Hydrated silica detections in Jezero crater and the surrounding NE Syrtis region

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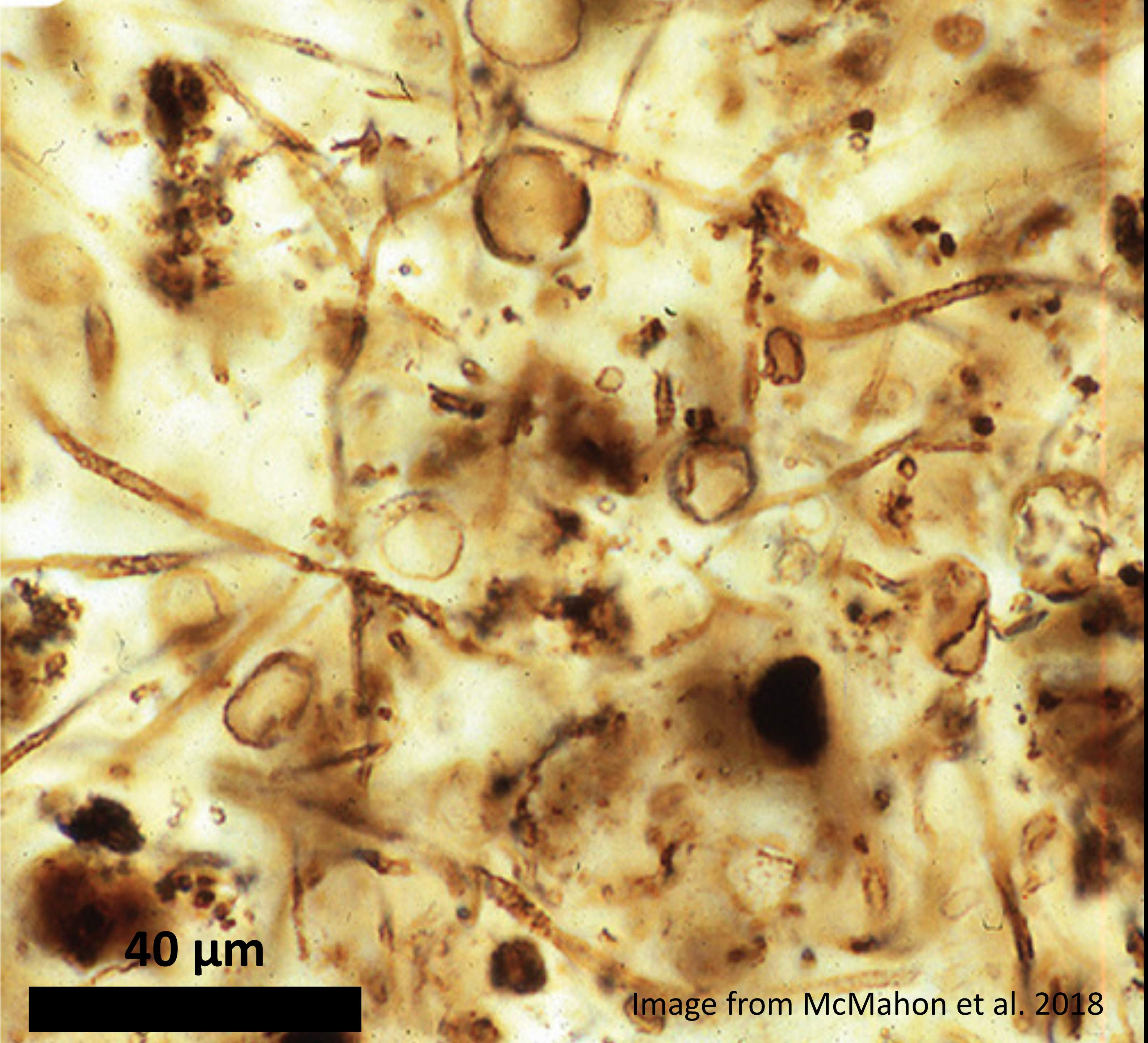


Image from McMahon et al. 2018

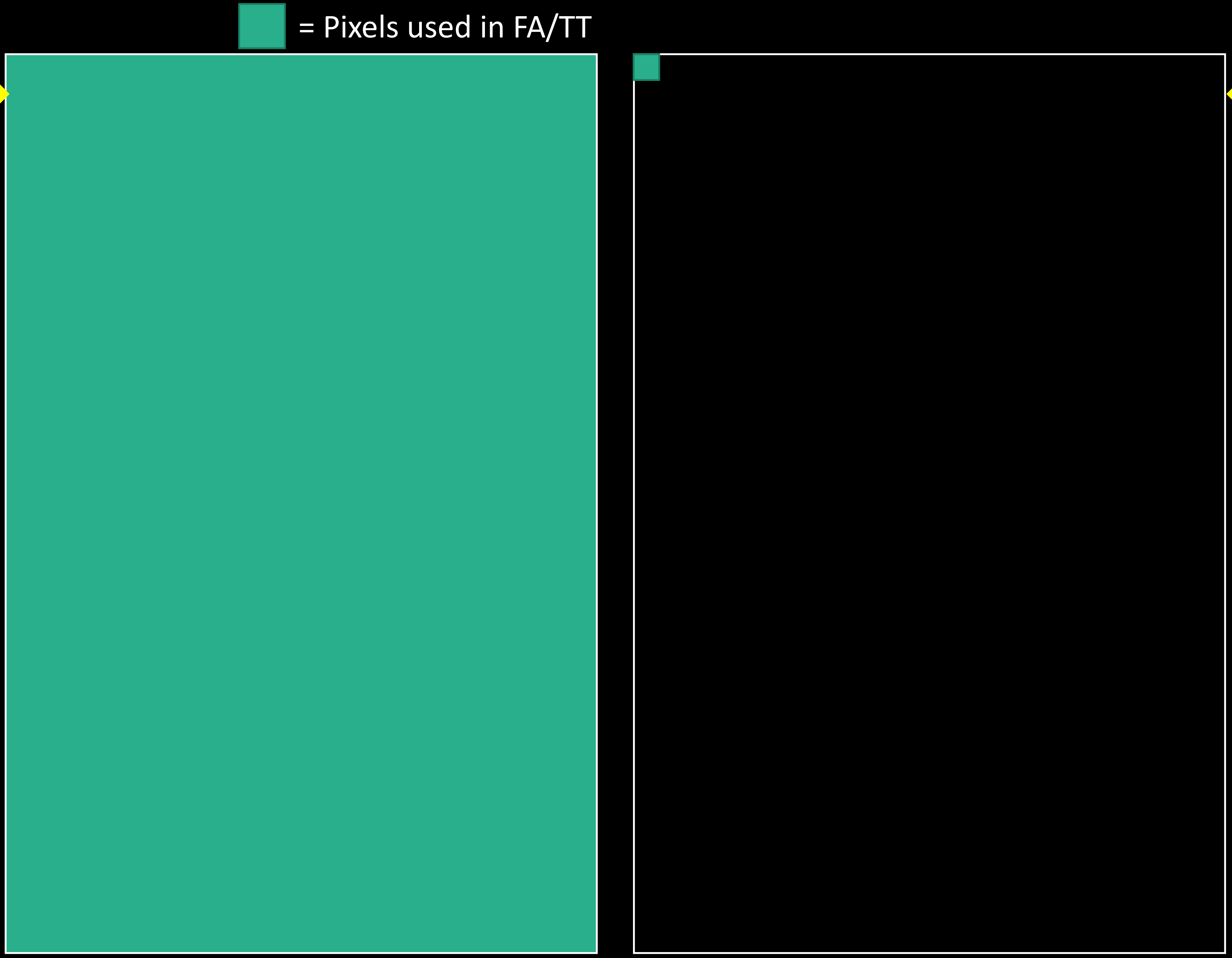
Silica has high biosignature preservation potential

Chert, fine-grained rock with high amorphous silica content, and siliceous sinter have been highlighted as targets with high biosignature preservation potential on Mars (McMahon et al. 2018).

Dynamic Aperture Factor Analysis/Target Transformation (DAFA/TT)

- Factor analysis and target transformation (Malinowski 1991) allows for detection of spectrally active compounds at low abundance and complex convolutions.
- Applied to CRISM by Amador et al. 2018 and Thomas & Bandfield 2017.
- Factor analysis estimates the number of independently varying spectral components by deriving orthogonal eigenvectors and associated eigenvalues.
- Target transformation effectively performs linear least-squares fitting of significant eigenvectors to a library spectrum.

Previous applications of FA/TT (Amador et al. 2018, Thomas & Bandfield 2017) used all pixels in CRISM image

