The Stratigraphy and Evolution of Lower Mt. Sharp from Spectral, Morphological, and Thermophysical Orbital Datasets

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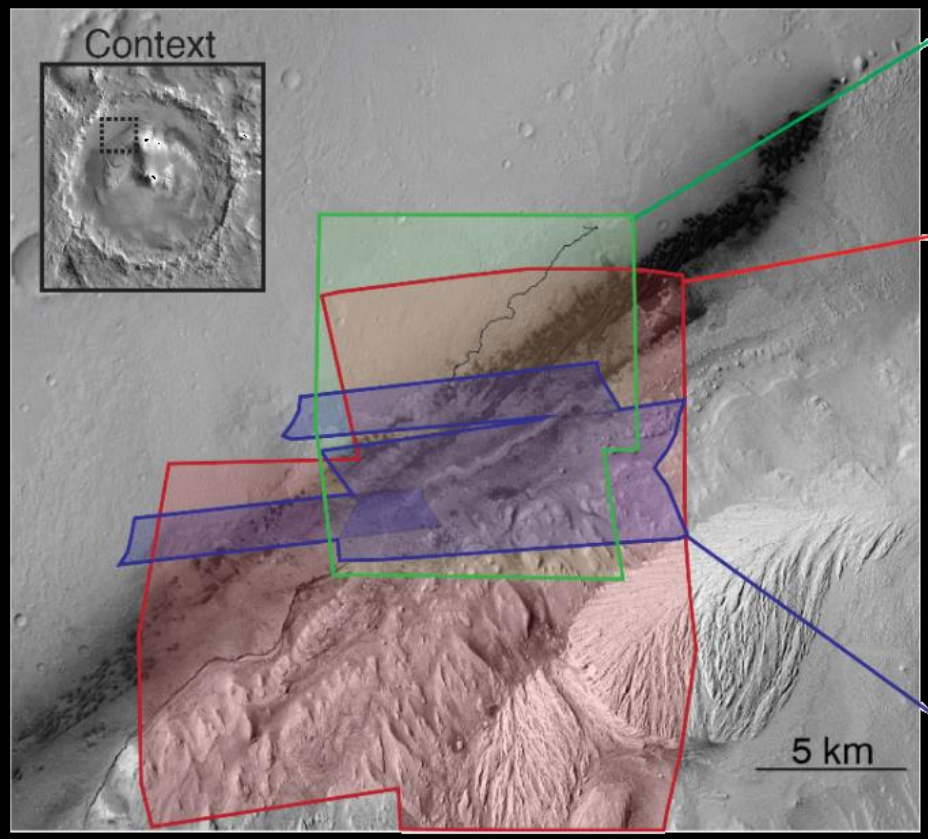
Jet Propulsion Laboratory
California Institute of Technology

Introduction

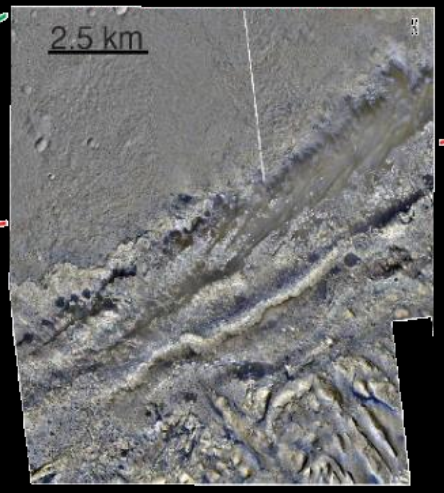
- Orbital-based maps over Mt. Sharp are key tools for
  - reconstructing time-ordered events in Mt. Sharp evolution
  - contextualizing Curiosity's exploration
- We examine newly derived, highest resolution orbital data and co-analysis of integrated datasets to generate detailed maps
- Incoporate observations from prior studies [*Anderson & Bell,* 2010; *Milliken, Grotzinger, & Thomson,* 2010; *Thomson et al.,* 2011; *Fraeman et al.,* 2013; *Le Deit et al.,* 2013] while increasing spatial resolution to discriminate small scale features

Orbital Datasets

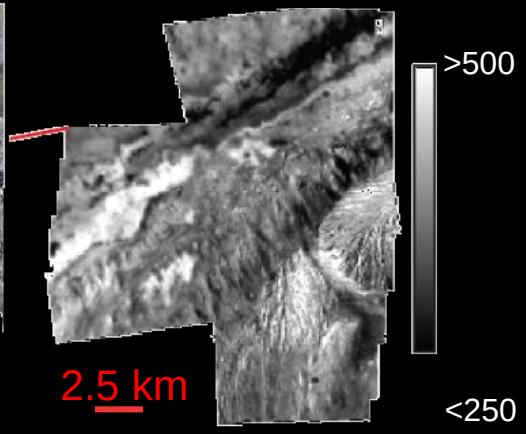
High-resolution orbital data products



MORPHOLOGY
HiRISE
Color Mosaic



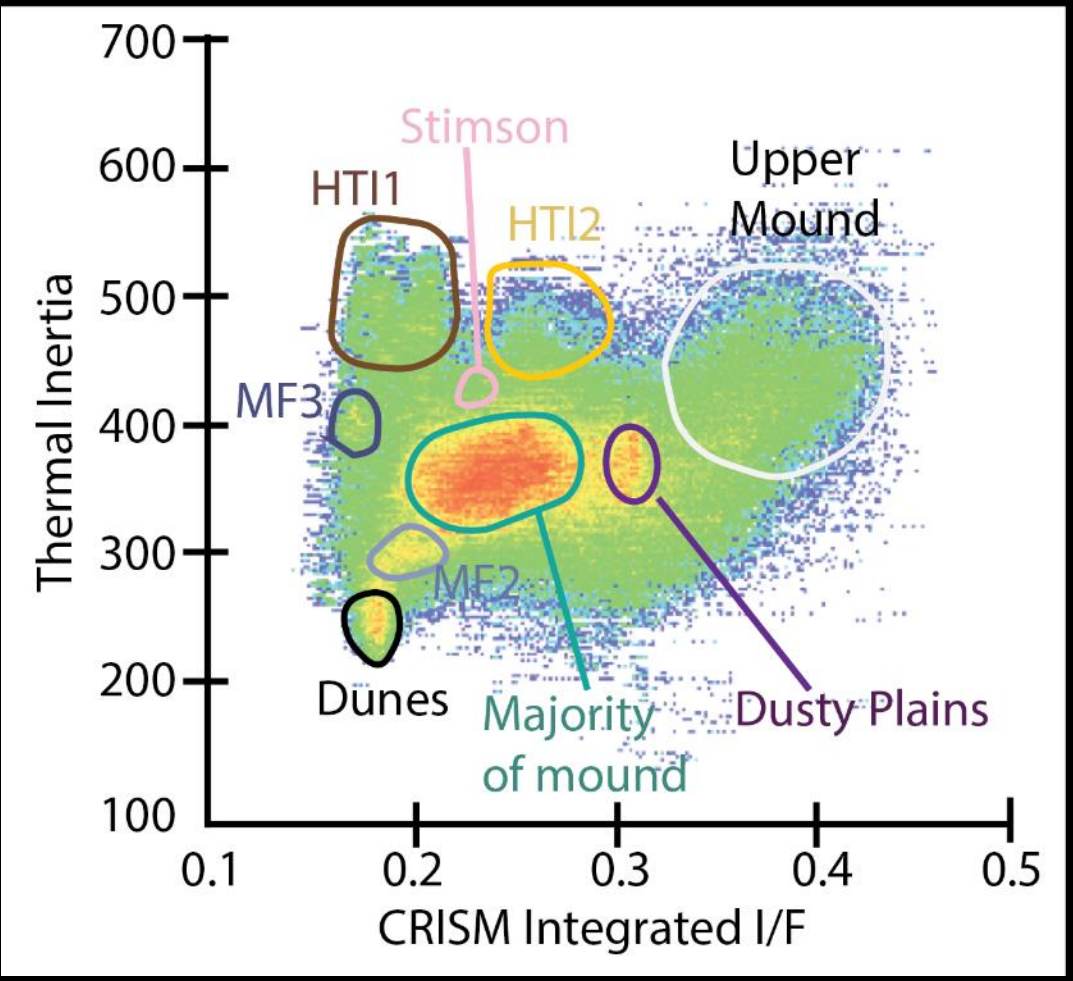
THERMOPHYSICAL PROPERTIES
THEMIS
Thermal Inertia

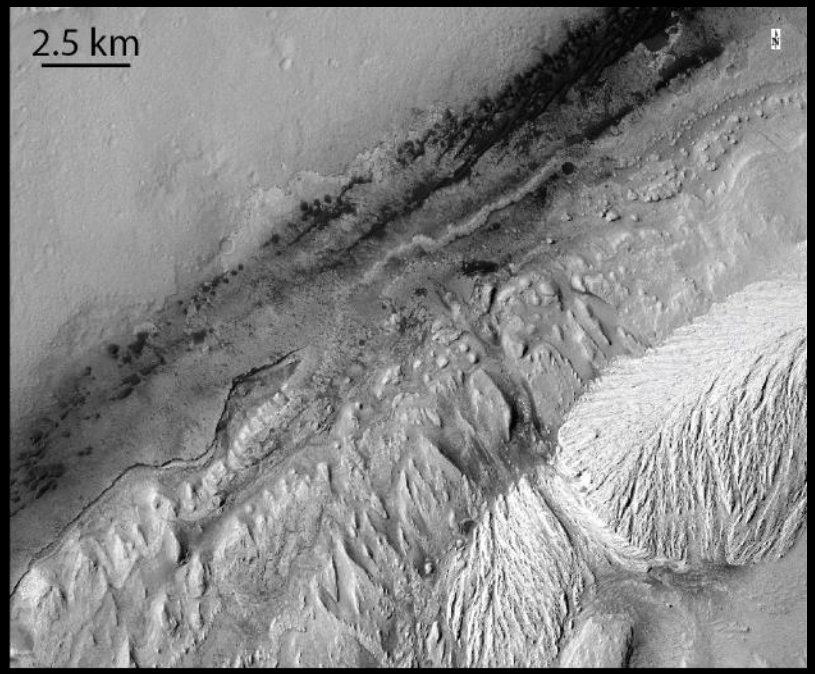


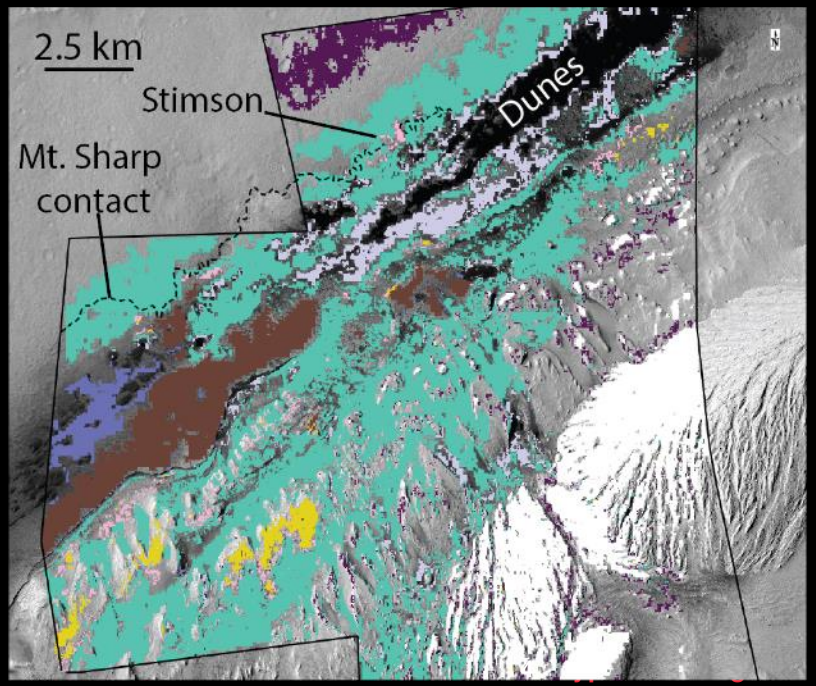
COMPOSITION
CRISM
Along-Track Oversampled Mosaic

