The Evolution of Lower Mt. Sharp: An Orbital Perspective

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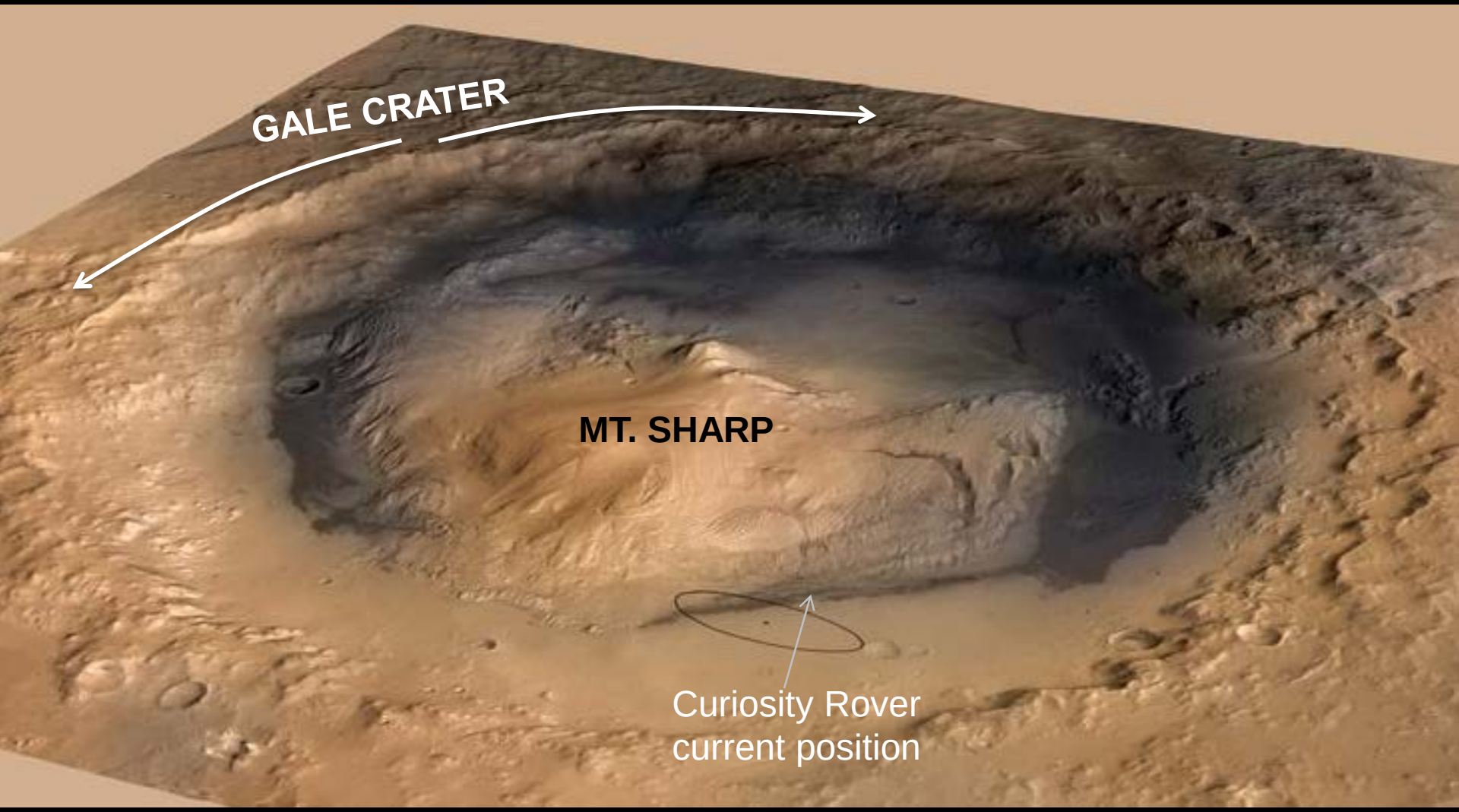
Jet Propulsion Laboratory
California Institute of Technology

Setting the Scene: Gale Crater and Mt. Sharp



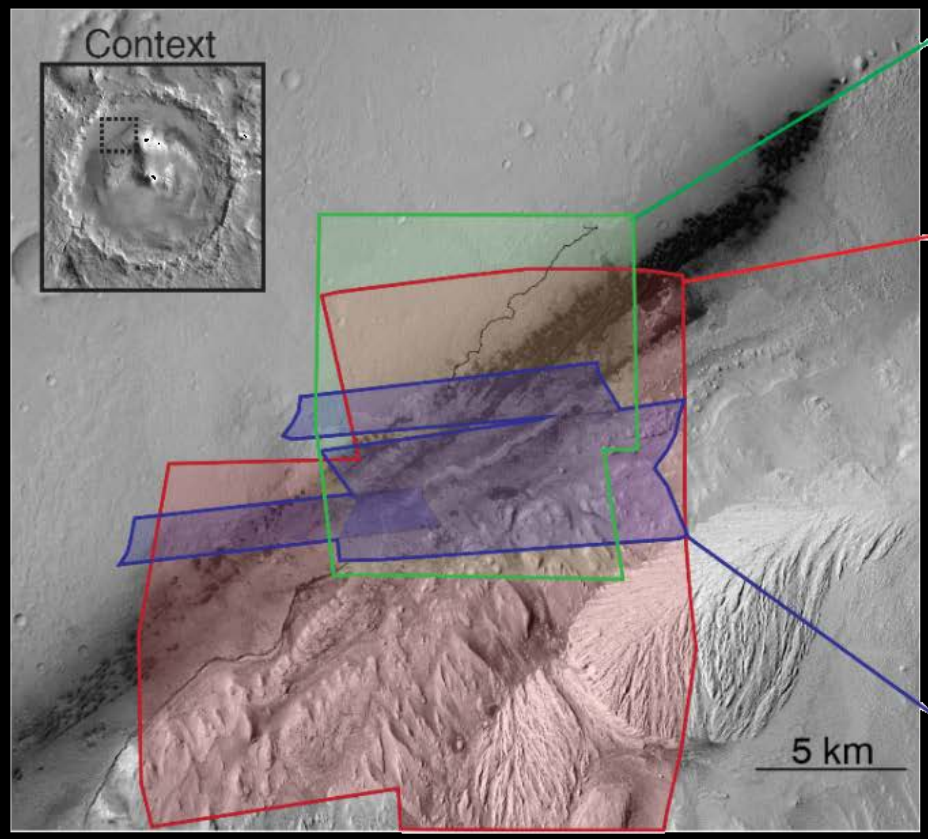
Curiosity's primary scientific goal is to explore and quantitatively assess a local region on Mars' surface as a potential habitat for life, past or present

Synergistic Rover and Orbital Data

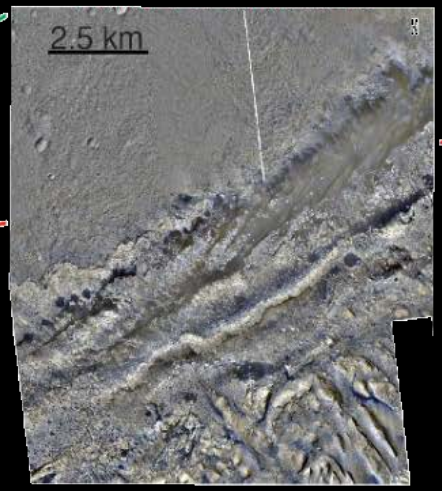
- Orbital-based maps over Mt. Sharp are key tools for
  - contextualizing Curiosity's exploration
  - reconstructing time-ordered events in Mt. Sharp evolution
- We examine newly derived, highest resolution orbital data and co-analysis of integrated datasets to generate detailed maps
- Incorporate observations 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

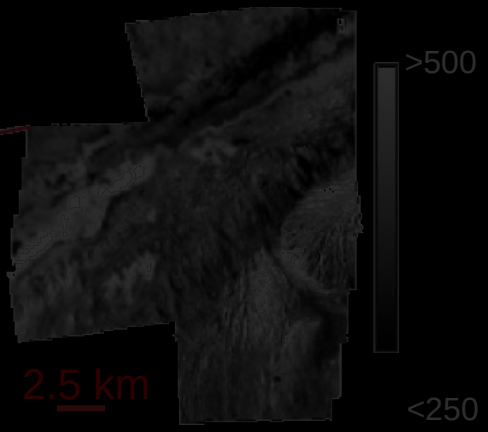
High-resolution orbital data products

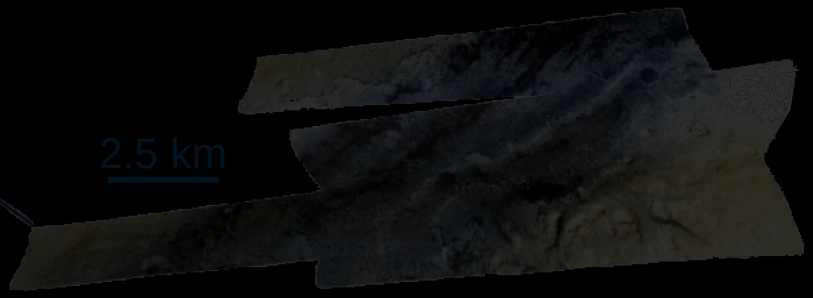


MORPHOLOGY
HiRISE
Color Mosaic



THERMOPHYSICAL PROPERTIES
THEMIS
Thermal Inertia

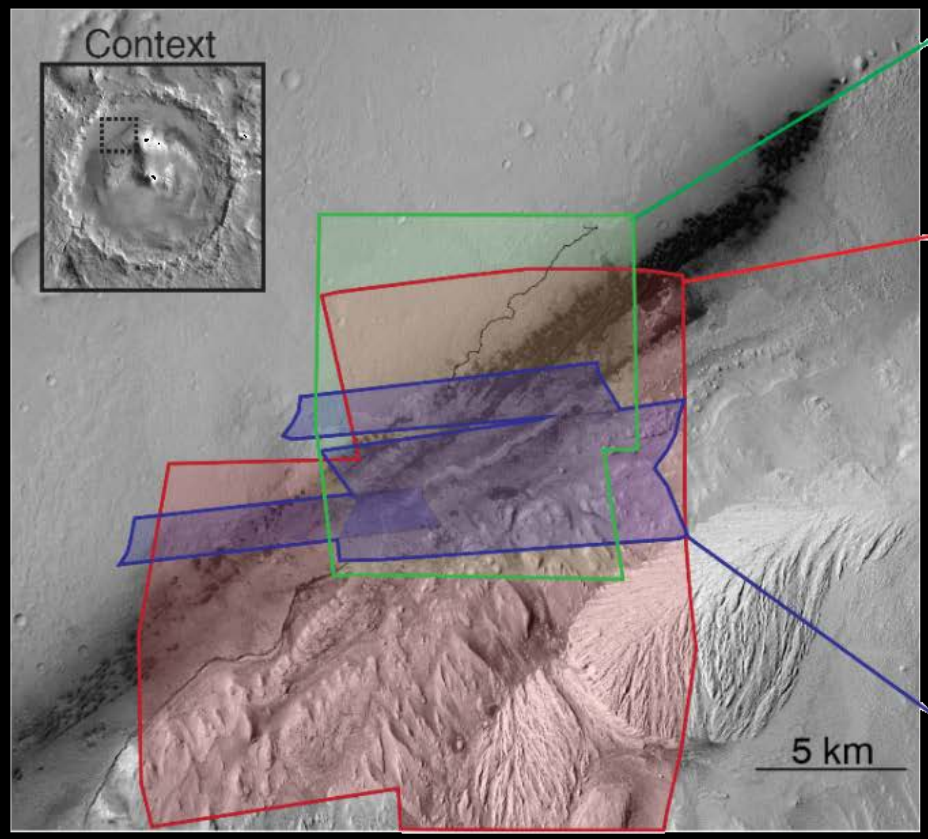




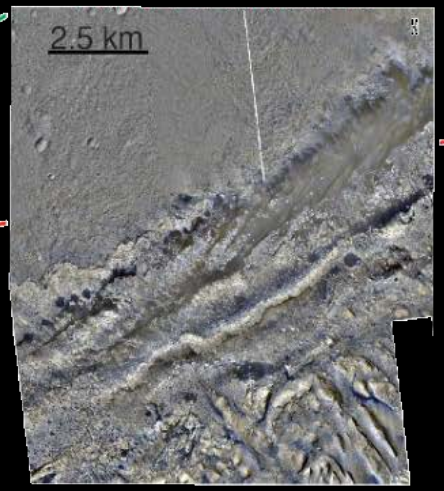
COMPOSITION
CRISM
Along-Track Oversampled Mosaic

Orbital Datasets

High-resolution orbital data products



MORPHOLOGY
HiRISE
Color Mosaic



THERMOPHYSICAL PROPERTIES
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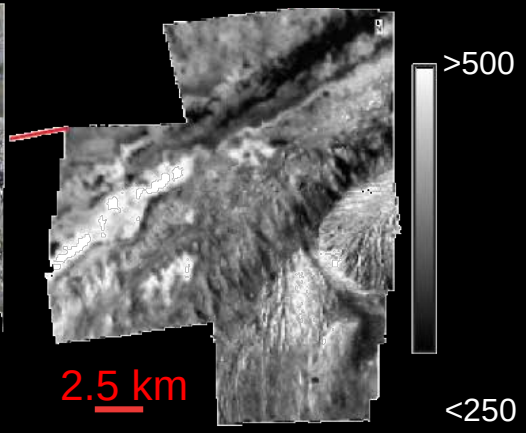
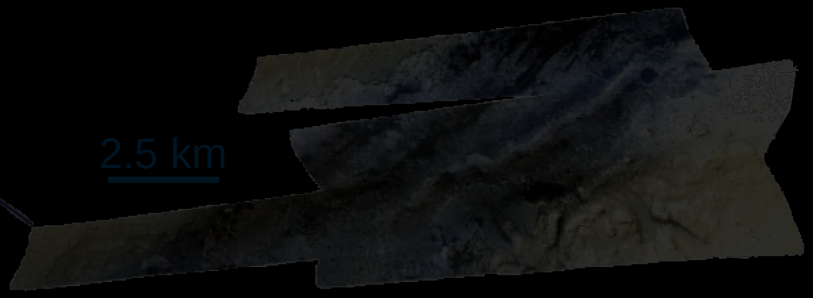
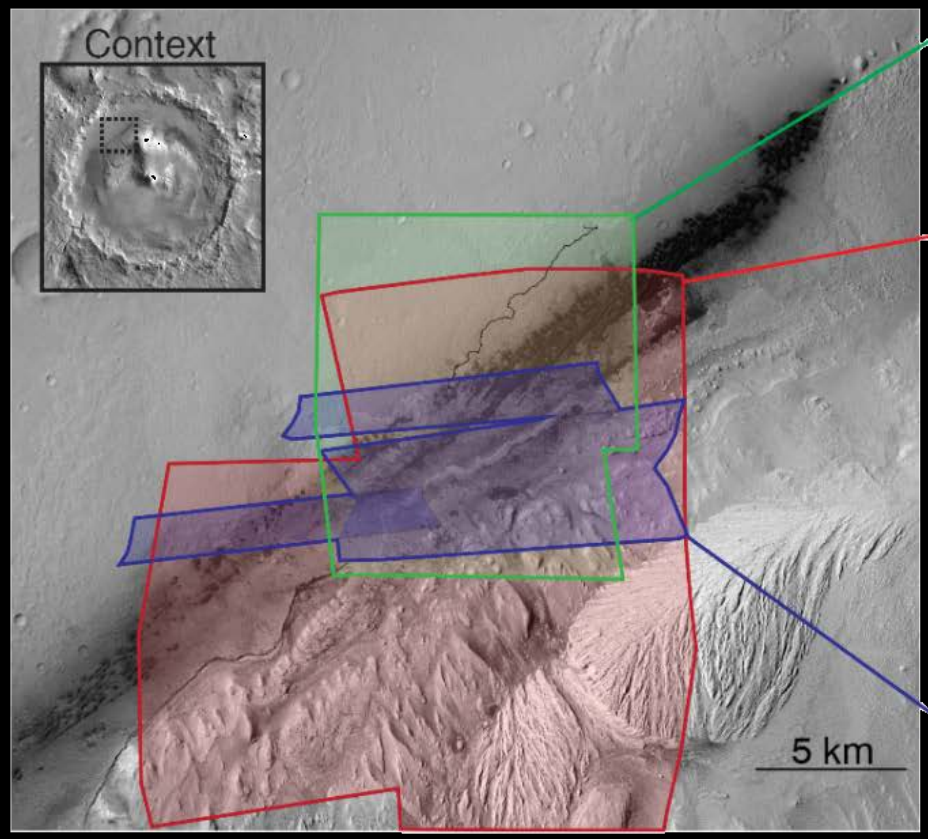




