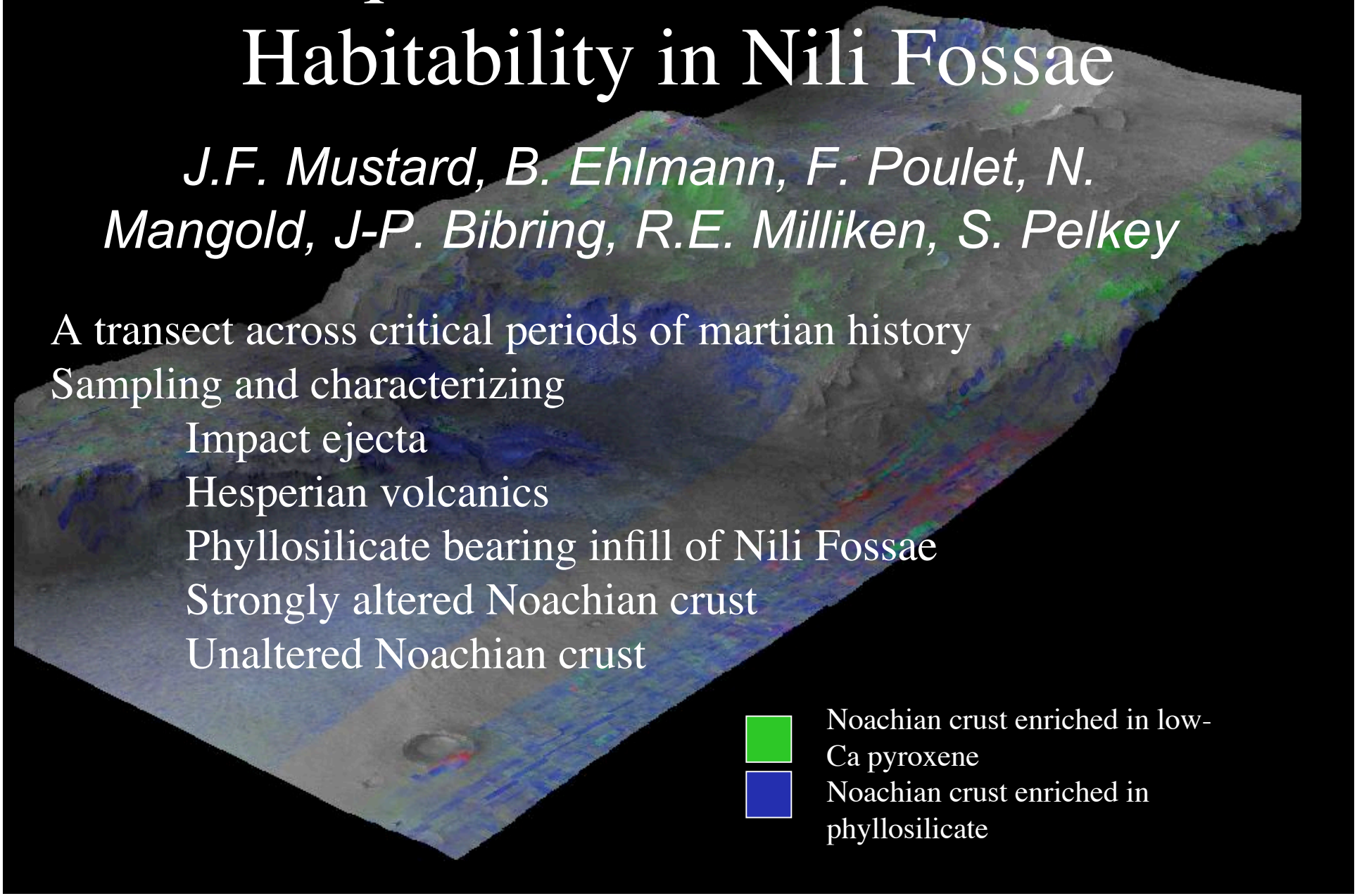
Aqueous Alteration and Habitability in Nili Fossae

J.F. Mustard, B. Ehlmann, F. Poulet, N. Mangold, J-P. Bibring, R.E. Milliken, S. Pelkey



A transect across critical periods of martian history

Sampling and characterizing

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

Noachian crust enriched in low-Ca pyroxene

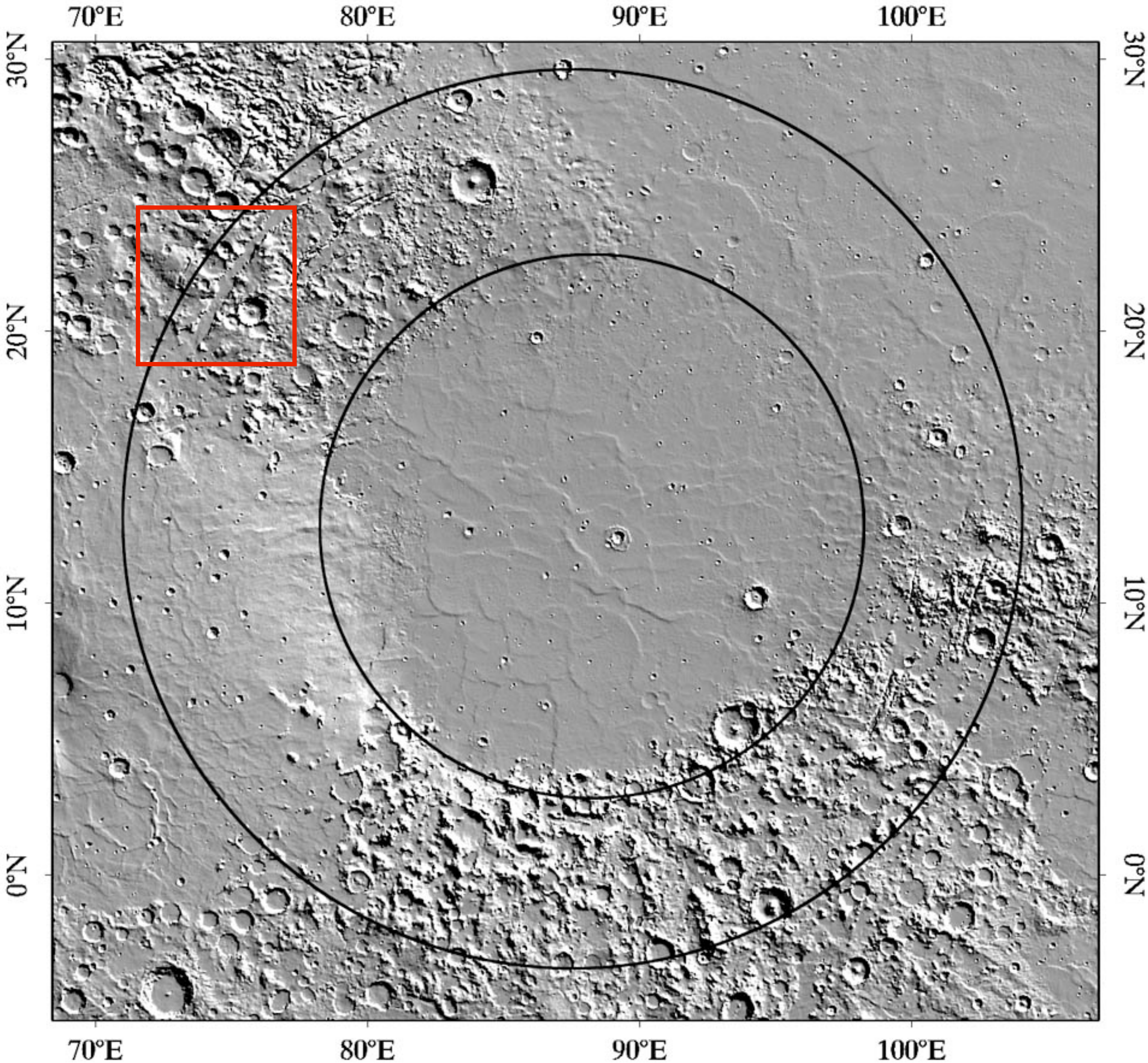
Noachian crust enriched in phyllosilicate