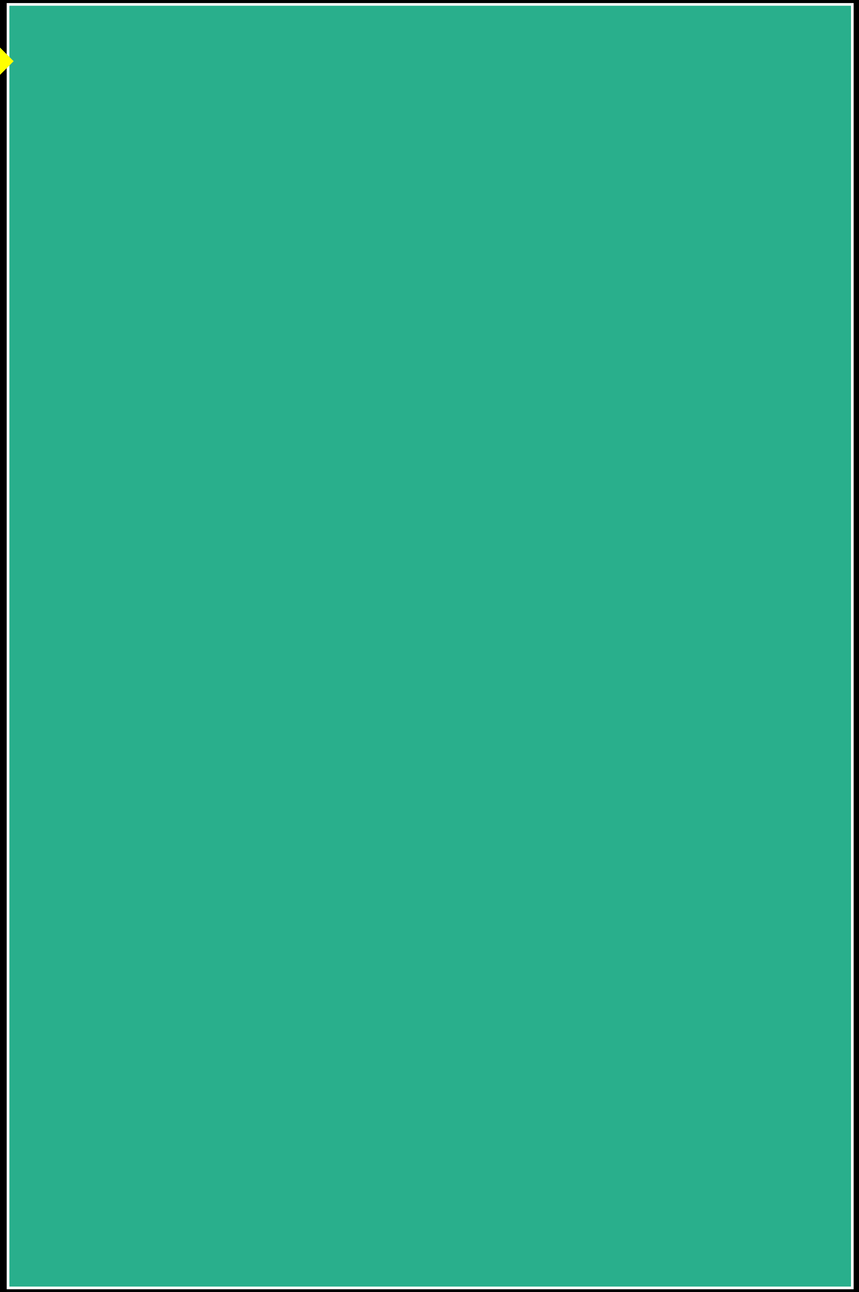


DAFA/TT uses clusters of pixels in a moving window

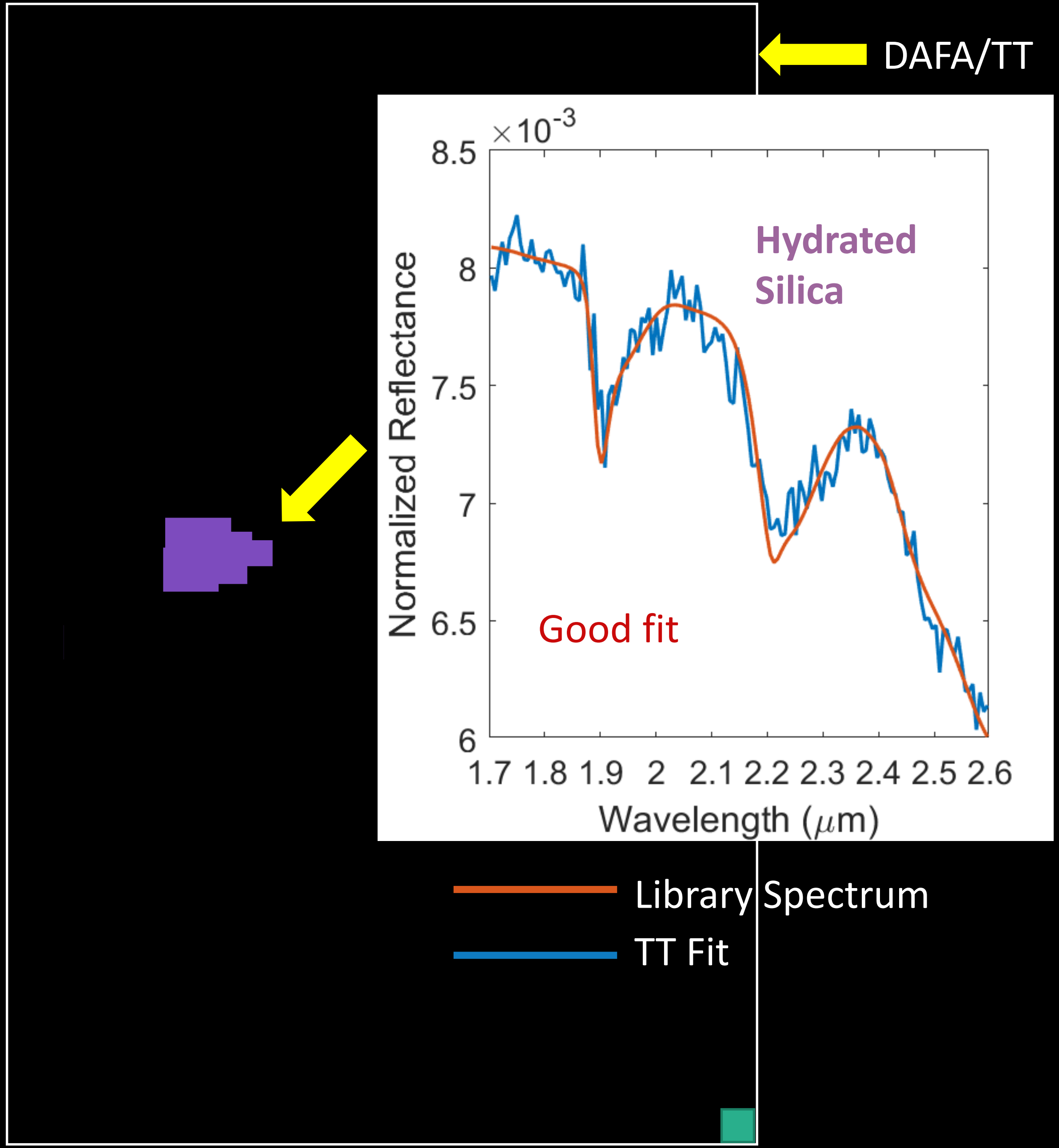
DAFA/TT allows for detection of minerals at low abundance and complex convolutions, allowing for characterization of mineral assemblage (Tarnas et al. 2018, Lin et al. 2018).

= Pixels used in FA/TT = FA/TT positive detections

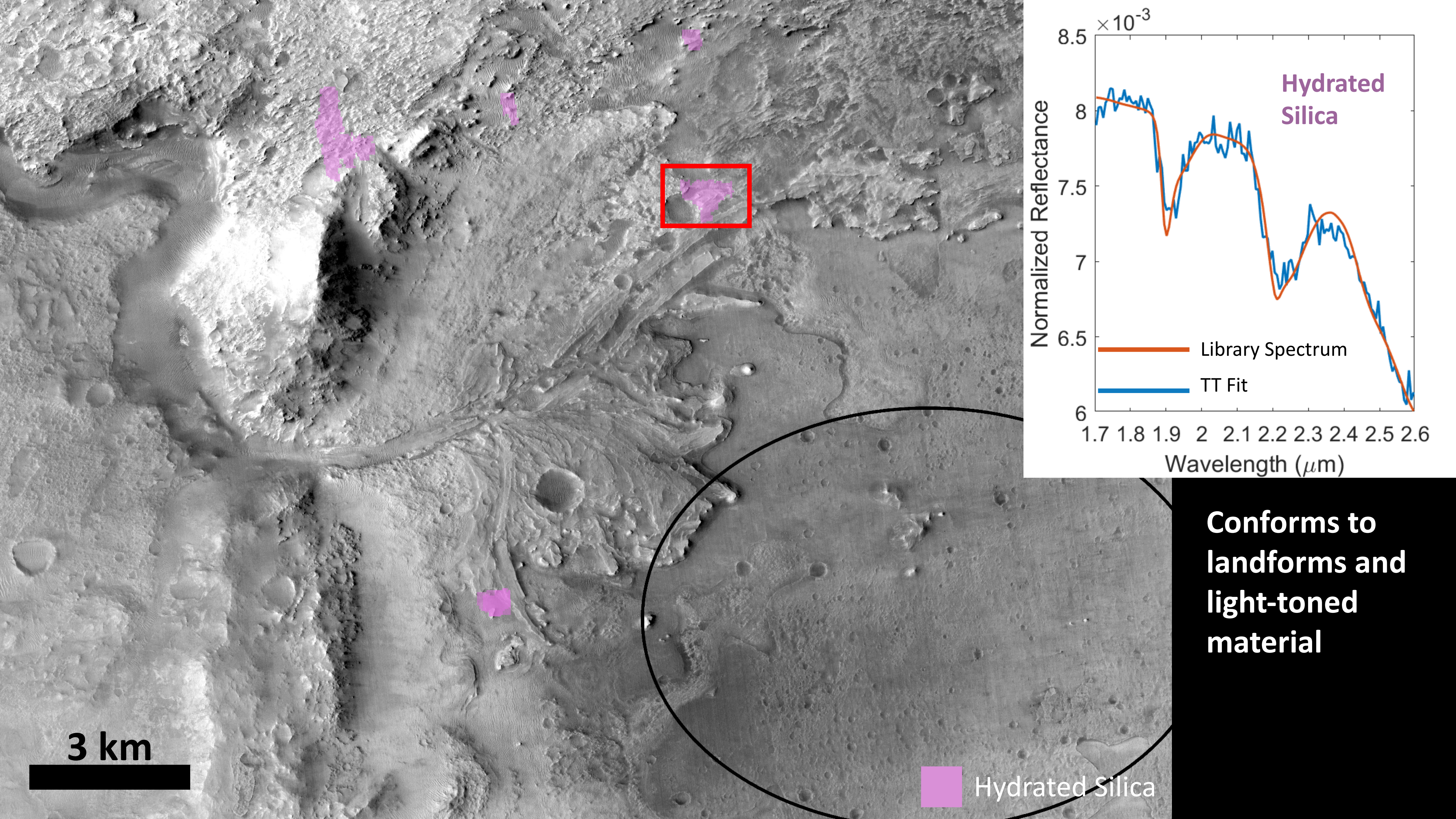
Previous applications of FA/TT (Amador et al. 2018, Thomas & Bandfield 2017) used all pixels in CRISM image



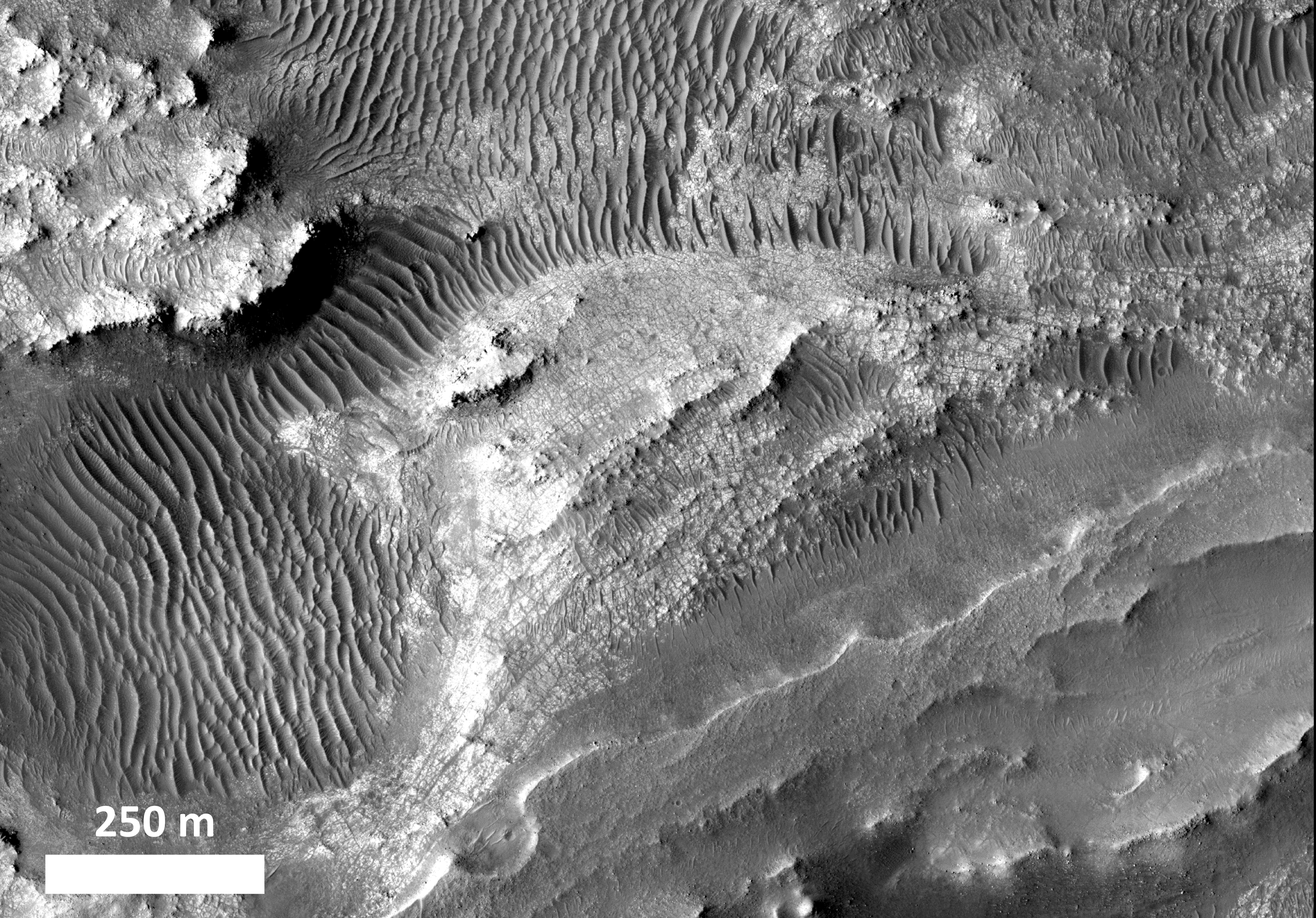
DAFA/TT



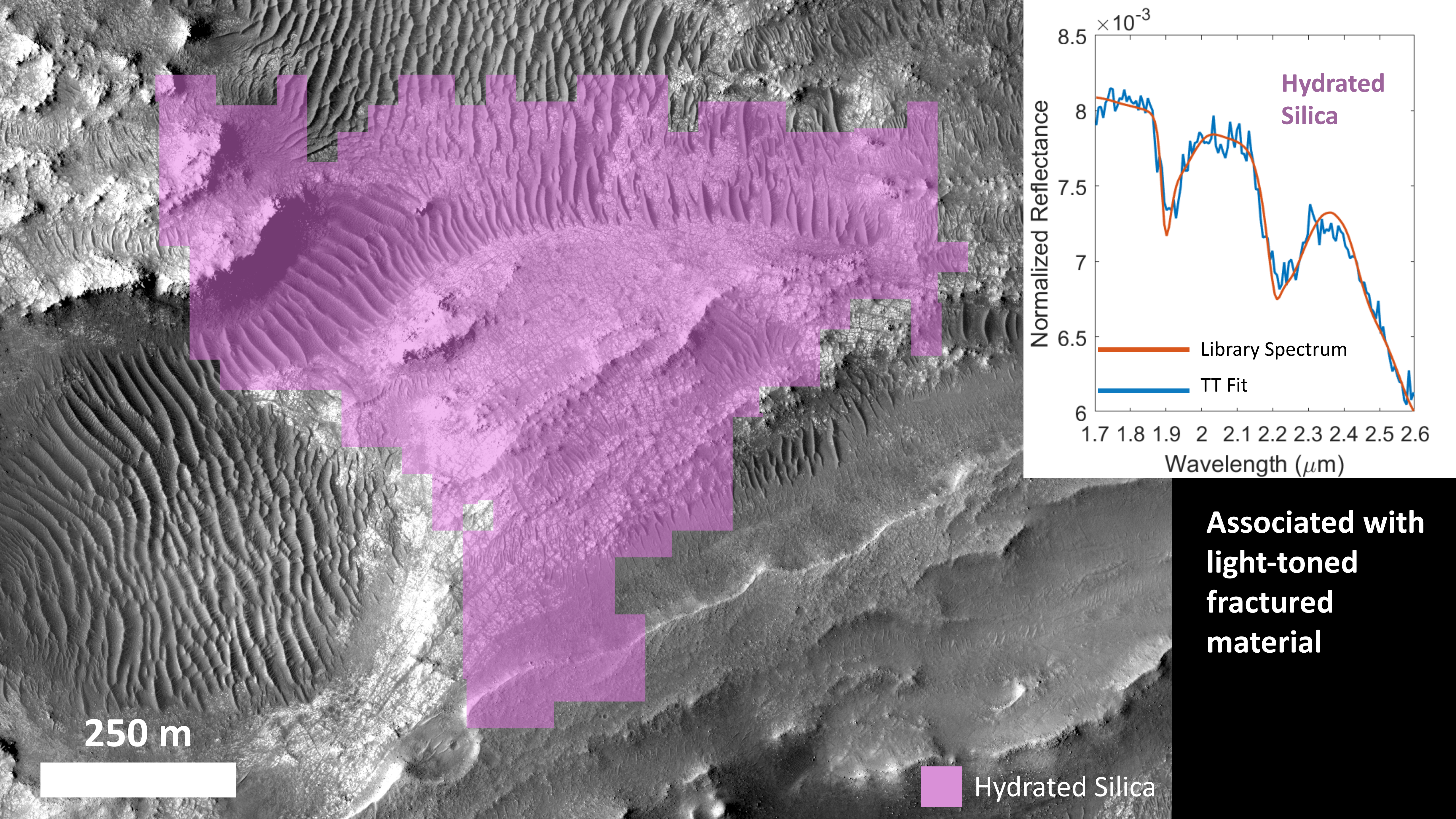
CTX and HiRISE mosaics are from Caltech's Murray Lab, courtesy of Jay Dickson