Coordinated Observations

Spatial correlations between albedo and thermal inertia highlight units

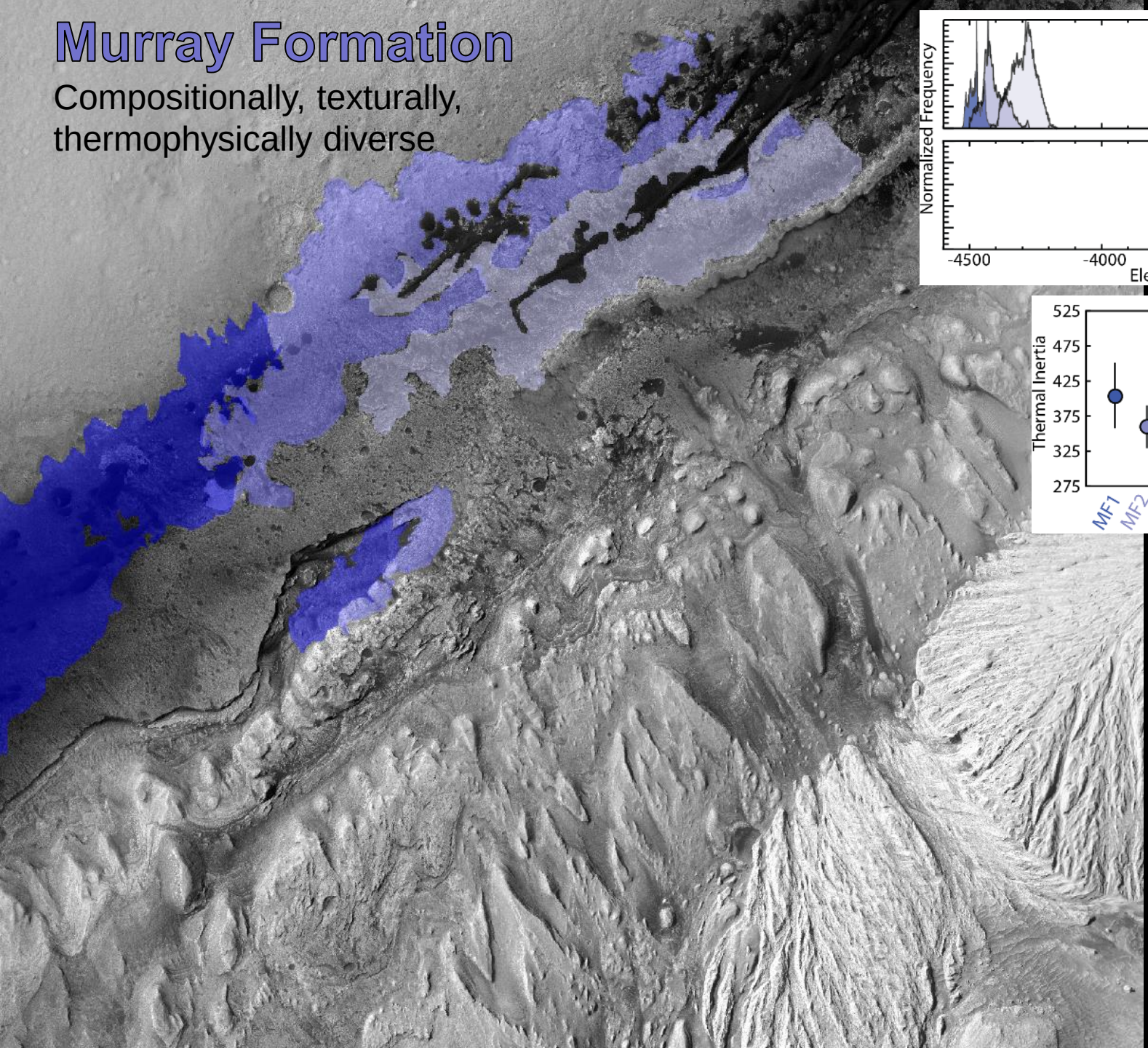


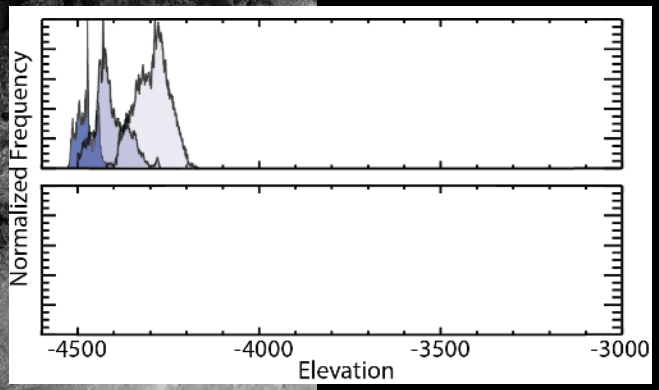


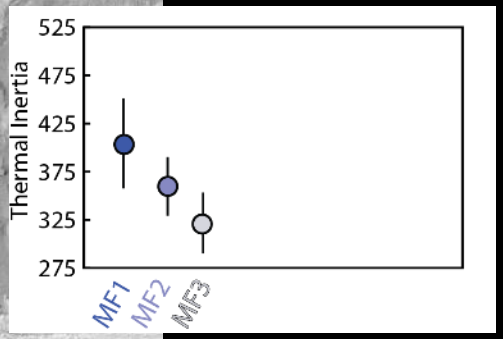


Murray Formation

Compositionally, texturally, thermophysically diverse

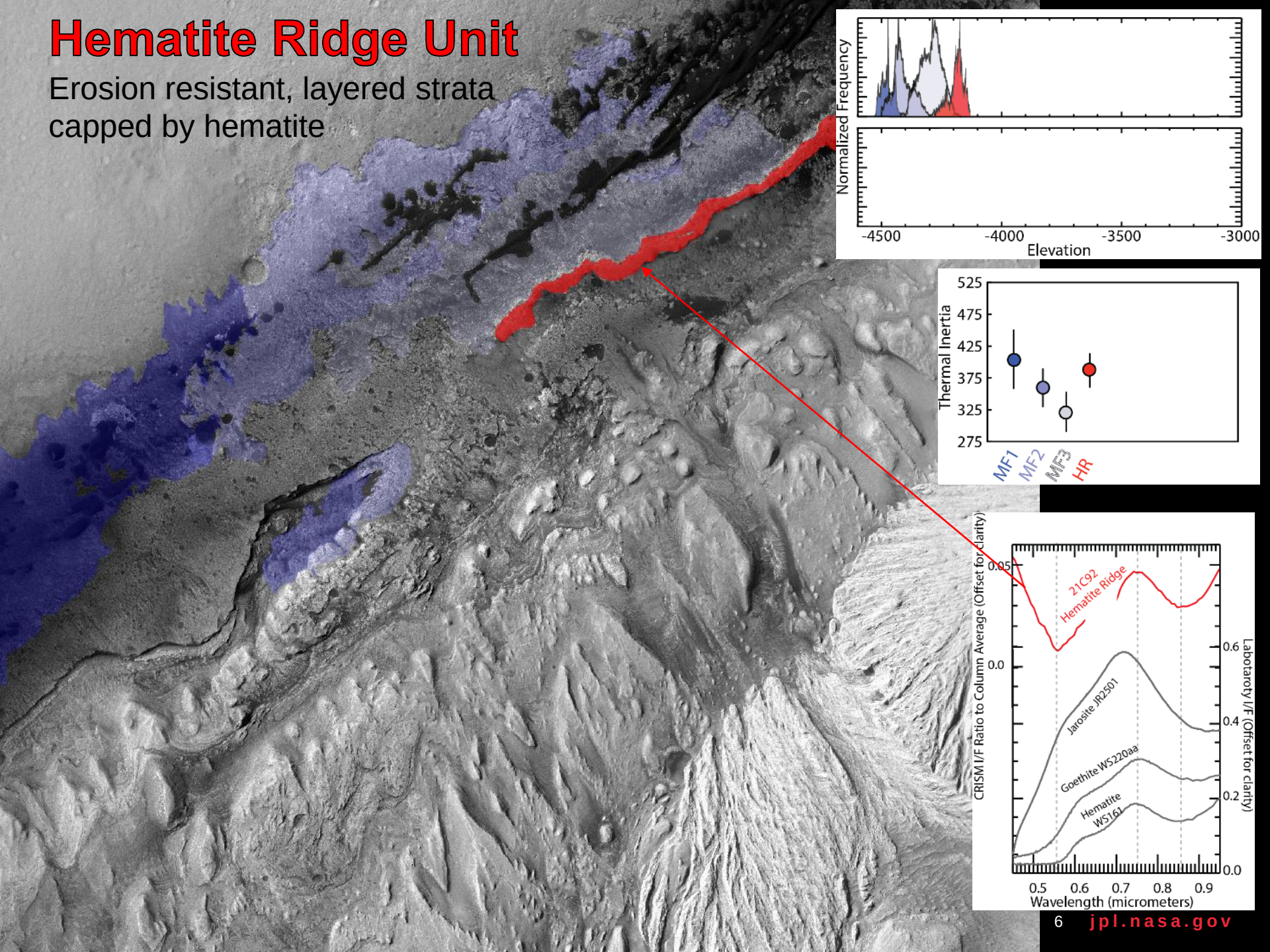






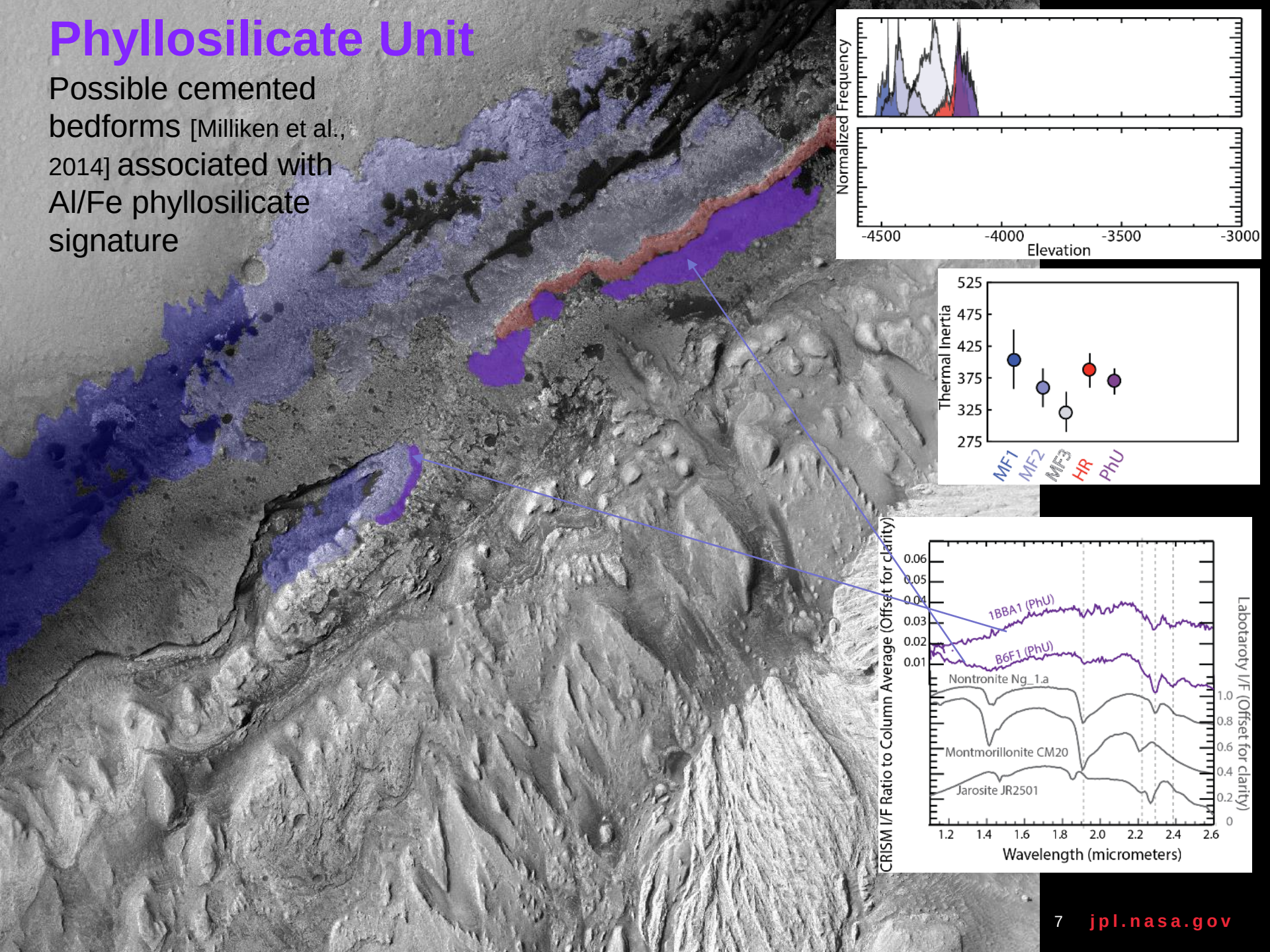
Hematite Ridge Unit

Erosion resistant, layered strata capped by hematite



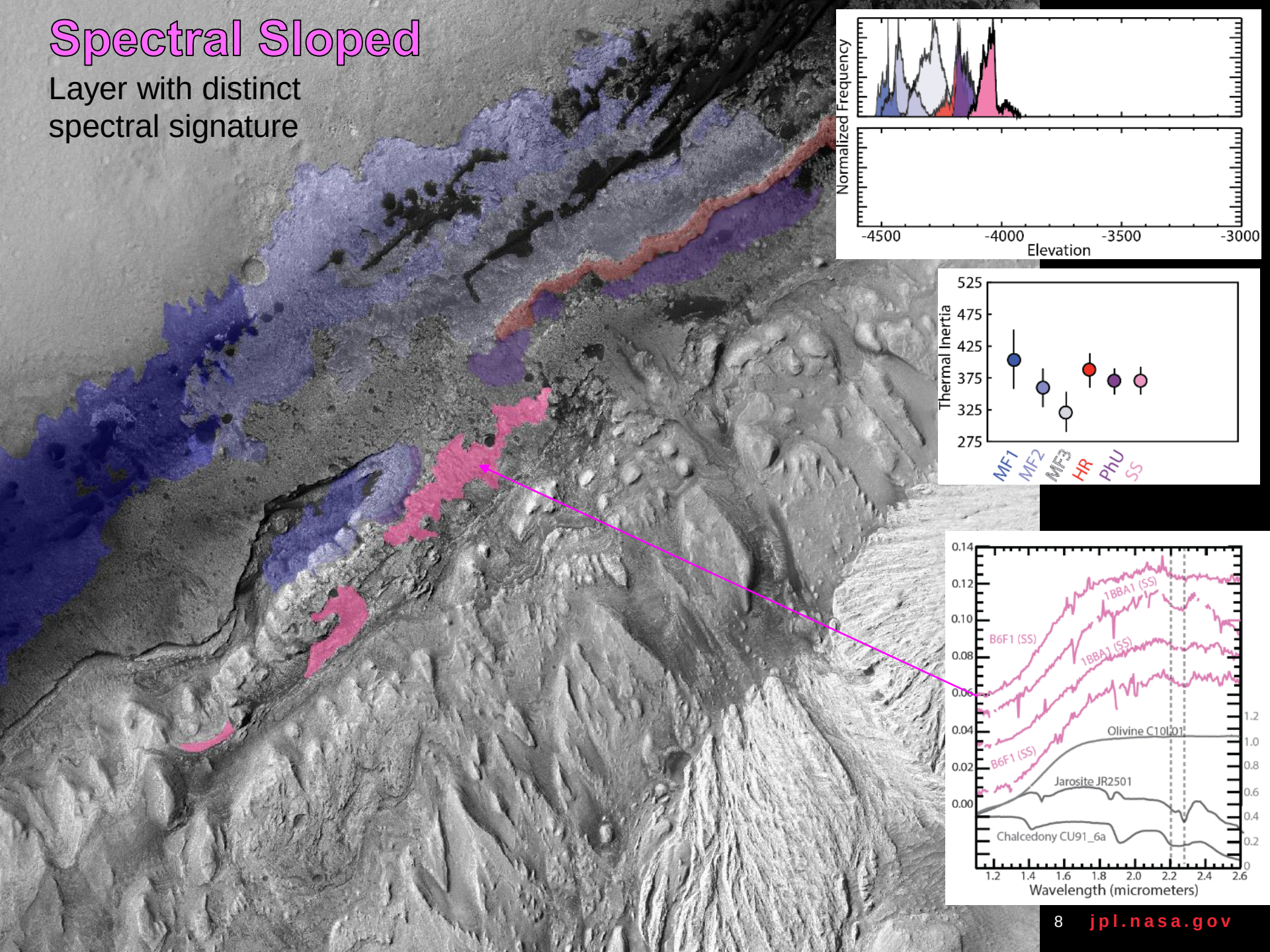
Phyllosilicate Unit

Possible cemented bedforms [Milliken et al., 2014] associated with Al/Fe phyllosilicate signature



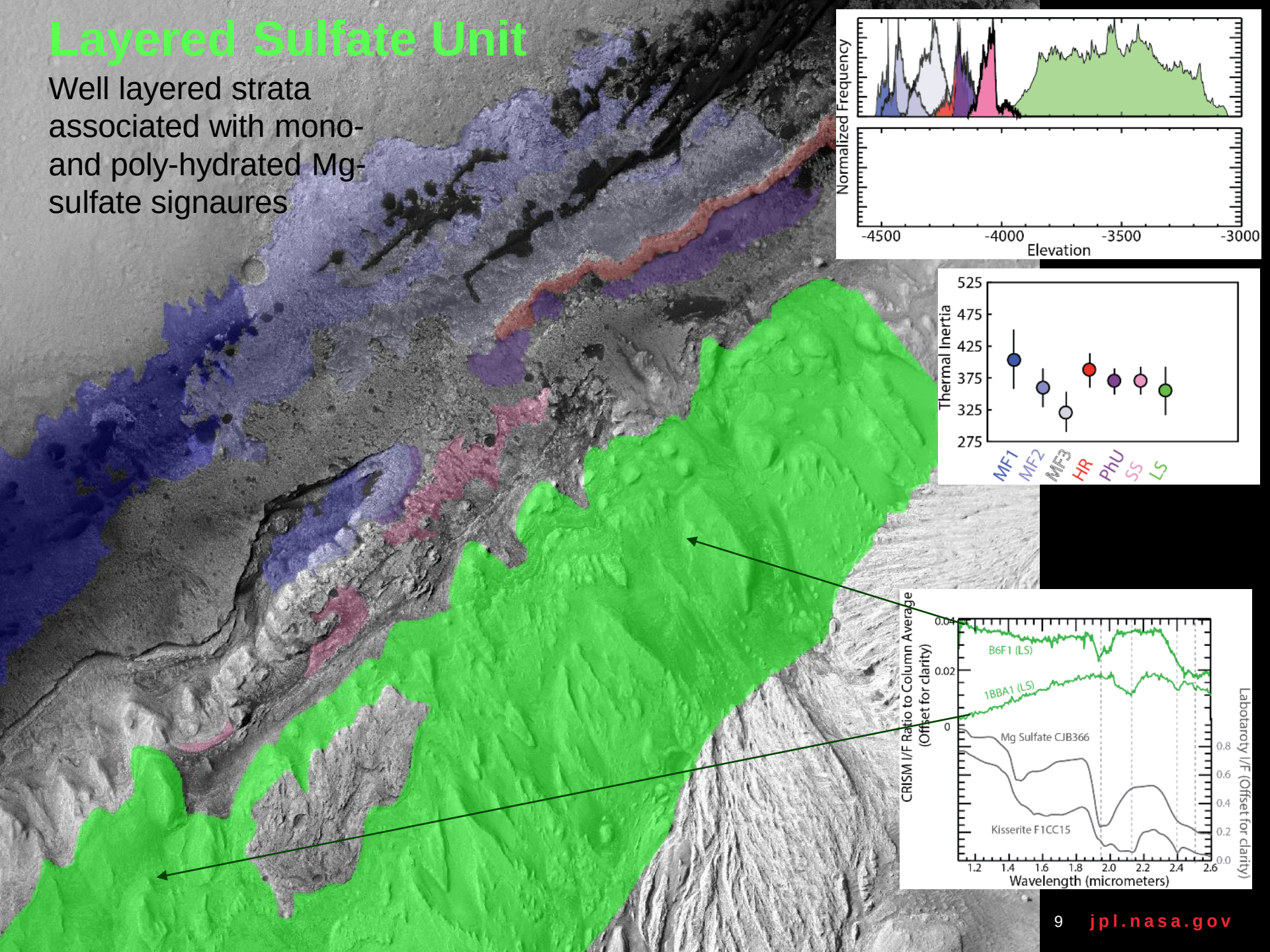
Spectral Sloped

Layer with distinct spectral signature



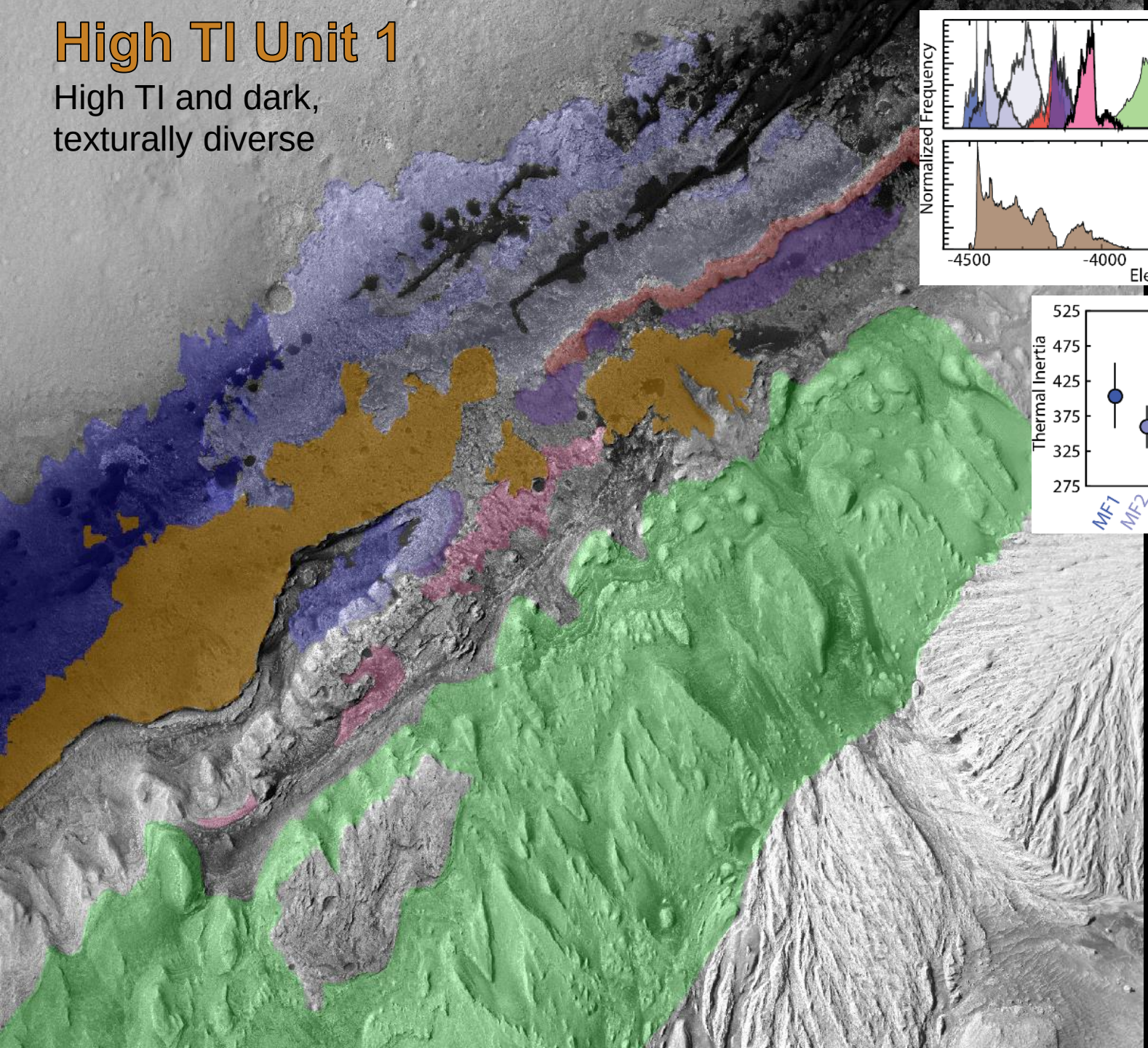
Layered Sulfate Unit

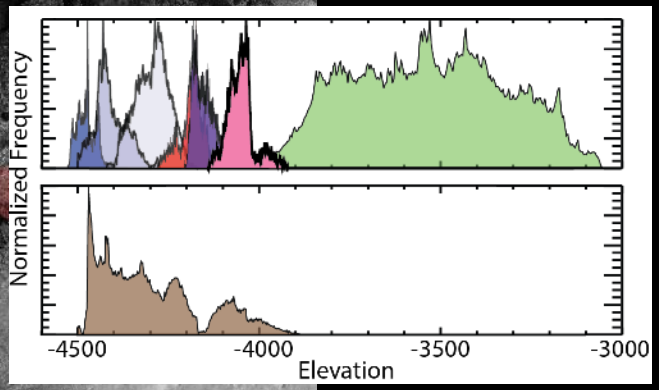
Well layered strata associated with mono- and poly-hydrated Mg-sulfate signaures