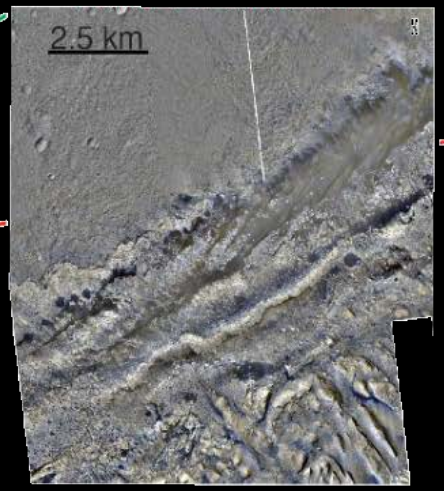
COMPOSITION
CRISM
Along-Track Oversampled Mosaic

Orbital Datasets

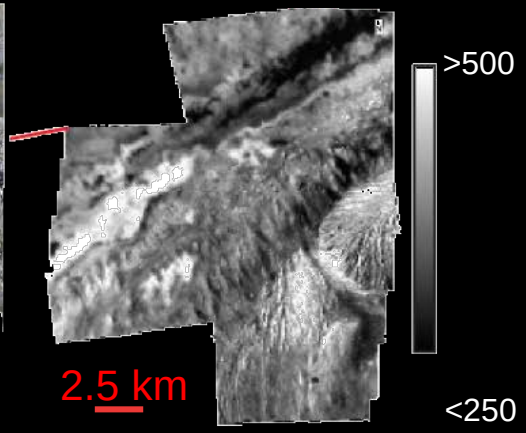
High-resolution orbital data products



MORPHOLOGY
HiRISE
Color Mosaic



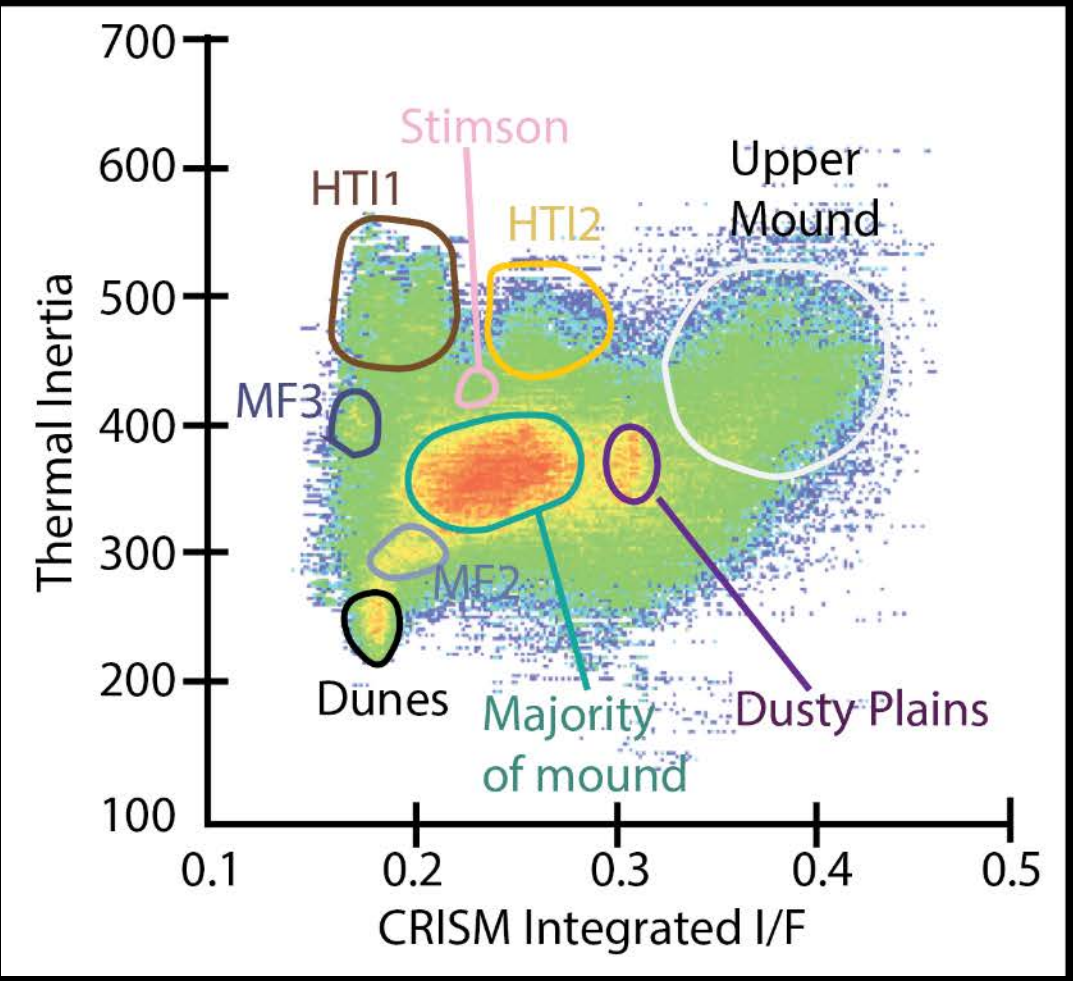
THERMOPHYSICAL PROPERTIES
THEMIS
Thermal Inertia

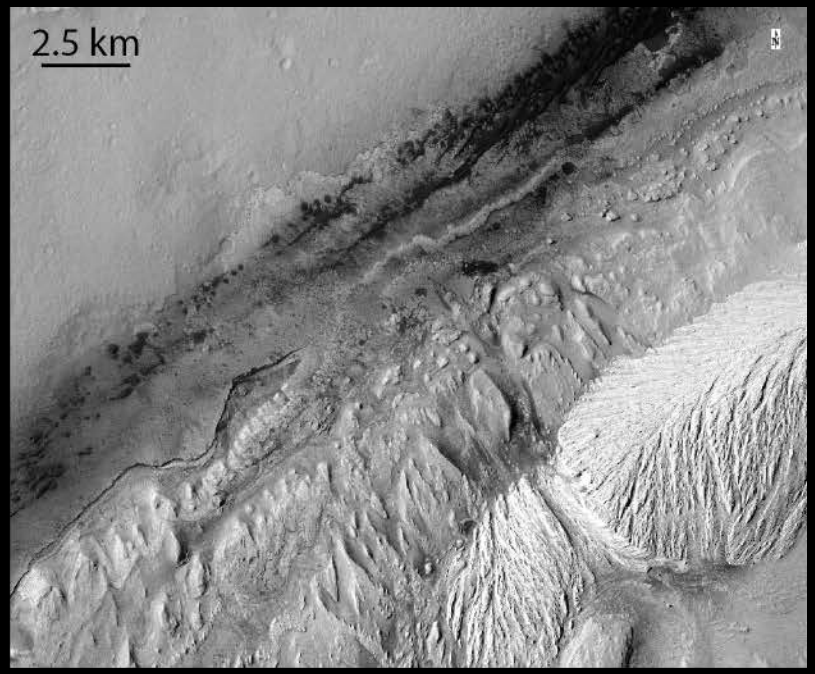


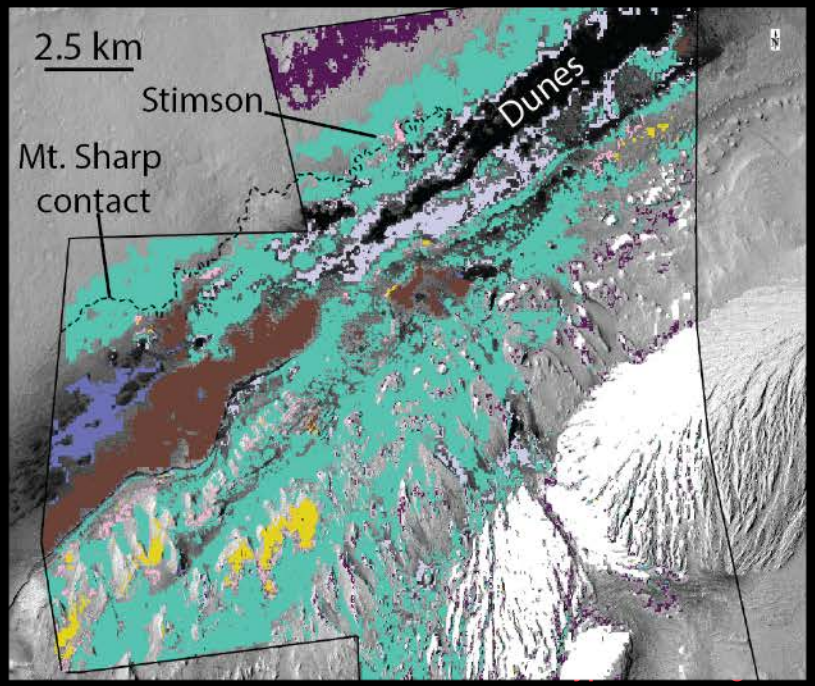
COMPOSITION
CRISM Hyperspectral Reflectance Data
Along-Track Oversampled Mosaic

Coordinated Observations

Spatial correlations between albedo and thermal inertia highlight units

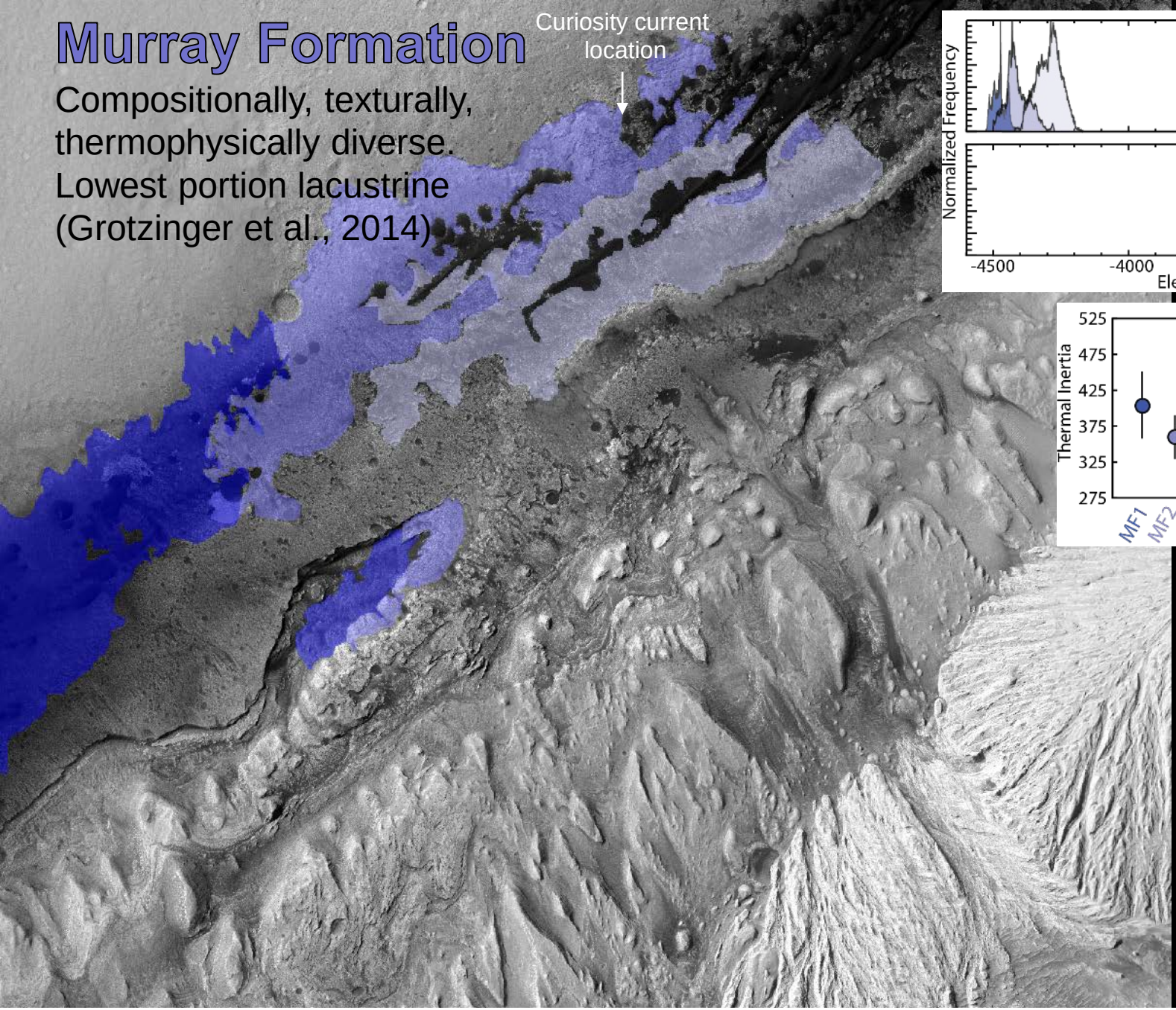


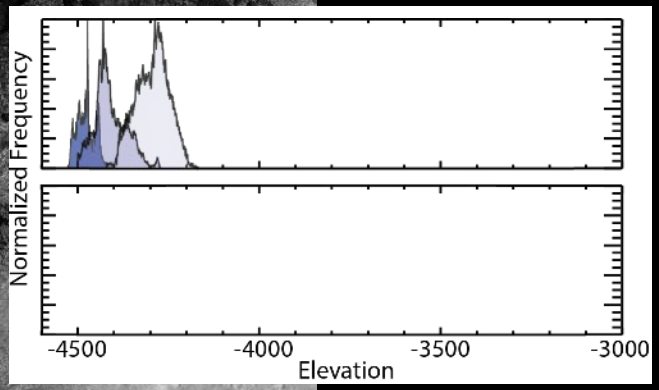


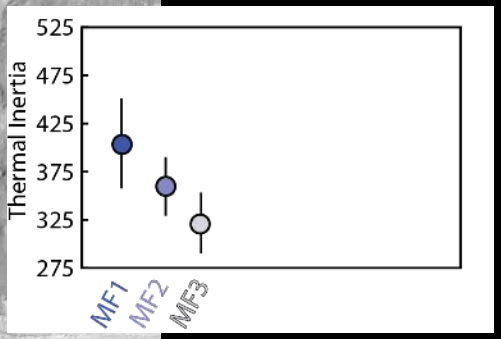


Murray Formation

Compositionally, texturally, thermophysically diverse. Lowest portion lacustrine (Grotzinger et al., 2014)