Nili Fossae Trough

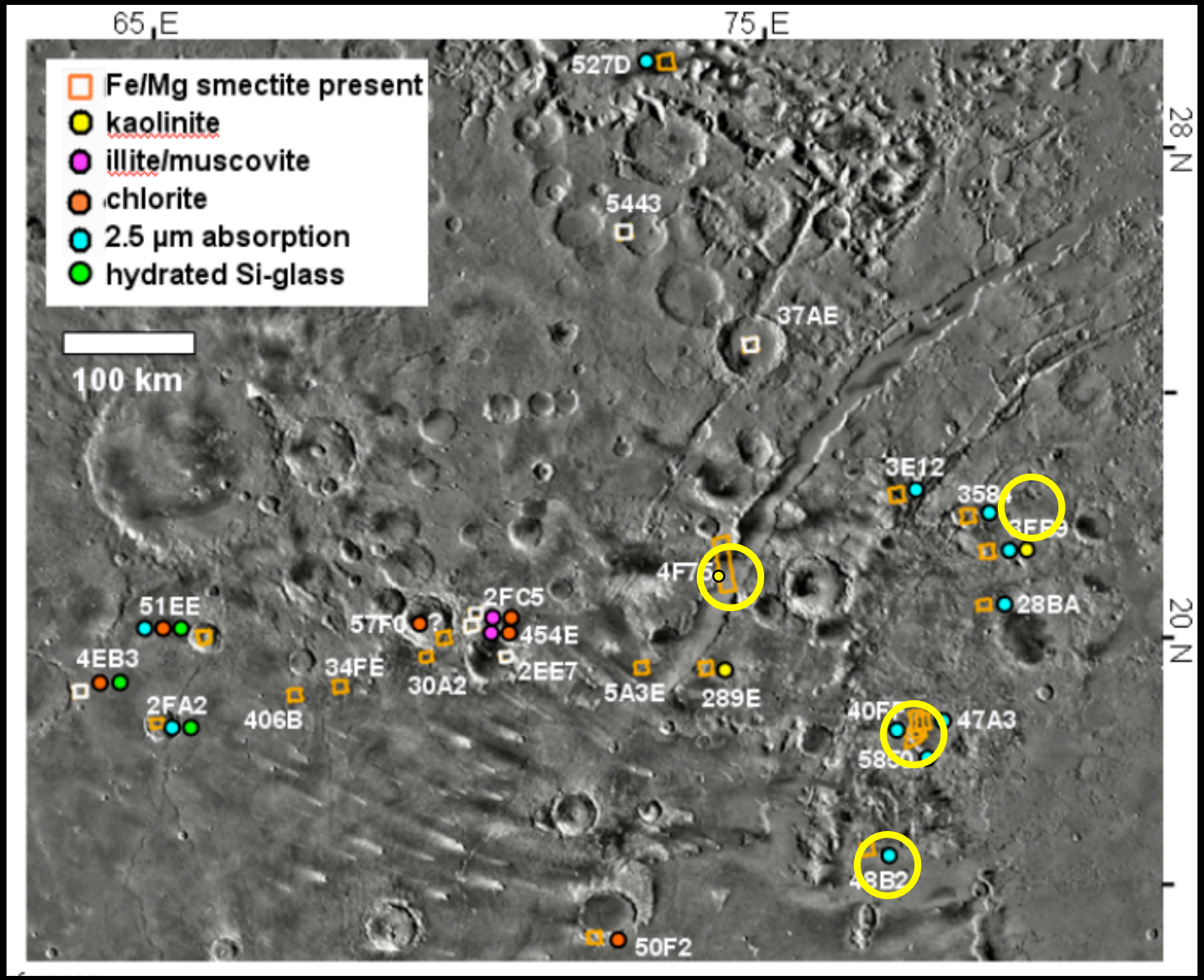
- Noachian is the most important period of habitability
  - Smectite clay mineral formation
  - Capturing, sequestering and preserving organic material and bio signatures
- Intact Noachian stratigraphy
  - Strongly enriched, DIVERSE phyllosilicate
  - Alteration processes: surface, shallow crust, hydrothermal, lacustrine (testable hypothesis)
  - Unaltered basement in contact with phyllosilicate => chemical disequilibrium
- Cross the Noachian-Hesperian boundary
- Hesperian volcanics of Syrtis Major sample a critical time-stratigraphic marker and major planetary lithology

Nili Fossae Trough

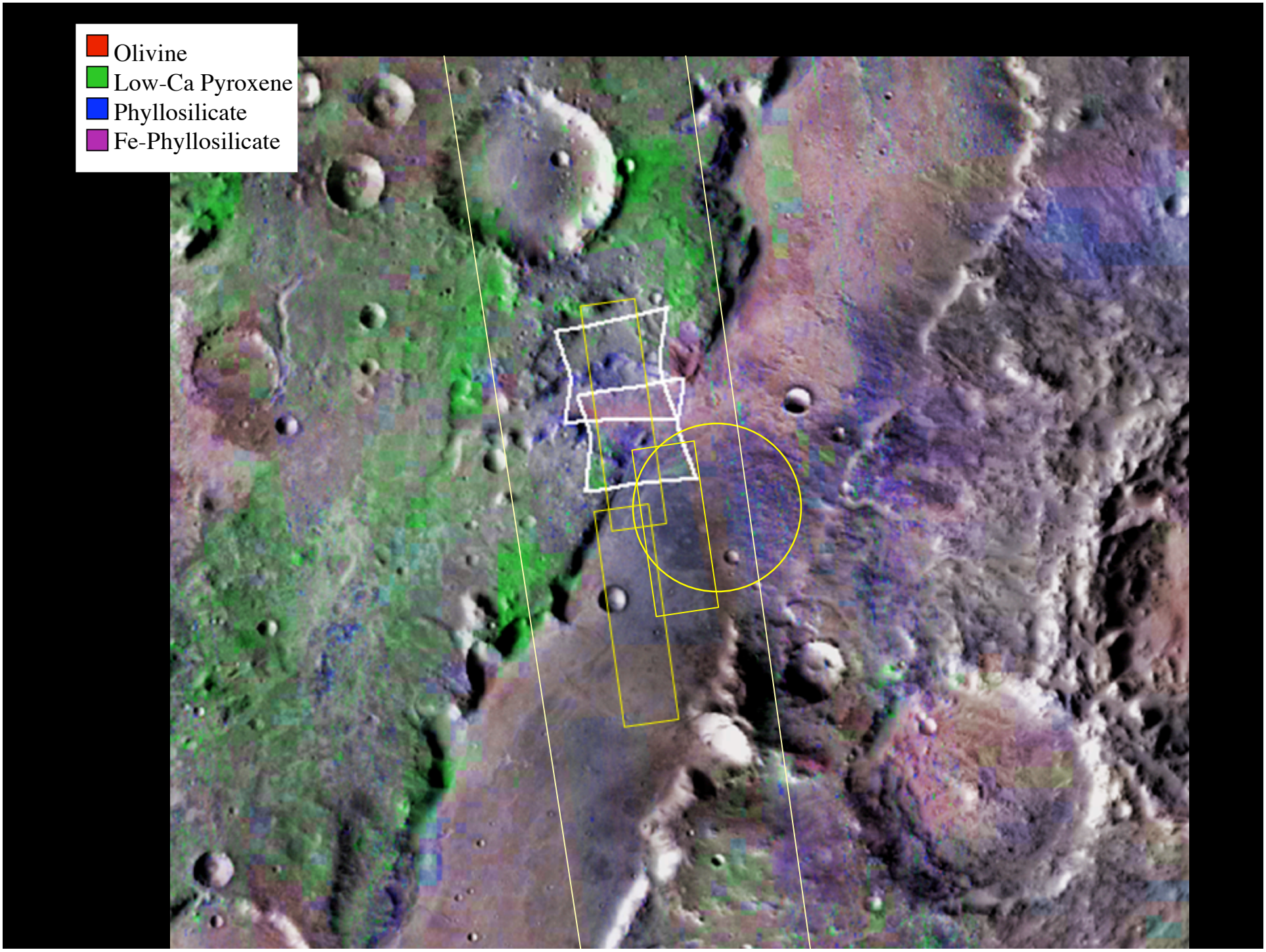
- Crustal Formation
- Isidis Basin Formation
- Nili Fossae trough develops
- Dissection and erosion of Nili Fossae walls by processes that include fluvial (formation of layered-bedded units)
- Infilling of Nili Fossae trough,
- Syrtis Major lavas pave the floor of the trough
- Emplacement of ejecta from 65 km diameter crater