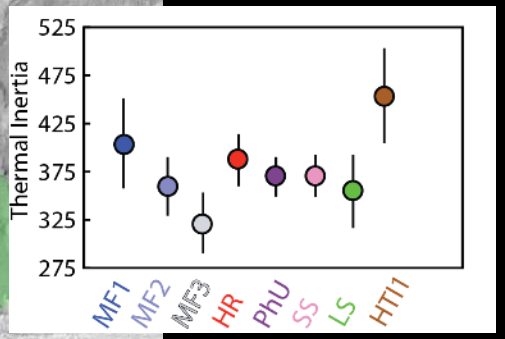


High TI Unit 1

High TI and dark, texturally diverse

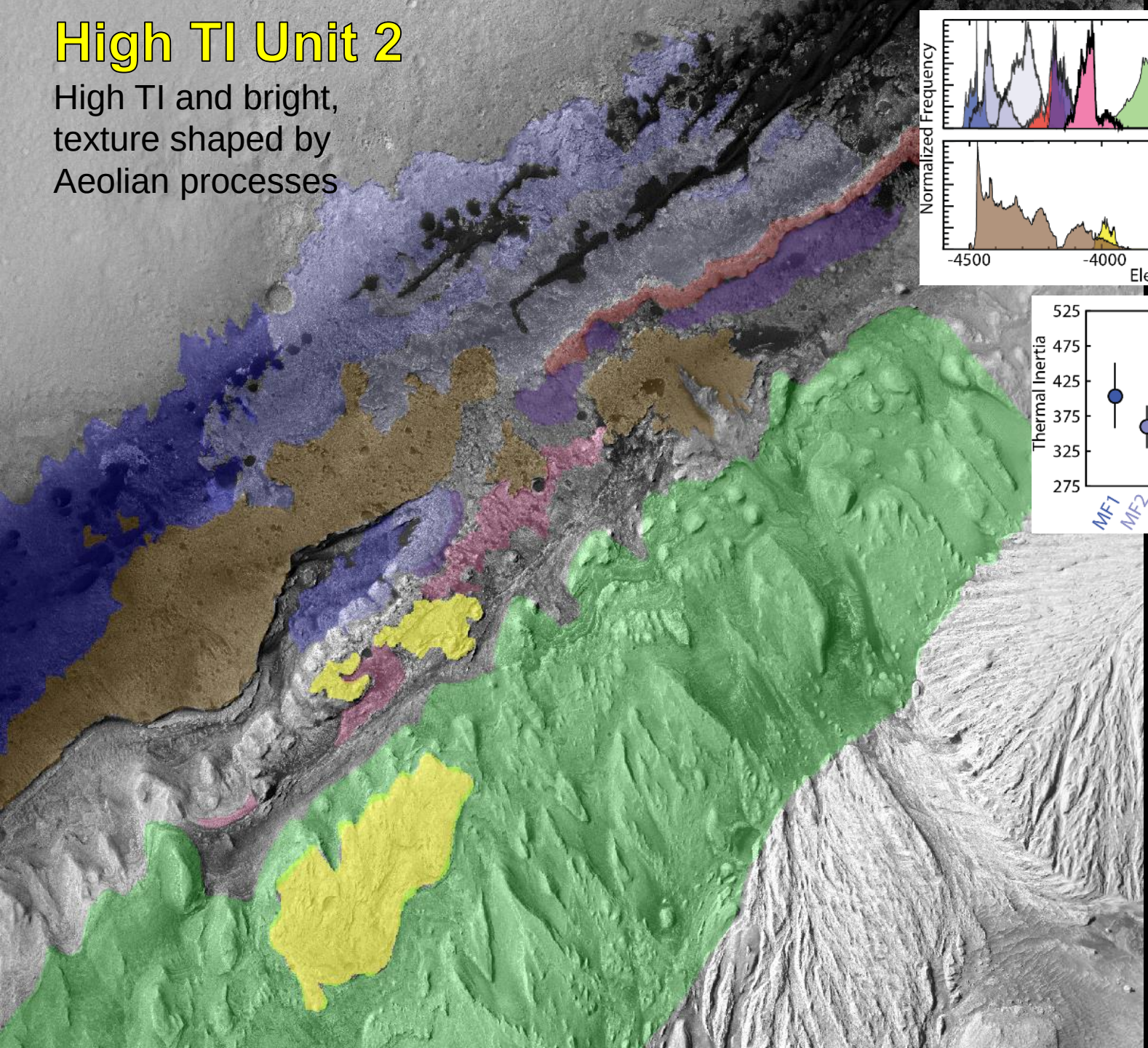


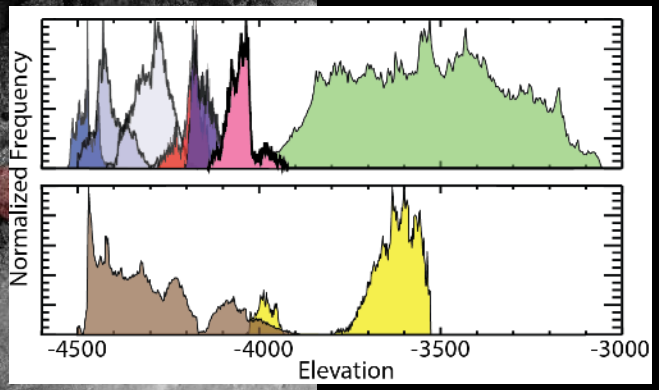


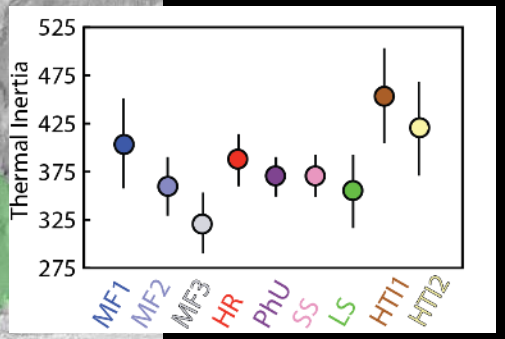


High TI Unit 2

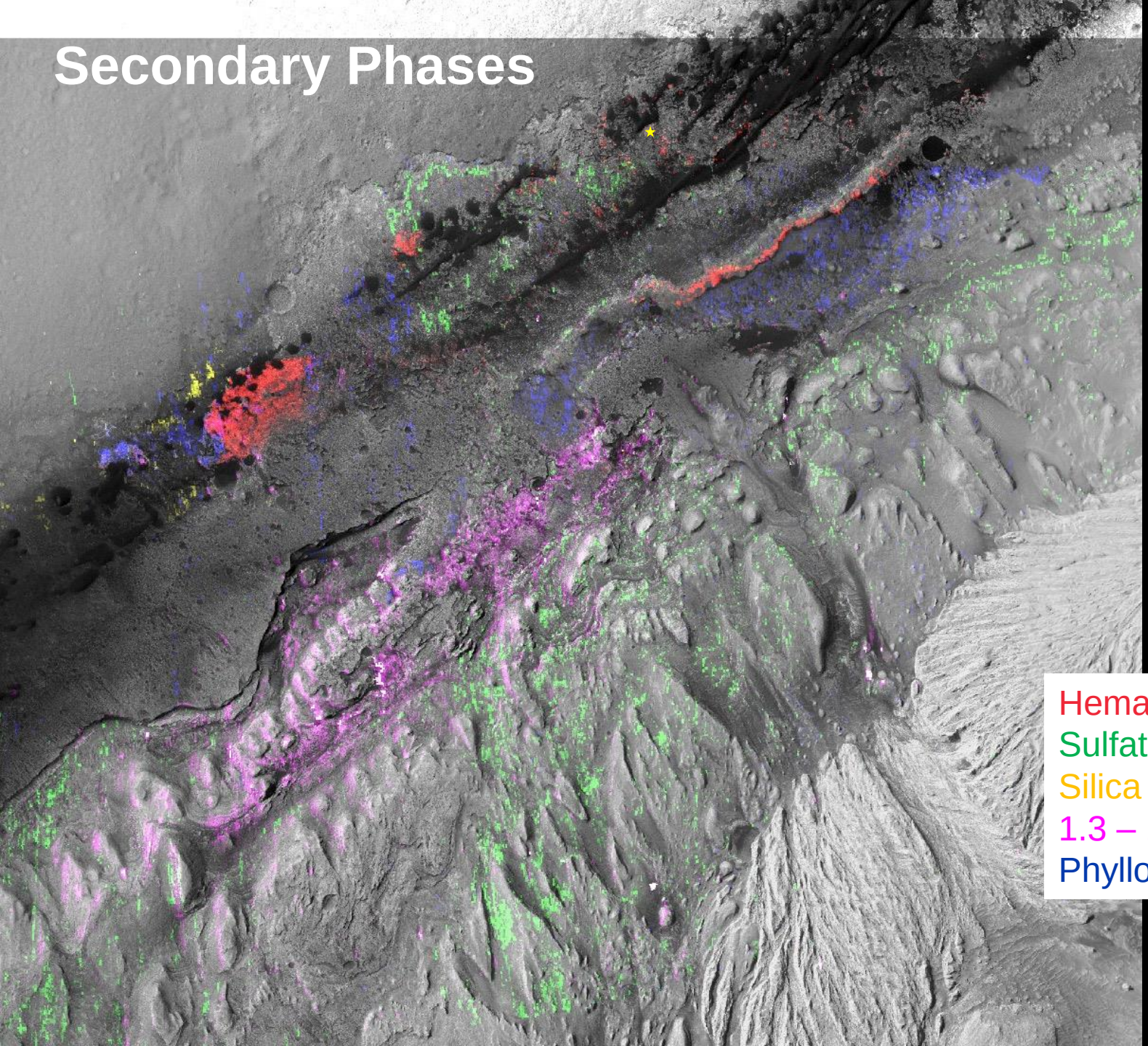
High TI and bright, texture shaped by Aeolian processes