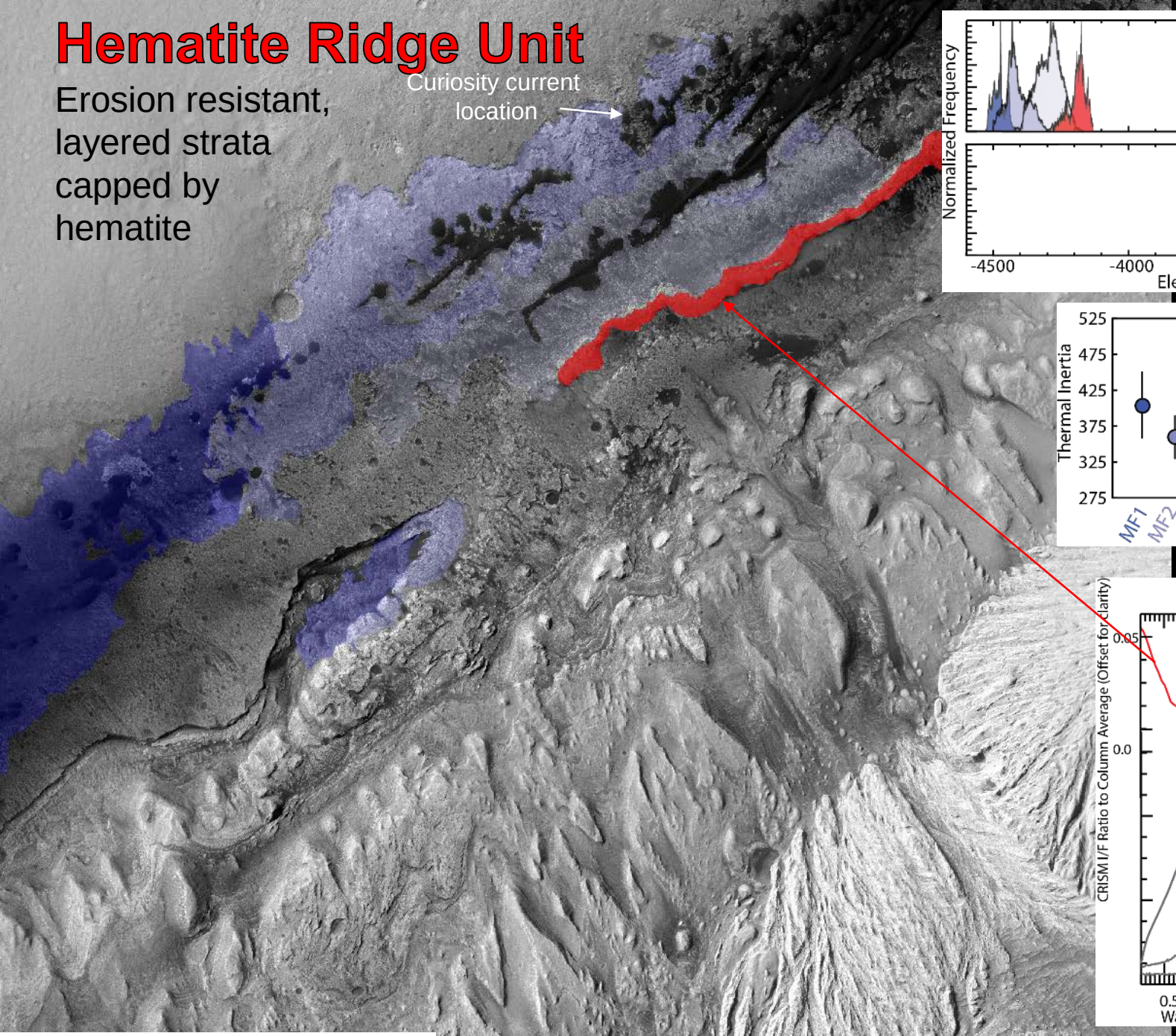


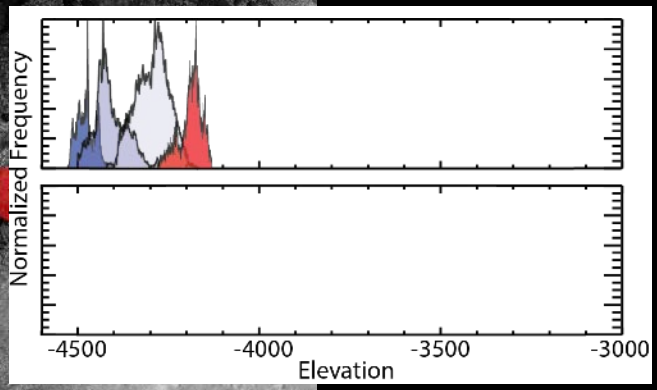
*Wide range of secondary phases throughout this unit, more details in a few slides

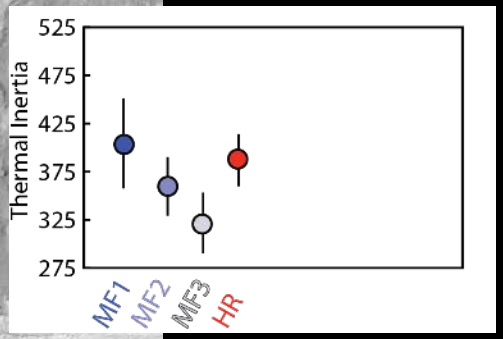
gov

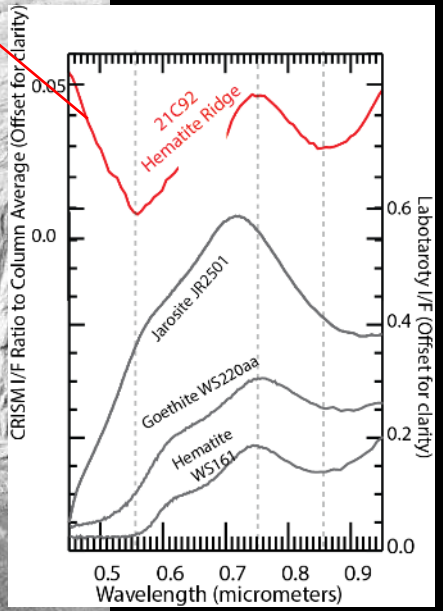
Hematite Ridge Unit

Erosion resistant, layered strata capped by hematite





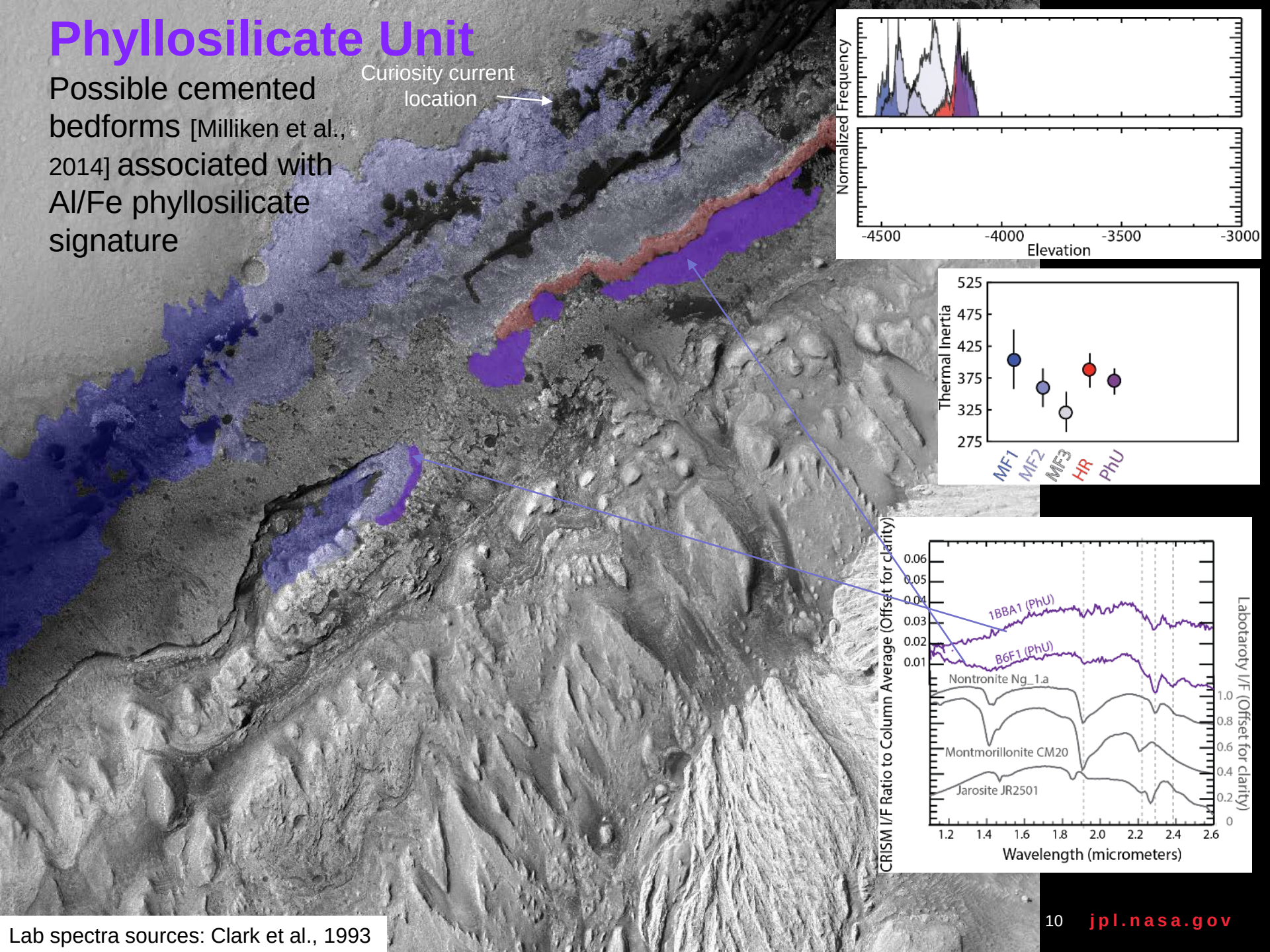




Lab spectra sources: Clark et al., 1993

Phyllosilicate Unit

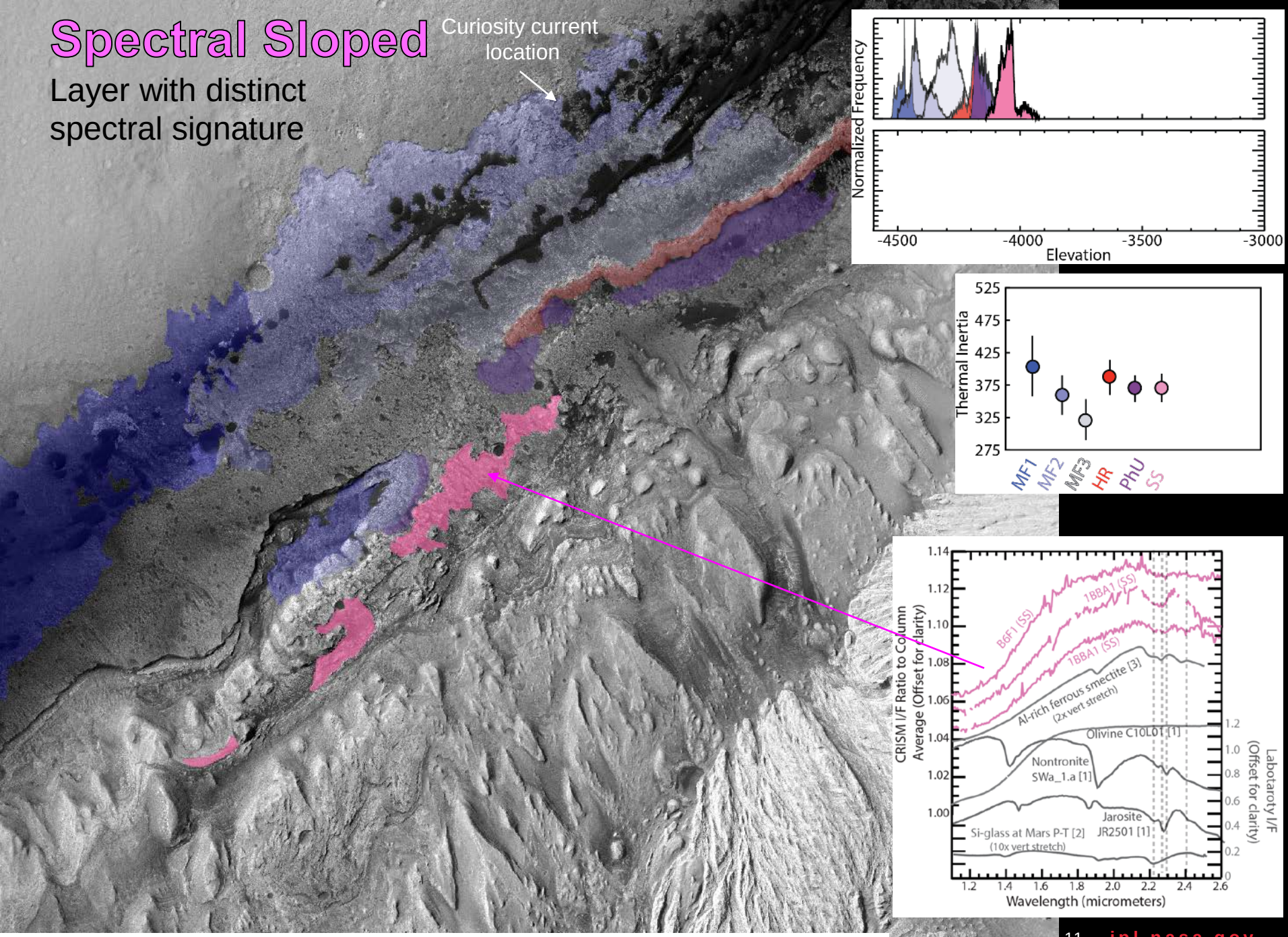
Possible cemented bedforms [Milliken et al., 2014] associated with Al/Fe phyllosilicate signature