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

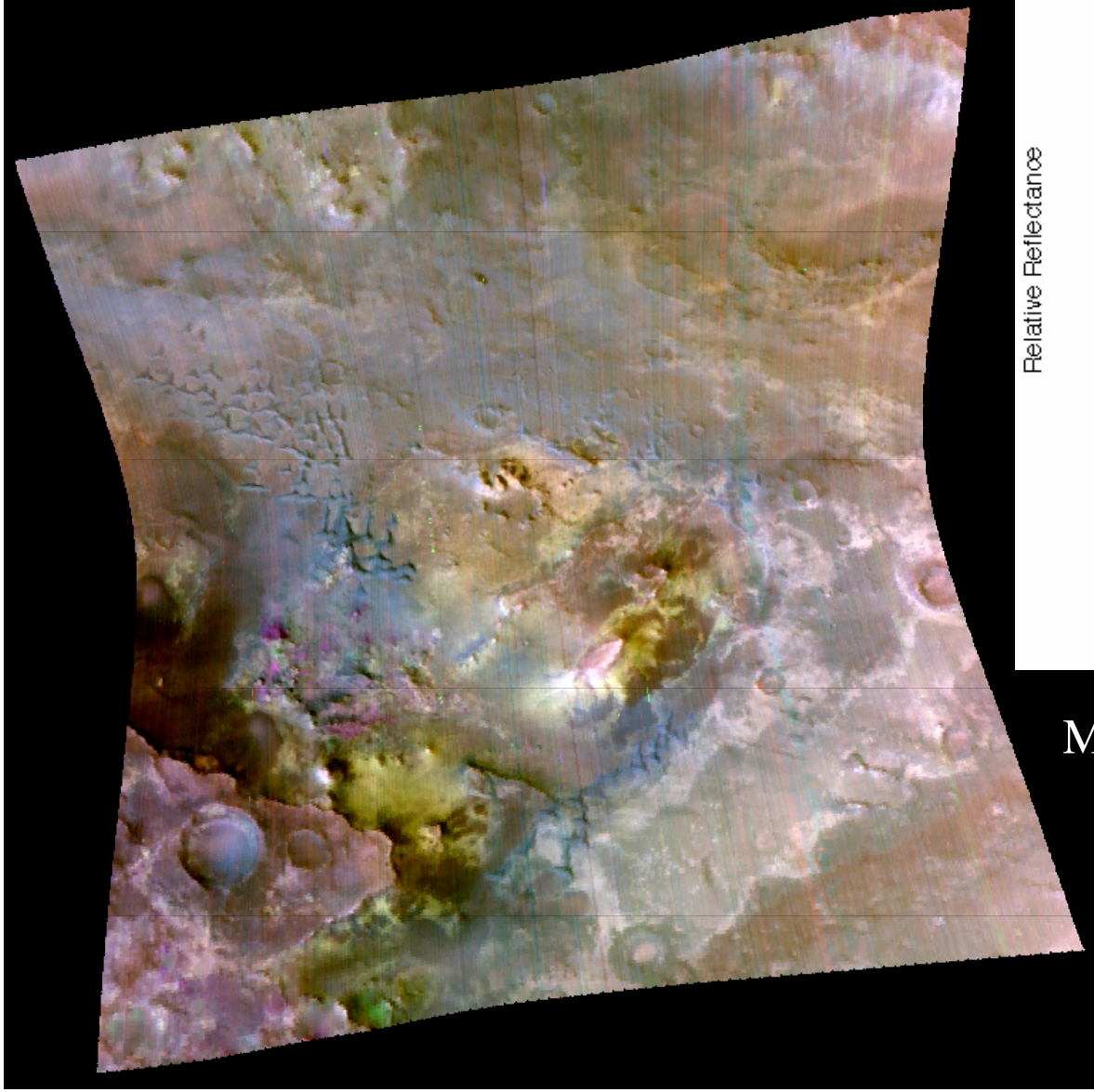
Noachian Crust: Extraordinary mineral diversity