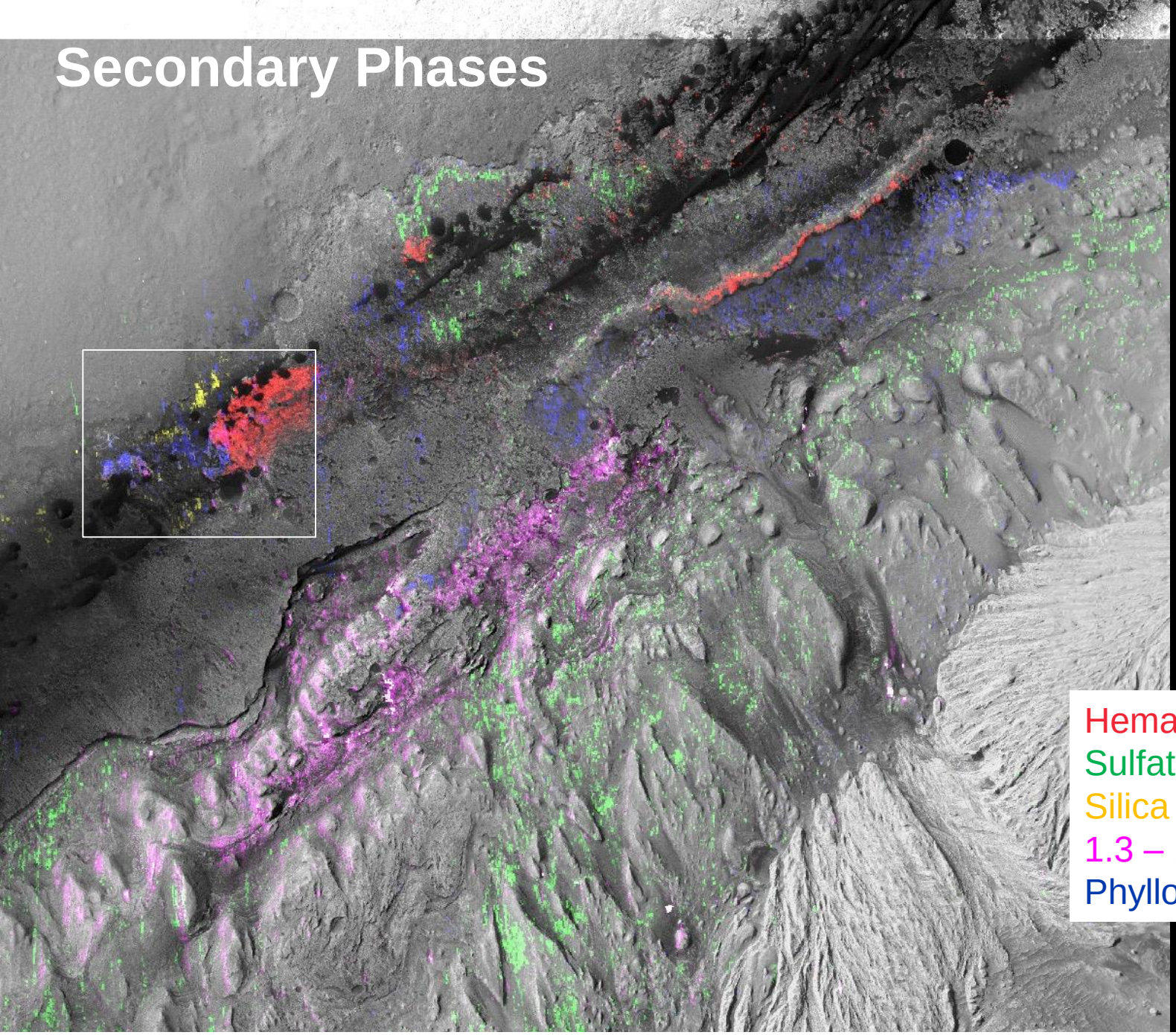




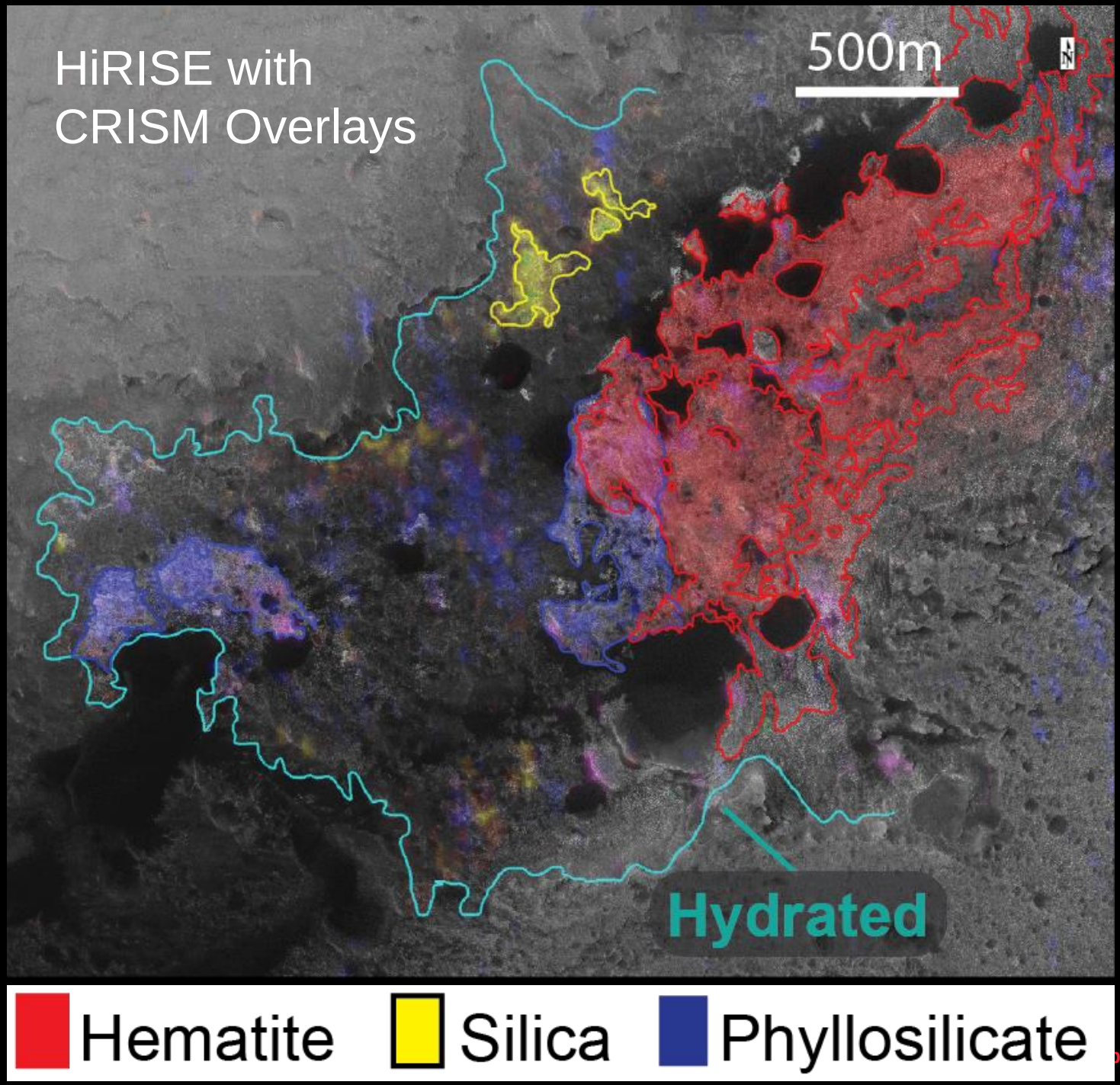
Secondary Phases

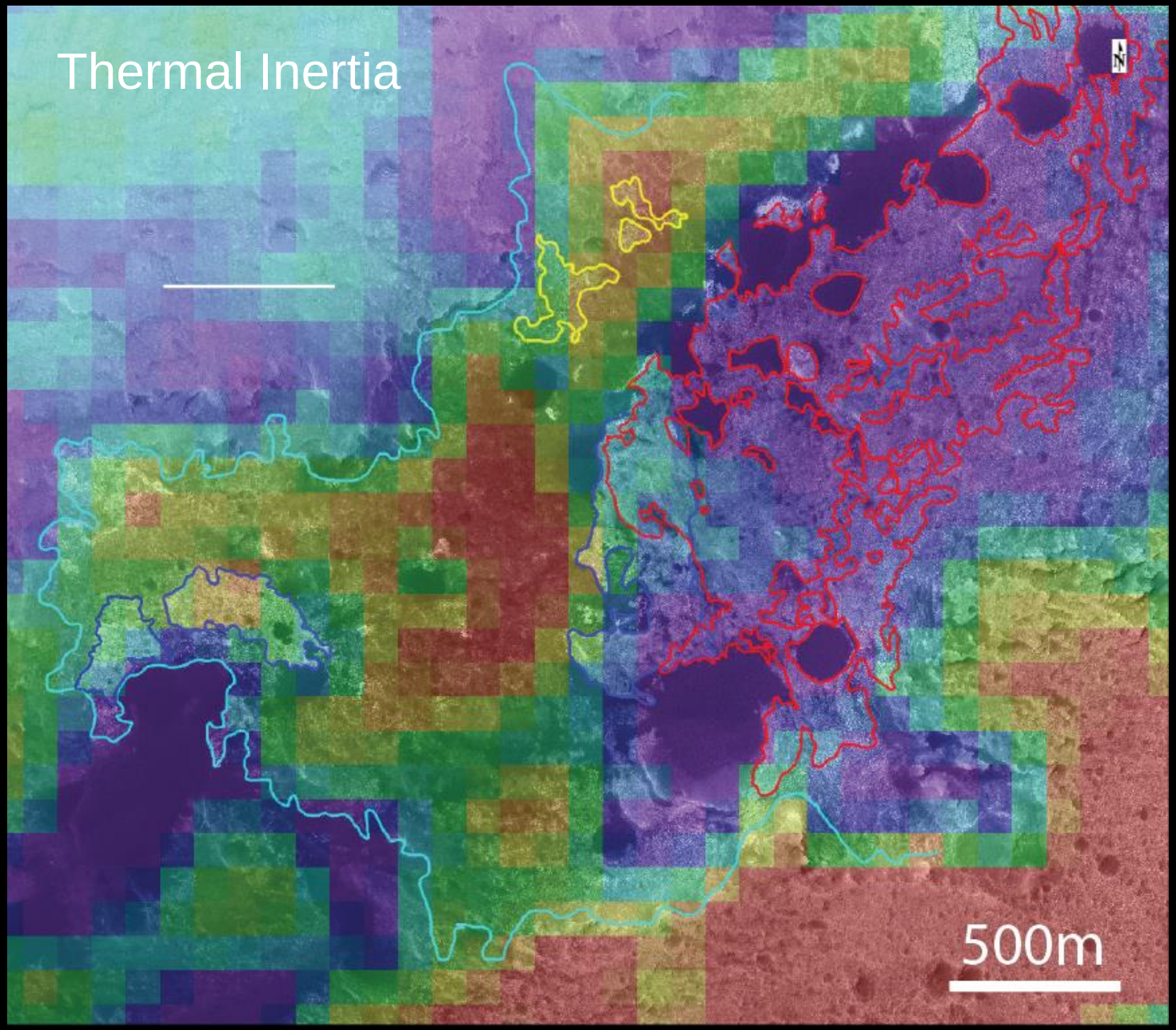


Secondary Phases

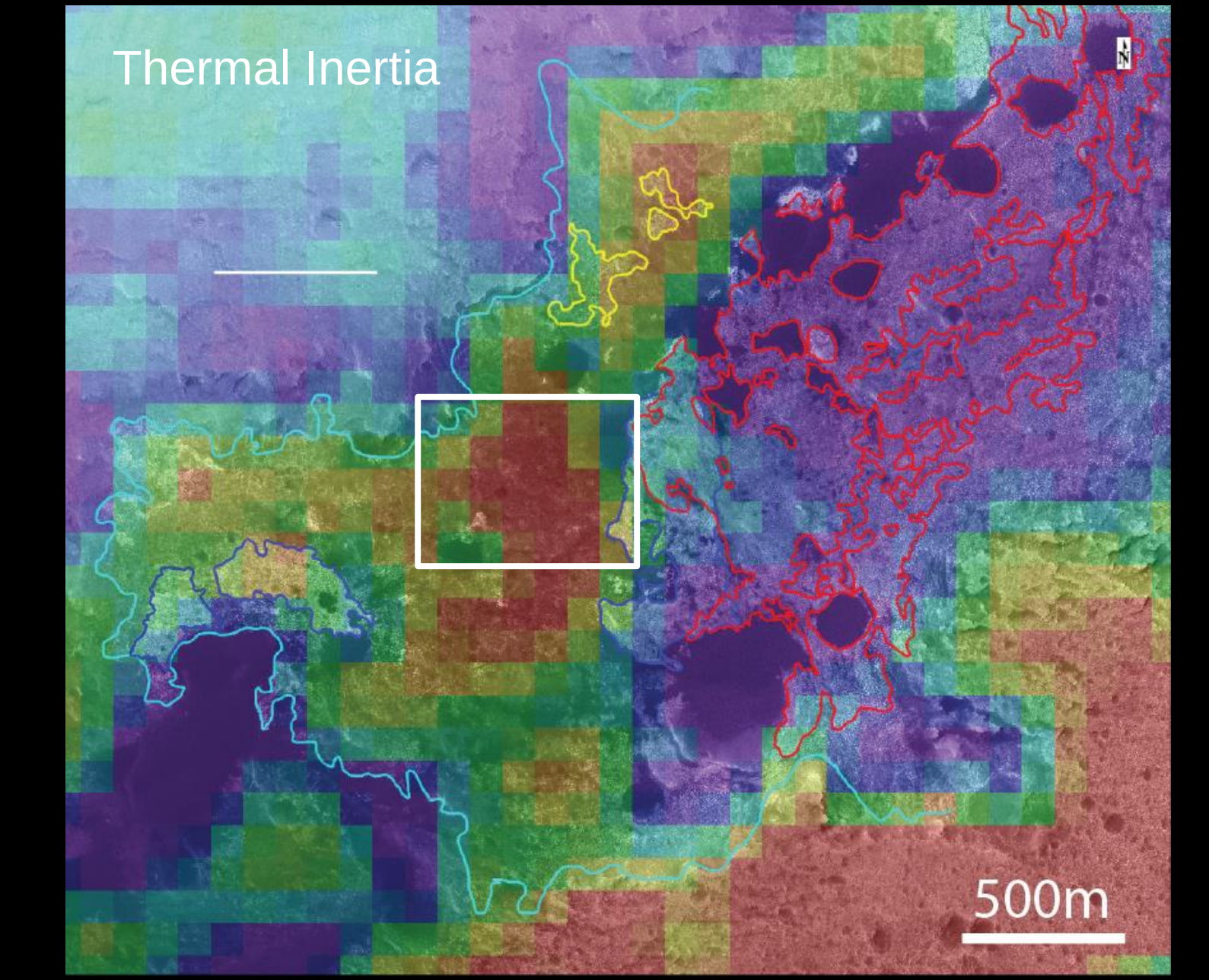


Details on parameter mapping see Fraeman et al., LPSC 2015; Pan et al., et al this conference


HiRISE with
CRISM Overlays
500m
N
Hydrated
Hematite
Silica
Phyllosilicate

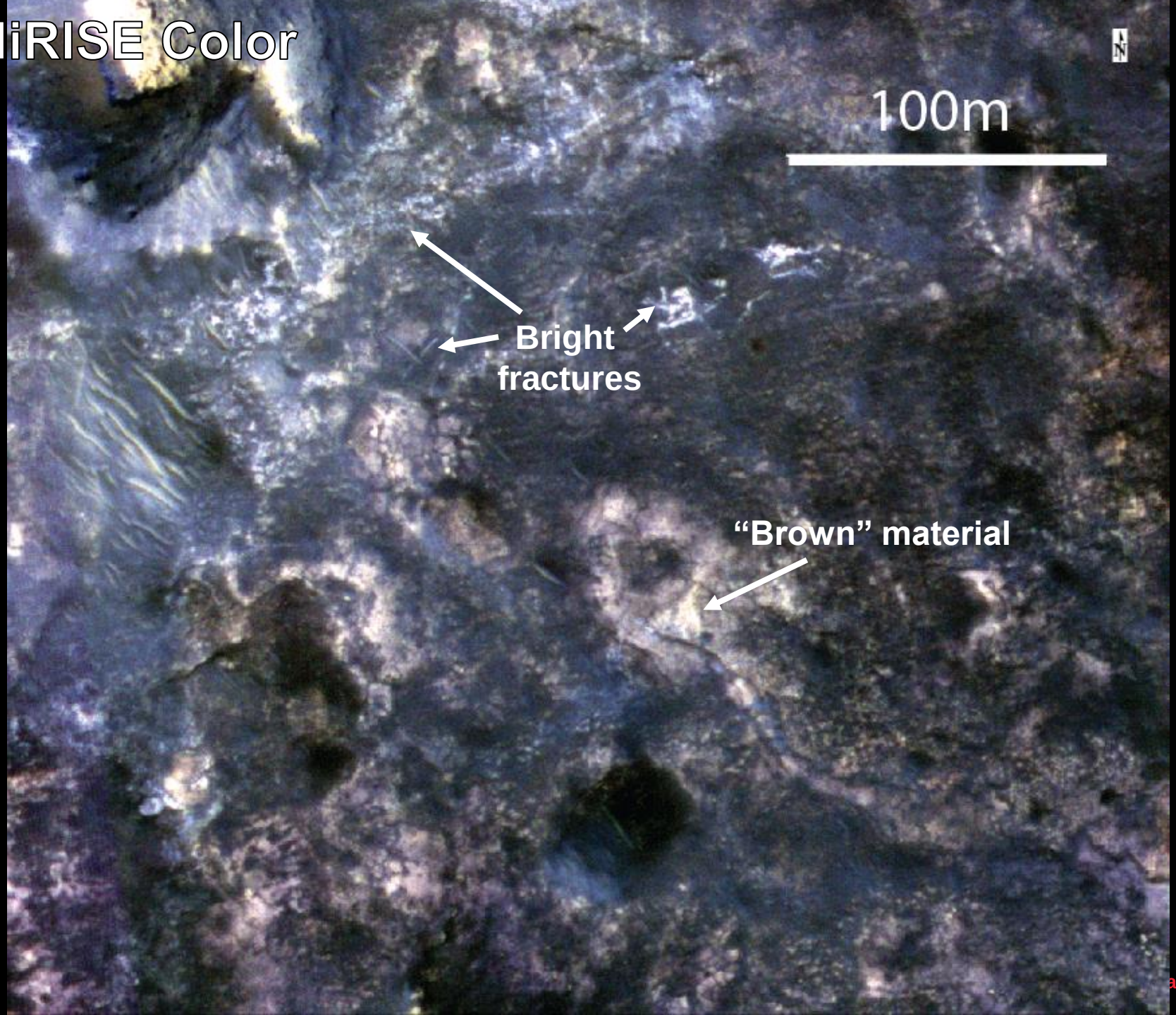


350 380



350 380

HiRISE Color



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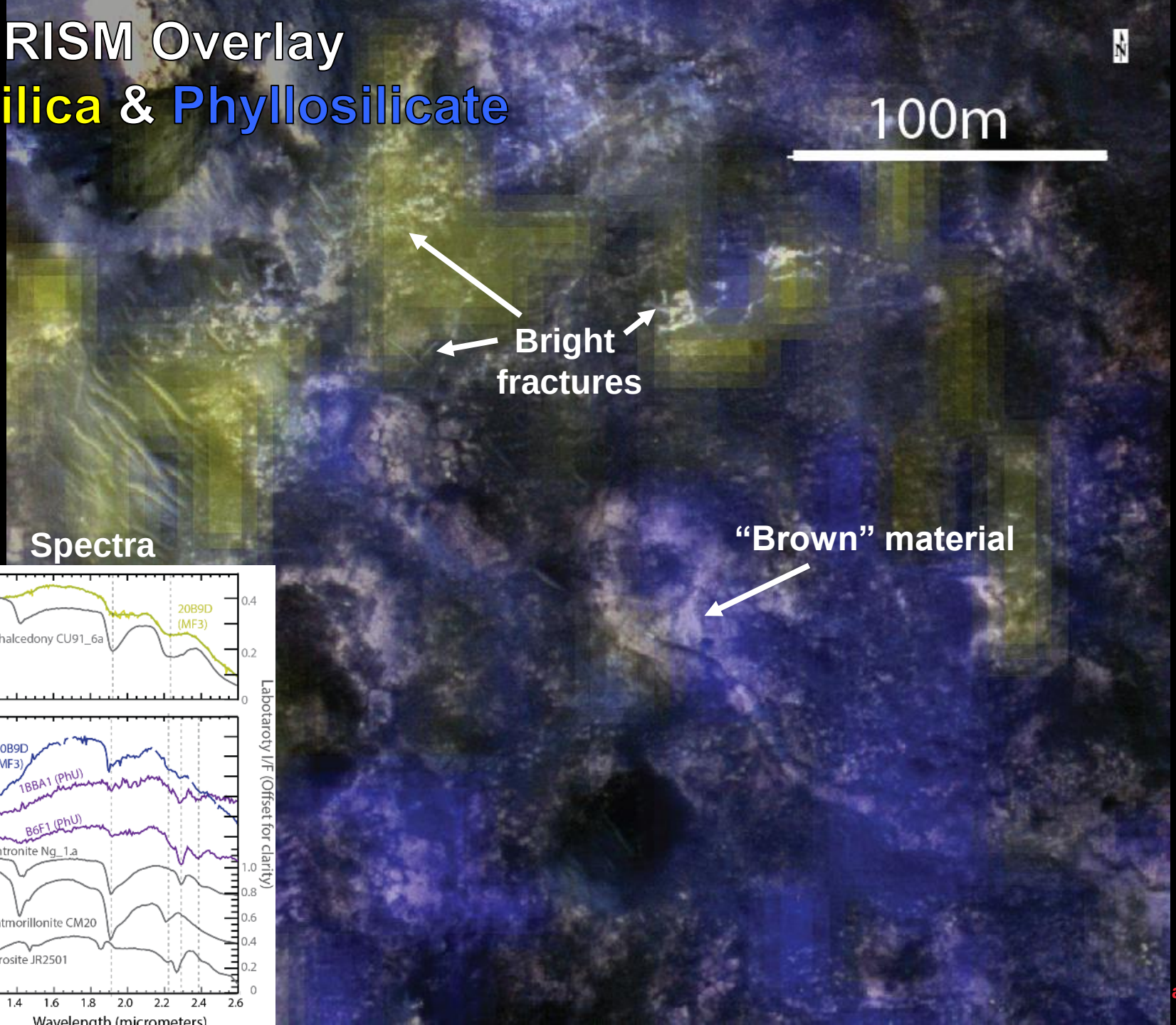
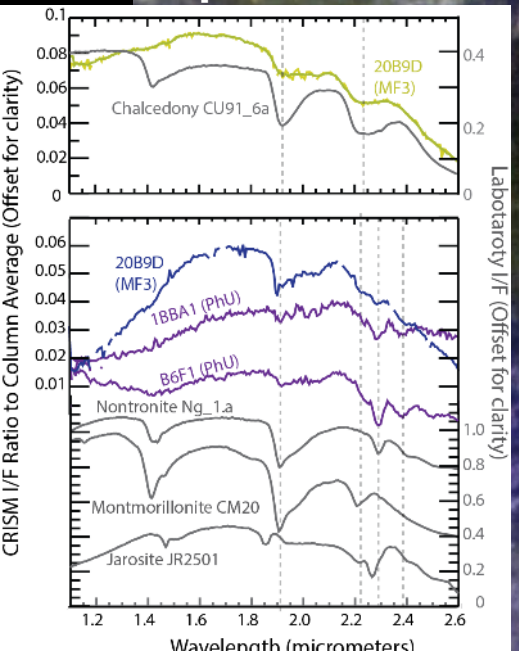
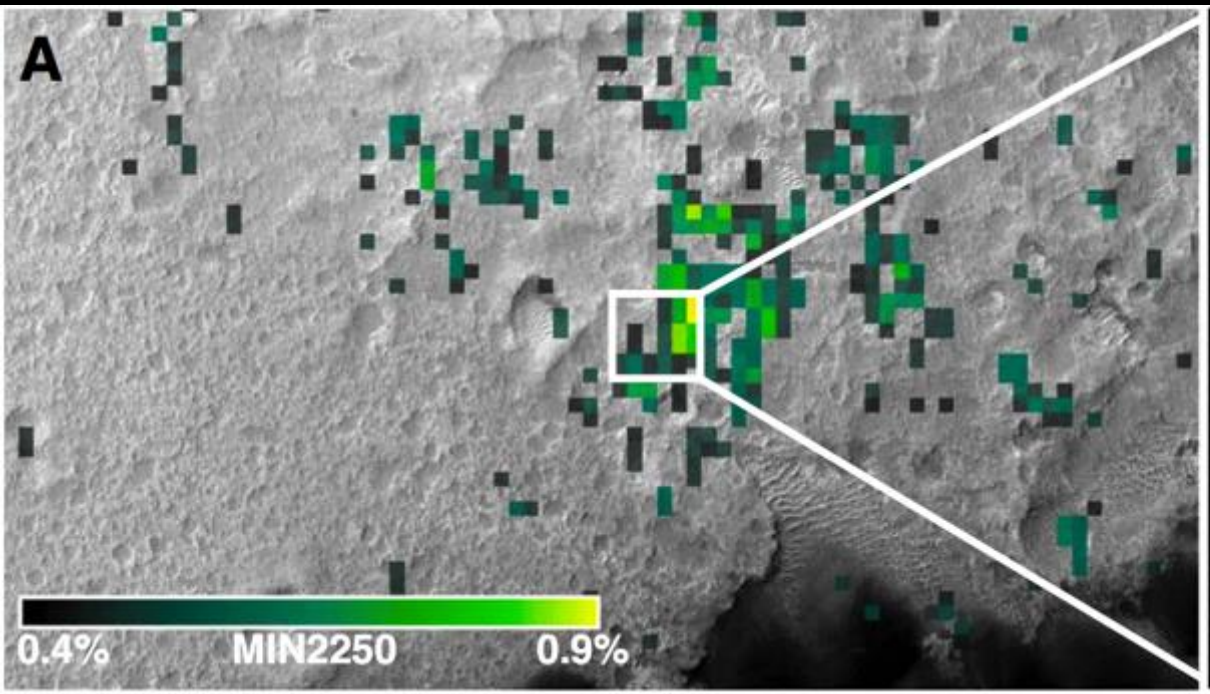
CRISM Overlay
Silica & Phyllosilicate