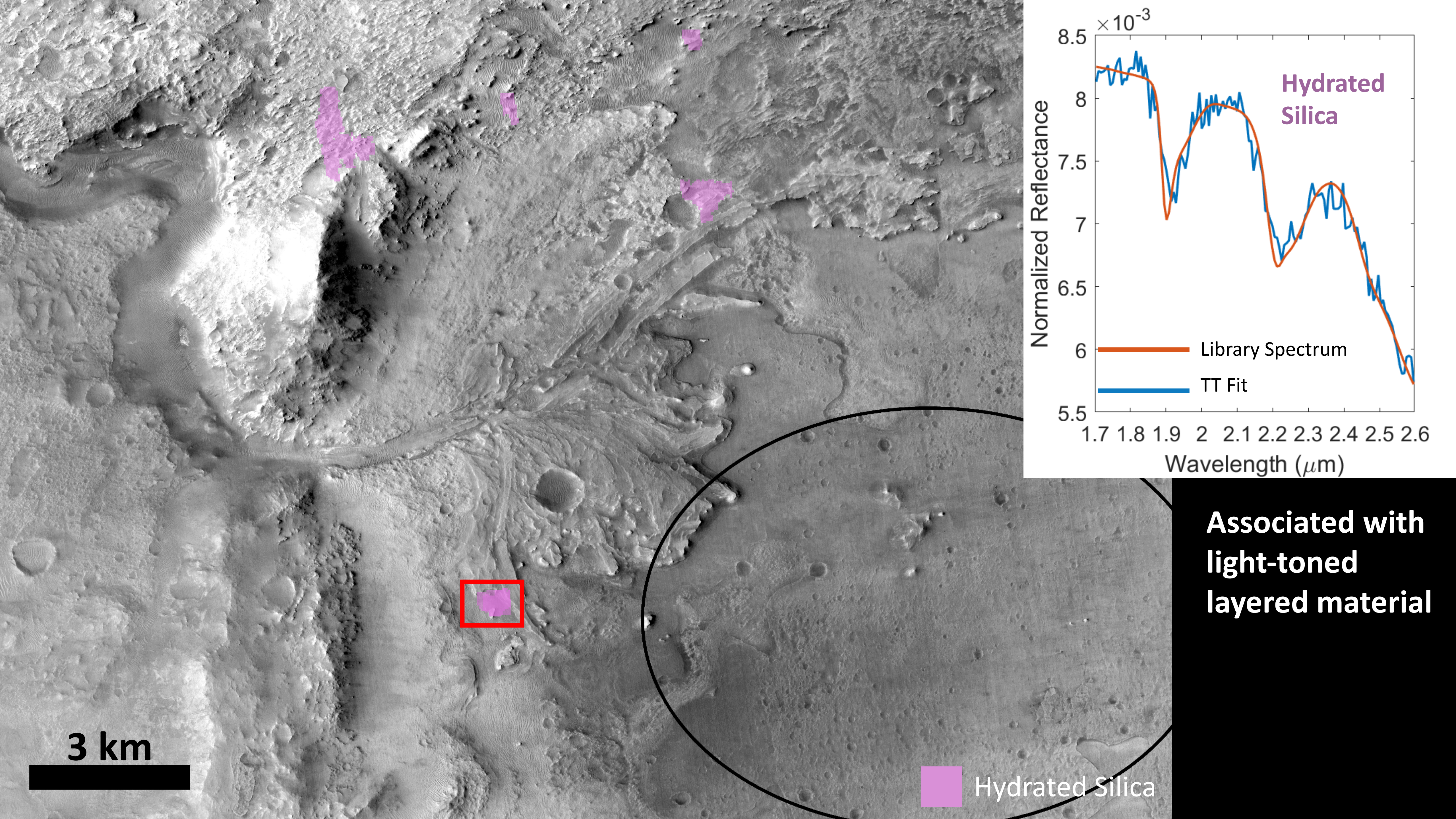
×10^-3
8.5
8
7.5
7
6.5
6
Normalized Reflectance
1.7 1.8 1.9 2 2.1 2.2 2.3 2.4 2.5 2.6
Wavelength (μm)
Hydrated Silica
Library Spectrum
TT Fit
Conforms to landforms and light-toned material
3 km
Hydrated Silica



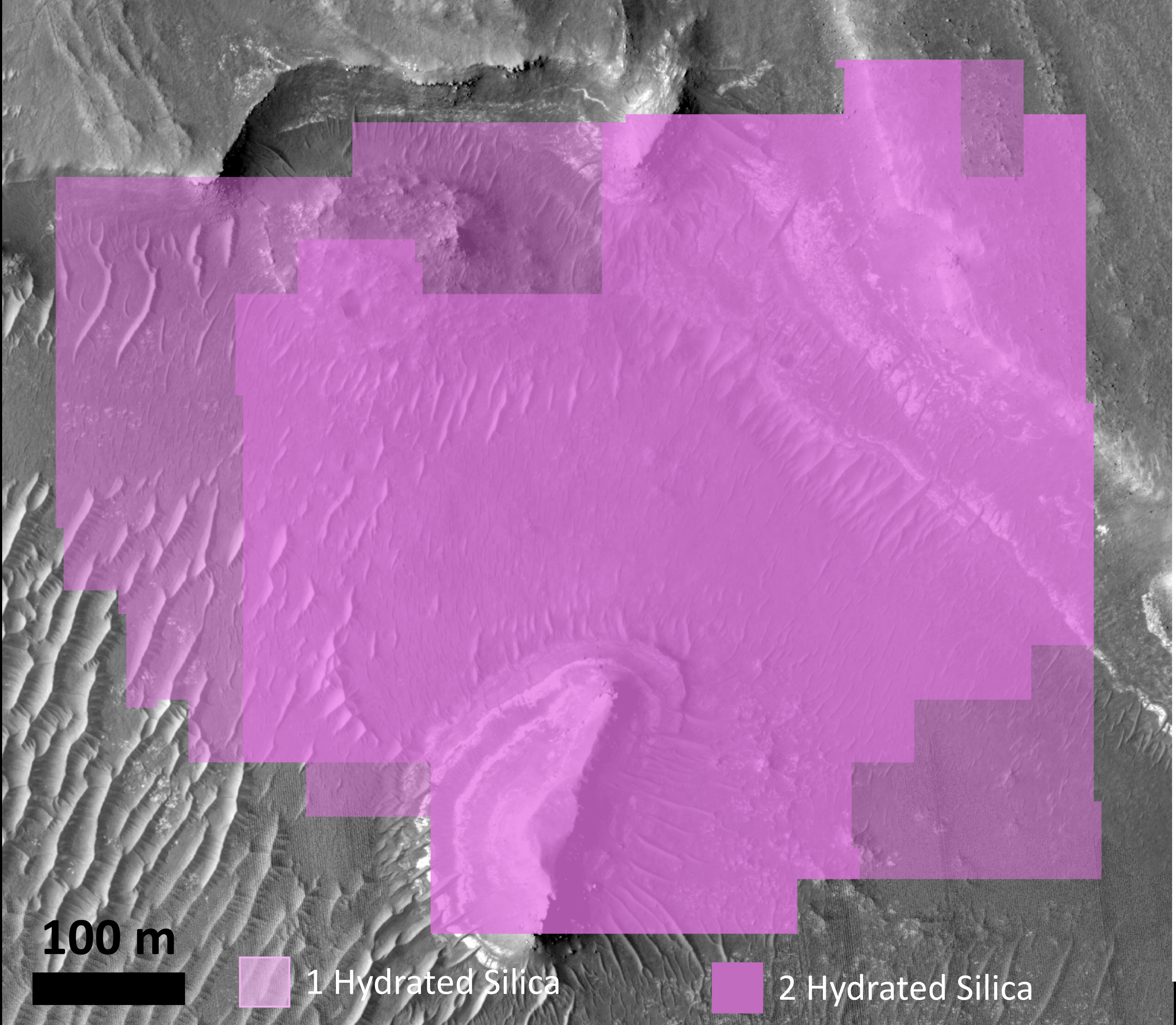
Associated with light-toned fractured material

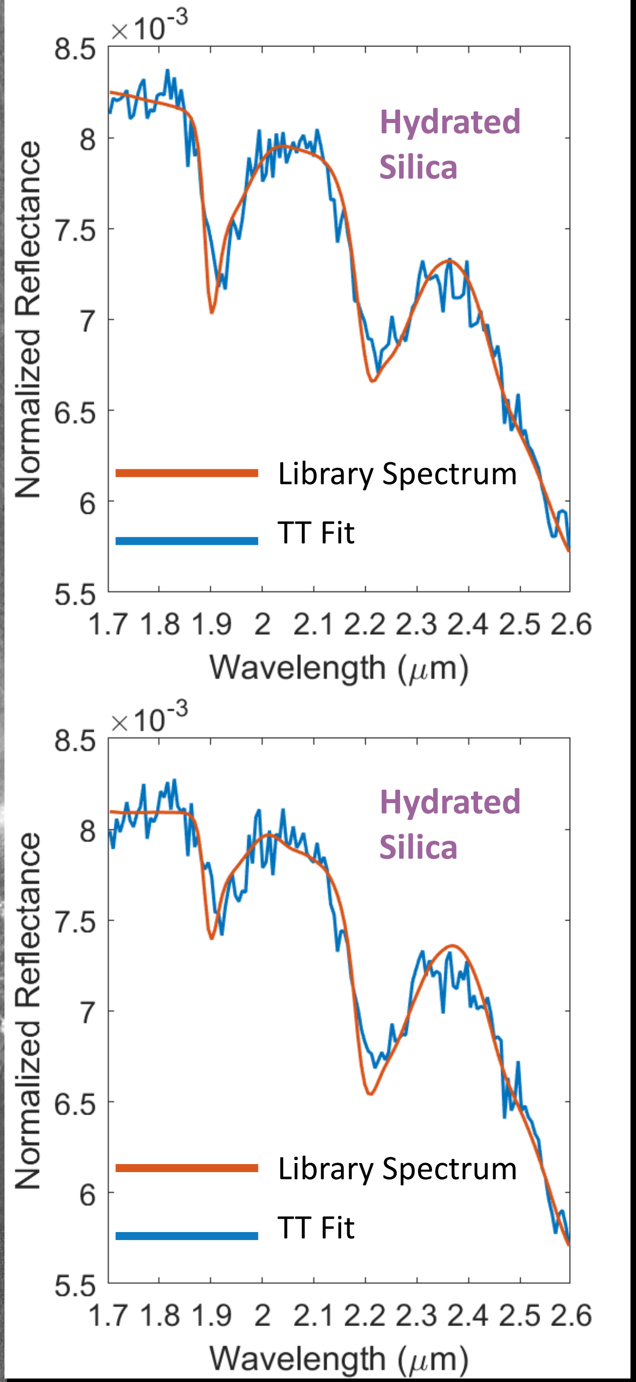


Associated with light-toned fractured material


×10^-3
8.5
8
7.5
7
6.5
6
5.5
Normalized Reflectance
1.7 1.8 1.9 2 2.1 2.2 2.3 2.4 2.5 2.6
Wavelength (μm)
Hydrated Silica
Library Spectrum
TT Fit
Associated with light-toned layered material
3 km
Hydrated Silica

Associated with light-toned layered material





Associated with light-toned layered material

What is the origin of this hydrated silica?