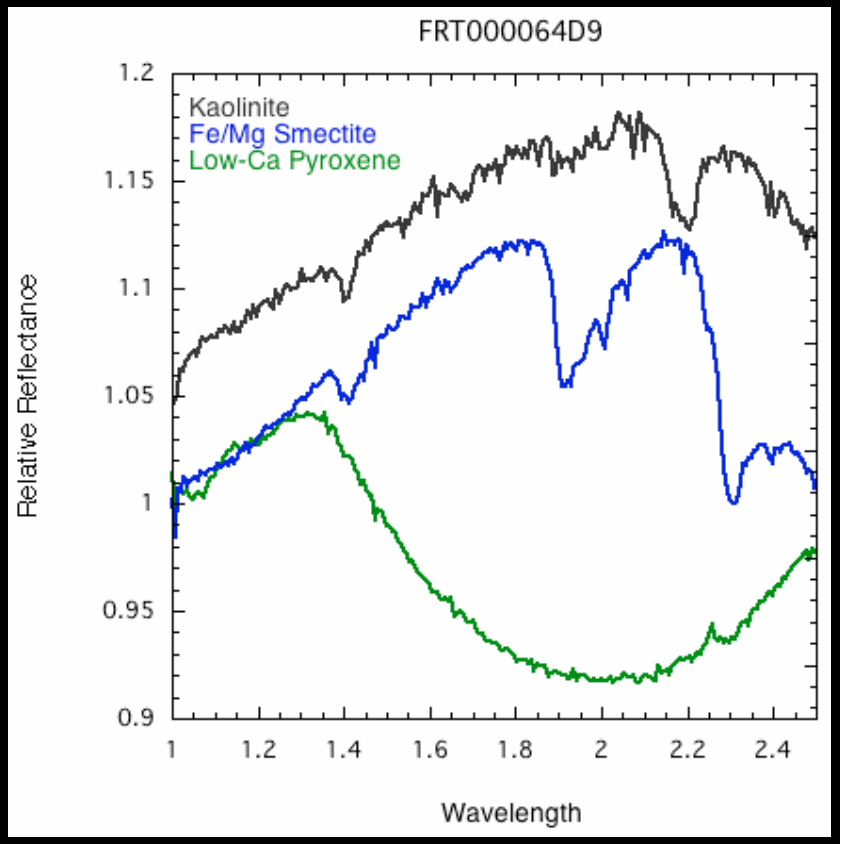


Ehlmann et al., 2007


Olivine
Low-Ca Pyroxene
Phyllosilicate
Fe-Phyllosilicate

FRT000064D9:
2.4, 1.8, 1.15 μm RGB

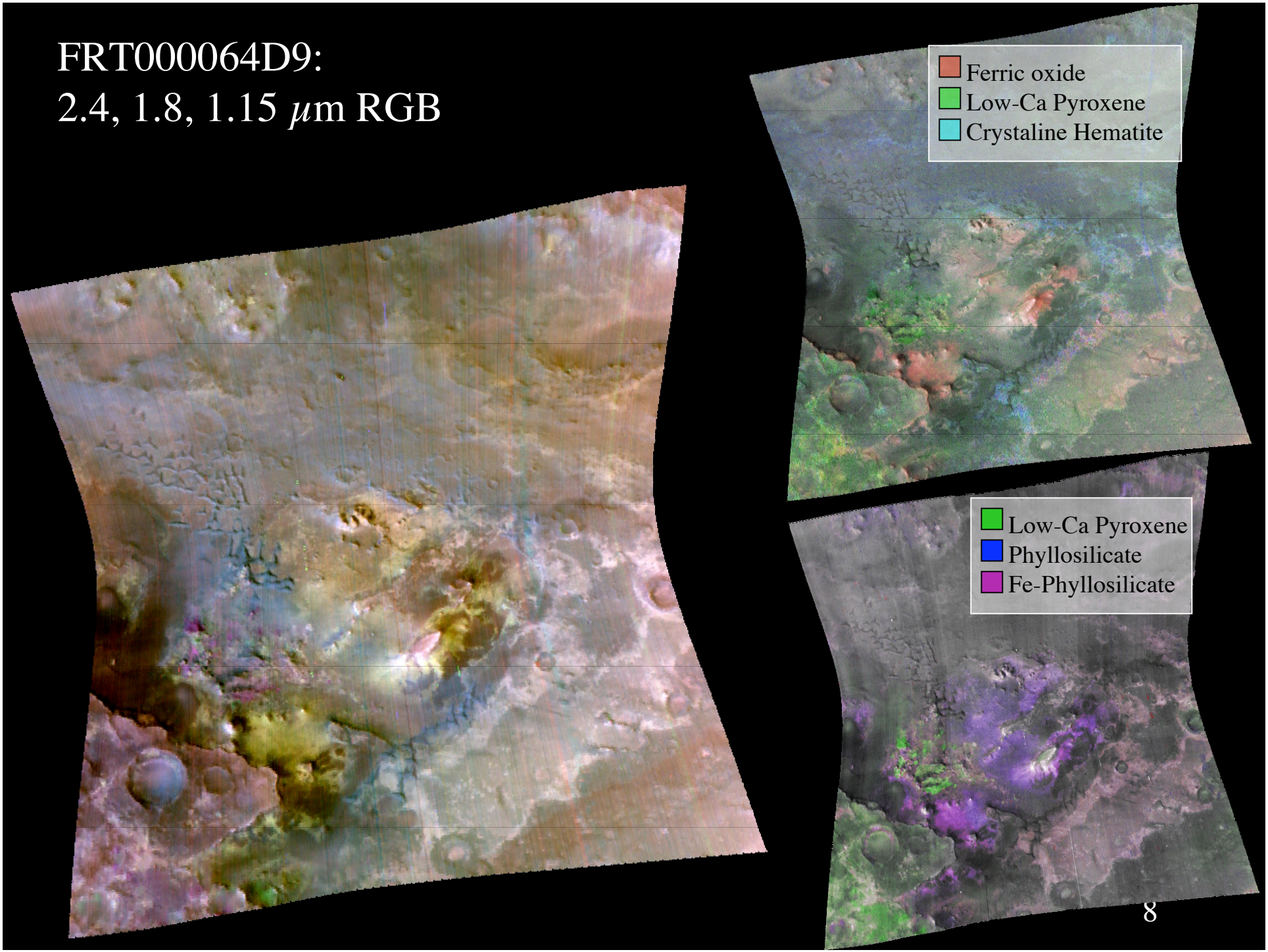


