Noachian/Phyllosian Stratigraphy in Nili Fossae

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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
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**
Regional Mineral Assemblages, Nili Fossae

Ehlmann et al., 2008; JGR 2009

Minerals in context with observation ID’s and coordinates

- Fe/Mg smectite
- kaolinite
- illite/muscovite
- chlorite
- hydrated Si-OH
- analcime (zeolite)
- Carbonate
- Other zeolite/sulfate
- Serpentine
- Prehnite
Mineralogy identified
Fe-oxide and crystalline hematite
Fe/Mg Smectite with variety of band positions, H₂O 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 $\mu$m RGB

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Both stretched 0.02-0.12
Dune fields show evidence for a weak olivine absorption. Note that pyroxene bands are apparent in the Lambert albedo spectra.
Red crystalline hematite is observed in discrete regions of the material filling the trough floor.
Fe-Mg phyllosilicate indicated by absorptions near 2.3, 1.91, and 1.41 μm

Spectra ratioed to brown-colored dunes
Fe-Mg phyllosilicate indicated by absorptions near 2.3, 1.91, and 1.41 μm

Possible absorption near 3 μm due to H₂O
Fe-Mg phyllosilicate indicated by absorptions near 2.3, 1.91, and 1.41 \( \mu m \)

The spectral properties of Fe/Mg phyllosilicates is relatively consistent across scene but with small variance in the 1.9 \( \mu m \) \( H_2O \) band.
Fill of Nili Fossae floor shows definitive absorptions for hydrated silicate, consistent with Fe/Mg smectite clay.
Small outcrops on the plateau show distinct absorptions diagnostic of kaolinite
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FRT000064D9: R=2.4 G=1.8 B=1.08 μm

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)
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Layered Sediments
Unaltered Noachian crust embedded in phyllosilicate-bearing formation

Blocks with possible carbonate signature

HiRISE Color

Layered Sediments

Low-Ca Pyroxene
Phyllosilicate
Fe-Phyllosilicate
Olivine
Low-Ca Pyroxene
Phyllosilicate
Fe-Phyllosilicate
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LCP-rich Noachian Crust
Smectite-rich Noachian Crust
Smectite-bearing Fossae Fill
Smectite-bearing Fossae Fill
Smectite-rich Noachian Crust
LCP-rich Noachian Crust

600 meters

5 kilometers

(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