Lab spectra sources: Clark et al., 1993

Spectral Sloped

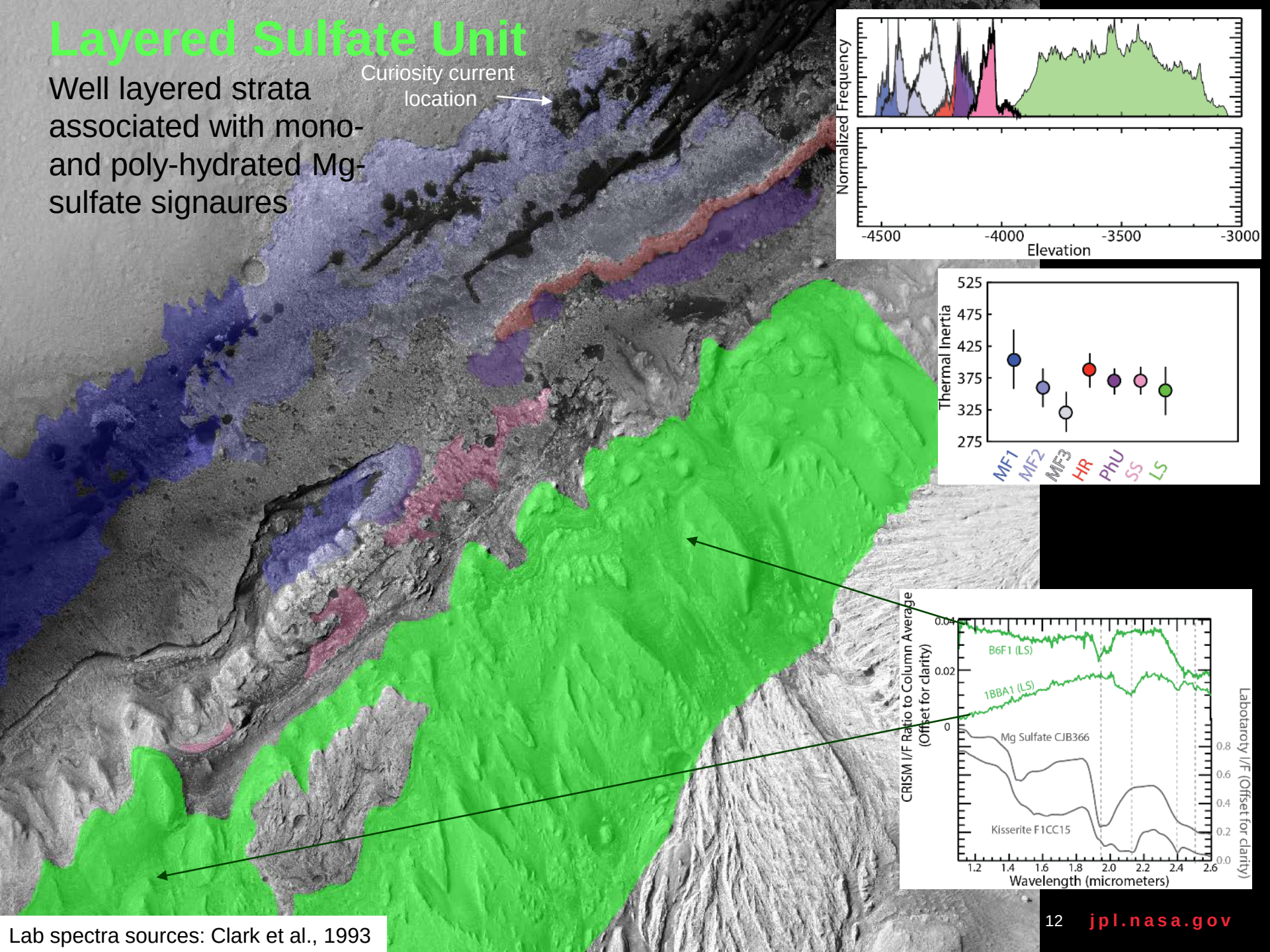
Layer with distinct spectral signature



Lab spectra sources: [1] Clark et al., 1993 [2] Swayze et al., 2007 [3] Chemtob et al., 2015

Layered Sulfate Unit

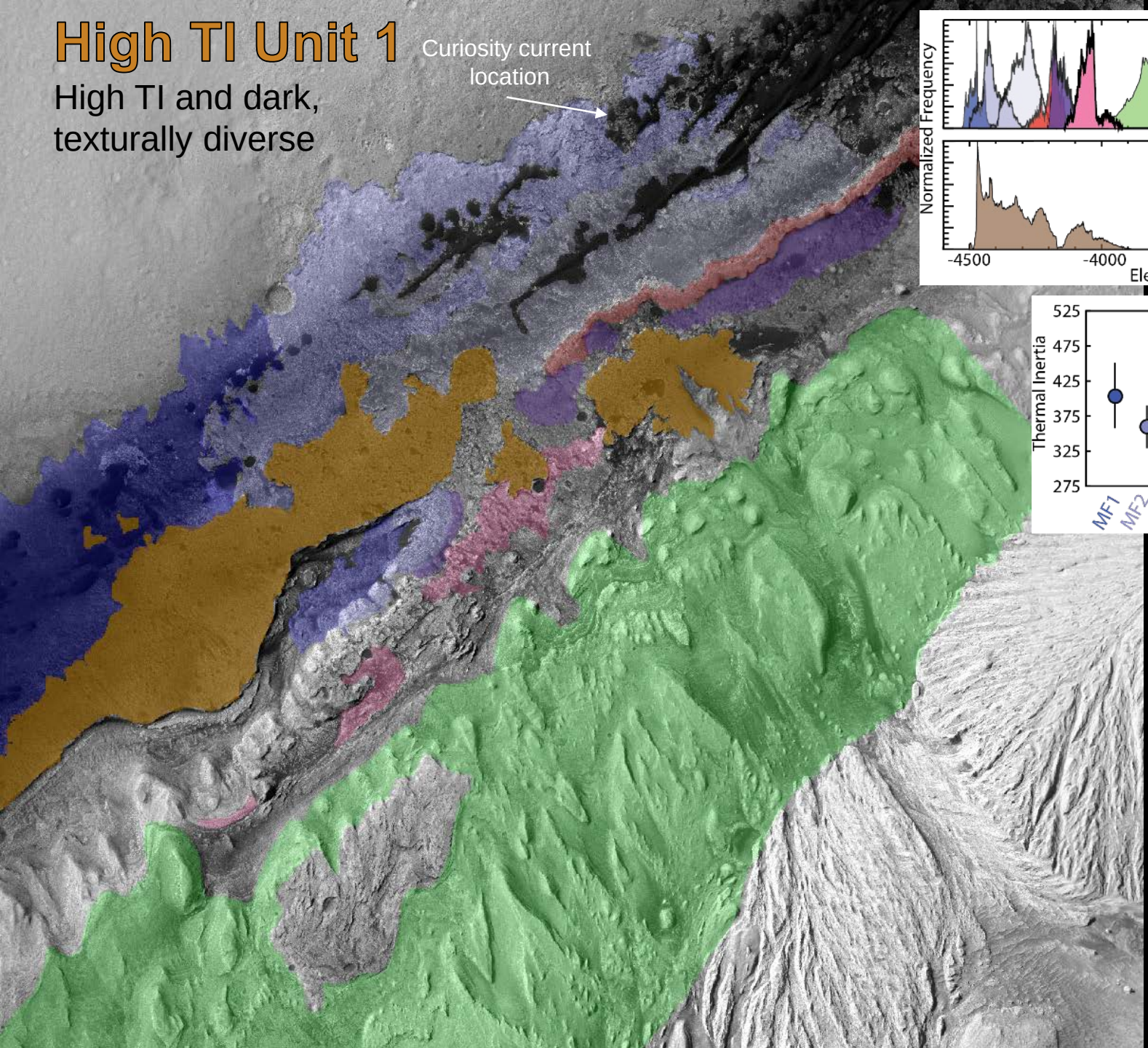
Well layered strata associated with mono- and poly-hydrated Mg-sulfate signaures