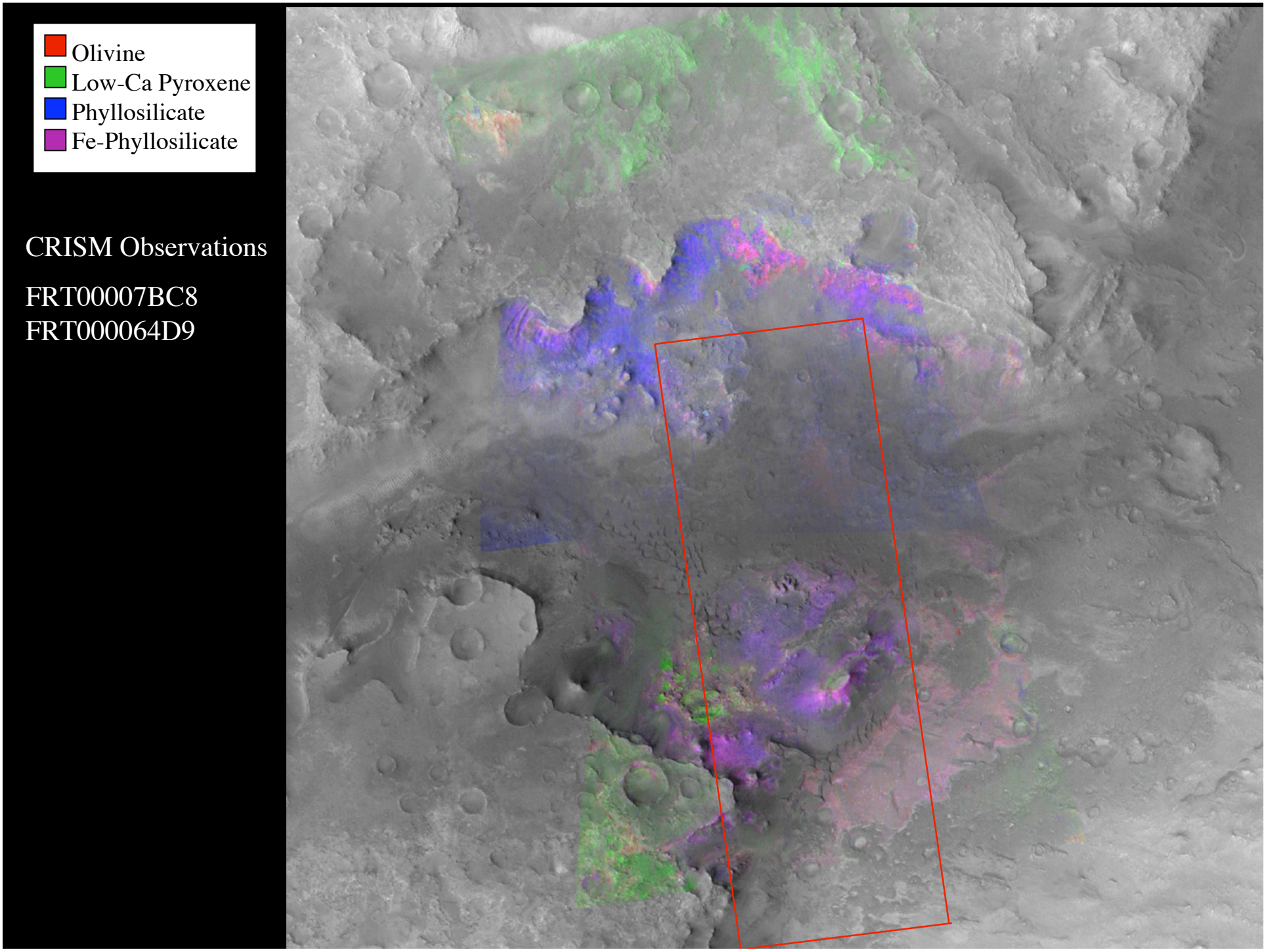


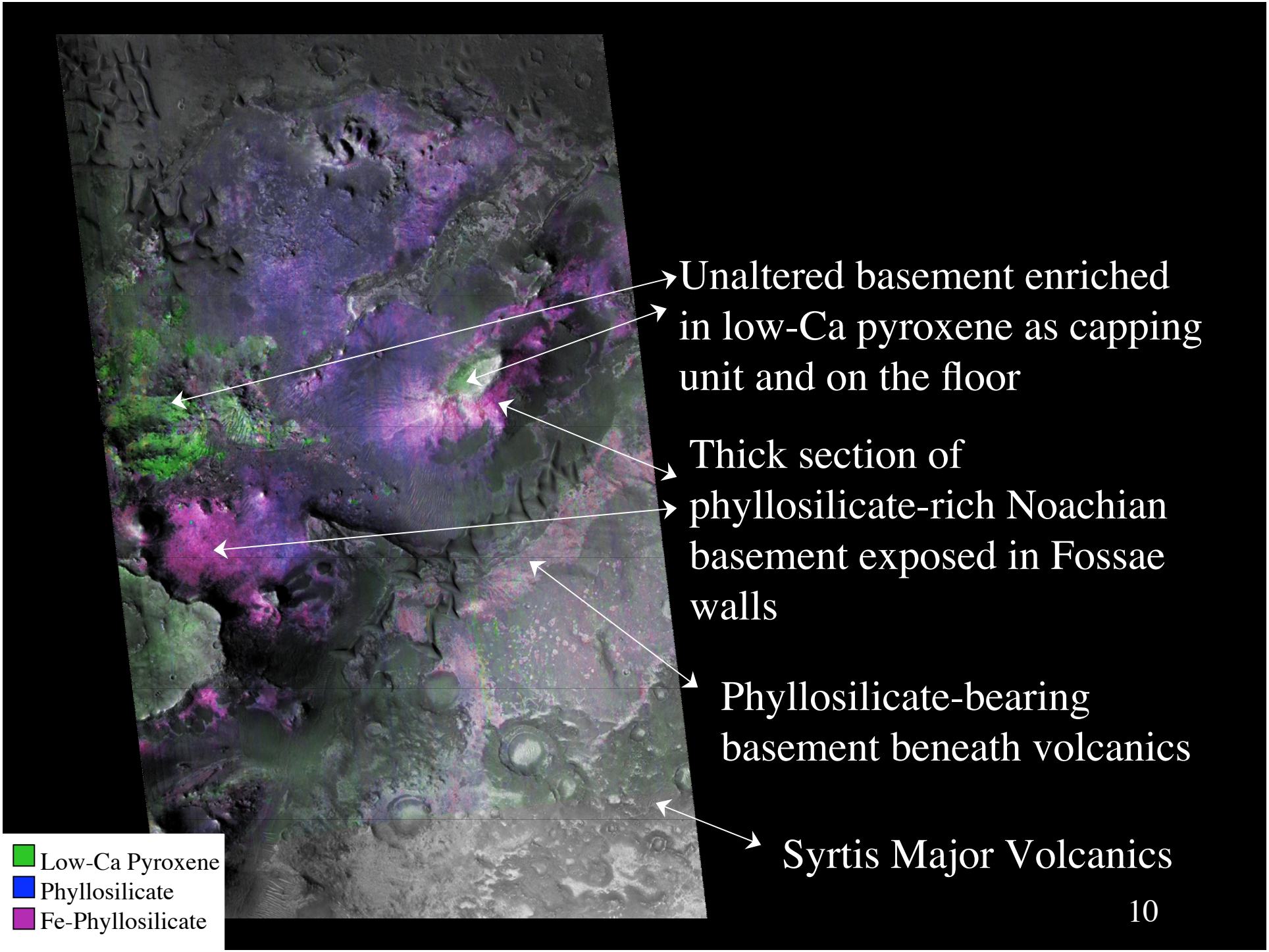
Mineralogy identified

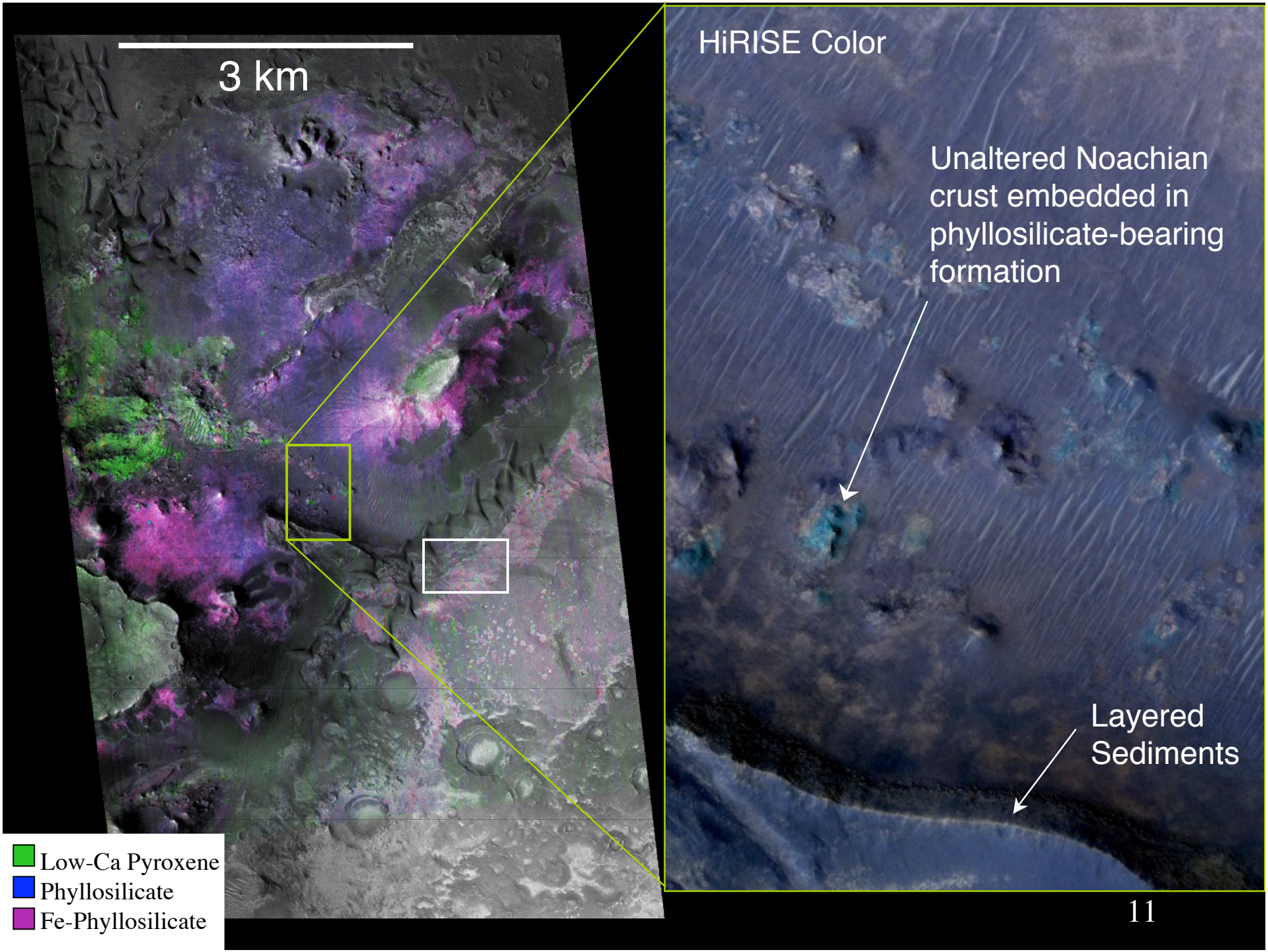
- Crystaline hematite
- Fe/Mg Smectite
- Kaolinite
- Pyroxene (Low and High Ca)
- Olivine