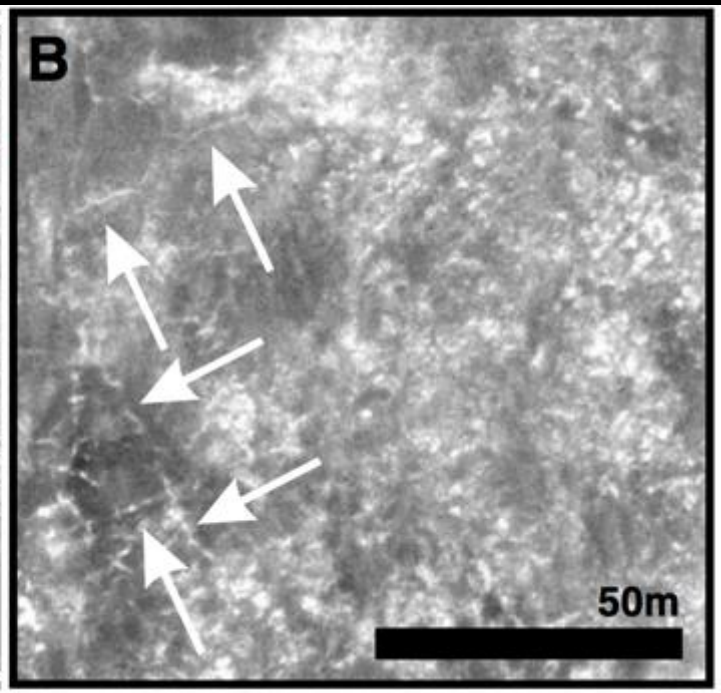


Spectra

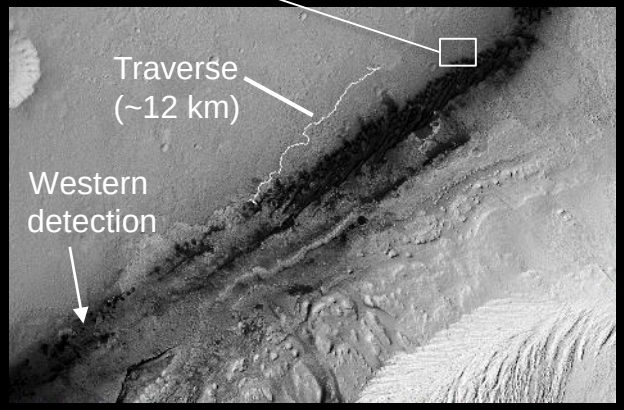


Similar Hydrated Si-textures in the NE



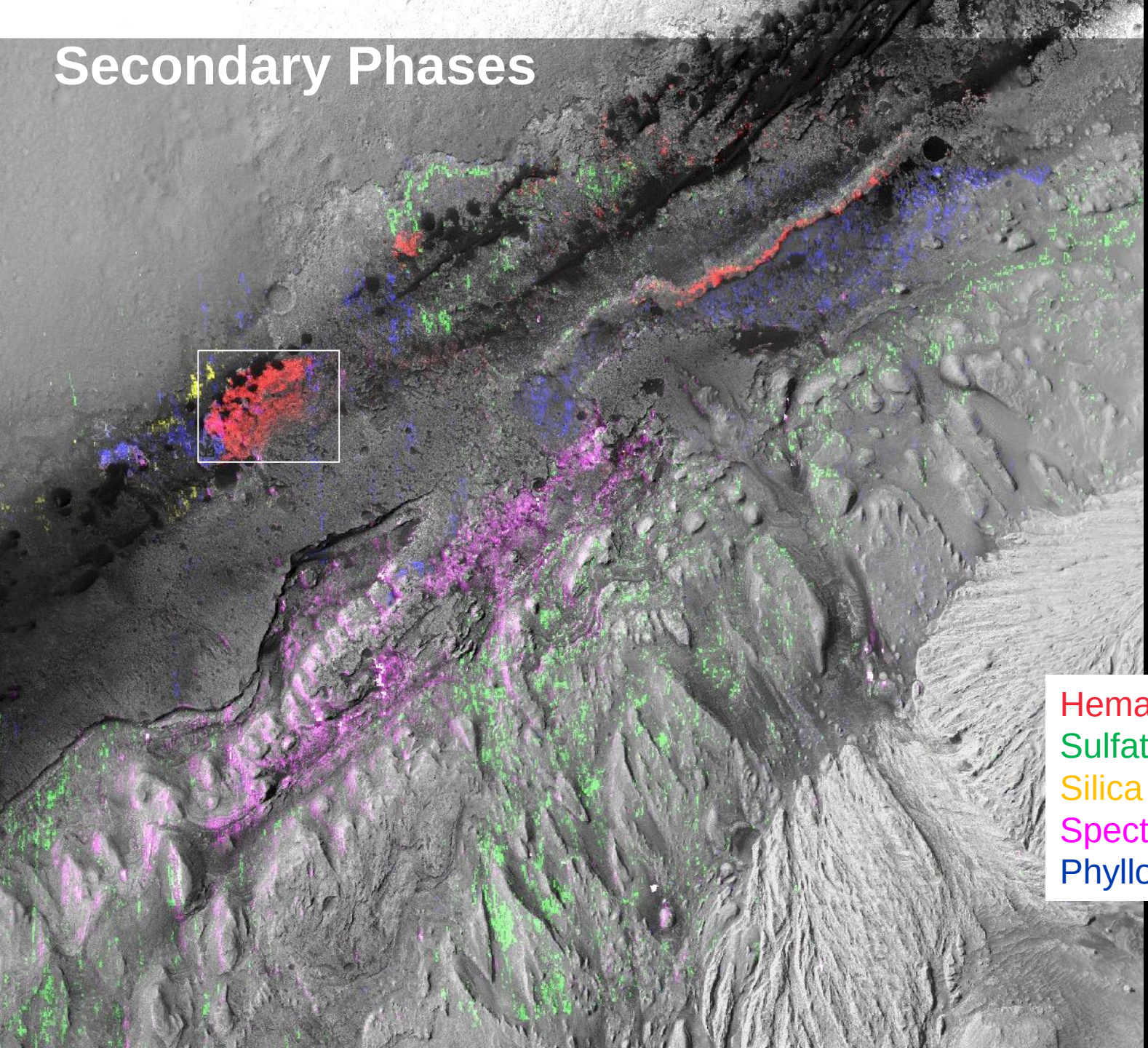


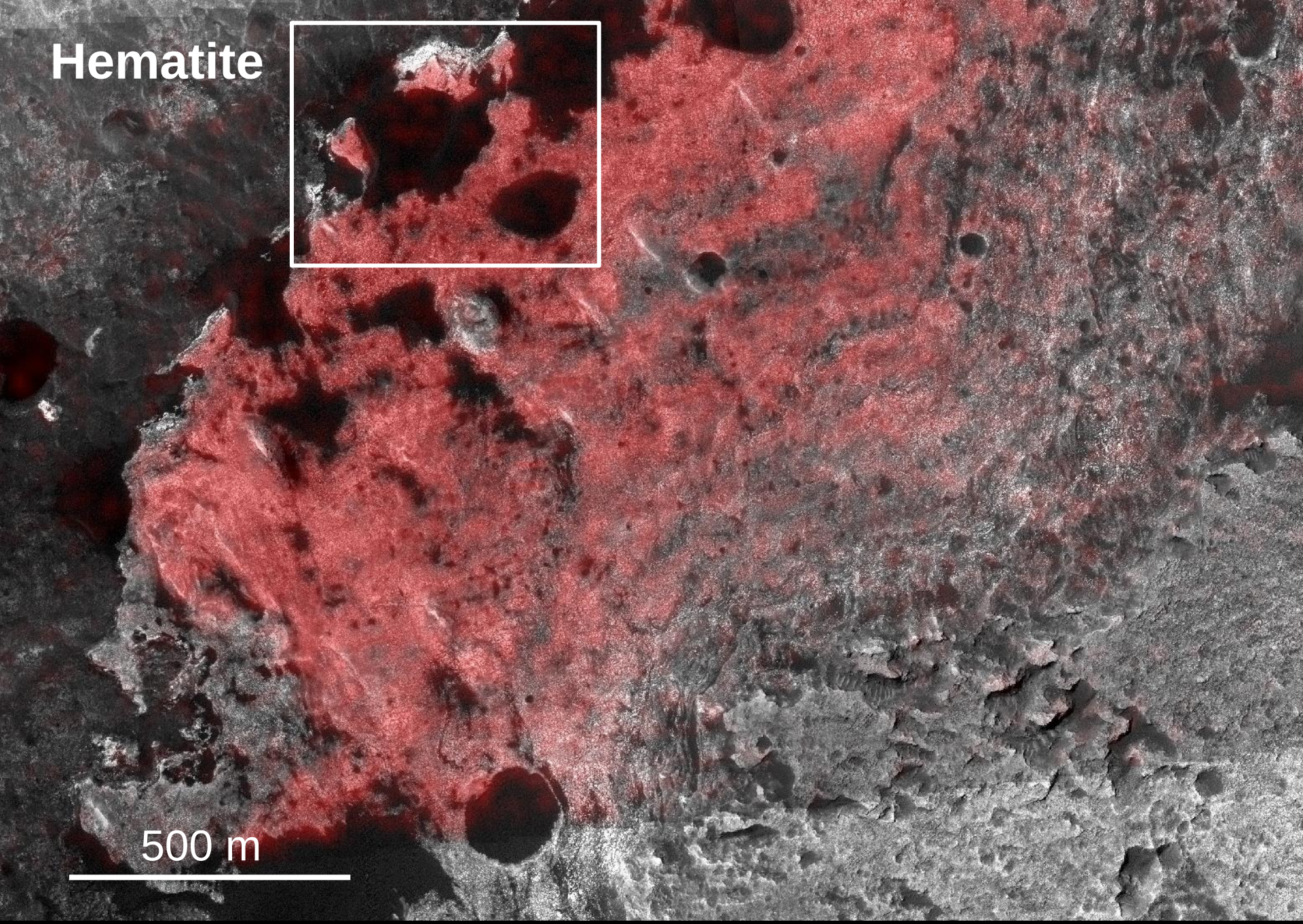
2.2 µm band depth map, Seelos et al., 2014



- Spectral signature of hydroxylated silica associated with polygonal fractured light toned terrain near base of Murray formation
- Outcrop large enough to resolve with FRT CRISM data
- Relationship between this outcrop and Murray formation unclear due to dune field cover