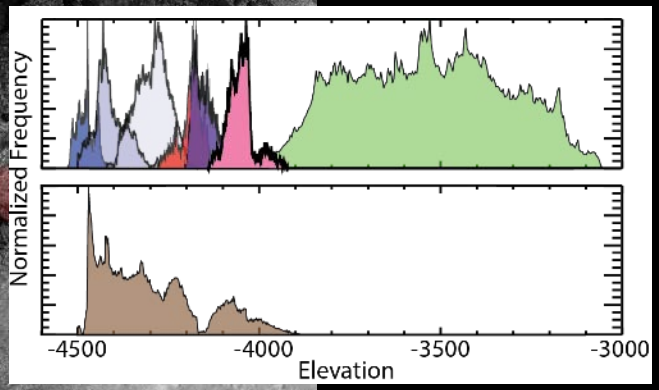


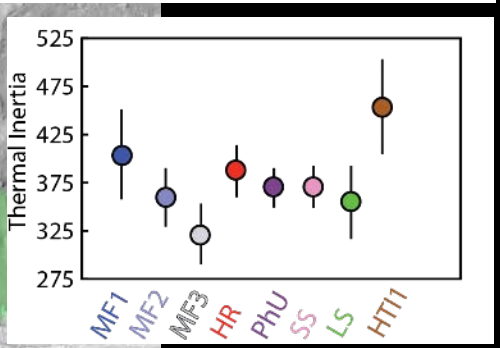
Lab spectra sources: Clark et al., 1993

High TI Unit 1

High TI and dark, texturally diverse

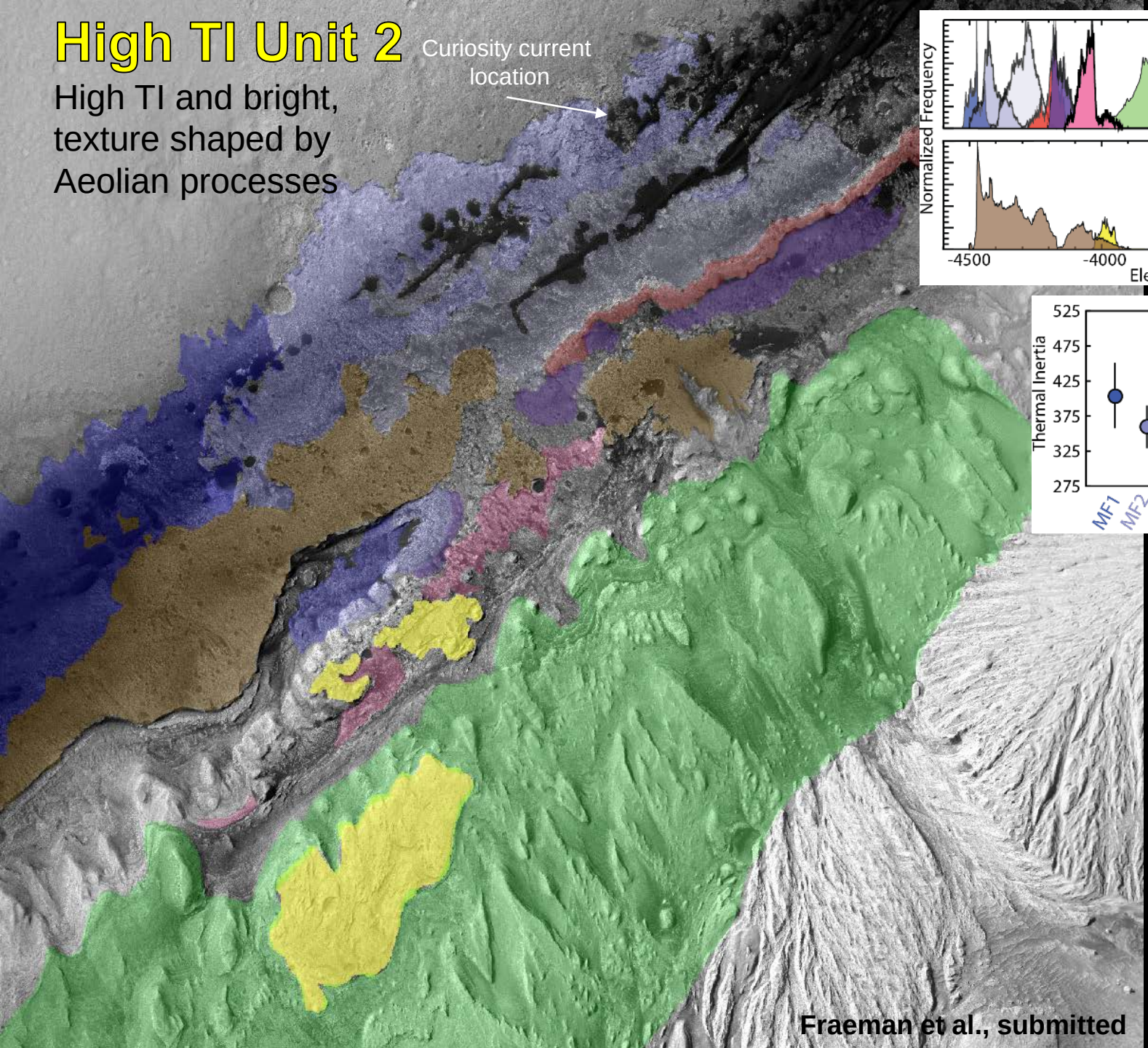


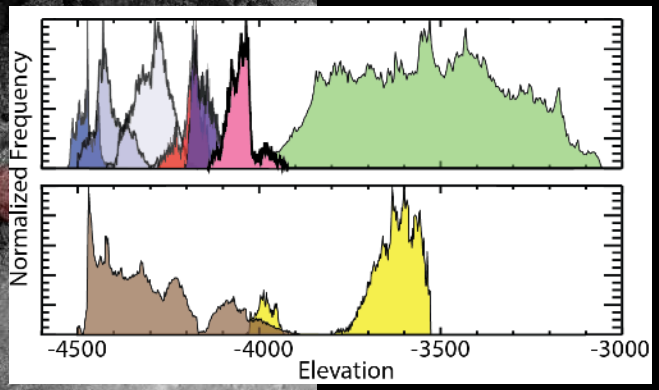


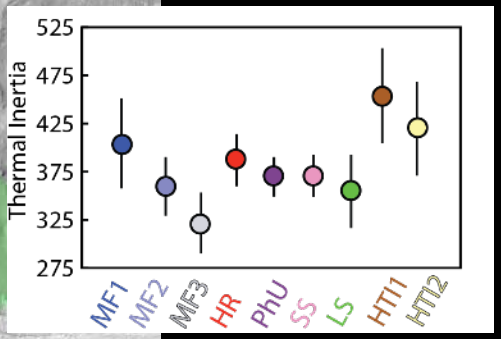


High TI Unit 2

High TI and bright, texture shaped by Aeolian processes

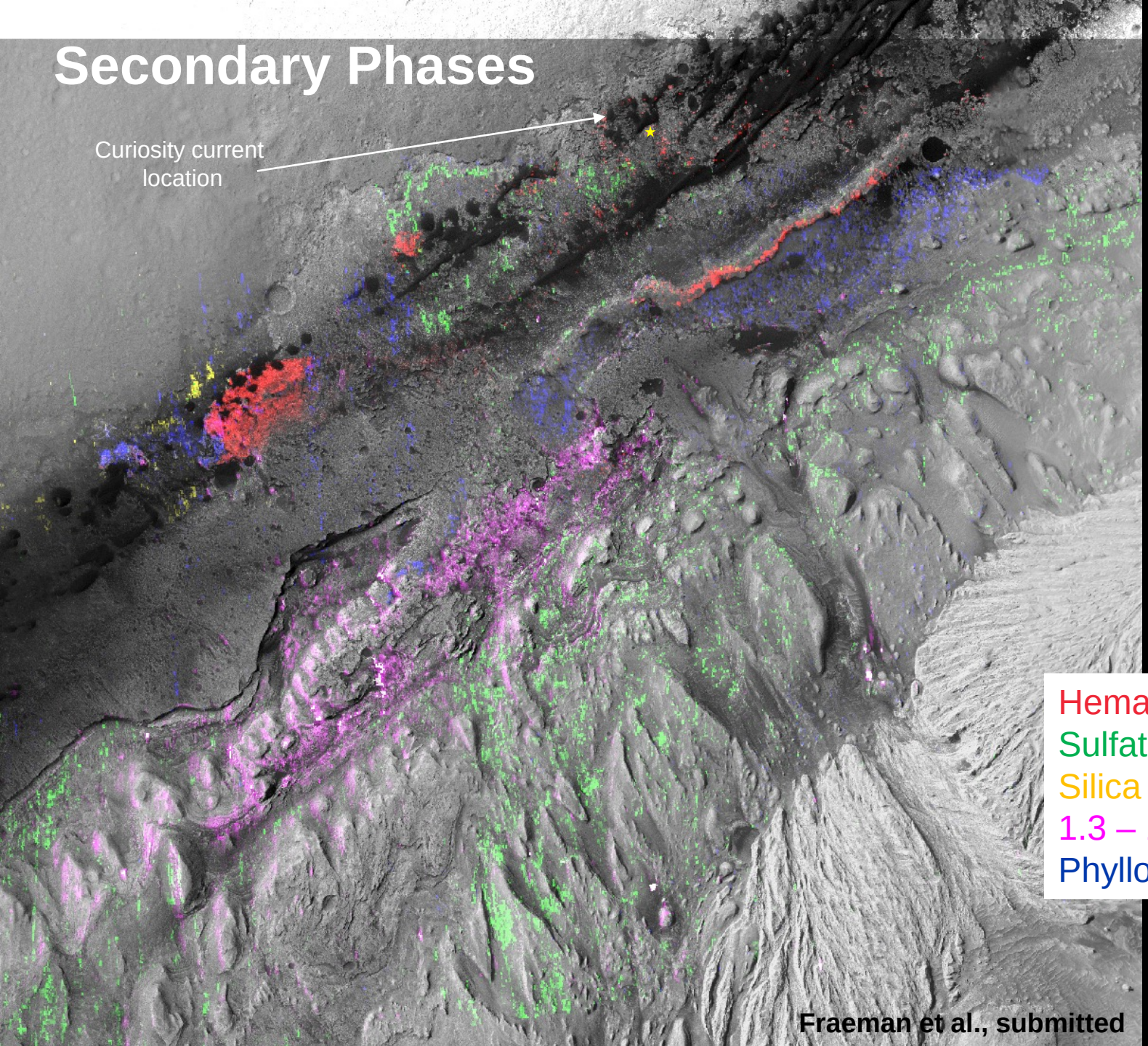






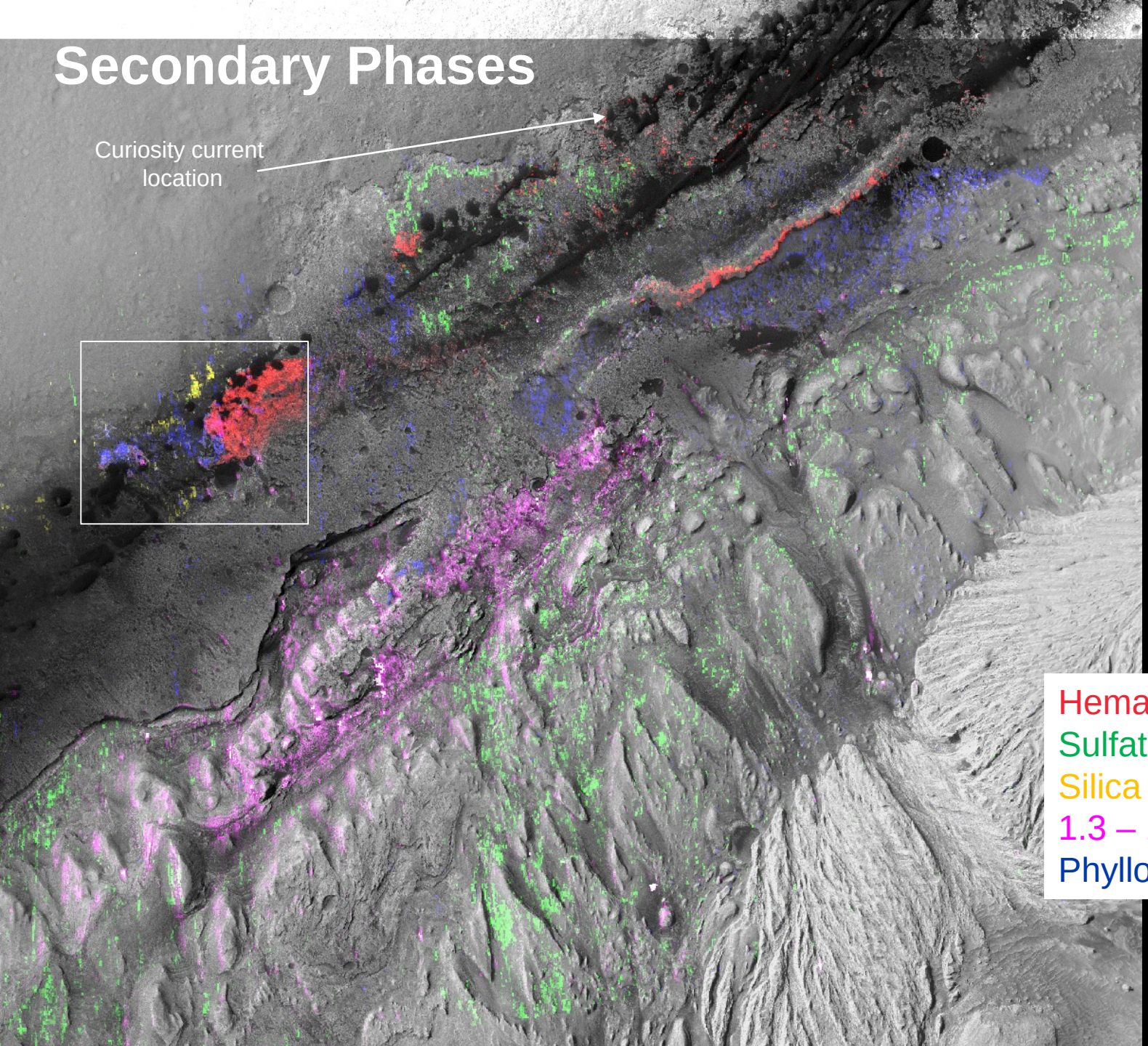
Fraeman et al., submitted

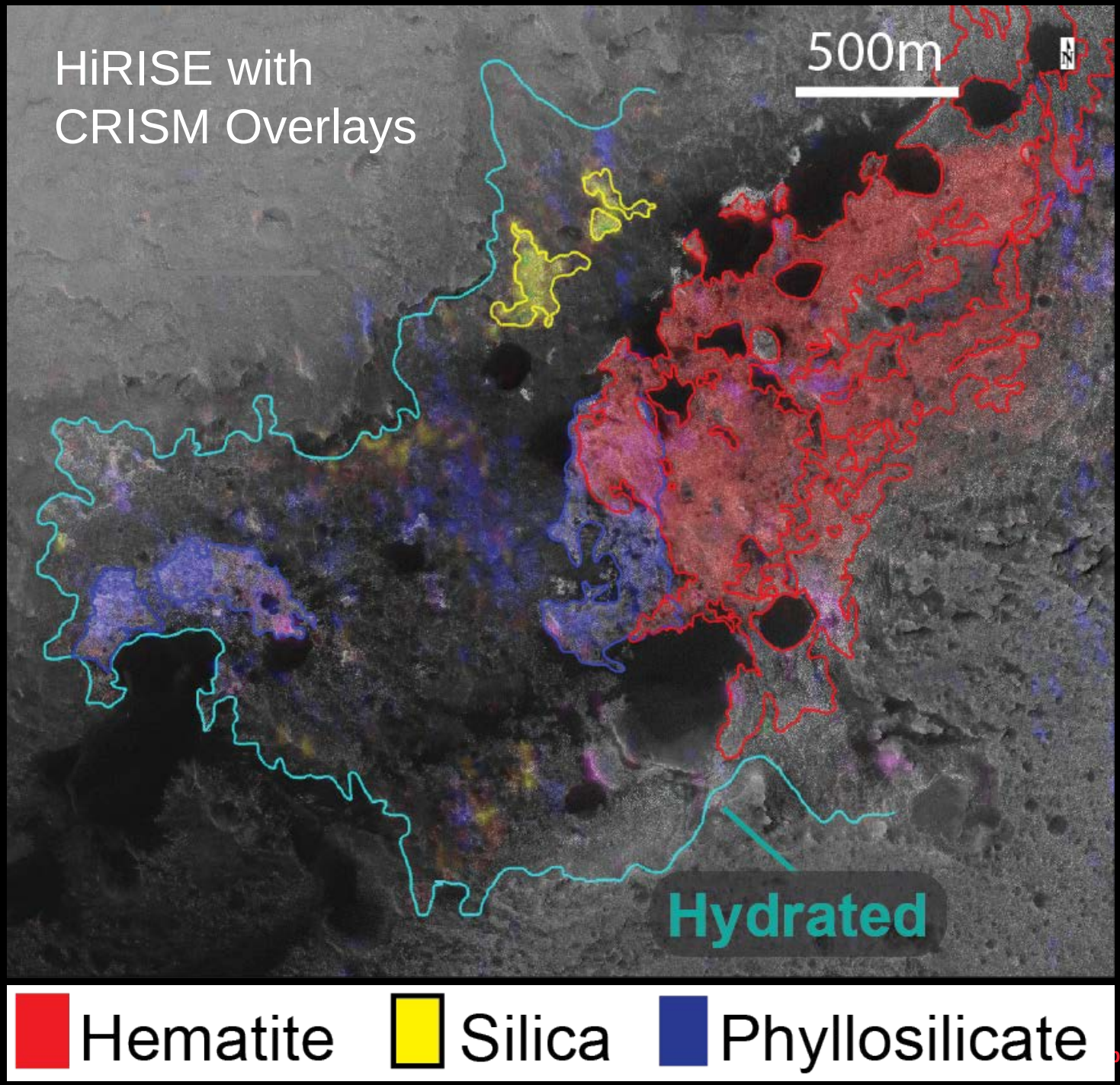
Secondary Phases

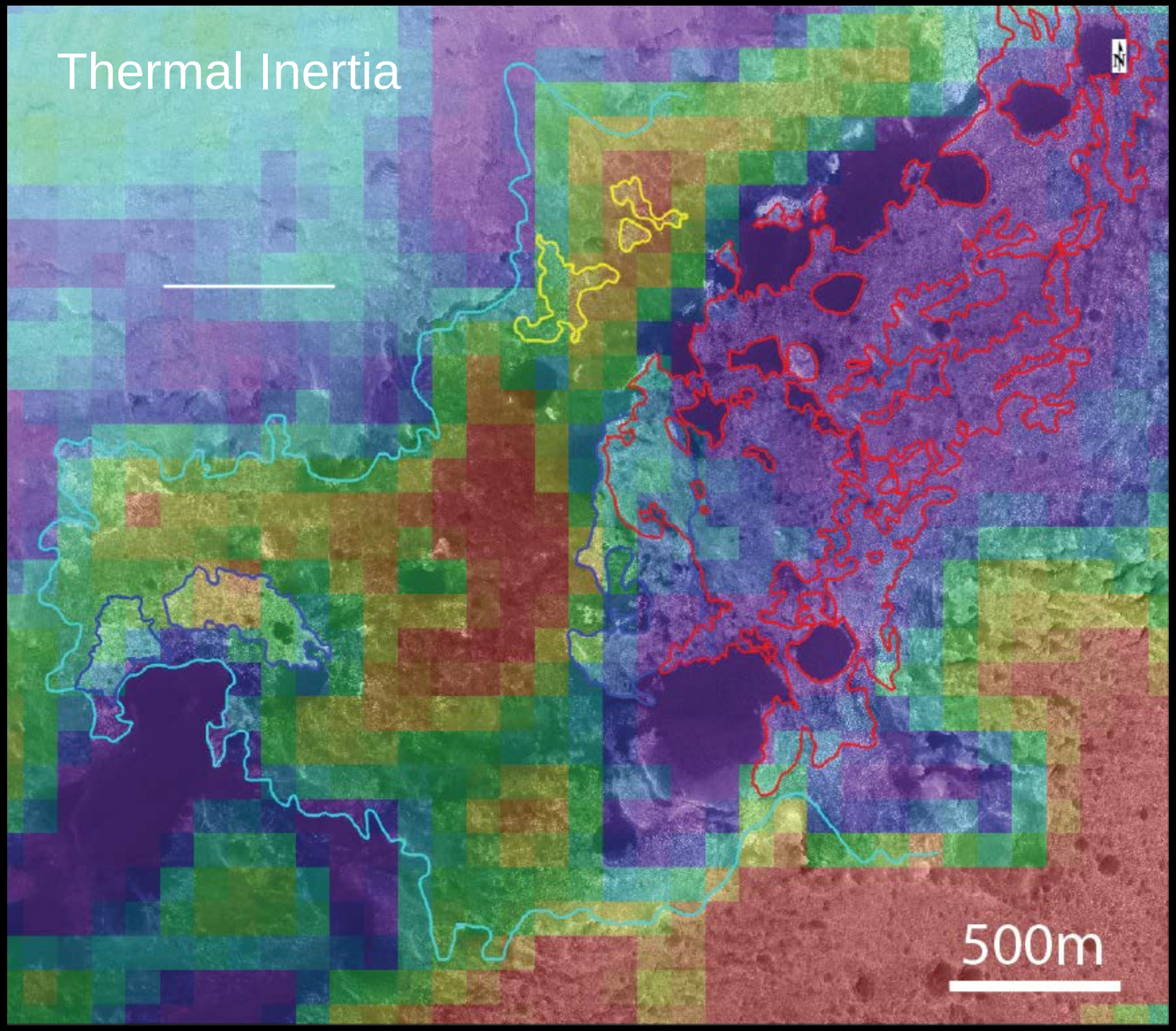