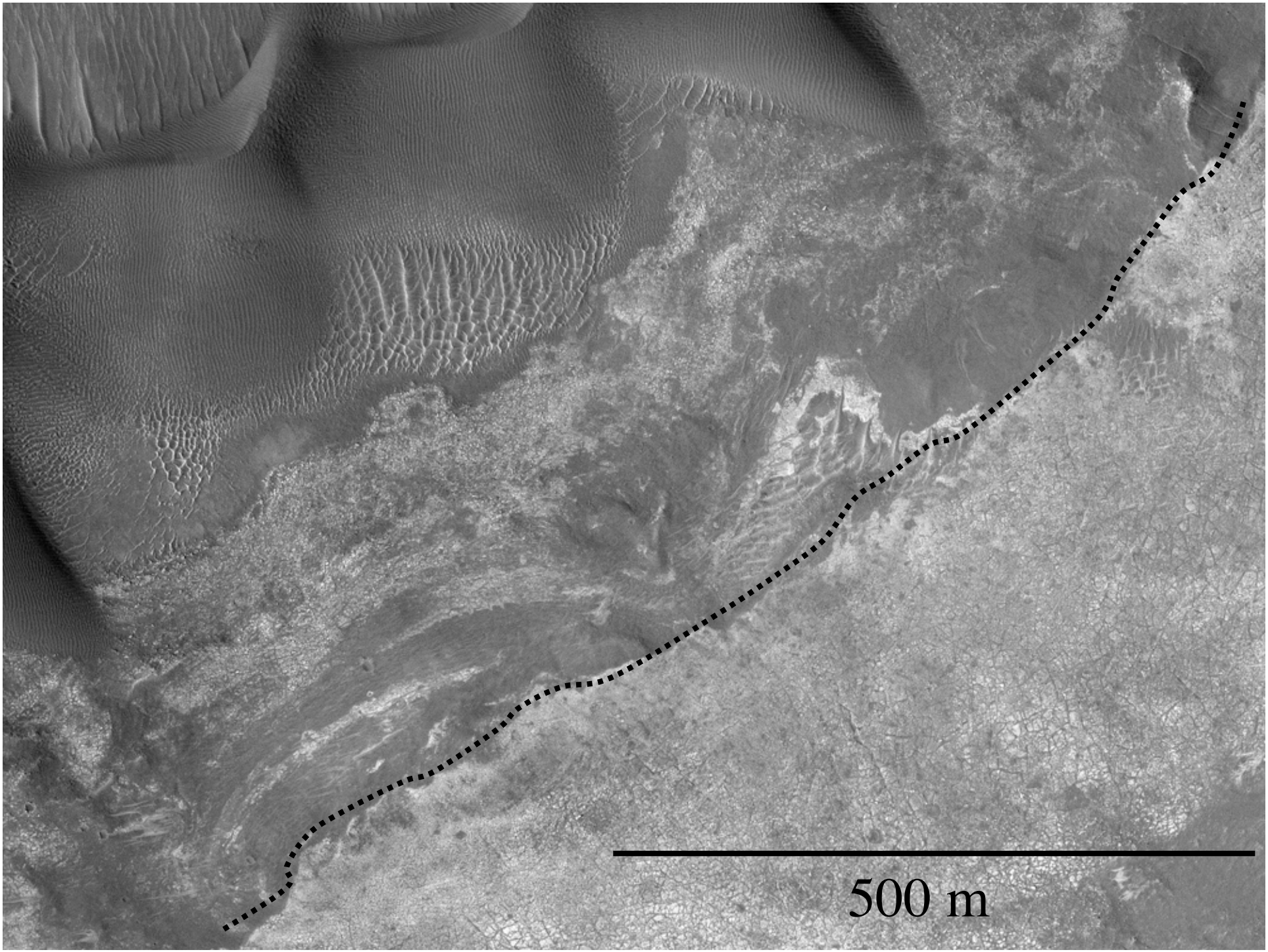
FRT000064D9:
2.4, 1.8, 1.15 μm RGB



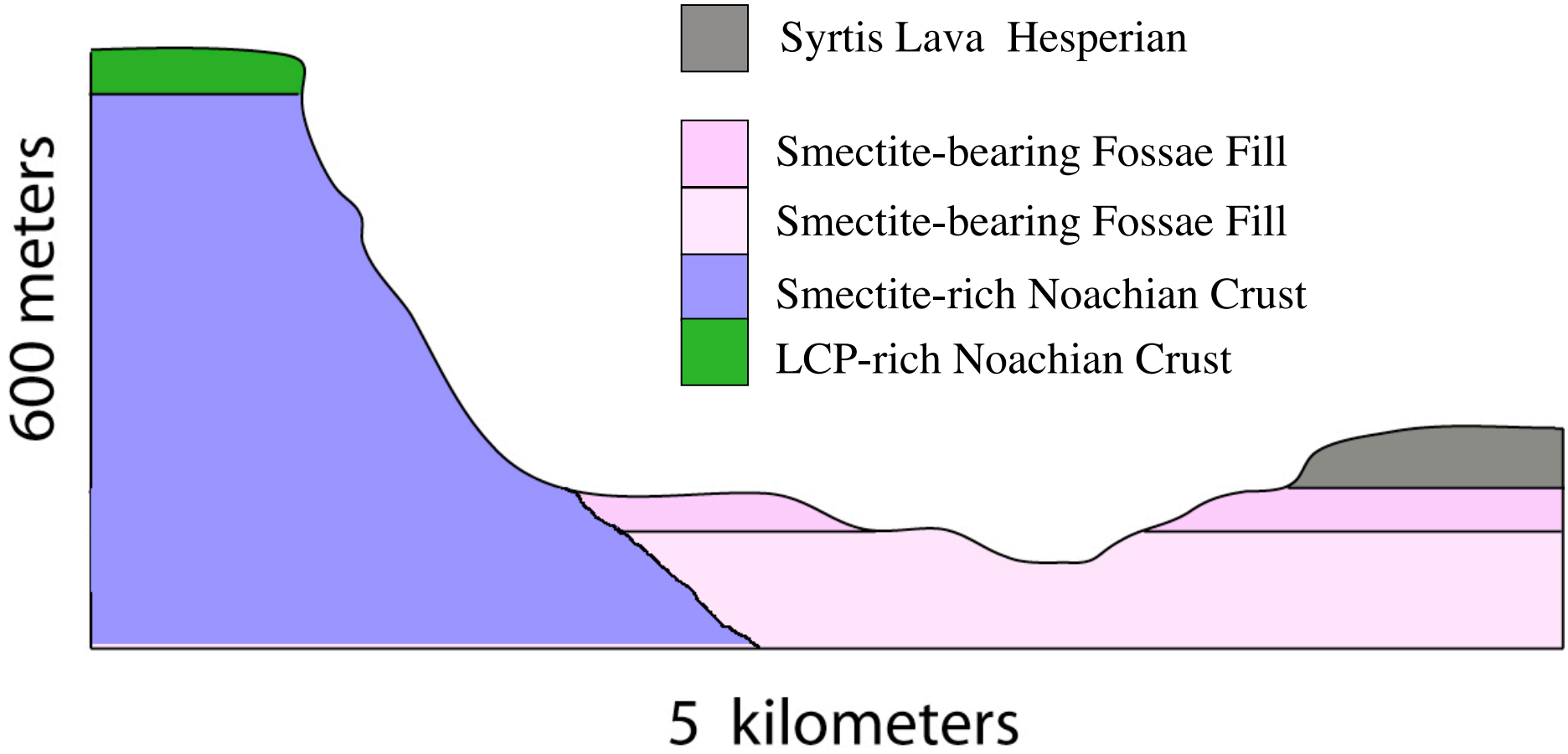

Olivine
Low-Ca Pyroxene
Phyllosilicate
Fe-Phyllosilicate
CRISM Observations
FRT00007BC8
FRT000064D9