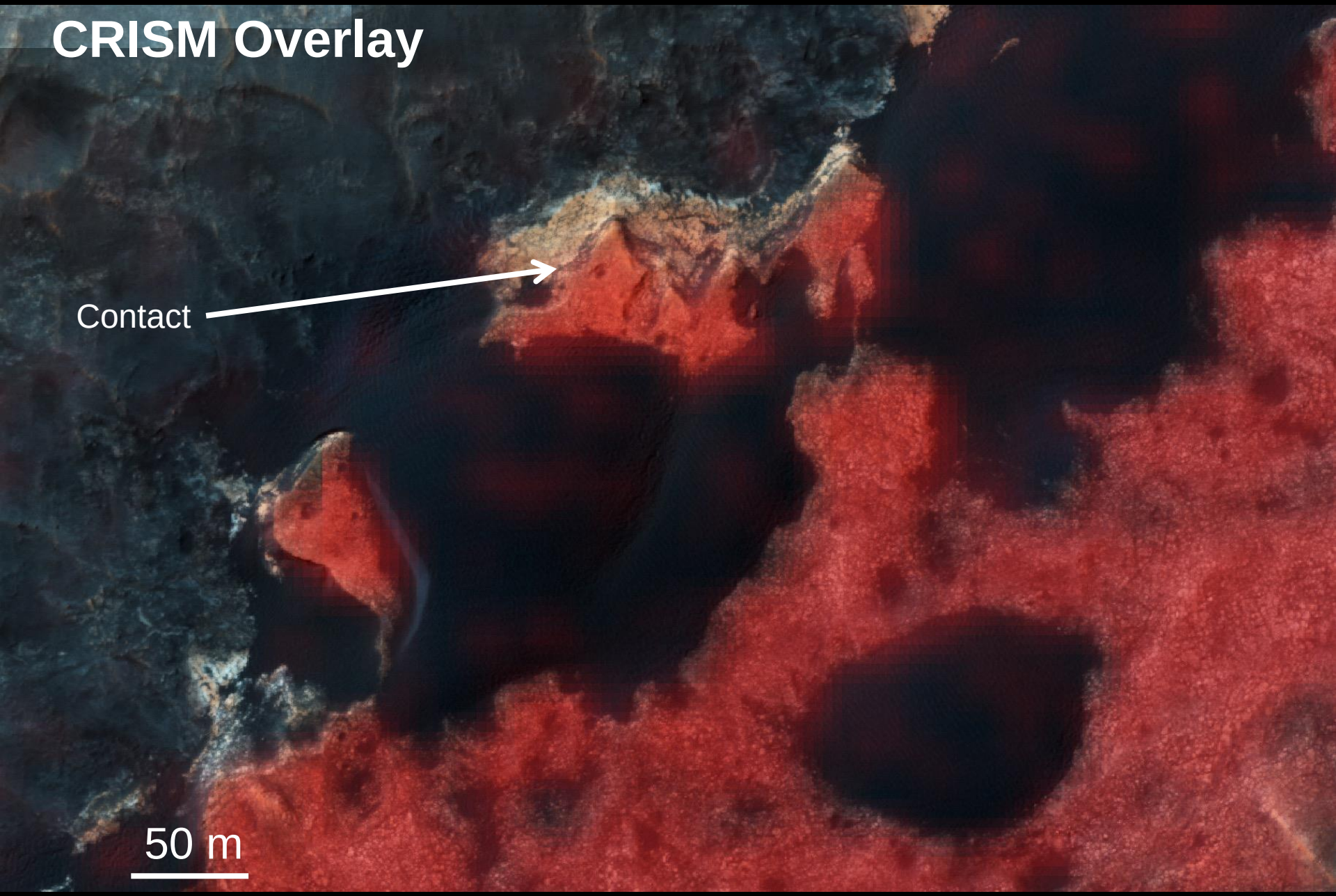
Secondary Phases



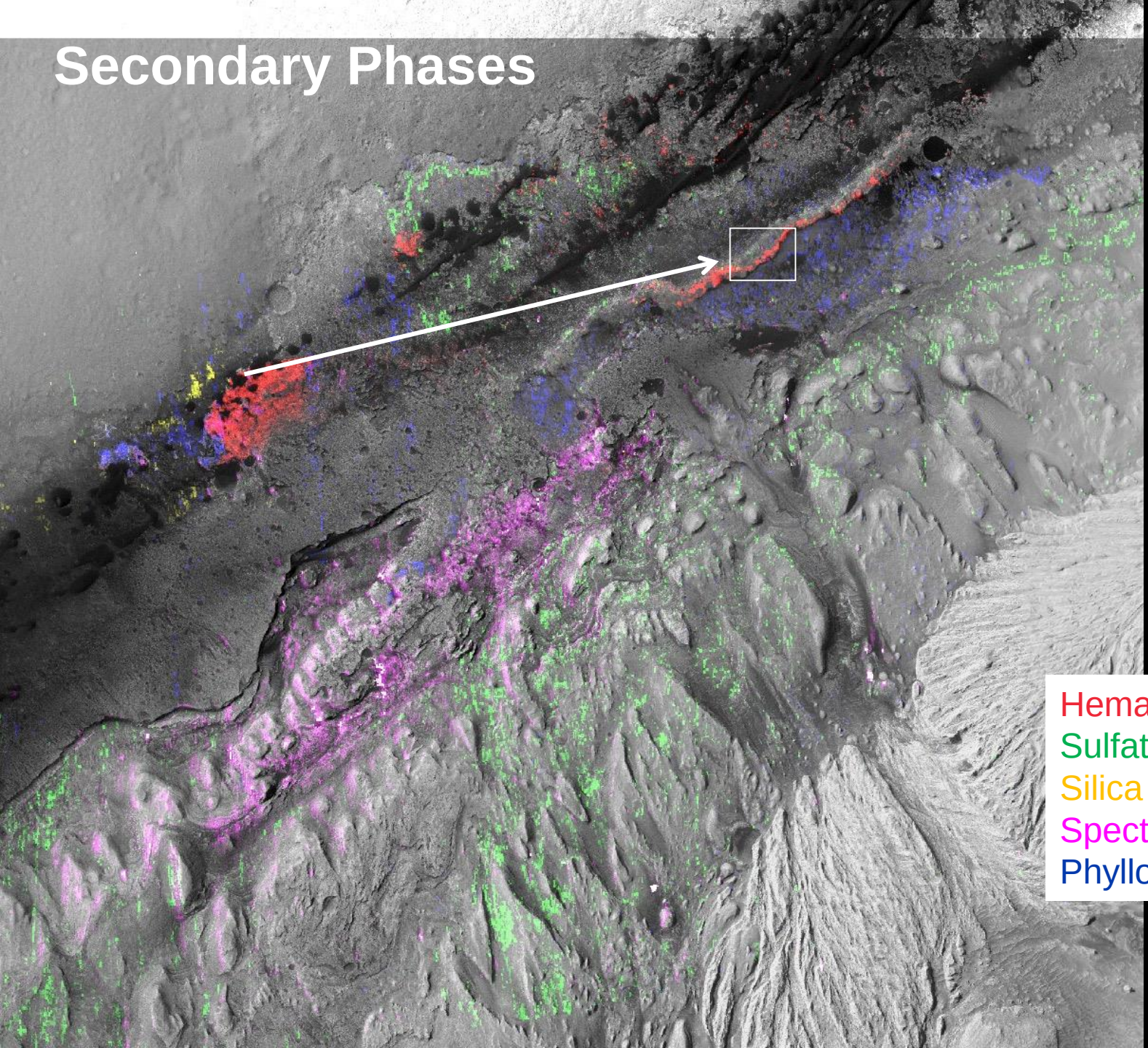

Hematite
500 m

HiRISE Color

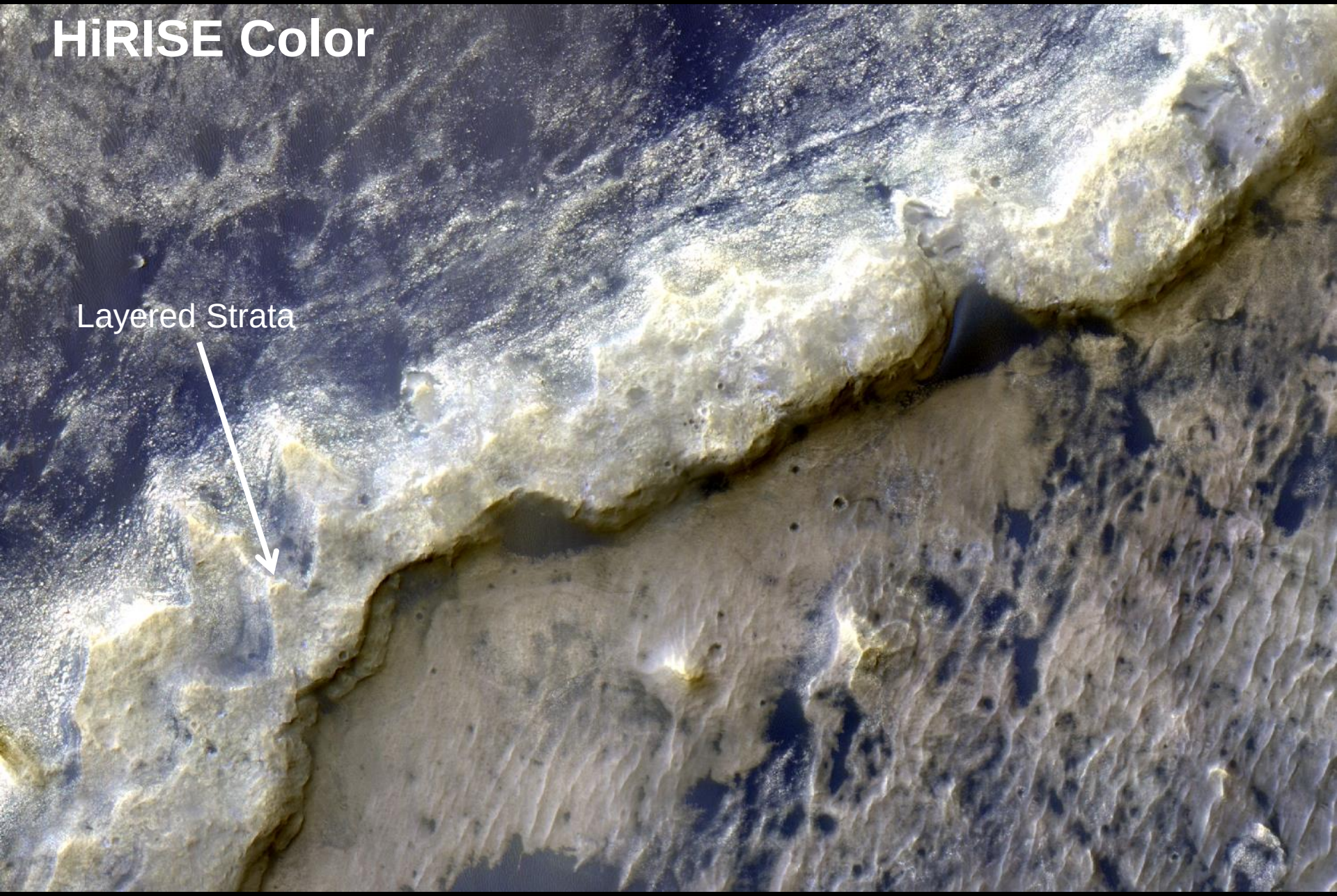
CRISM Overlay



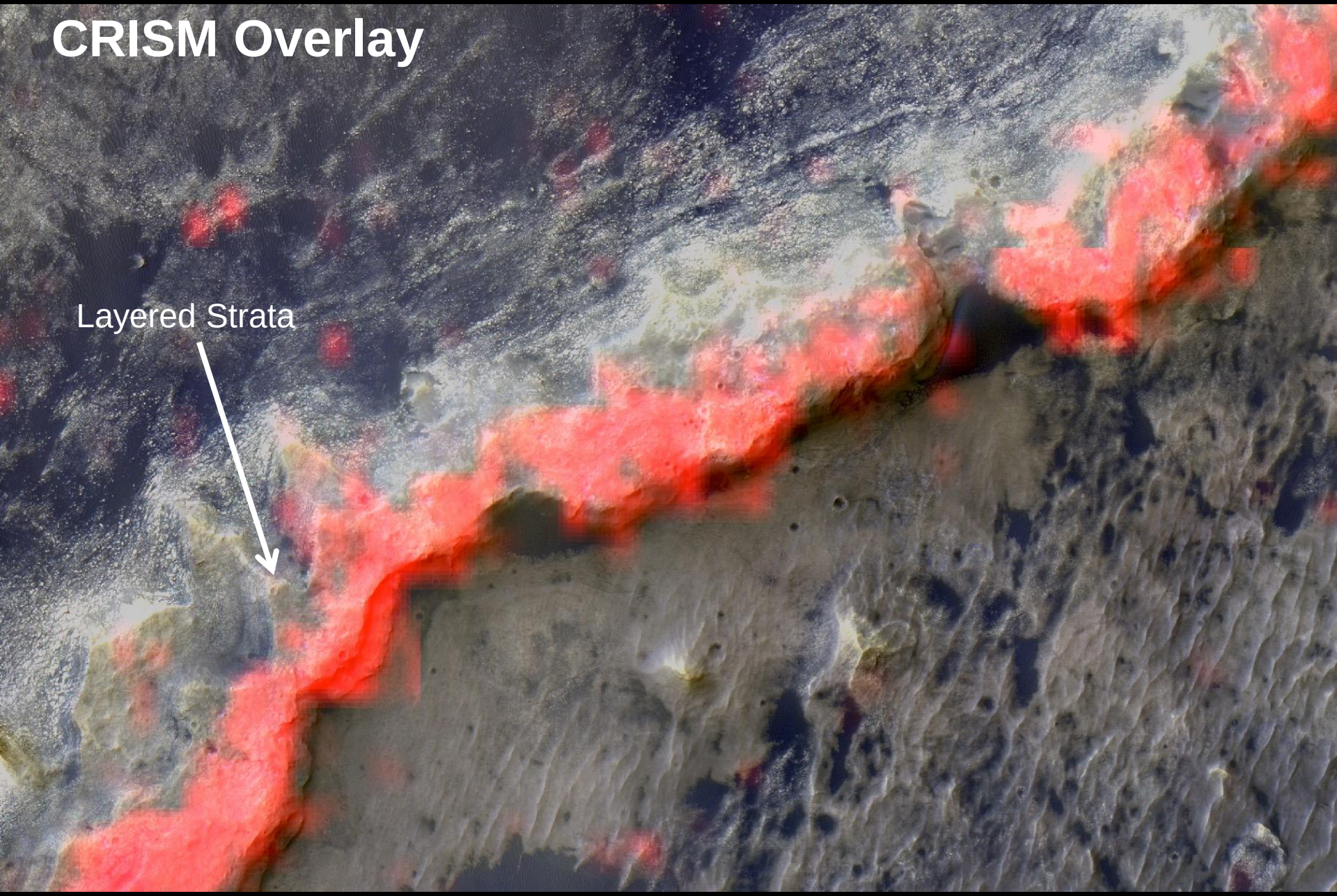
Secondary Phases



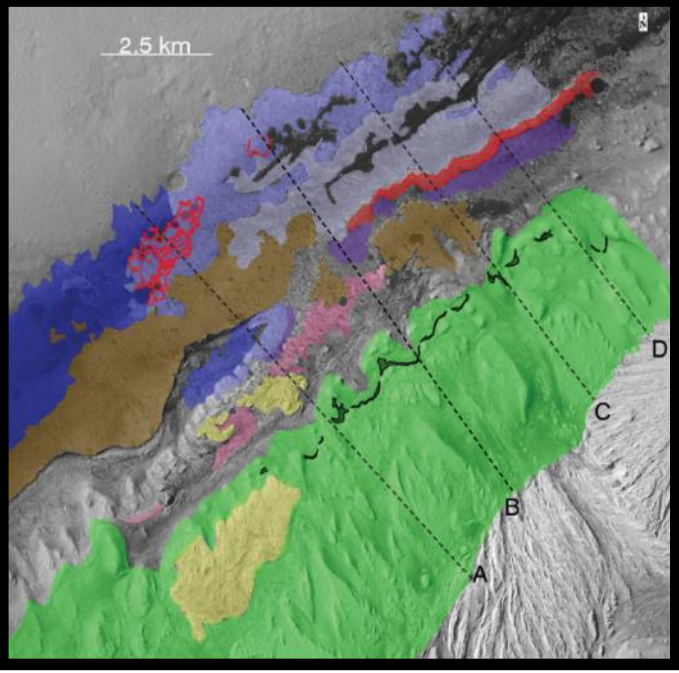
HiRISE Color



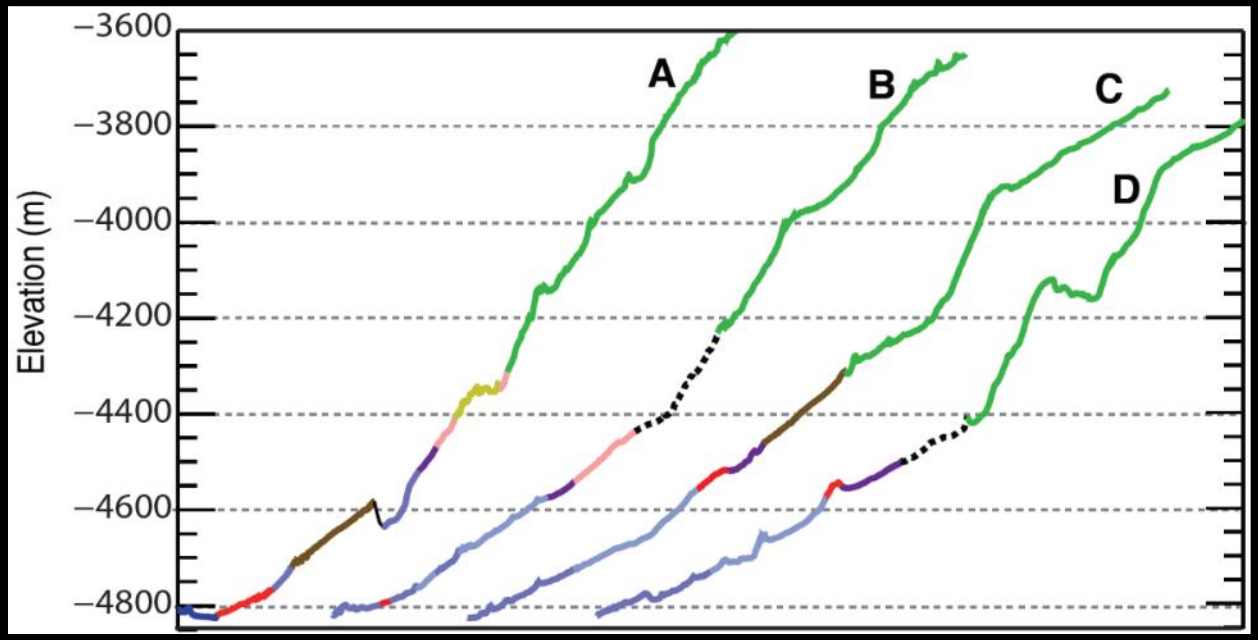
CRISM Overlay

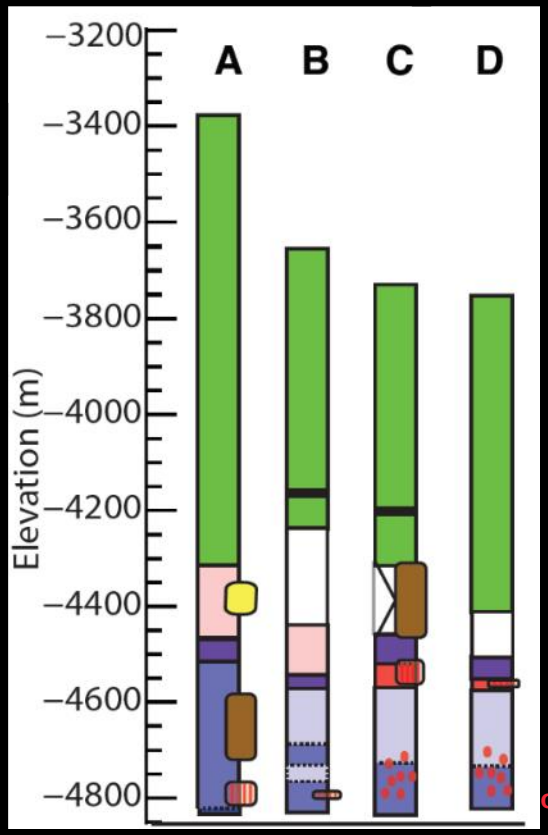


Units versus Elevation



- Murray 1 (MF1)
- Murray 2 (MF2)
- Murray 3 (MF3)
- Hematite Ridge (HR)
- Phyllosilicate Unit (PhU)
- Sub-sulfate (SS)
- Layered Sulfate (LS)
- High TI Unit 1 (HTI1)
- High TI Unit 2 (HTI2)
- Marker bed (Milliken et al., 2010)
- Large hematite deposits
- Weak hematite signature
- Not mapped