Fraeman et al., submitted

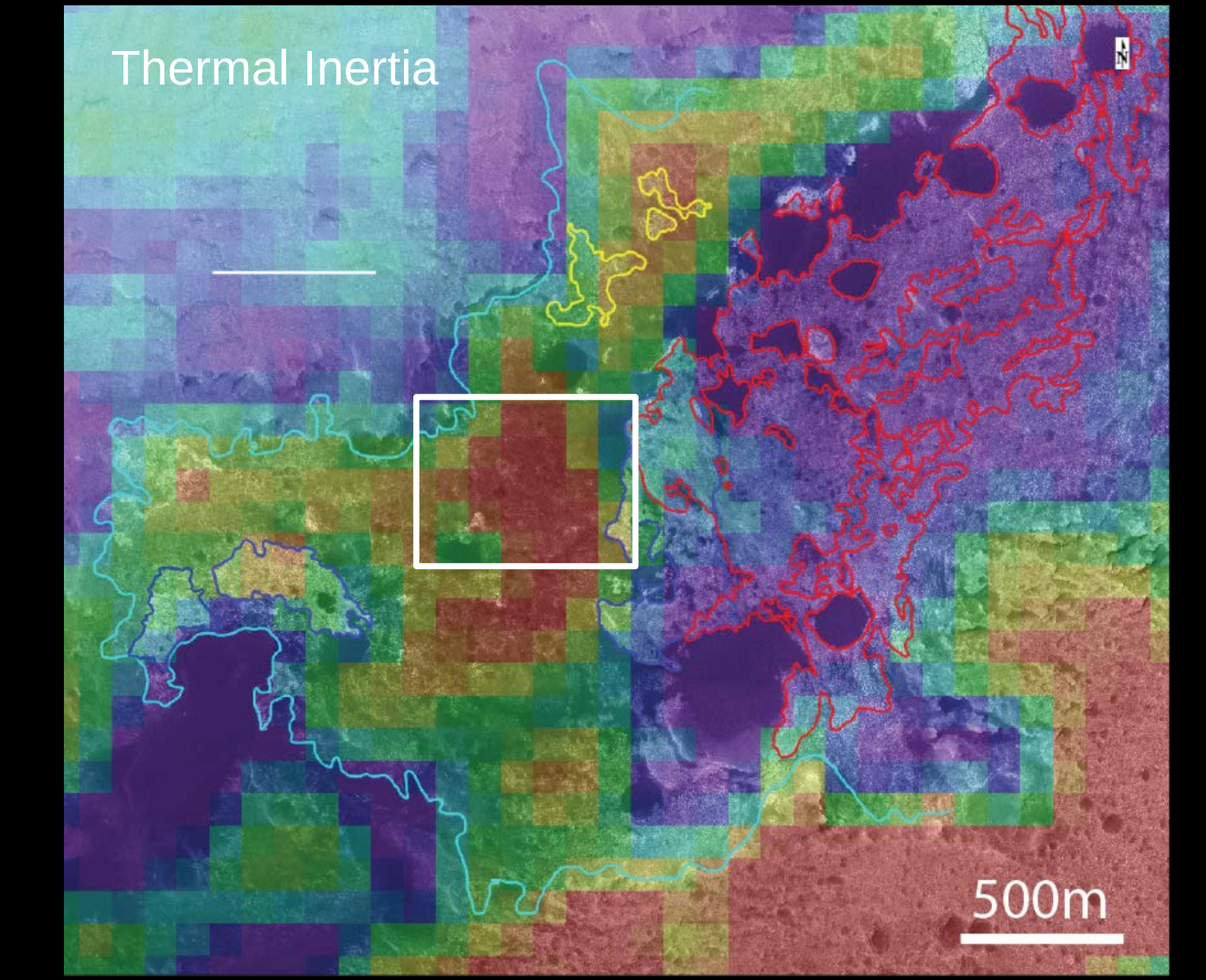
Secondary Phases




HiRISE with
CRISM Overlays
500m
N
Hydrated
Hematite
Silica
Phyllosilicate

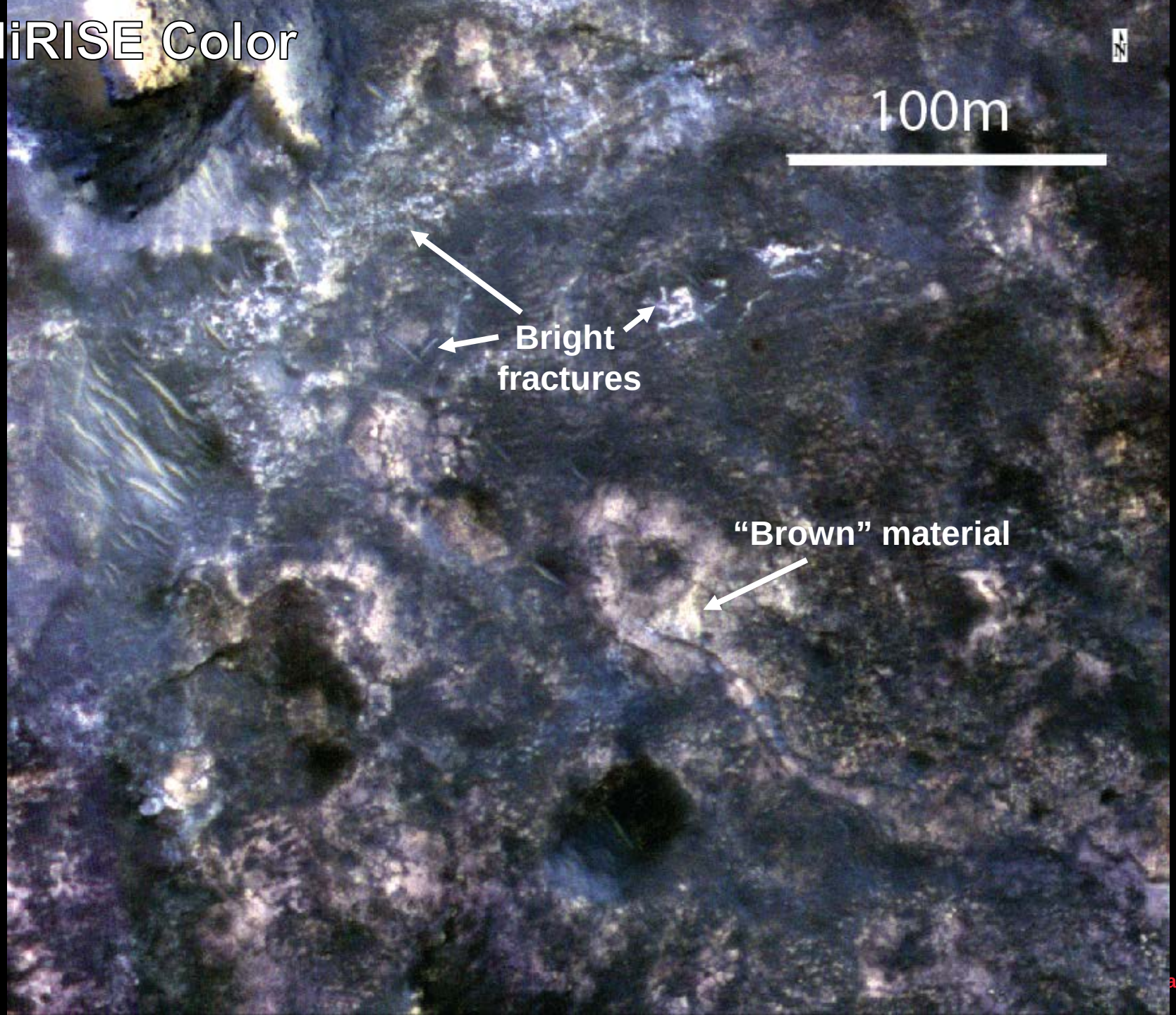


350 380



350 380

HiRISE Color



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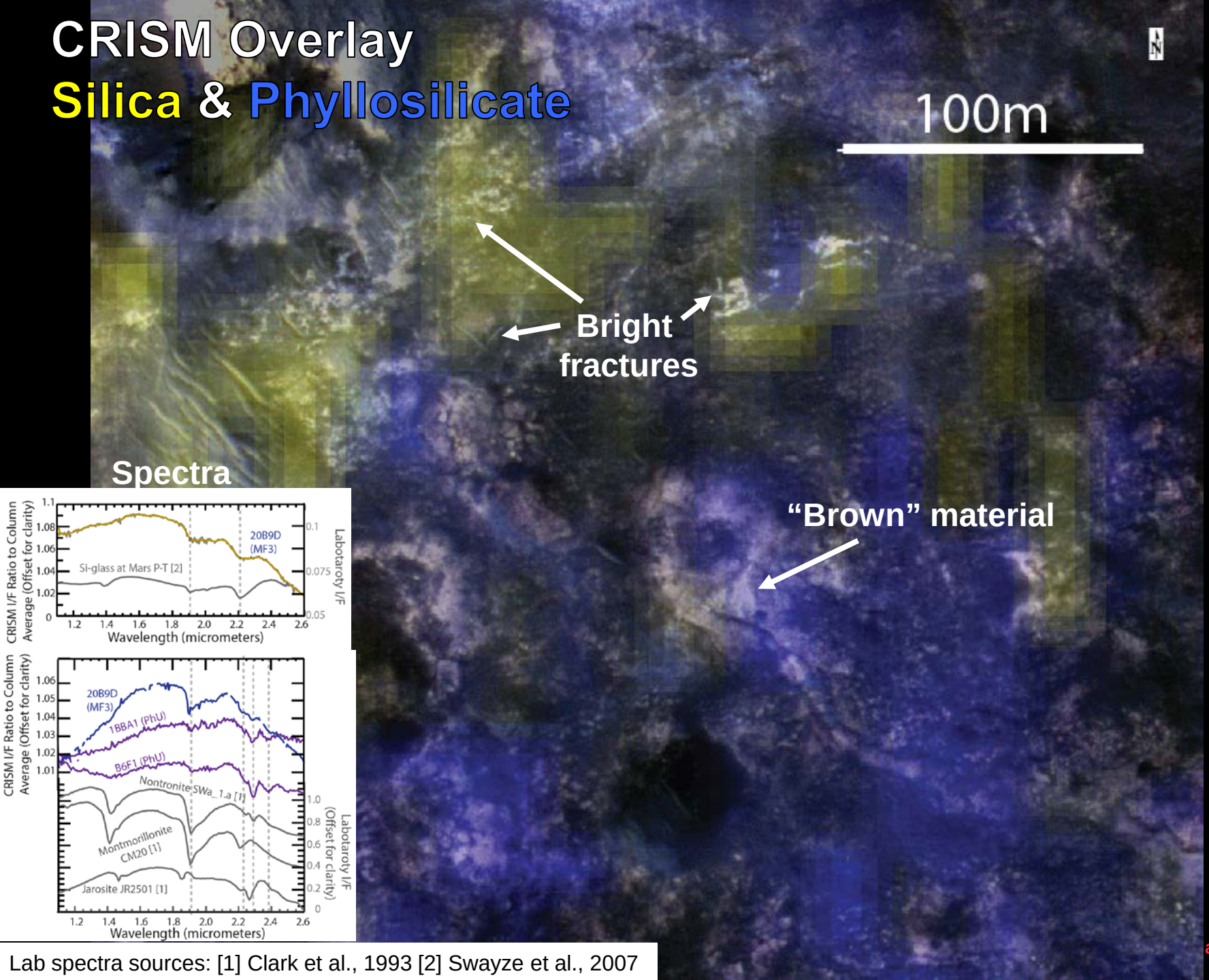
CRISM Overlay
Silica & Phyllosilicate



Lab spectra sources: [1] Clark et al., 1993 [2] Swayze et al., 2007

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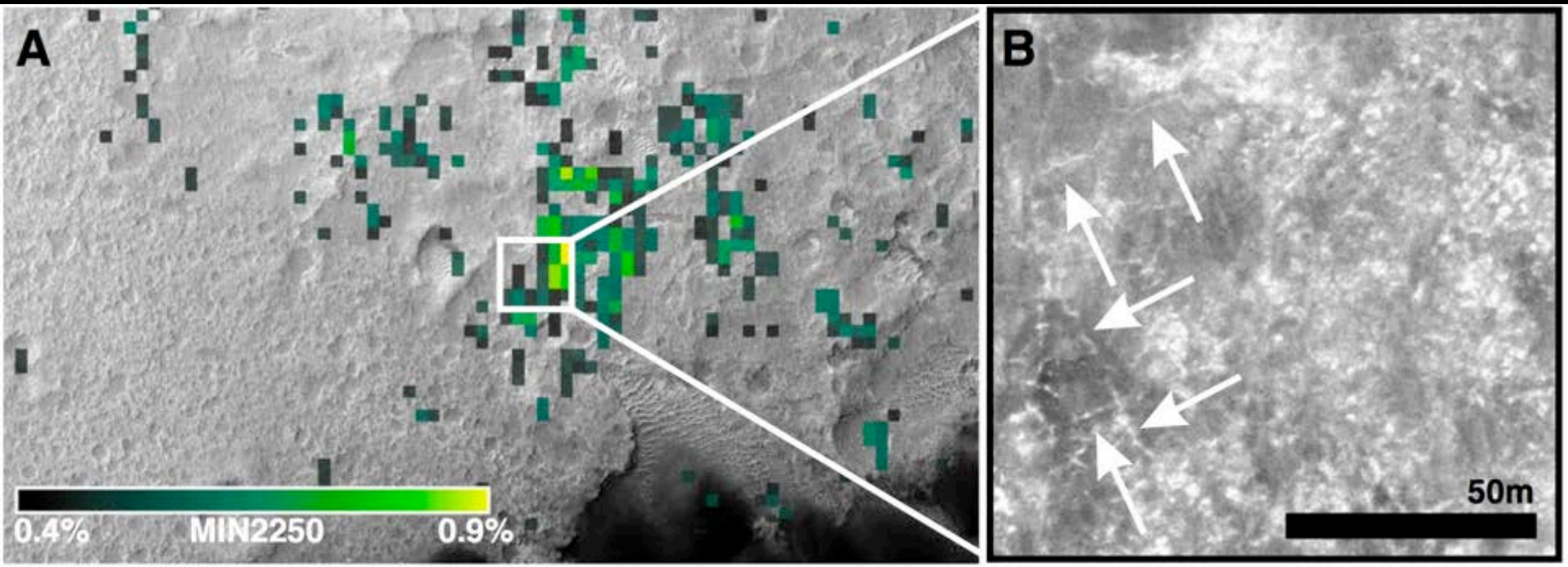
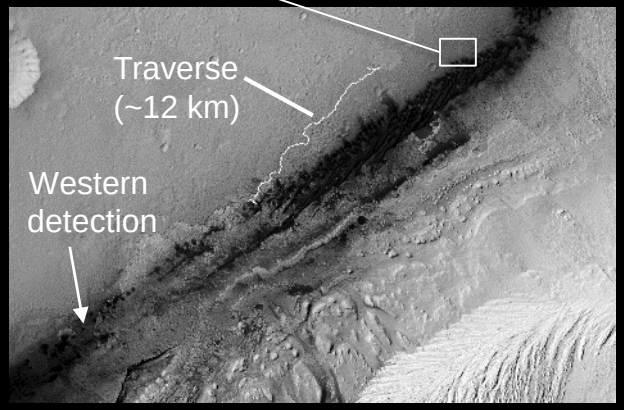
Similar Hydrated Si-textures in the NE