Detrital → Moderate biosignature preservation potential

Authigenic → High biosignature preservation potential

Authigenic origin scenario

1. Formed during deposition of Jezero delta.
2. Formed during later diagenetic event (as seen in Gale crater).

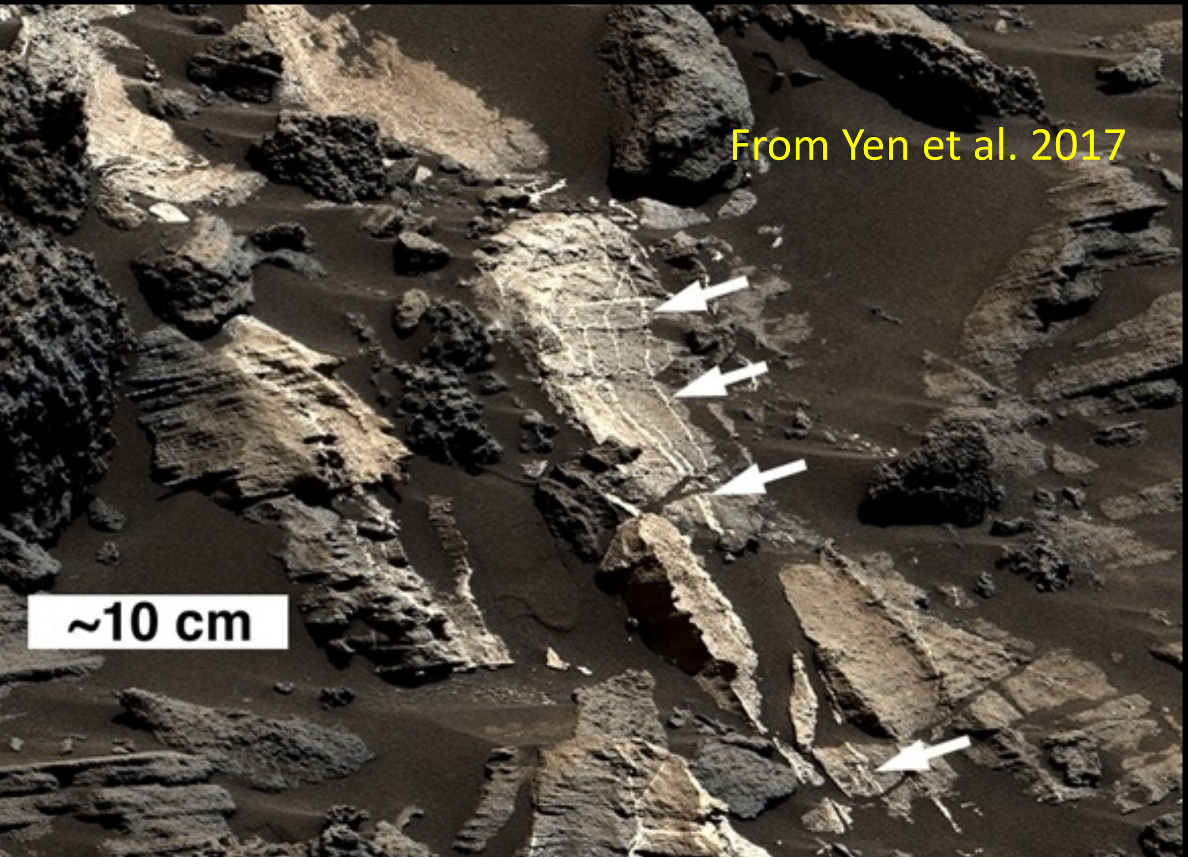
Authigenic origin scenario

1. Formed during deposition of Jezero delta.

Promising biosignature preservation material for lake-hosted habitable environment, if surface life existed.

Authigenic origin scenario

2. Formed during later diagenetic event (as seen in Gale crater).

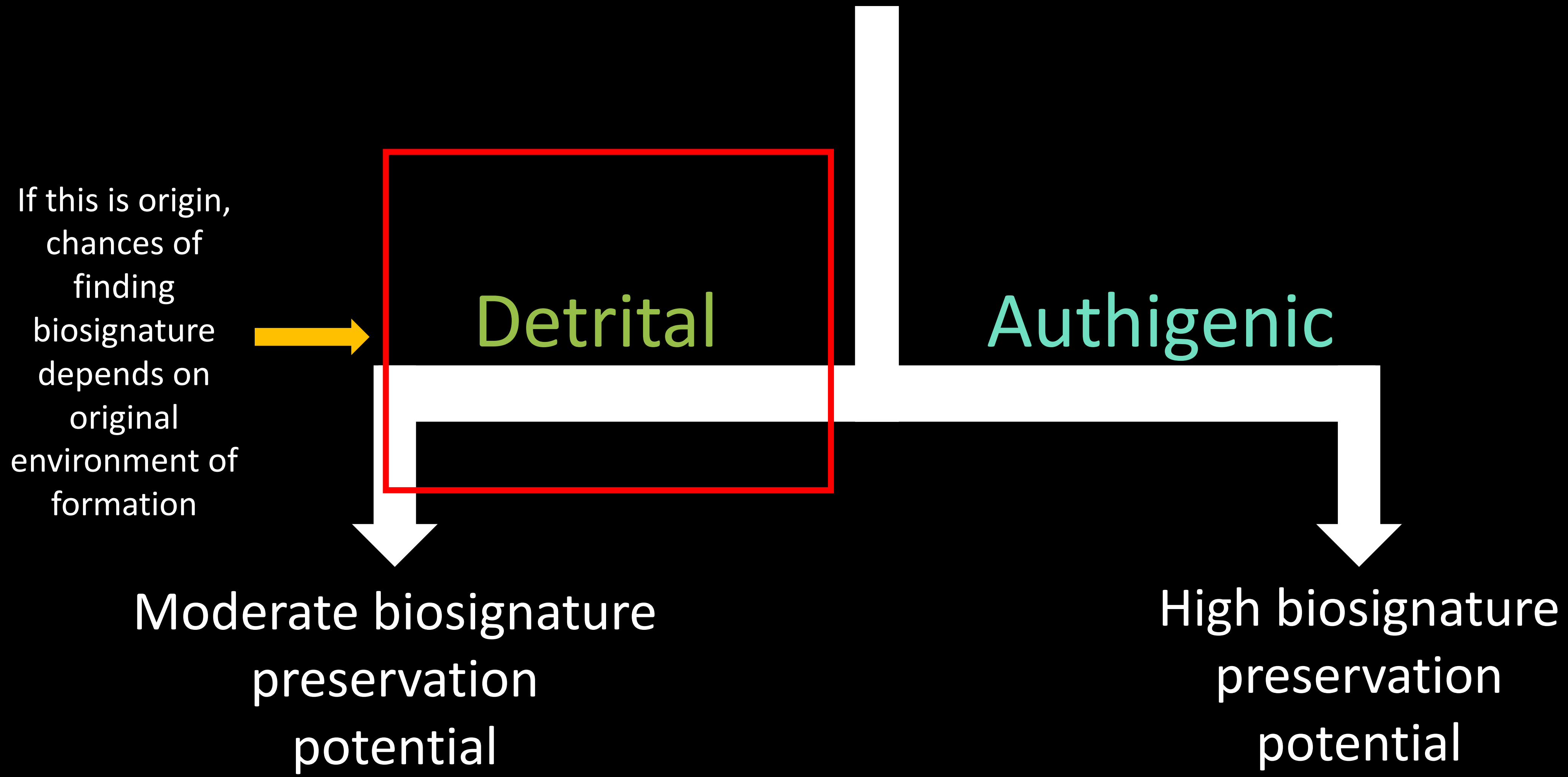


Alteration halos form where aqueous fluids passively and actively enriched silica content (Yen et al. 2017).

Observations in Gale are "consistent with infiltration of subsurface fluids, initially acidic and then alkaline" (Yen et al. 2017).

Potentially less favorable for habitability.

What is the origin of this hydrated silica?



We will now explore detrital origin scenario

Examining the source –mineral assemblages associated with hydrated silica in greater NE Syrtis region

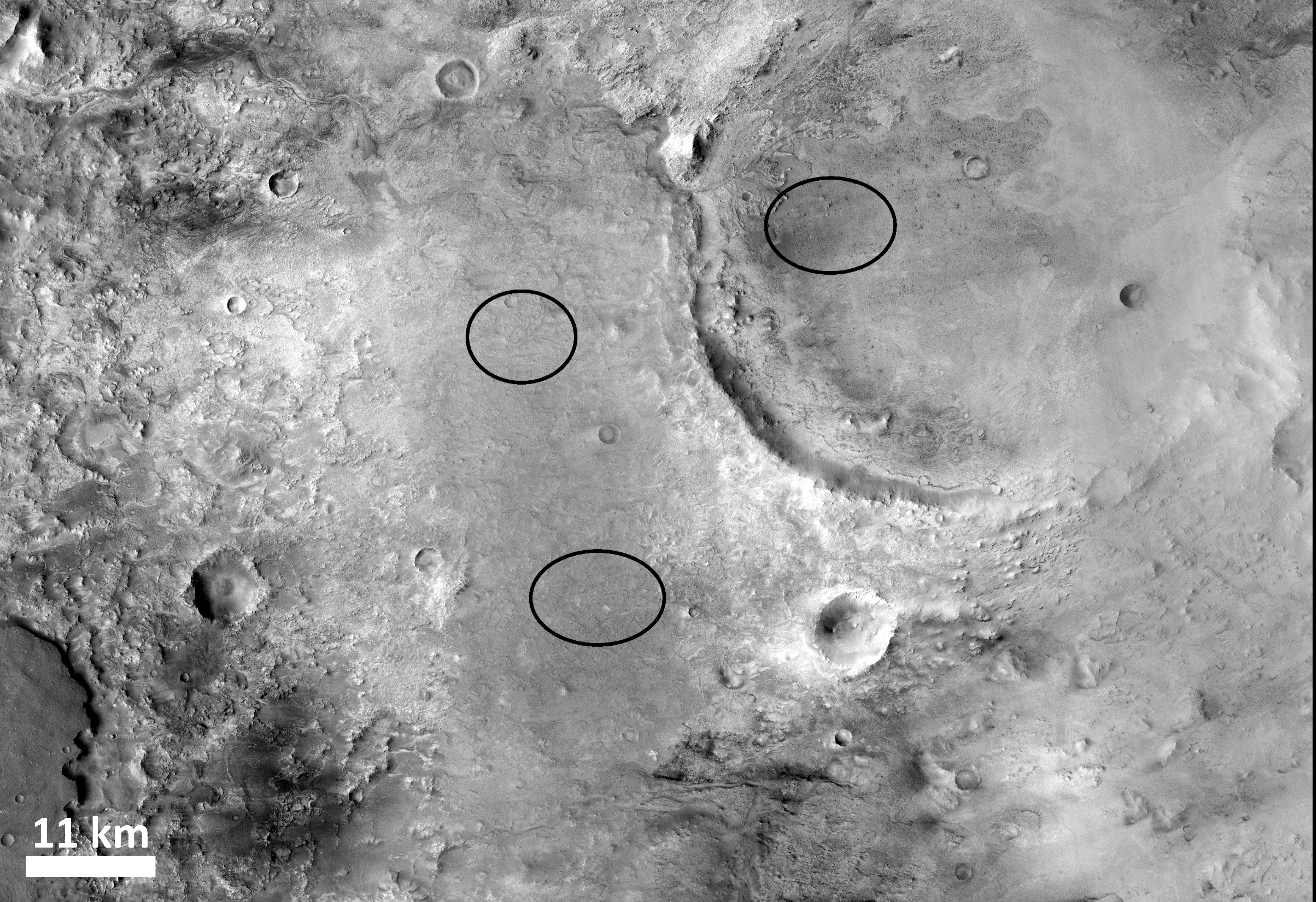
Assemblage 1: Hydrated Silica + Magnesite

Assemblage 2: Hydrated Silica + Jarosite + Monohydrated Sulfate

Assemblage 3: Hydrated Silica + Al-Phyllosilicate

Assemblage 4: Isolated Hydrated Silica

These assemblages may be produced in radically different hydrated silica formation environments


11 km

CRISM images used:

HRL000040ff
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FRT0001182A
FRT00016A73
FRT000161EF
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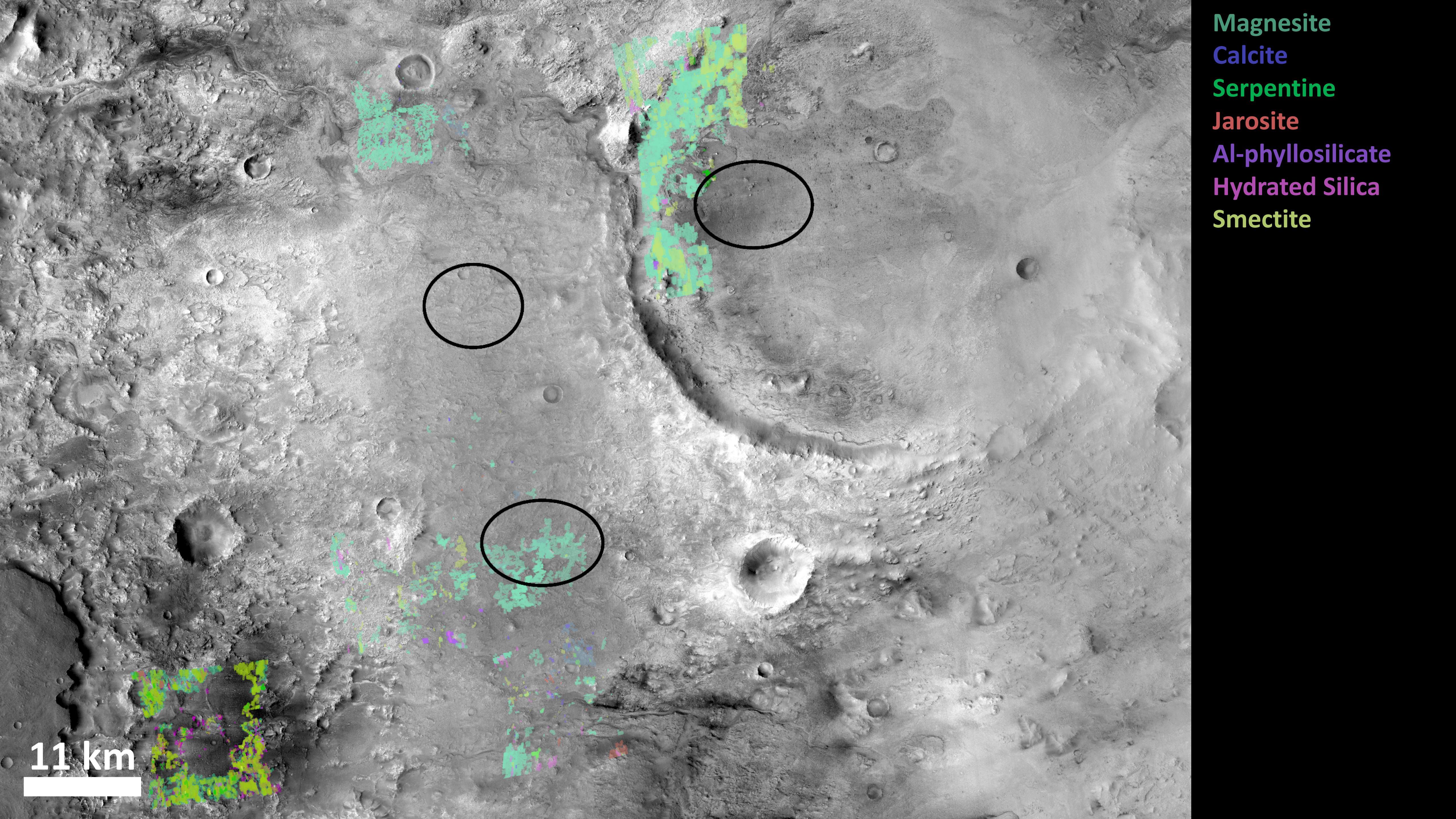
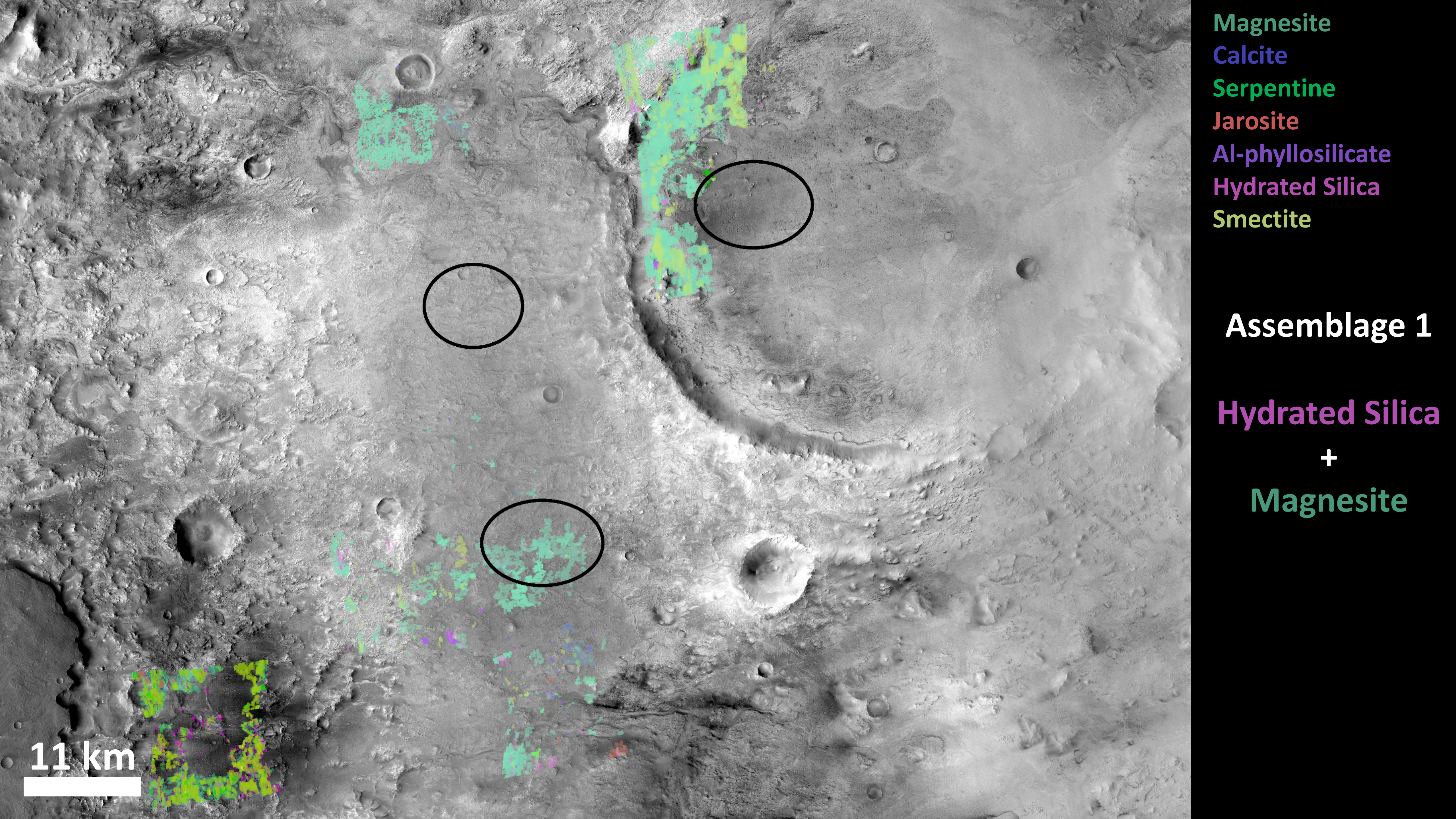
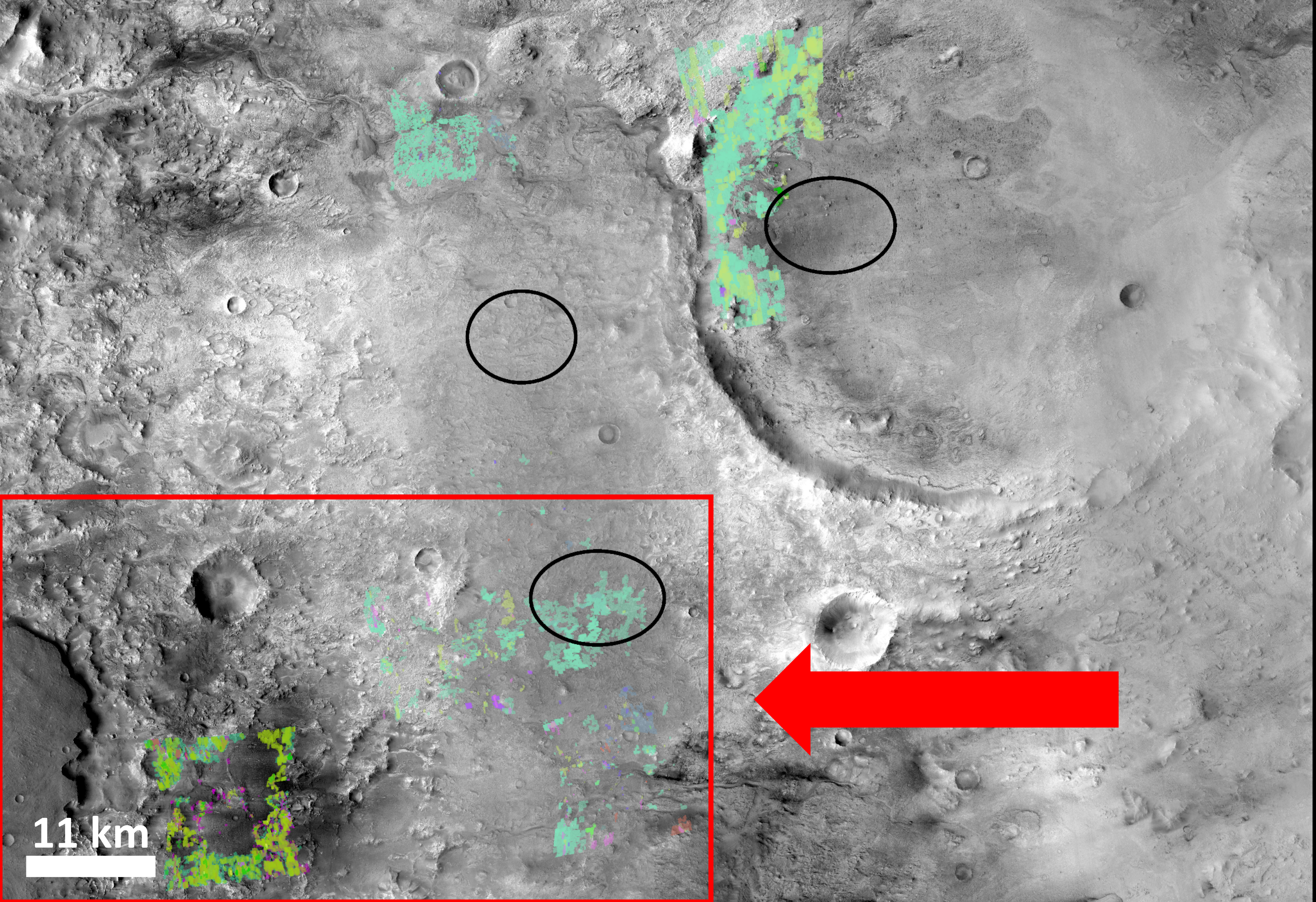
FRT00017B1B


Magnesite
Calcite
Serpentine
Jarosite
Al-phyllosilicate
Hydrated Silica
Smectite
11 km



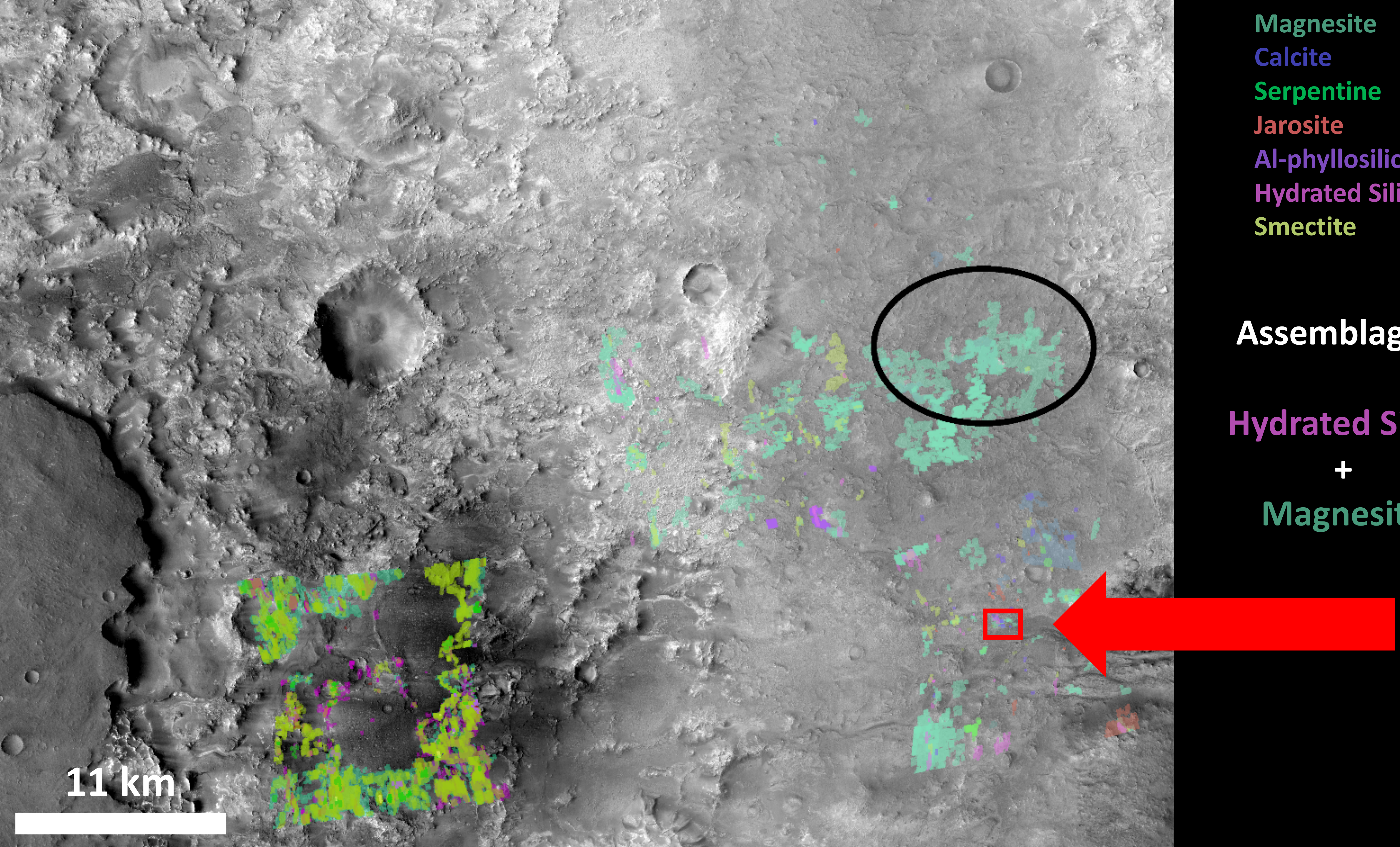
Magnesite
Calcite
Serpentine
Jarosite
Al-phyllosilicate
Hydrated Silica
Smectite
Assemblage 1
Hydrated Silica
+
Magnesite
11 km