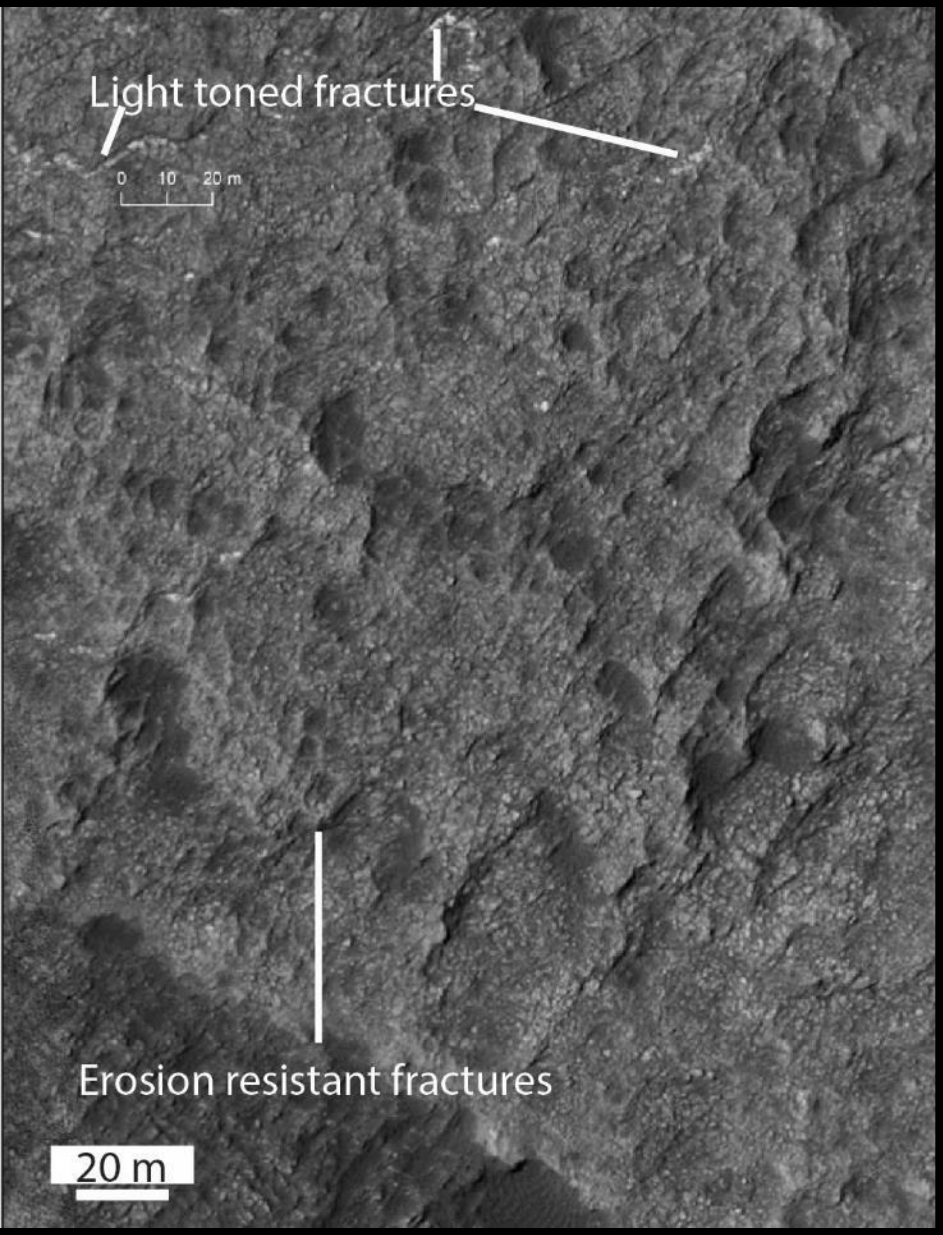


Conclusions

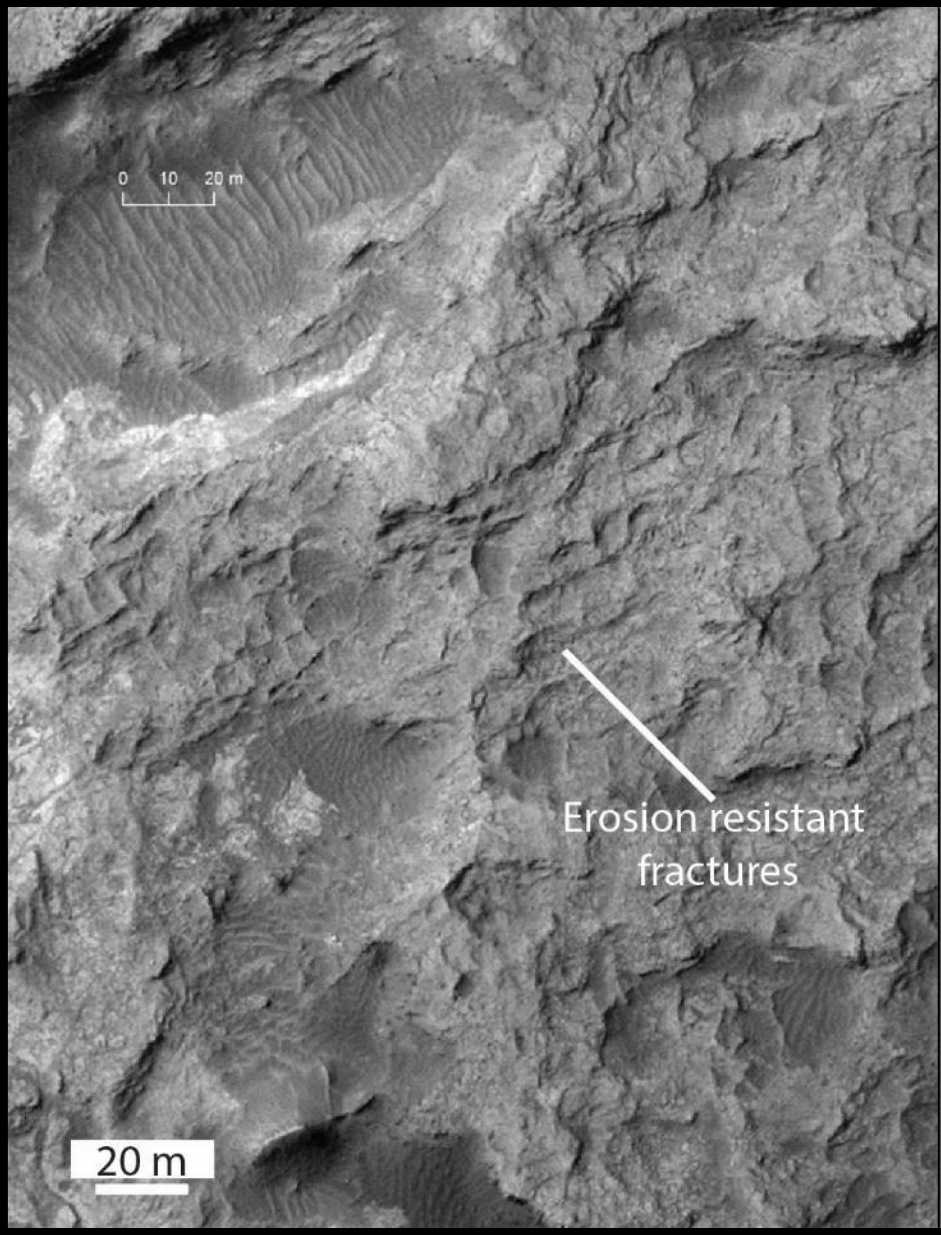
- Many Mt. Sharp layers are +/-50m of horizontal along NW corner of mound
- High thermal inertia units are younger and unconformable with primary horizontal layers, implies multiple episodes of Mt. Sharp burial and erosion
- TI variation linked with spectral (and textural) changes likely caused by variations in cementation, porosity, and sand cover
- Large spatial distribution of silica show silica enrichment was pervasive and widespread; geologic settings in orbital data consistent with rover hypotheses for multiple stages of silica enrichment (see also Frydenvang et al. Abstract #2349, Rampe et al., Abstract #2543)
- Hematite deposits stratigraphically controlled suggesting they are (1) primary depositional products or (2) formed through secondary diagenetic fluids controlled by stratigraphically residual matrix porosity or fracture porosity (see also Hurowitz et al., Abstract #1751)
- Hematite detection at multiple stratigraphic positions show redox interfaces were widespread through time and/or space during Mt. Sharp's formation

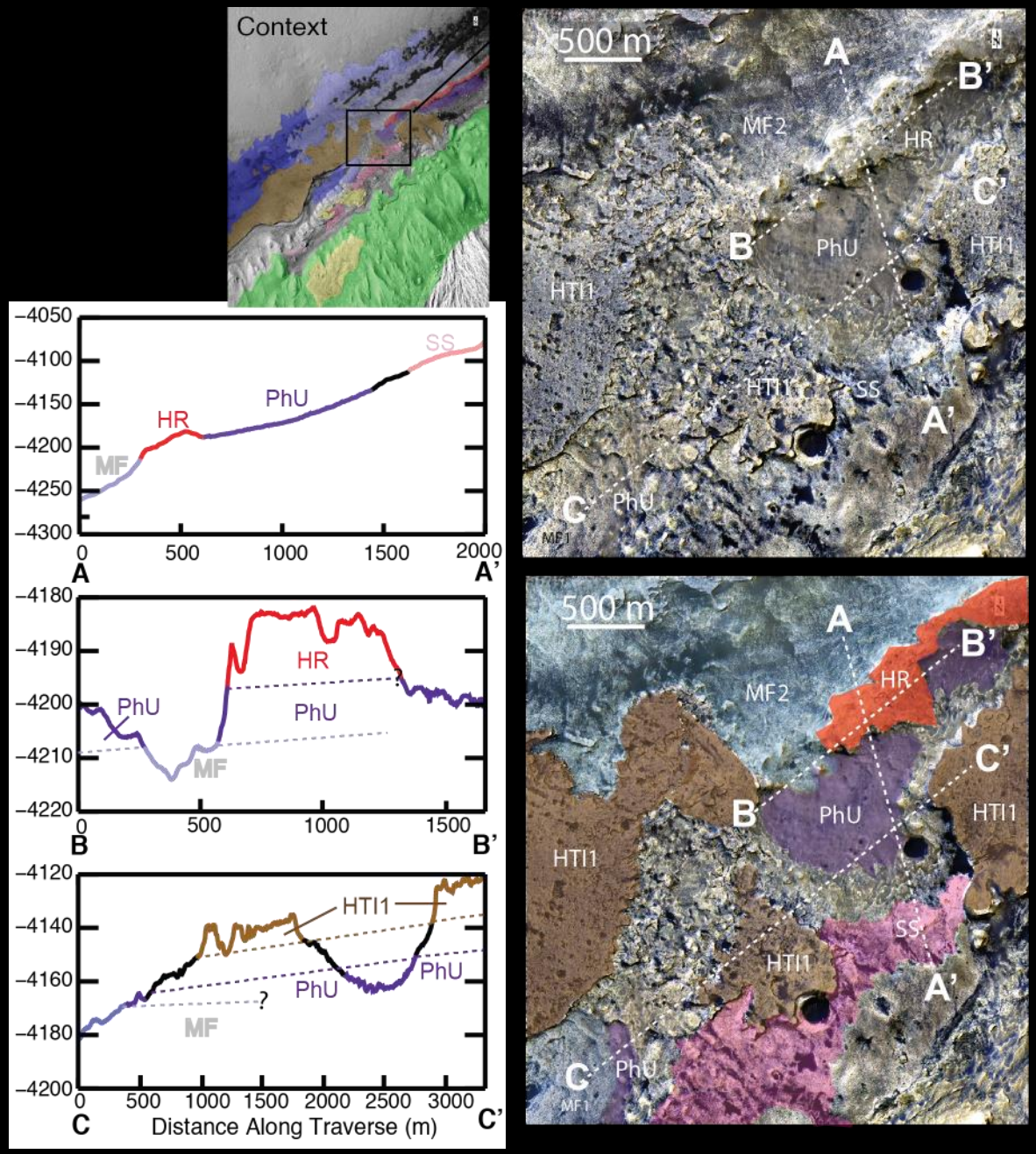
Extras

High Thermal Inertia Unit

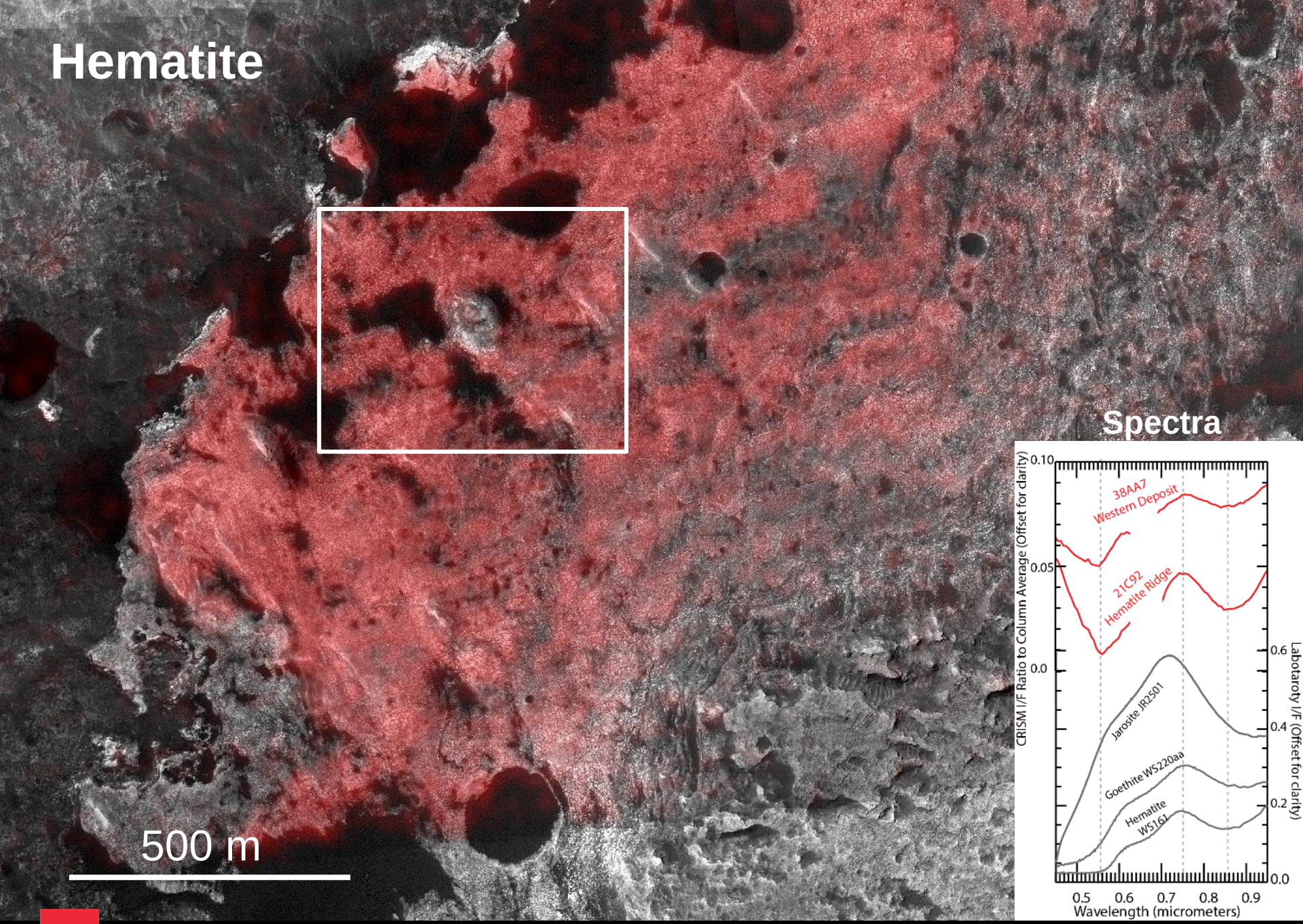


Stimson Unit




Context
500 m
A
B'
MF2
HR
C'
B
PhU
HTI1
HTI1
HTI1
SS
A'
C
PhU
MF1
500 m
A
B'
MF2
HR
C'
B
PhU
HTI1
HTI1
SS
HTI1
A'
C
PhU
MF1
SS
HR
PhU
MF
HR
PhU
PhU
MF
HTI1
PhU
PhU
?
MF
A
A'
B
B'
C
C'
Distance Along Traverse (m)