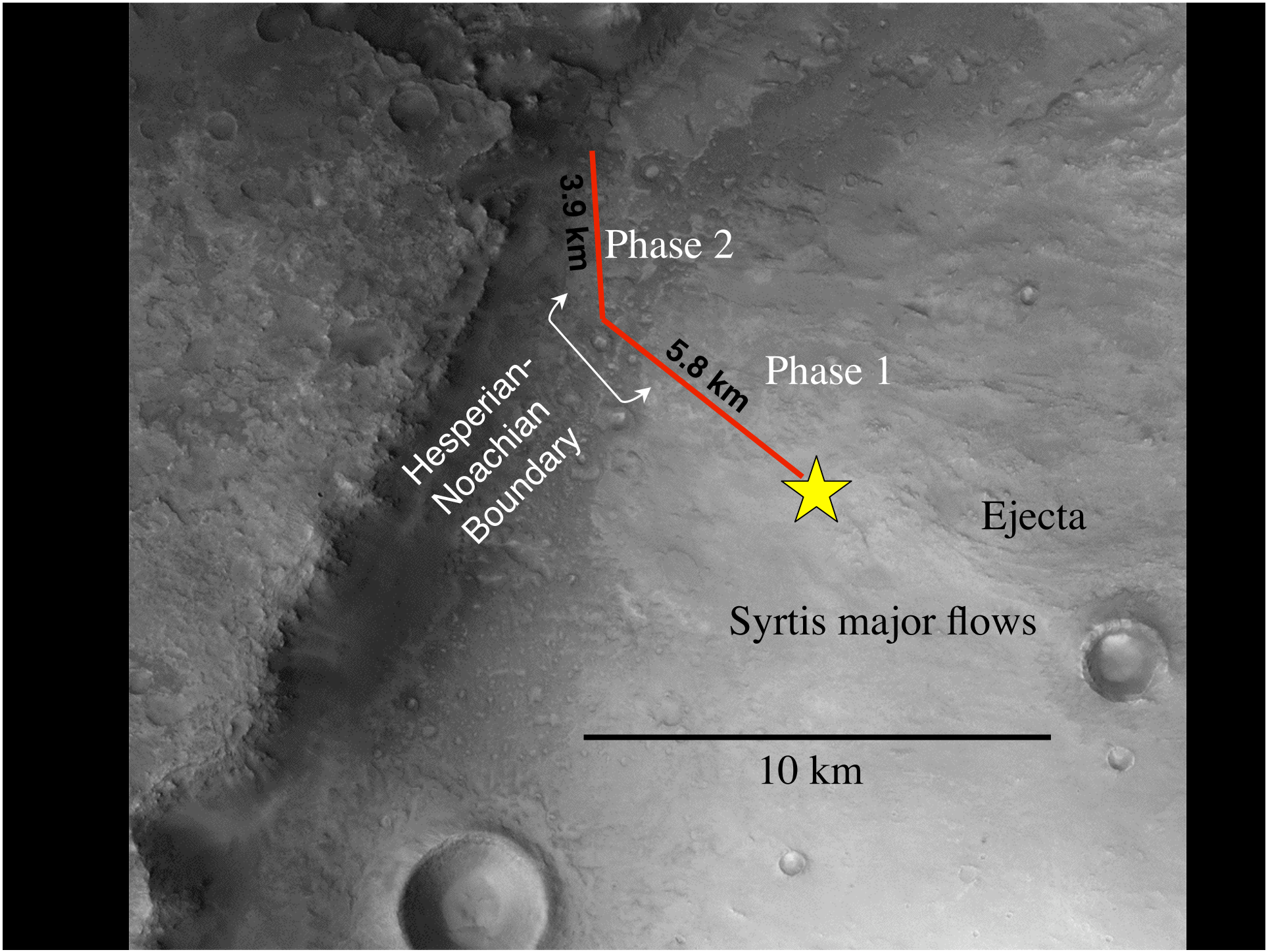

Unaltered basement enriched in low-Ca pyroxene as capping unit and on the floor
Thick section of phyllosilicate-rich Noachian basement exposed in Fossae walls
Phyllosilicate-bearing basement beneath volcanics
Syrtis Major Volcanics
Low-Ca Pyroxene
Phyllosilicate
Fe-Phyllosilicate