Magnesite
Calcite
Serpentine
Jarosite
Al-phyllosilicate
Hydrated Silica
Smectite

Assemblage 1

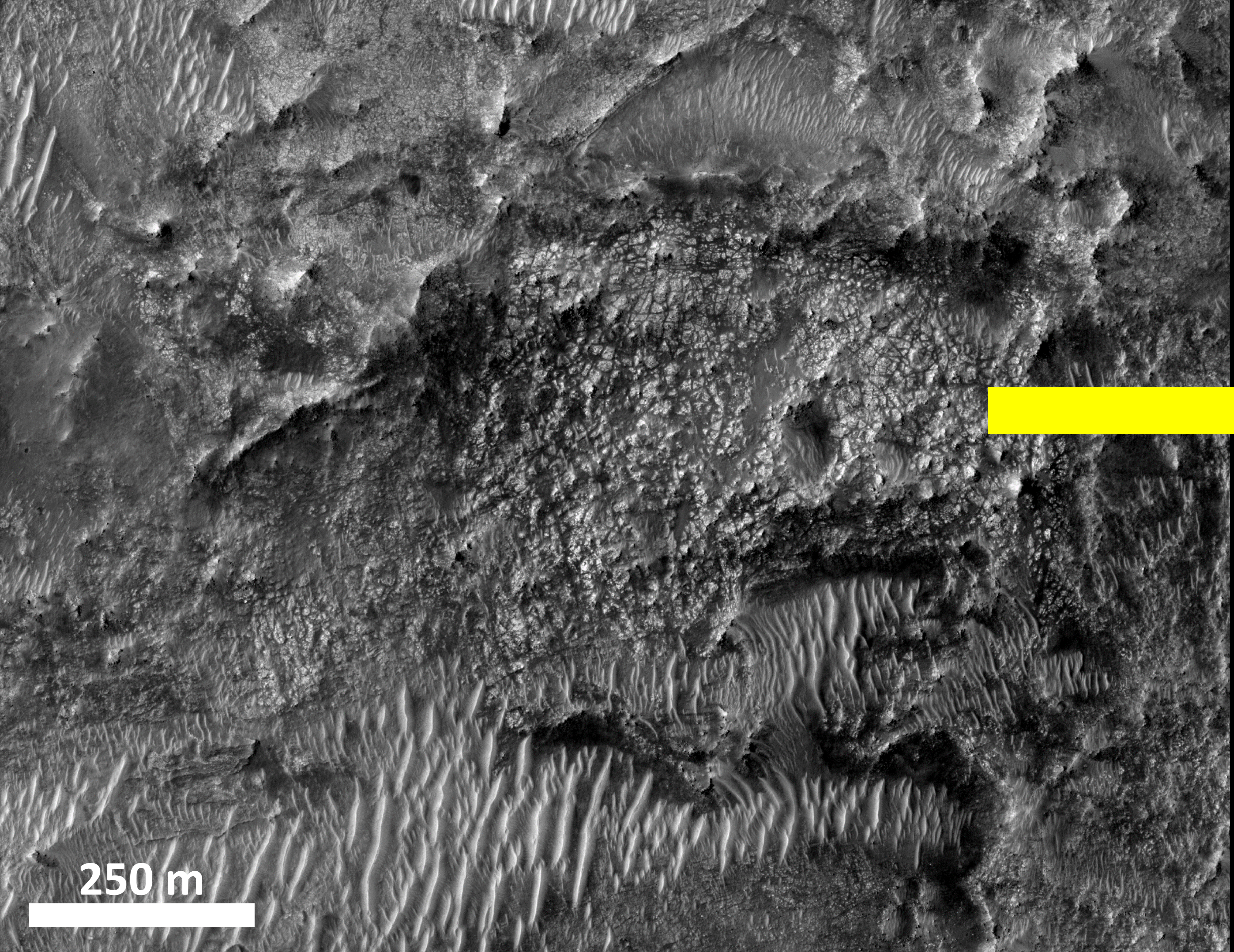
Hydrated Silica
+
Magnesite

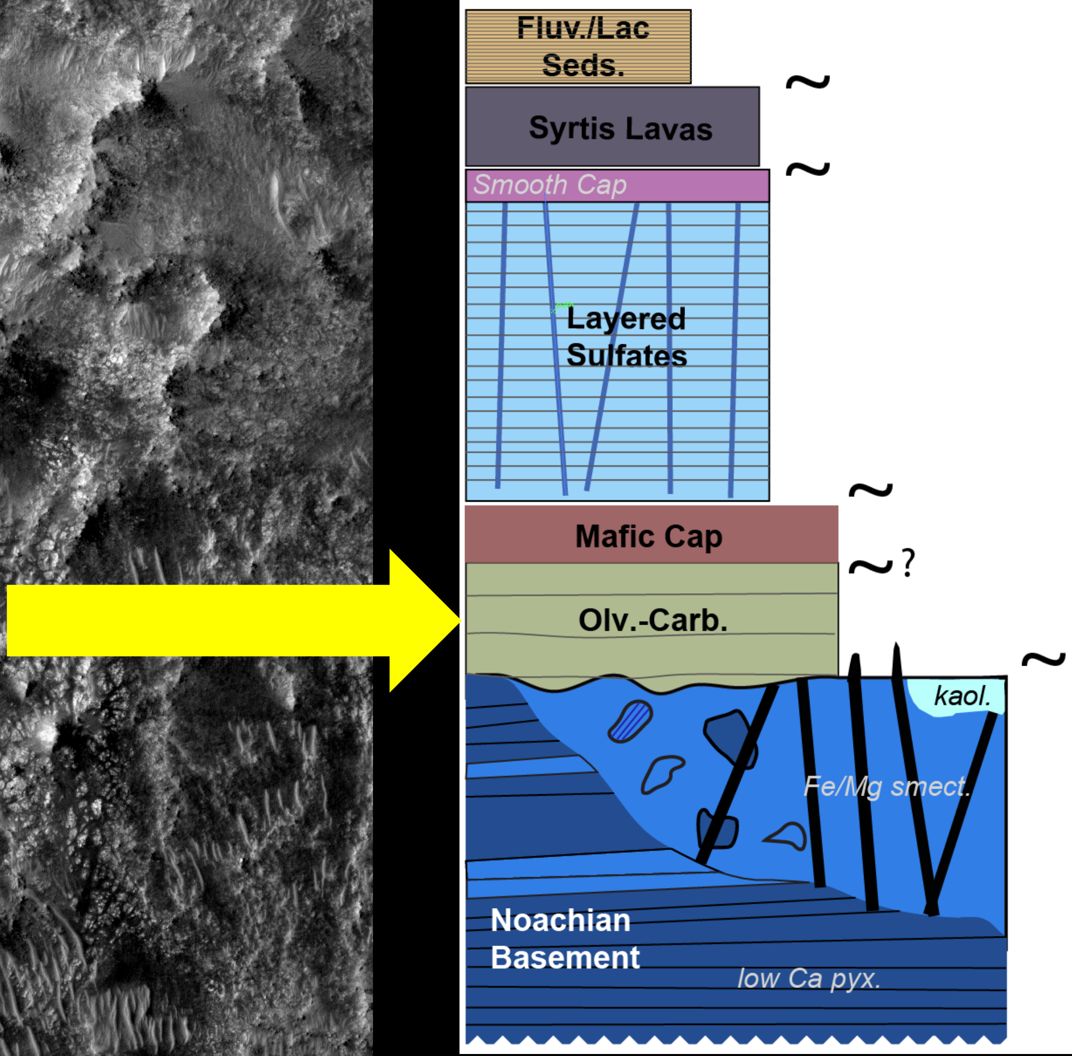


Magnesite
Calcite
Serpentine
Jarosite
Al-phyllosilicate
Hydrated Silica
Smectite

Assemblage 1

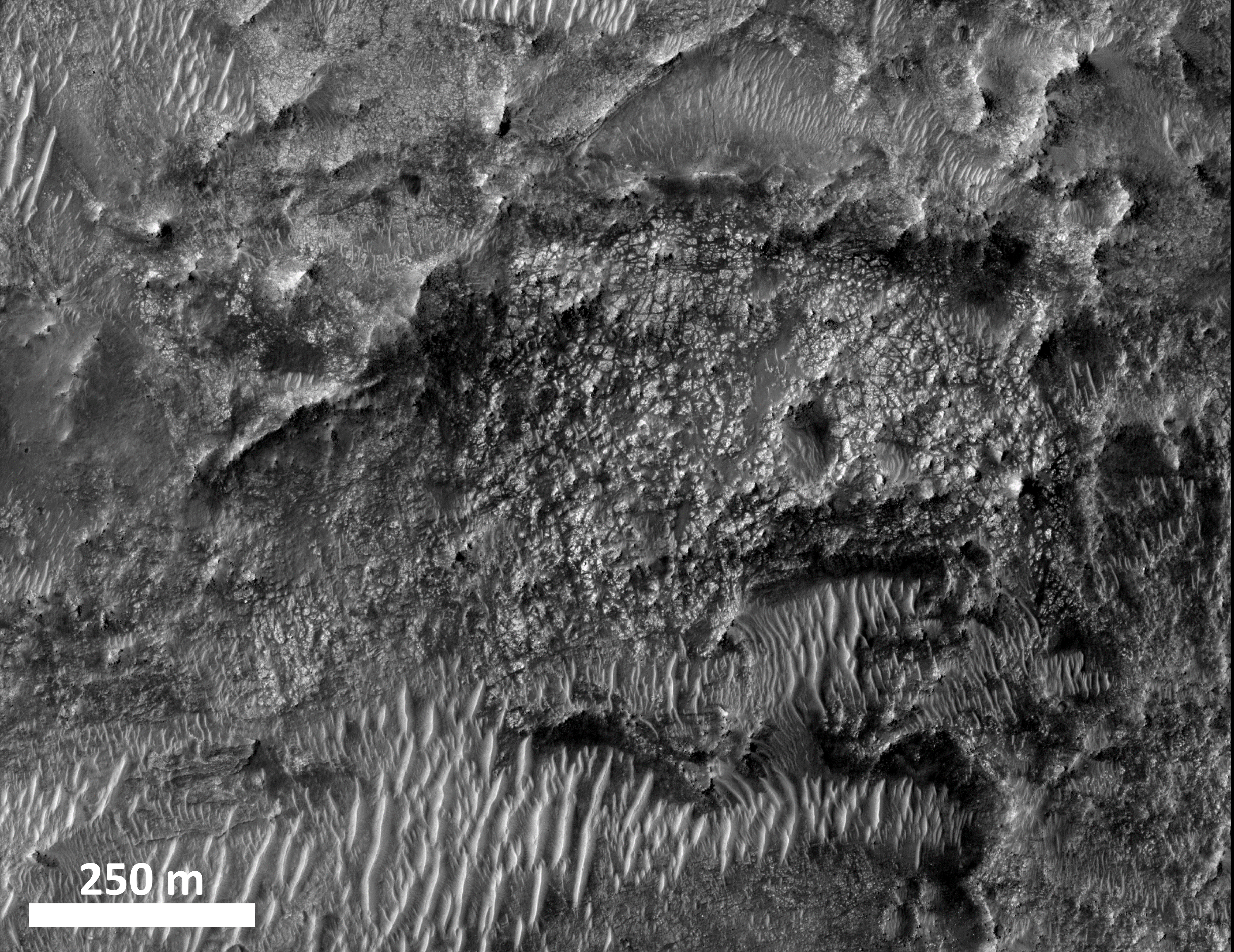
Hydrated Silica
+
Magnesite





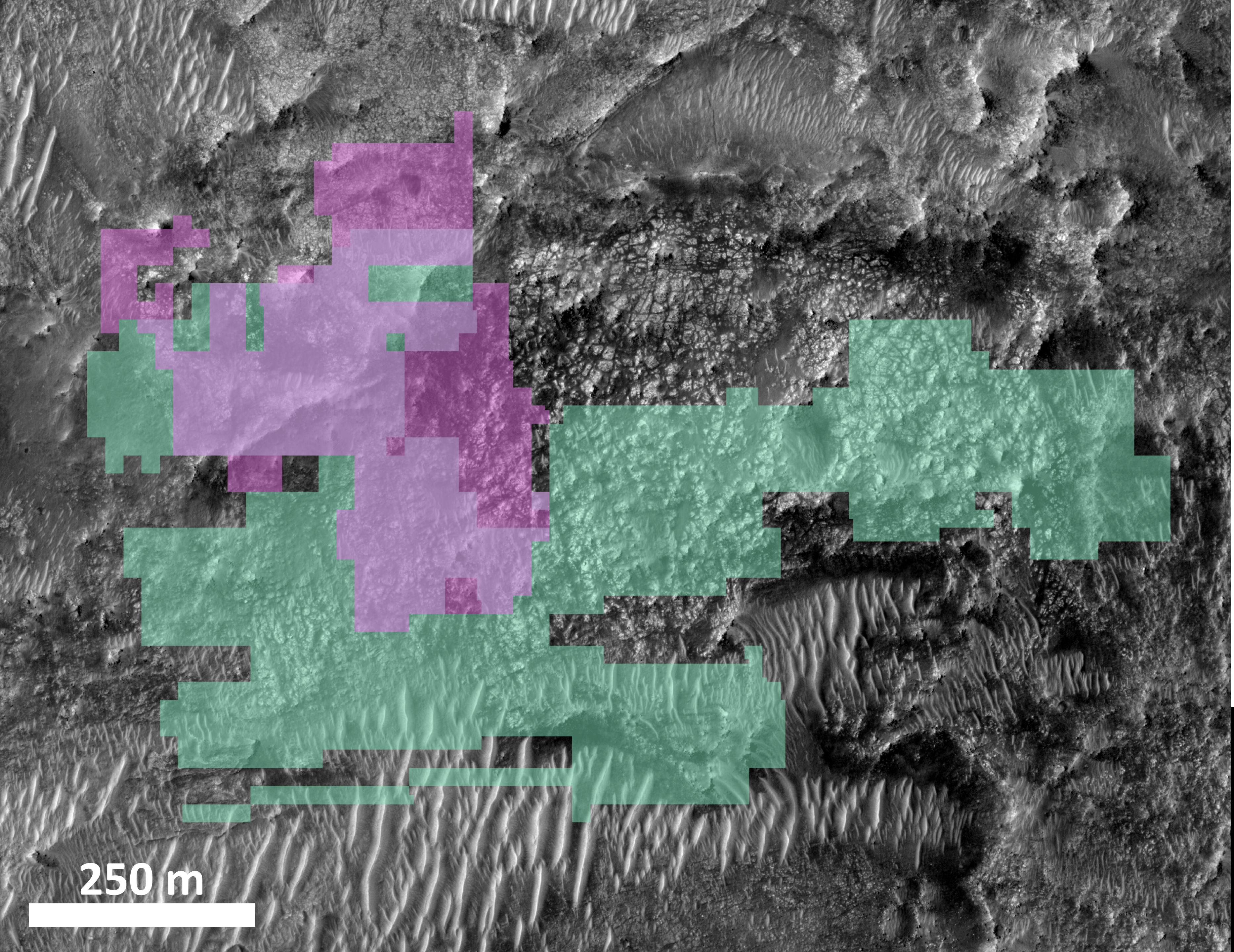