Hematite

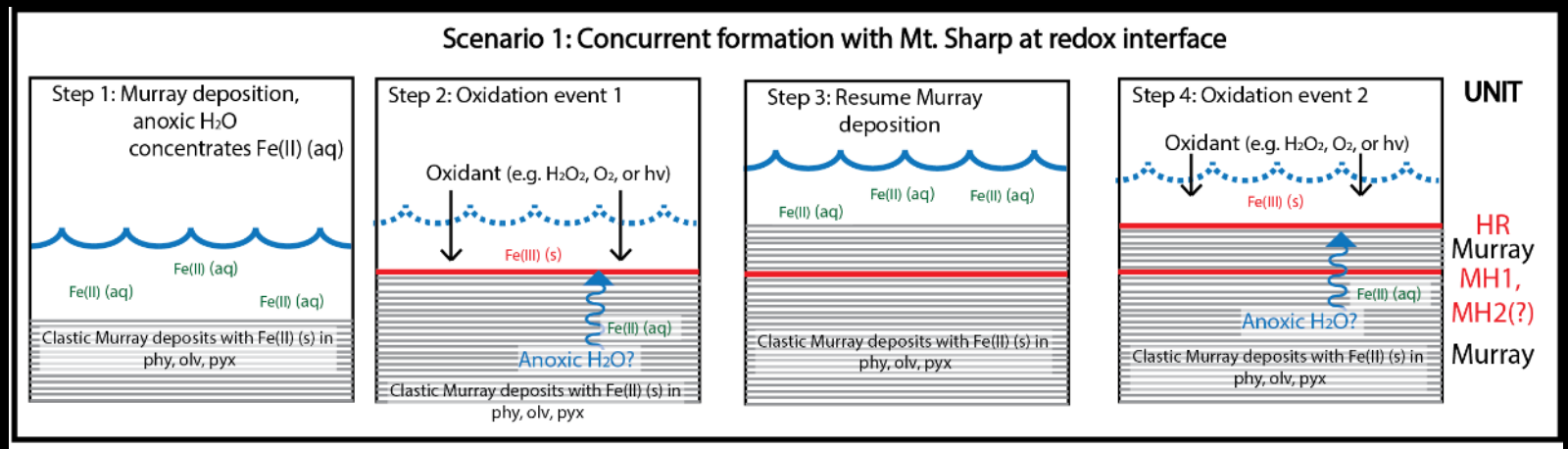


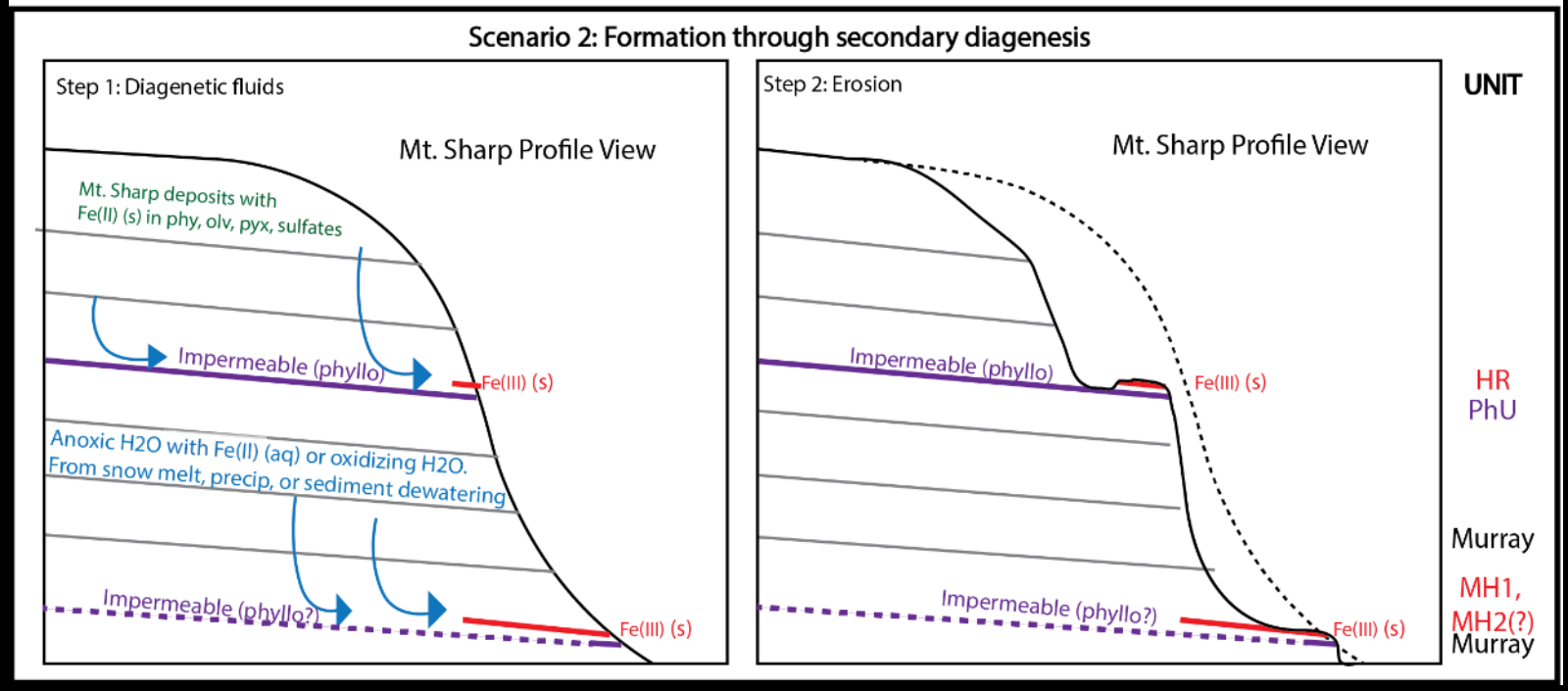
Spectra

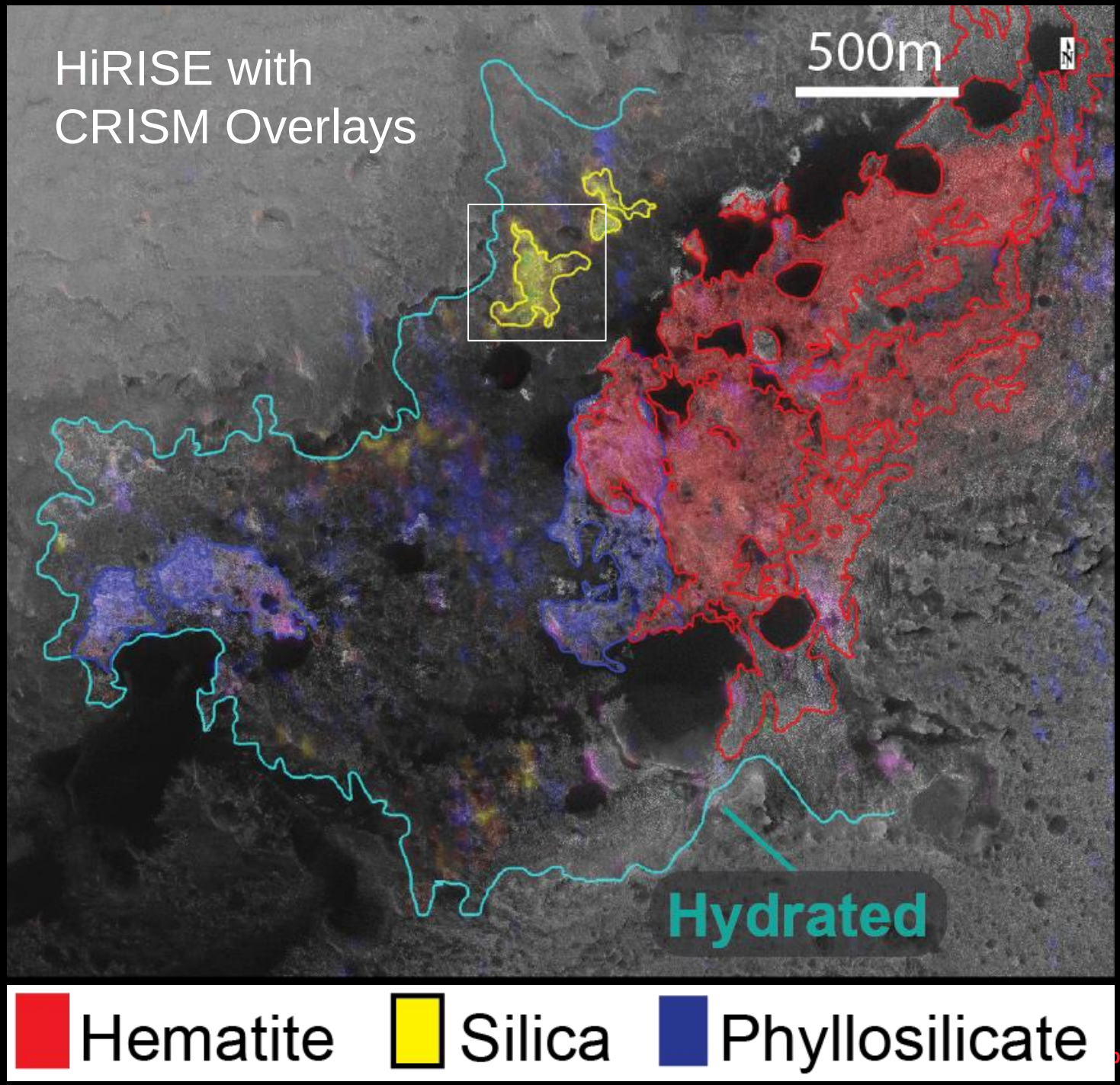
HiRISE Color

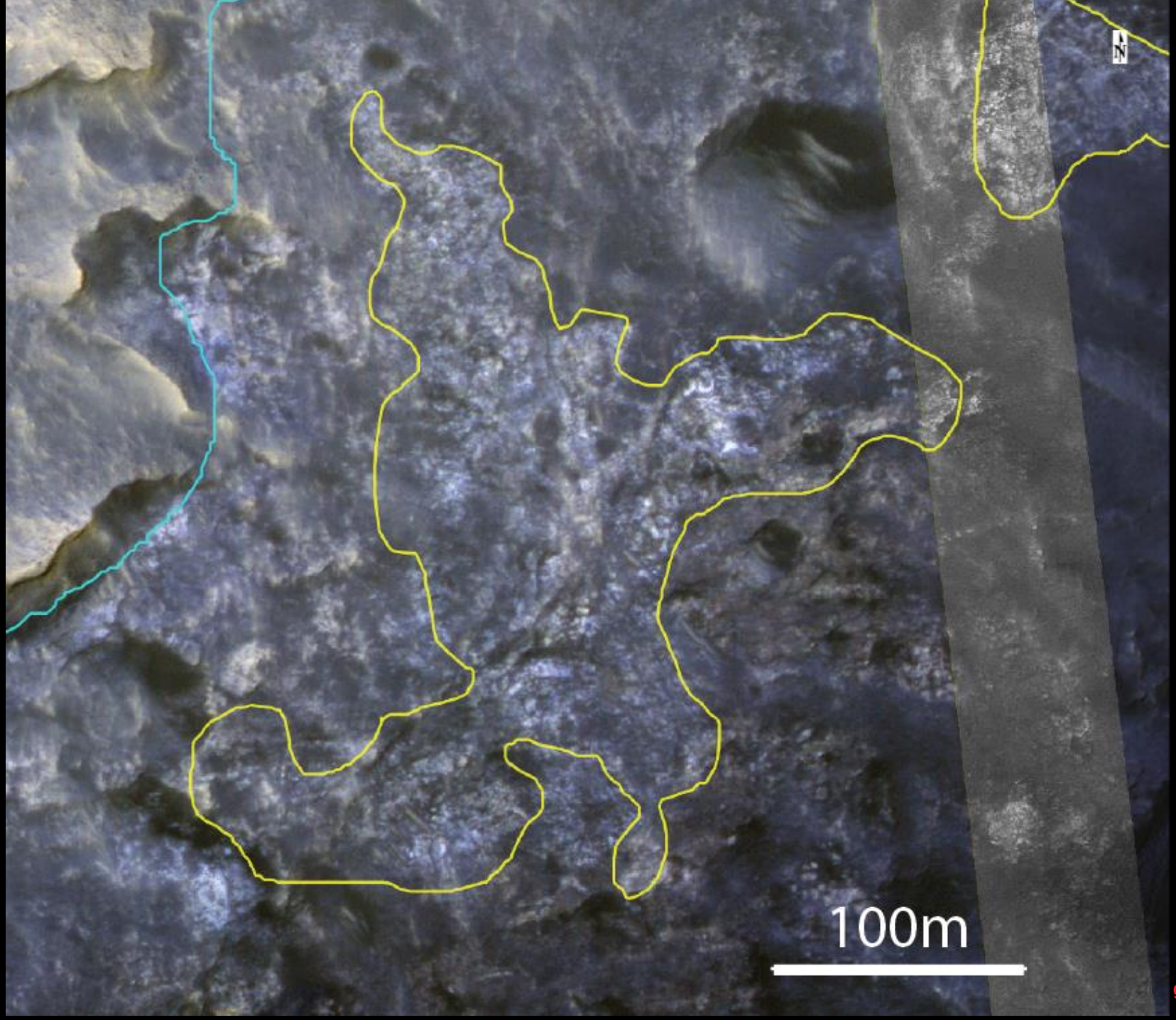
CRISM Overlay

Formation Scenarios






HiRISE with
CRISM Overlays
500m
N
Hydrated
Hematite
Silica
Phyllosilicate



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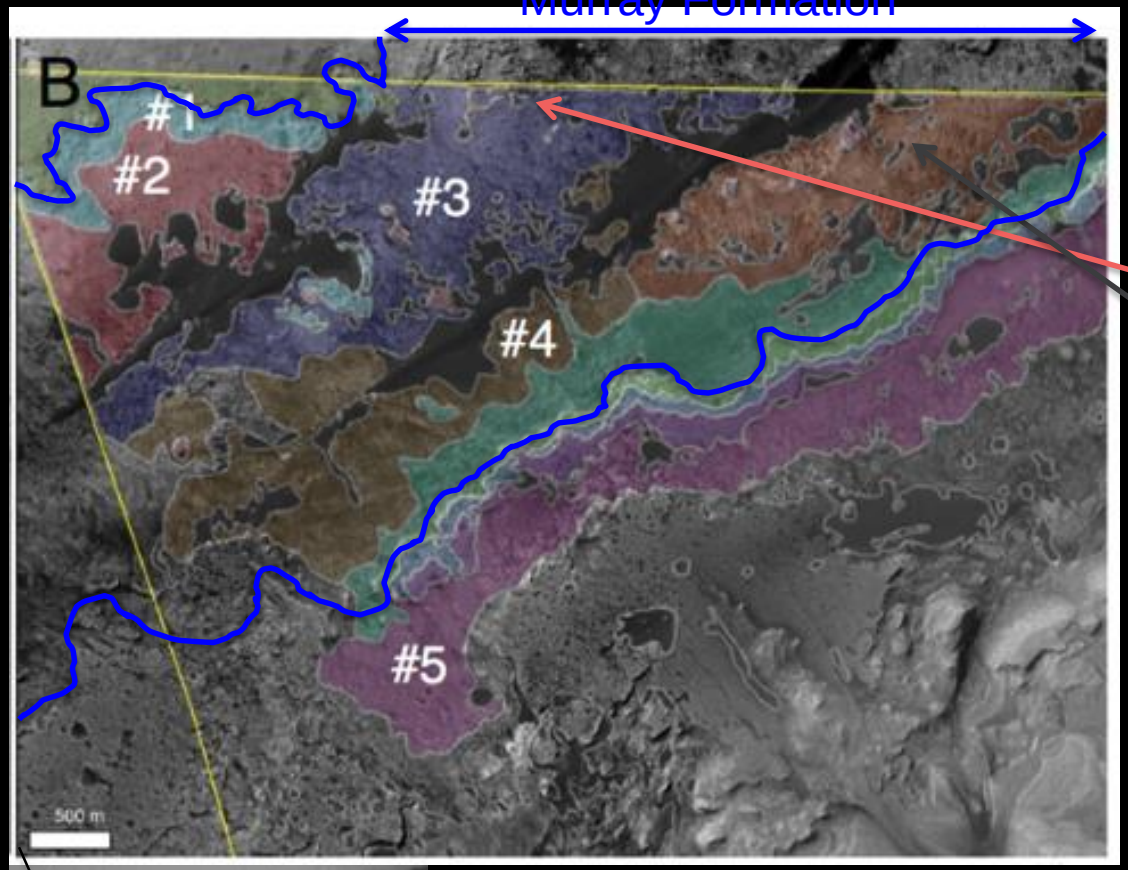
Detection #2: Average Murray Formation spectrum



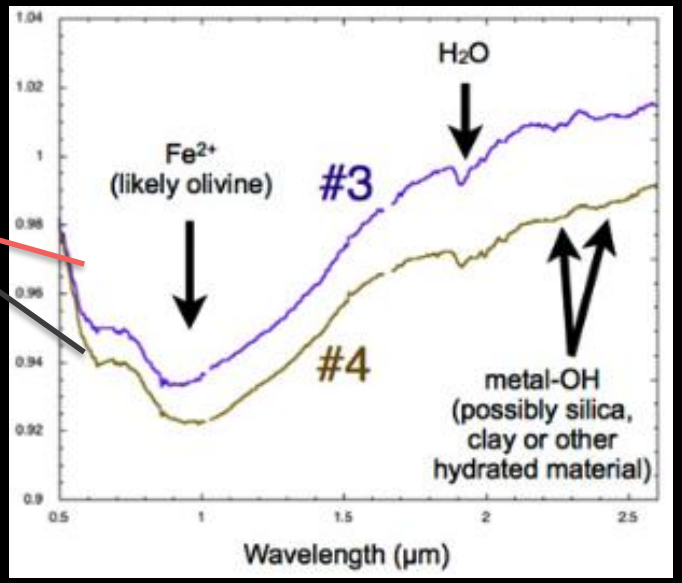
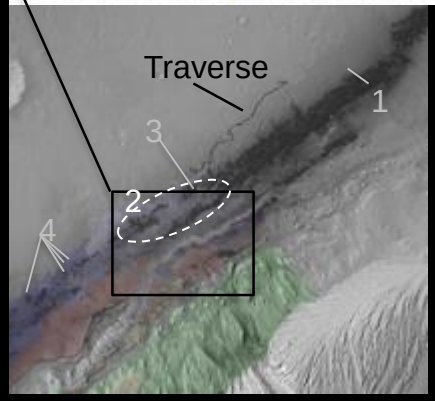
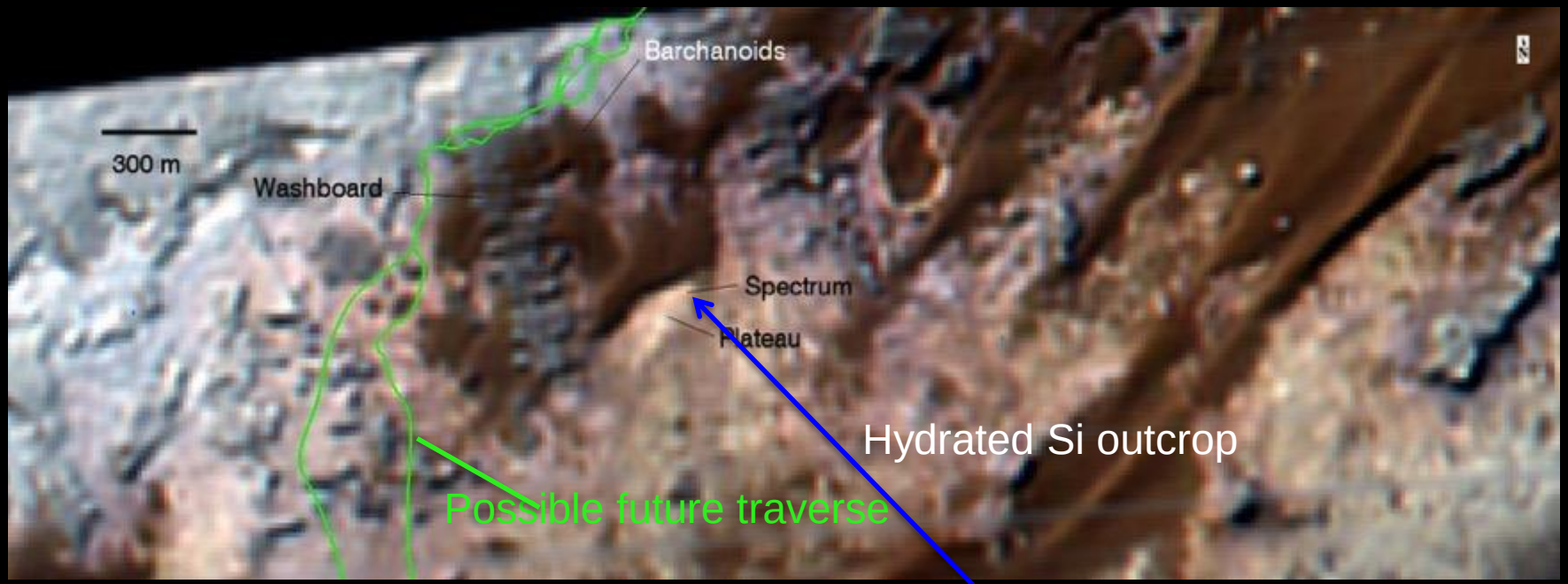
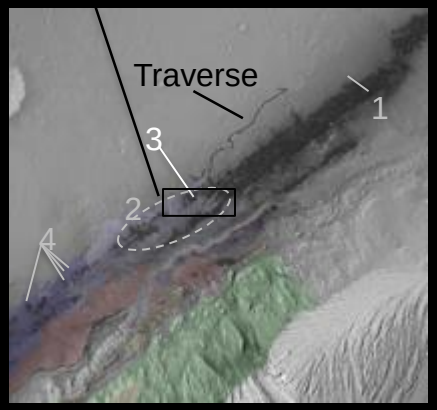


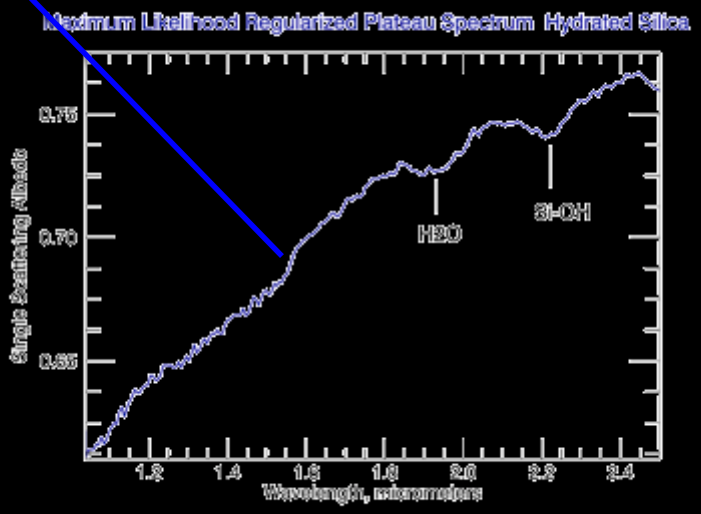
Fig. from MSL Extended Mission Proposal, spectrum courtesy R. Milliken



- Small outcrops, mixing with other phases, + CRISM noise makes identification of individual Si-OH bearing outcrops within middle Murray formation a challenge


Barchanoids
300 m
Washboard
Spectrum
Plateau
Hydrated Si outcrop
Possible future traverse


Traverse
1
3
2
4


Maximum Likelihood Regularized Plateau Spectrum Hydrated Silica
H2O
Si-OH
Wavelength, micrometers

Jet Propulsion Laboratory
California Institute of Technology

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