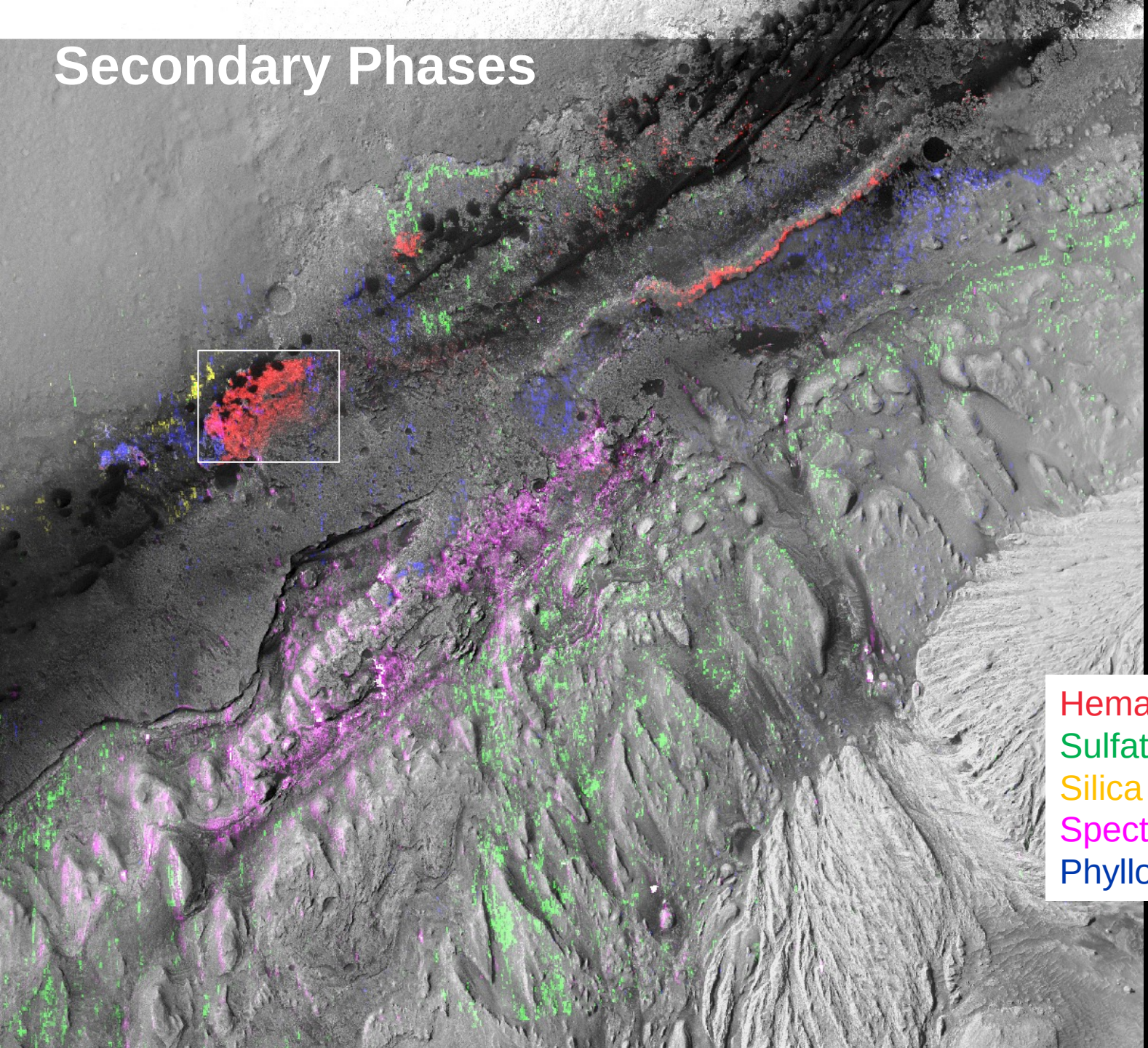


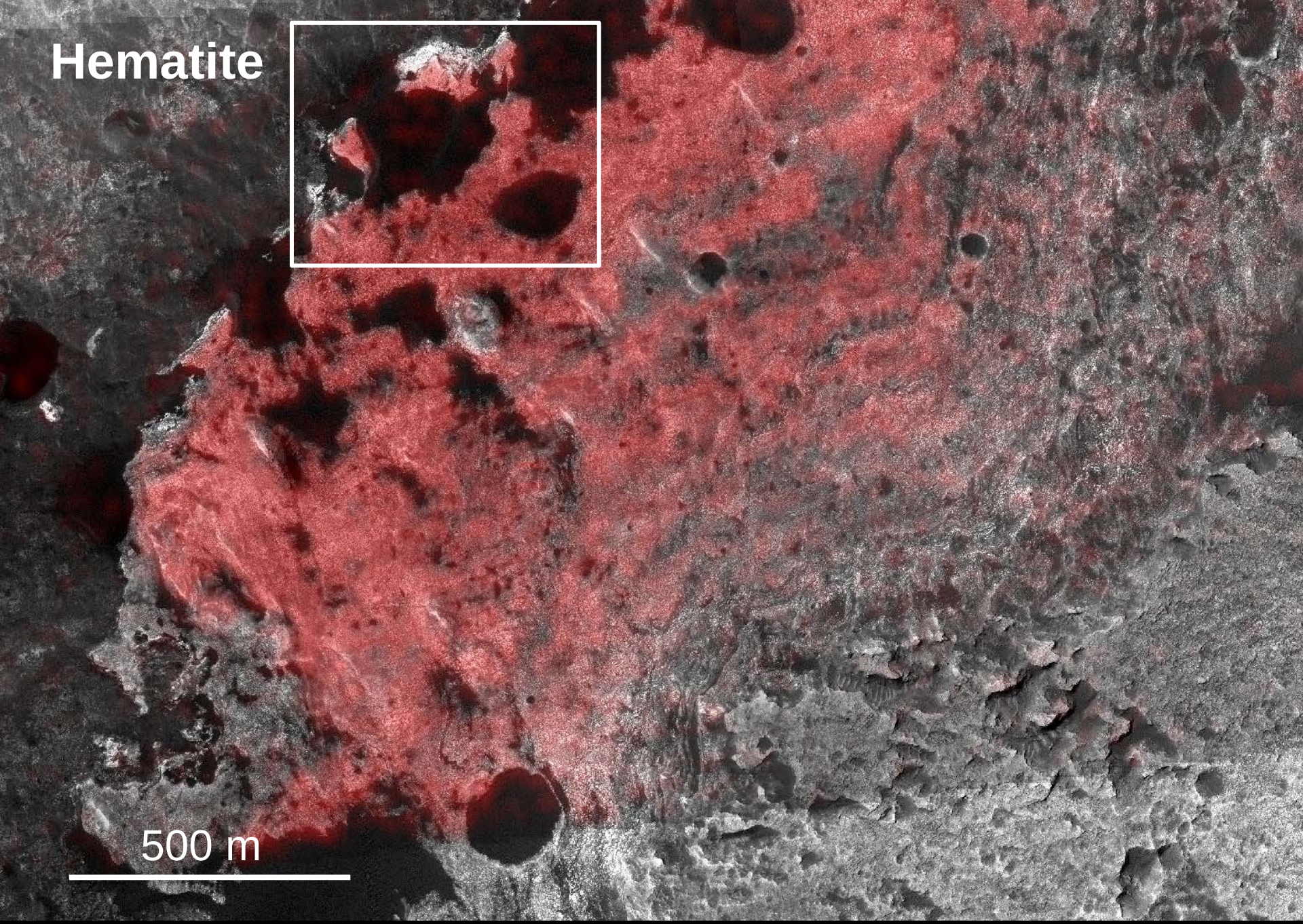
2.2 µm band depth map, Seelos et al., 2014