Associated with fractured unit

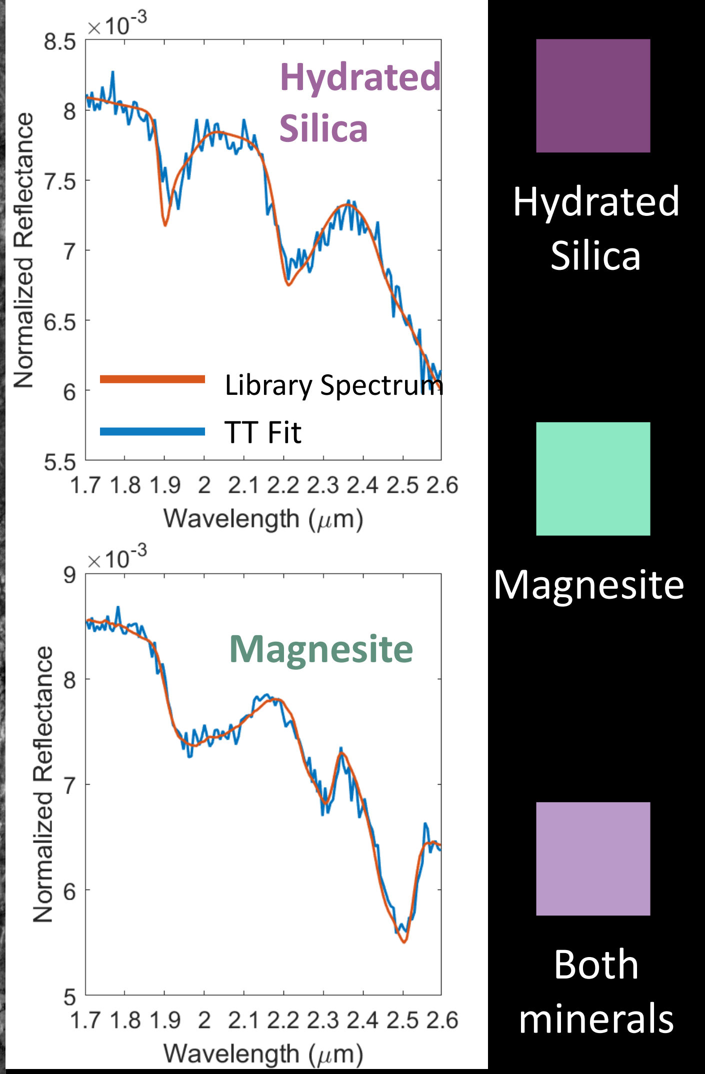
Mineral assemblage interpreted to form in neutral-alkaline environment



Associated with fractured unit

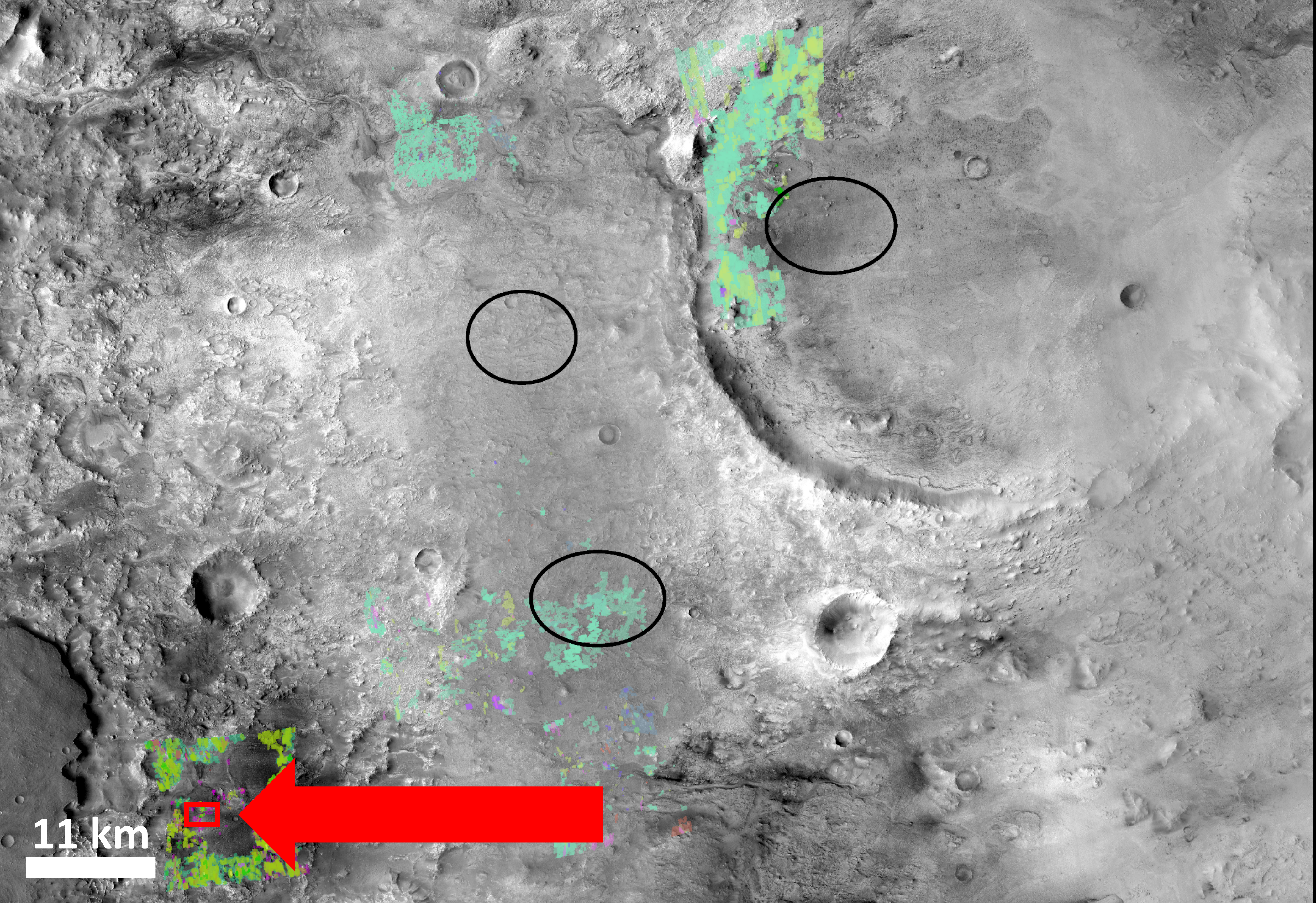
Mineral assemblage interpreted to form in neutral-alkaline environment





Associated with fractured unit

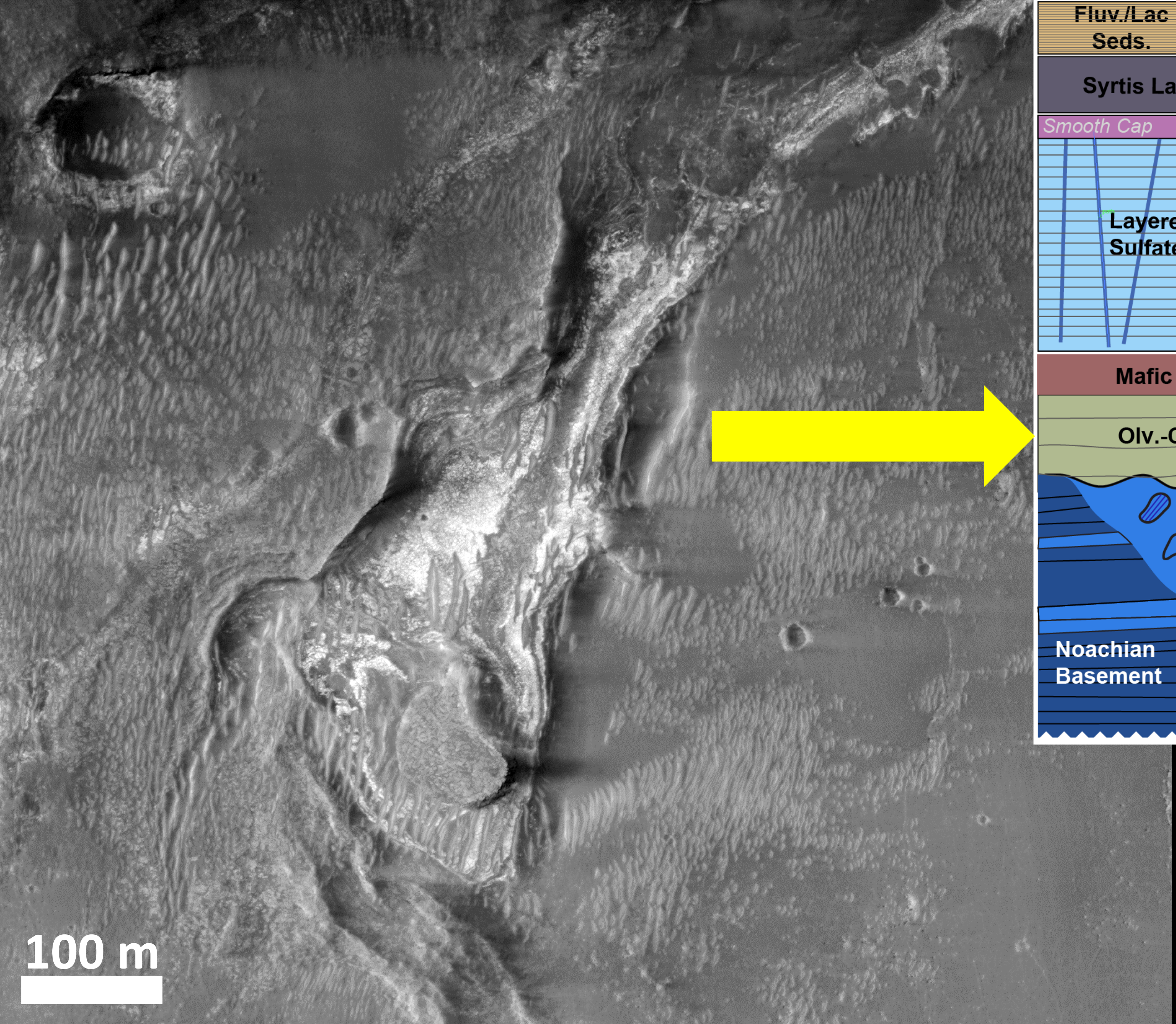
Mineral assemblage interpreted to form in neutral-alkaline environment