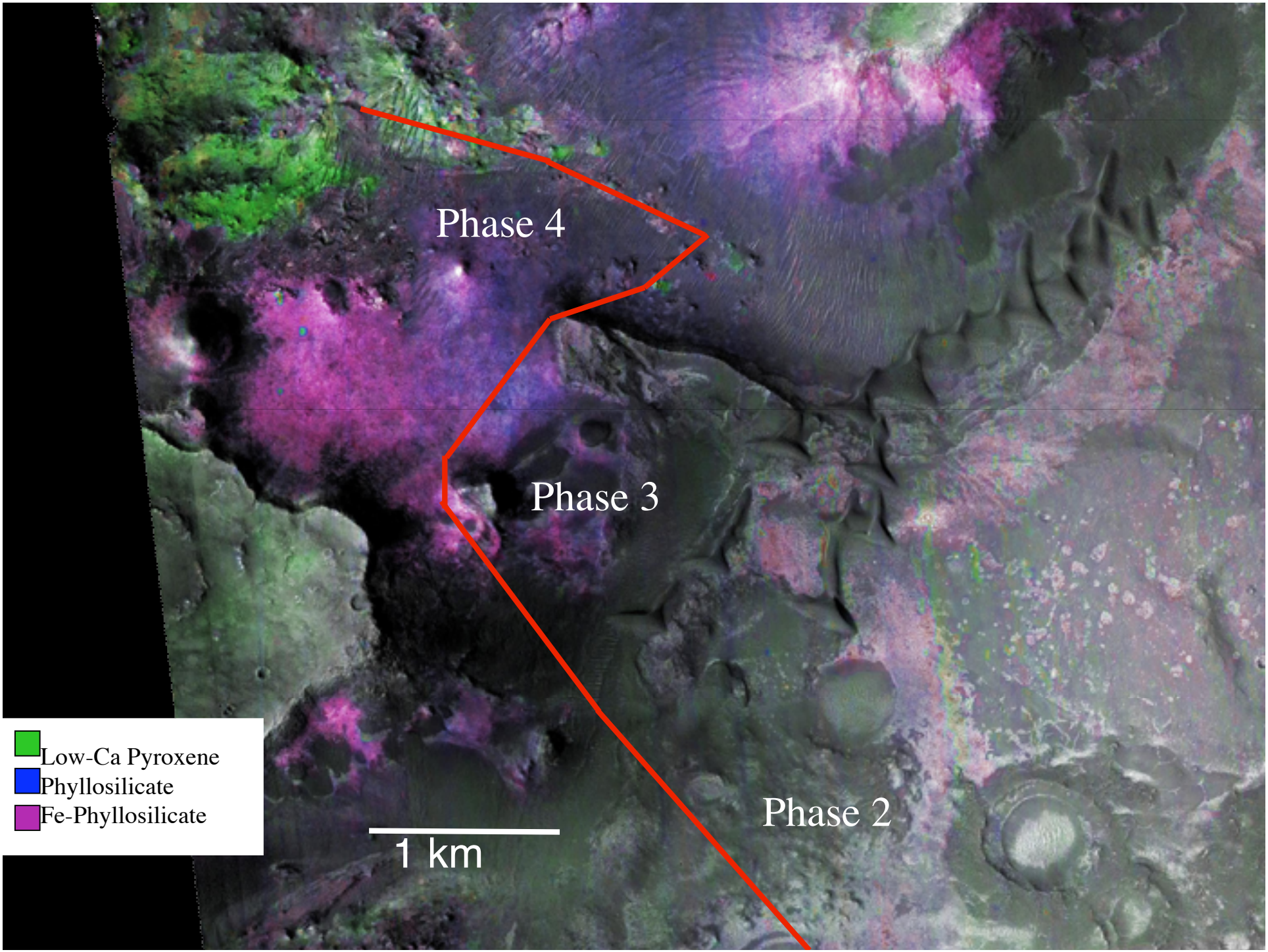

3 km
HiRISE Color
Unaltered Noachian crust embedded in phyllosilicate-bearing formation
Layered Sediments
Low-Ca Pyroxene
Phyllosilicate
Fe-Phyllosilicate

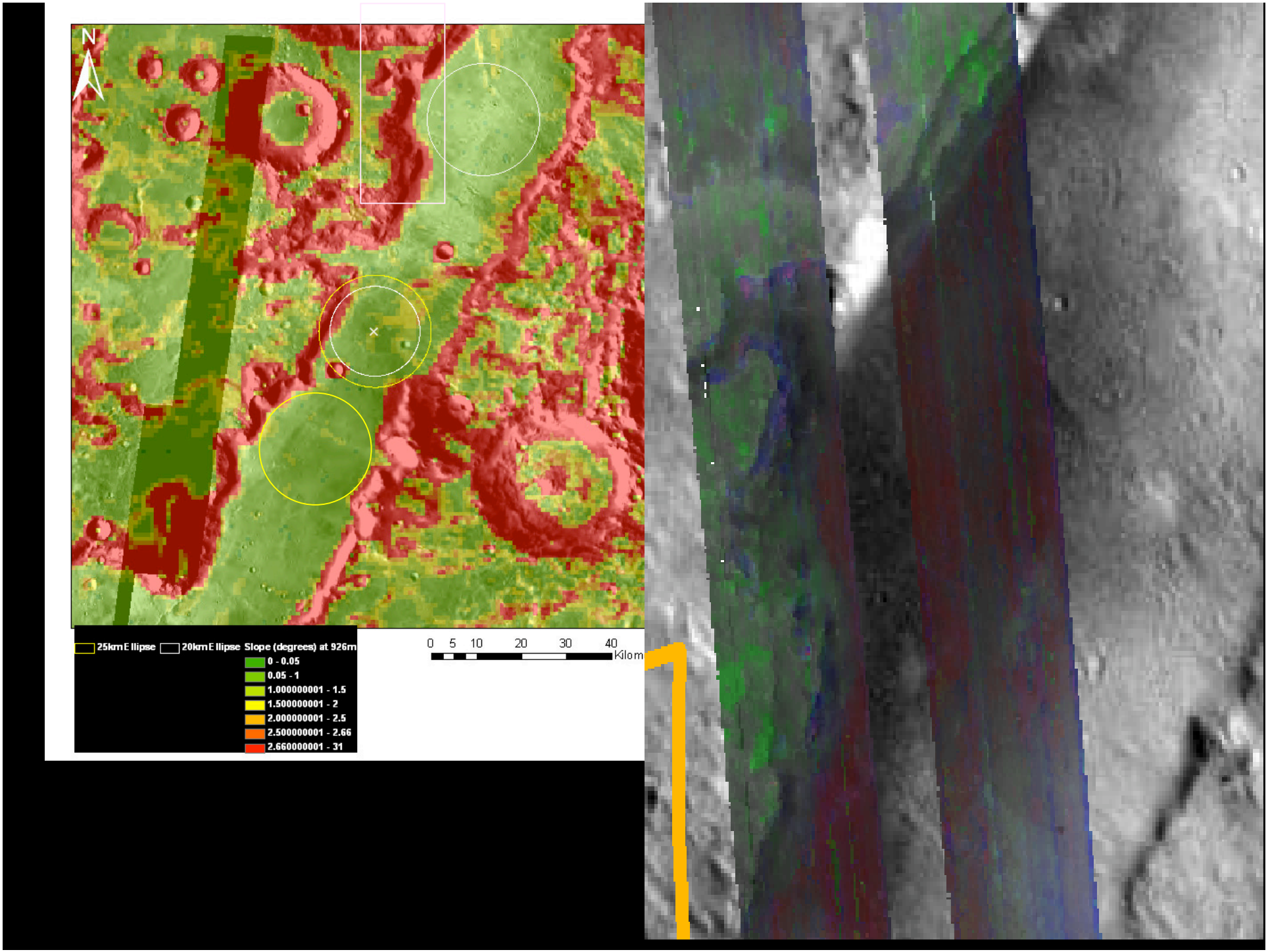

500 m


500 m


Syrtis Lava Hesperian
Smectite-bearing Fossae Fill
Smectite-bearing Fossae Fill
Smectite-rich Noachian Crust
LCP-rich Noachian Crust
600 meters
5 kilometers


3.9 km
Phase 2
5.8 km
Phase 1
Hesperian-
Noachian
Boundary
Ejecta
Syrtis major flows
10 km


Phase 4
Phase 3
Phase 2
Low-Ca Pyroxene
Phyllosilicate
Fe-Phyllosilicate
1 km


N
25km Ellipse
20km Ellipse
Slope (degrees) at 926m
0 - 0.05
0.05 - 1
1.000000001 - 1.5
1.500000001 - 2
2.000000001 - 2.5
2.500000001 - 2.66
2.660000001 - 31
0 5 10 20 30 40
Kilom

Nili Fossae Trough

- Ellipse Science:
  - Sample a major igneous and time-stratigraphic unit for Mars
  - Characterize well preserved, phyllosilicate-bearing eject deposits of a 65 km diameter impact crater
  - Traverse the Hesperian-Noachian boundary
  - Characterize Nili Fossae fill and phyllosilicate sediments
- Monument Valley Science:
  - Mineralogy, geochemistry, and stratigraphy of Noachian crust highly enriched in phyllosilicate
  - Characterize mineralogic diversity as seen from orbit and assess hypotheses for alteration ==> Noachian habitability
  - Sample unaltered, in situ Noachian crust
  - Access alteration fronts

Nili Fossae Trough

- Ability to assess biological potential with MSL Payload
  - Full suite of the MSL payload will be essential to understand site
  - Includes crustal formation, igneous processes, alteration processes and crustal, near surface, and surface environments
- Evidence for habitably environment
  - Mineralogy, geochemistry, and stratigraphy of Noachian crust highly enriched in phyllosilicate
  - DIVERSE phyllosilicates suggest a range of water-rich environments with gradients in energy, T, P including sedimentary
- Preservation of biosignatures
  - Abundant smectite clay ideal for capturing and preserving organics
  - Access unaltered, in situ Noachian crust in contact with alteration
- Ability to characterize geologic setting
  - Important stratigraphic transitions in the landing ellipse
  - Clear stratigraphy including Noachian units