- 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

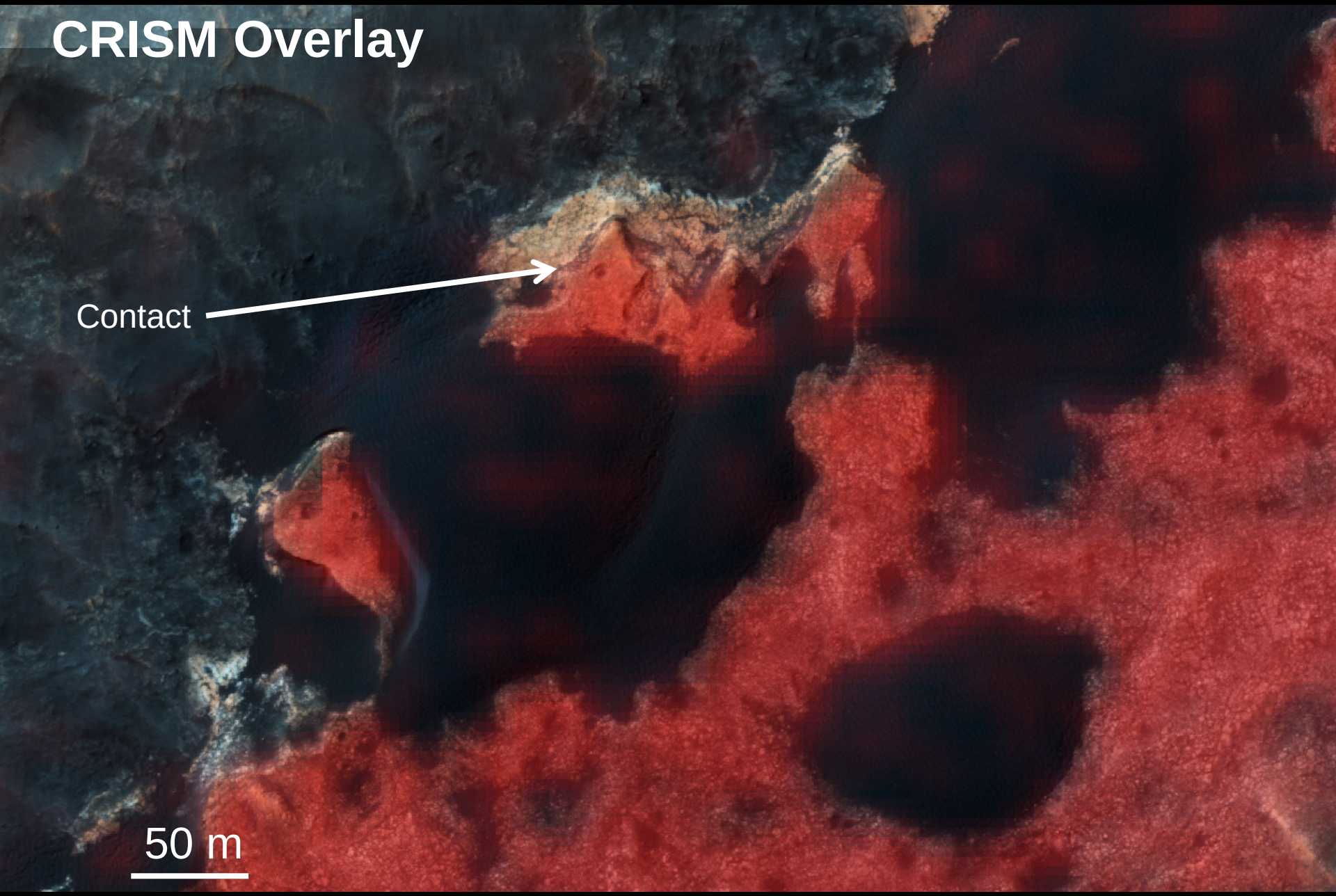
Secondary Phases



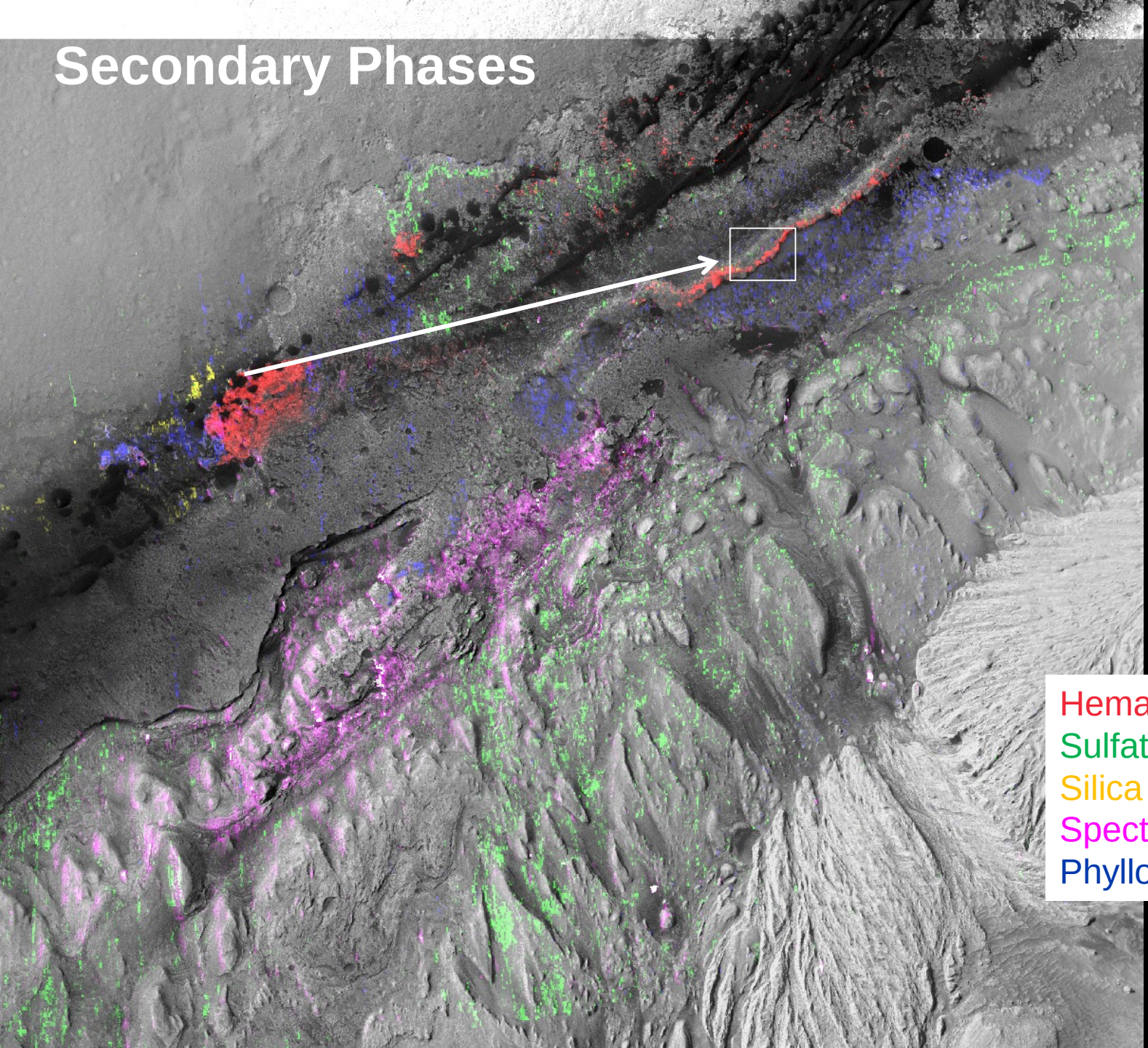

Hematite
500 m

HiRISE Color

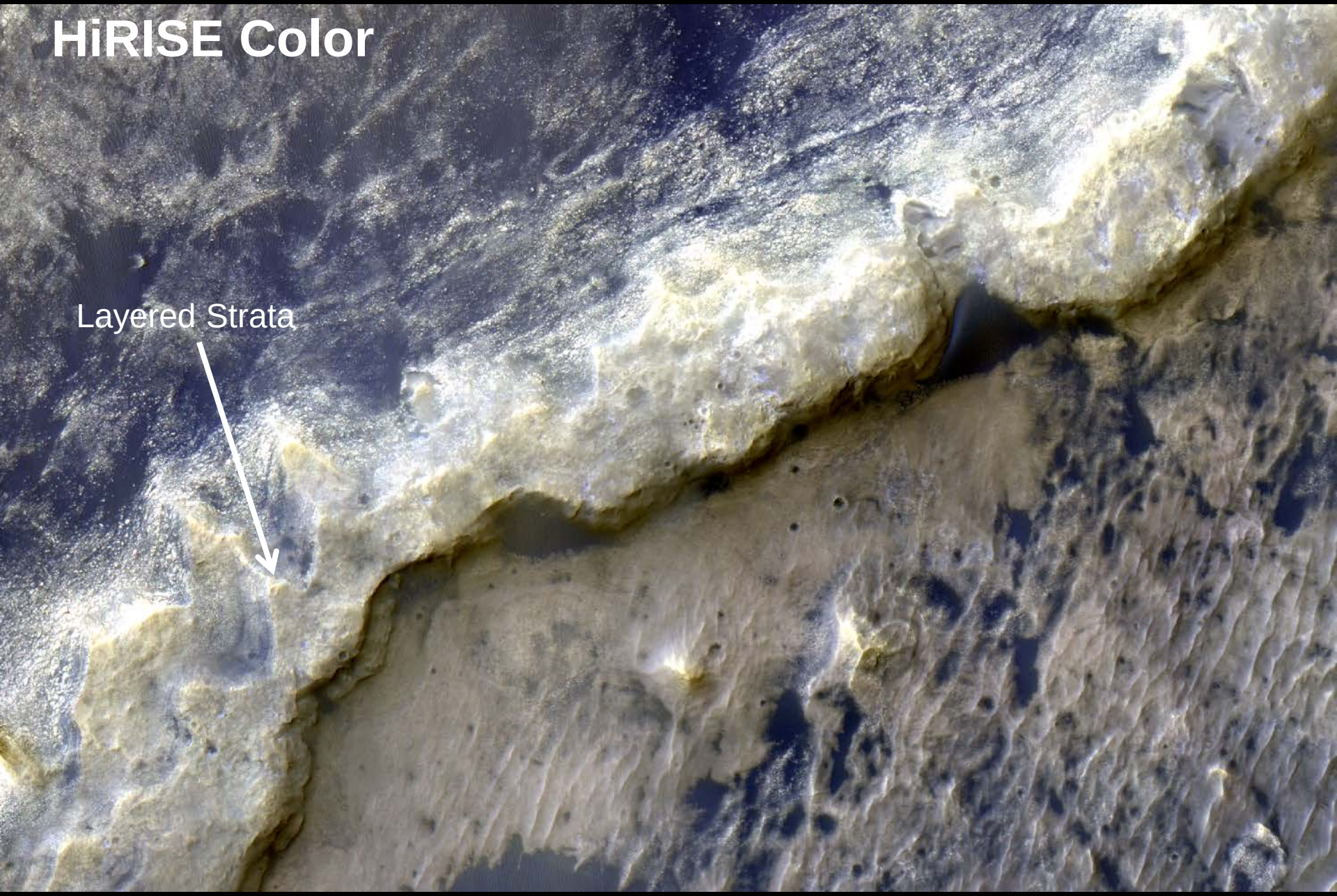
CRISM Overlay



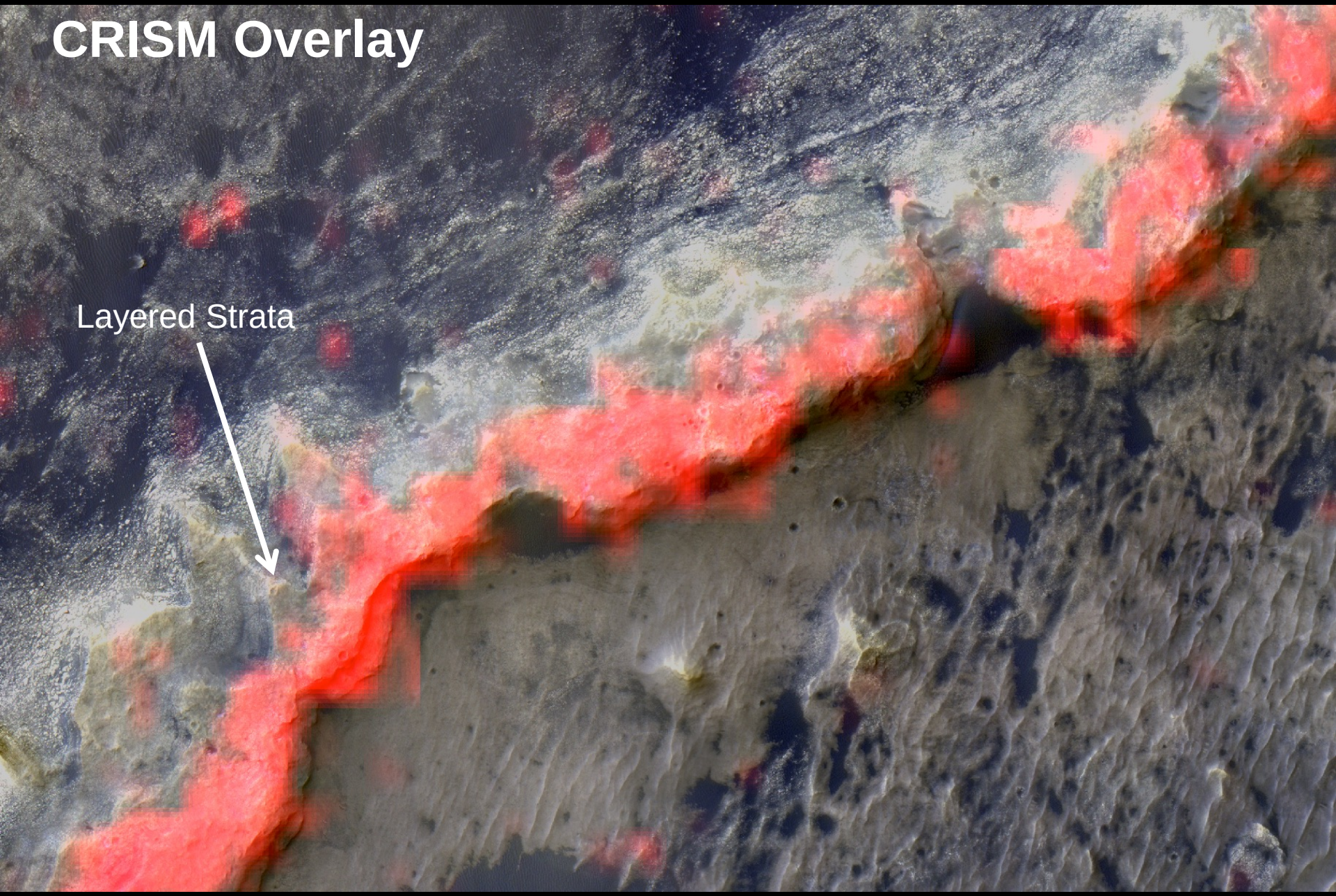
Secondary Phases

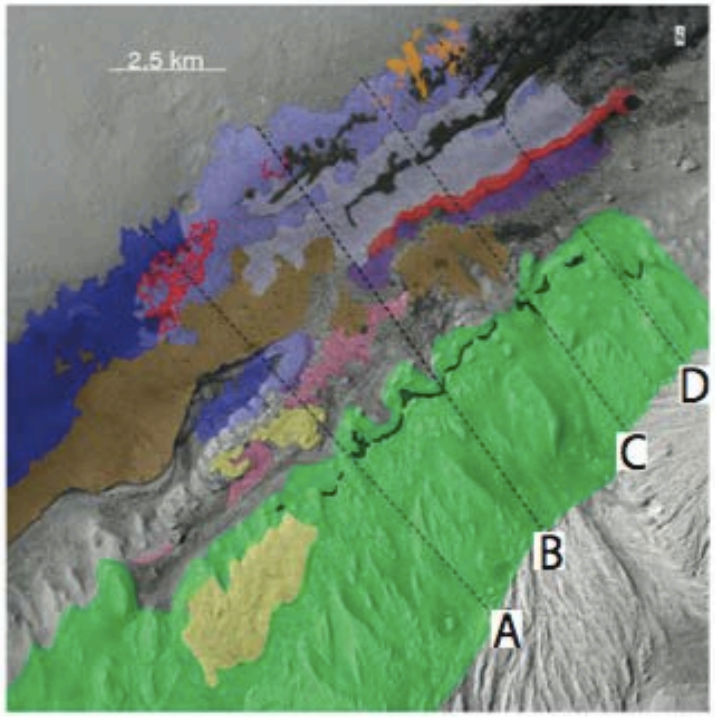


HiRISE Color



CRISM Overlay





SICCAR POINT GROUP

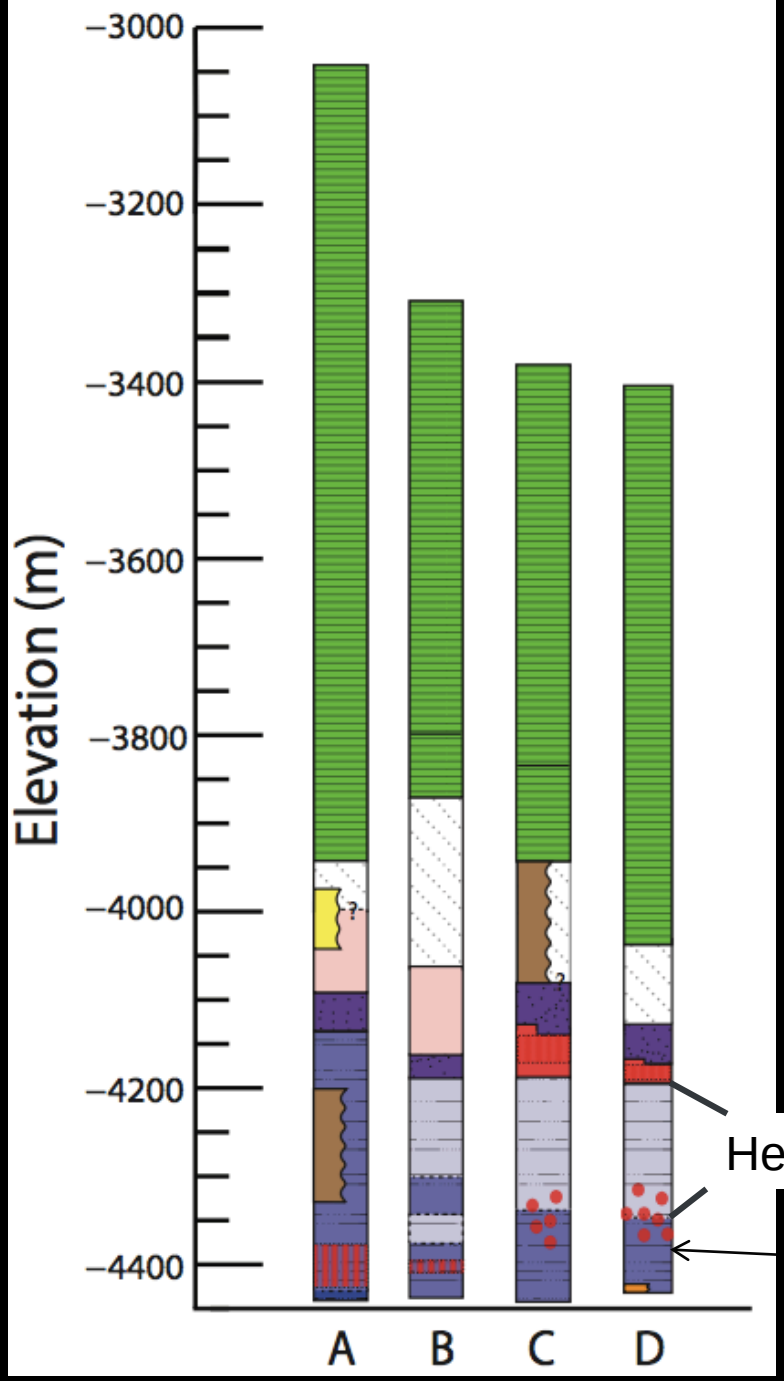
- High TI Unit 1 (HTI1)
- High TI Unit 2 (HTI2)
- Stimson formation*

MT SHARP GROUP

- Layered Sulfate (LS)
- Sub-sulfate (SS)
- Hematite Ridge (HR)
- Phyllosilicate Unit (PhU)
- Murray 2 (MF2)
- Murray 1 (MF1)
- Murray 3 (MF3)

- Marker bed (Milliken et al., 2010)
- Large hematite deposits
- Weak hematite signature
- Not mapped
- Unconformity
- Relative timing uncertain

*Stimson formation defined based on mapping using Curiosity imaging data in *Grotzinger et al.*, 2015 & *Watkins et al.*, 2016.



Fraeman et al., submitted

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
- 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
- Hematite detection at multiple stratigraphic positions show redox interfaces were widespread through time and/or space during Mt. Sharp's formation