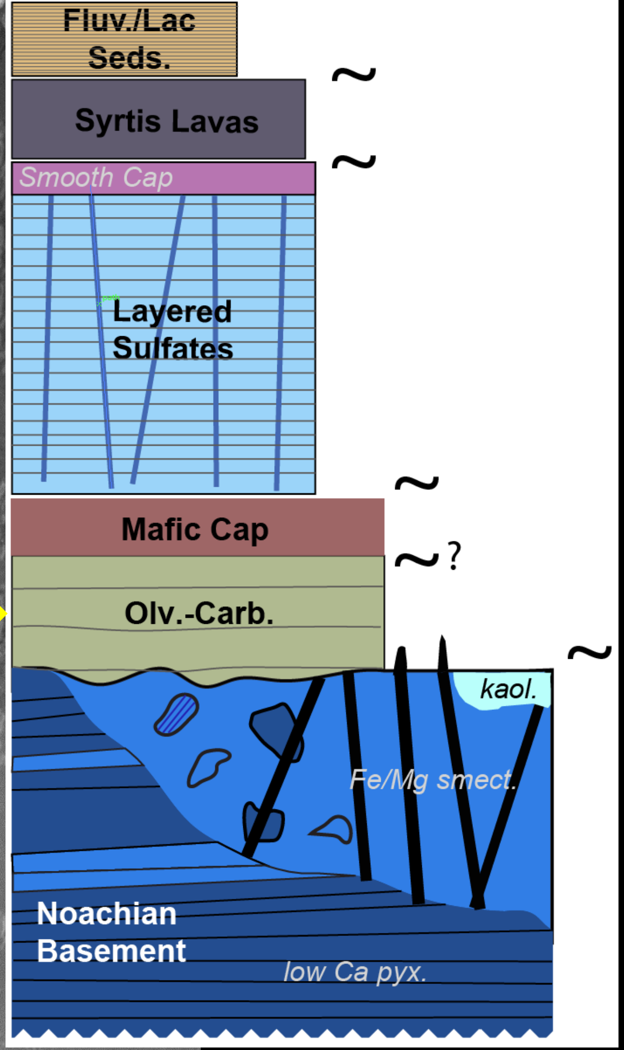


Magnesite
Calcite
Serpentine
Jarosite
Al-phyllosilicate
Hydrated Silica
Smectite

Assemblage 2

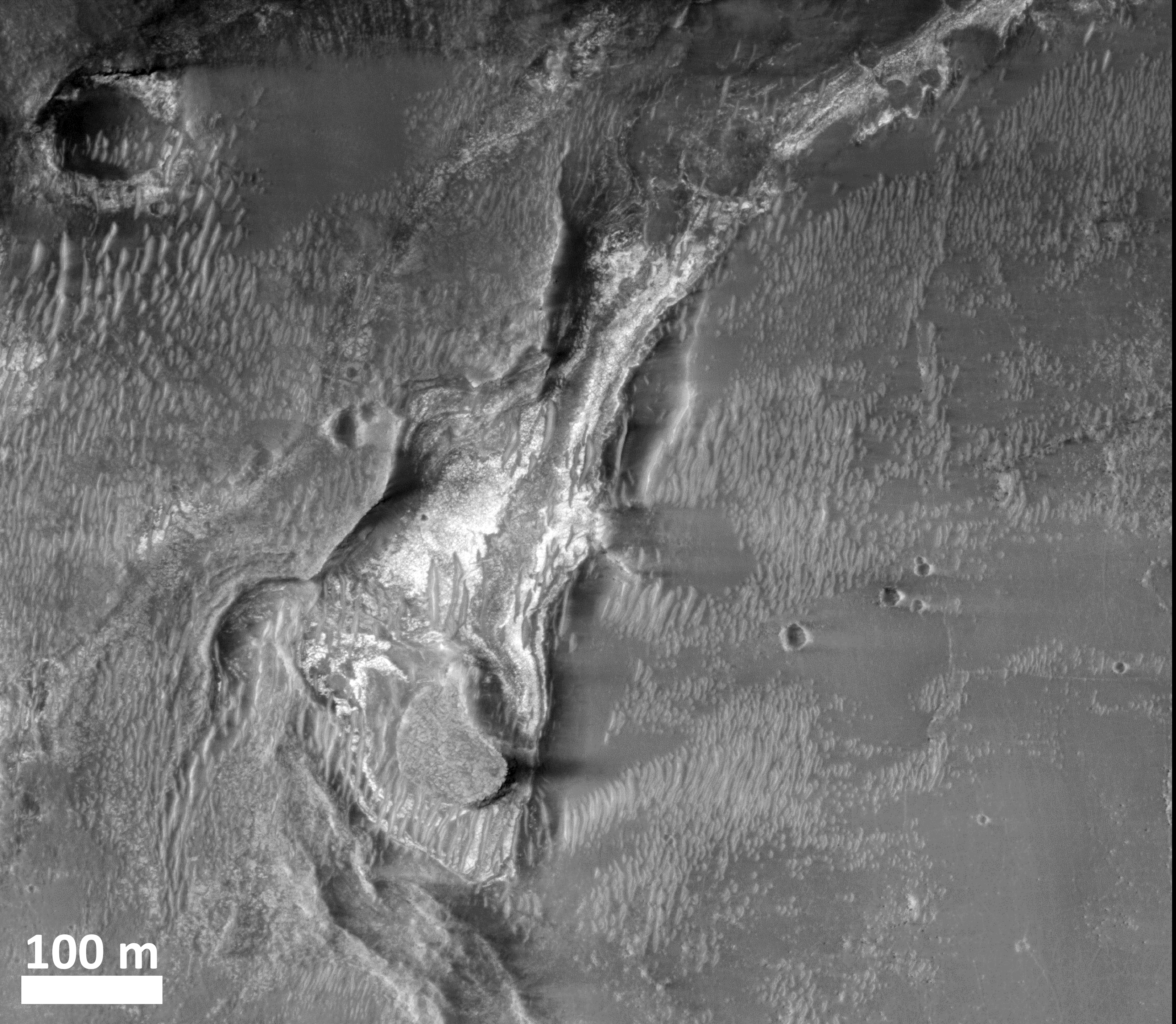
Hydrated Silica
+
Jarosite
+
Monohydrated Sulfate





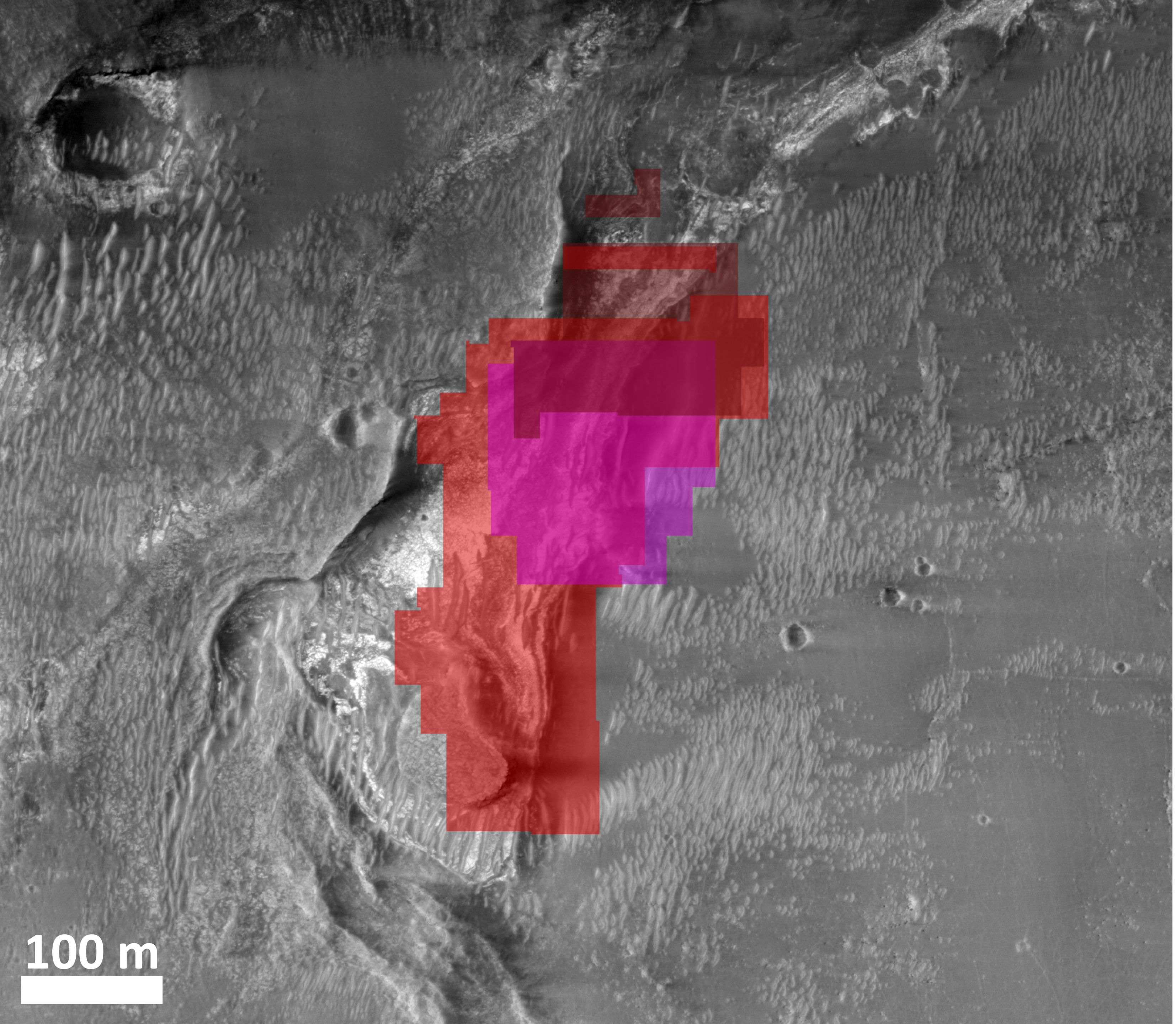
Associated with fractured unit

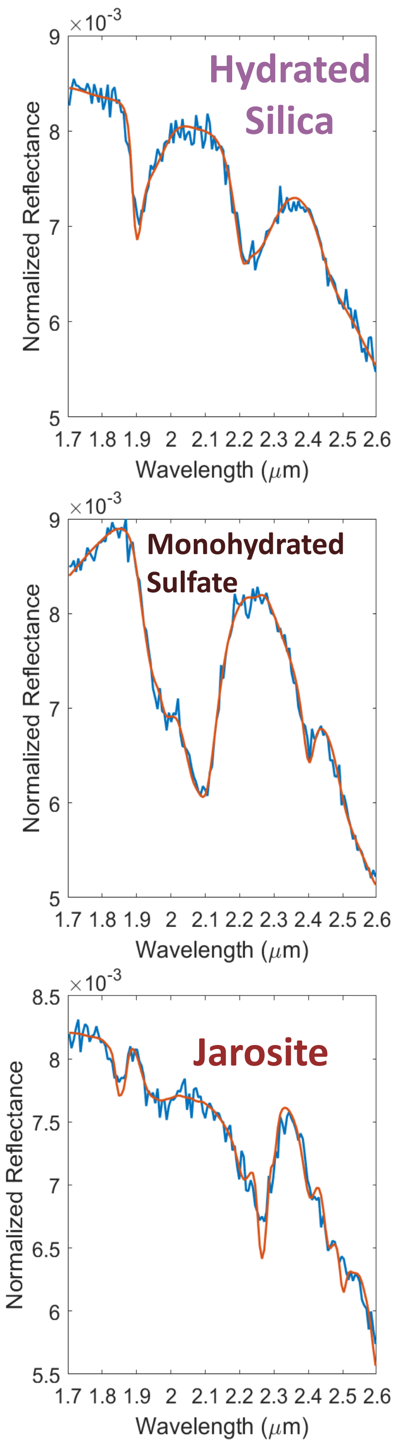
Mineral assemblage interpreted to form in acidic formation environment (e.g. Milliken et al. 2008).



Associated with fractured unit

Mineral assemblage interpreted to form in acidic formation environment (e.g. Milliken et al. 2008).





Associated with fractured unit

Mineral assemblage interpreted to form in acidic formation environment (e.g. Milliken et al. 2008).

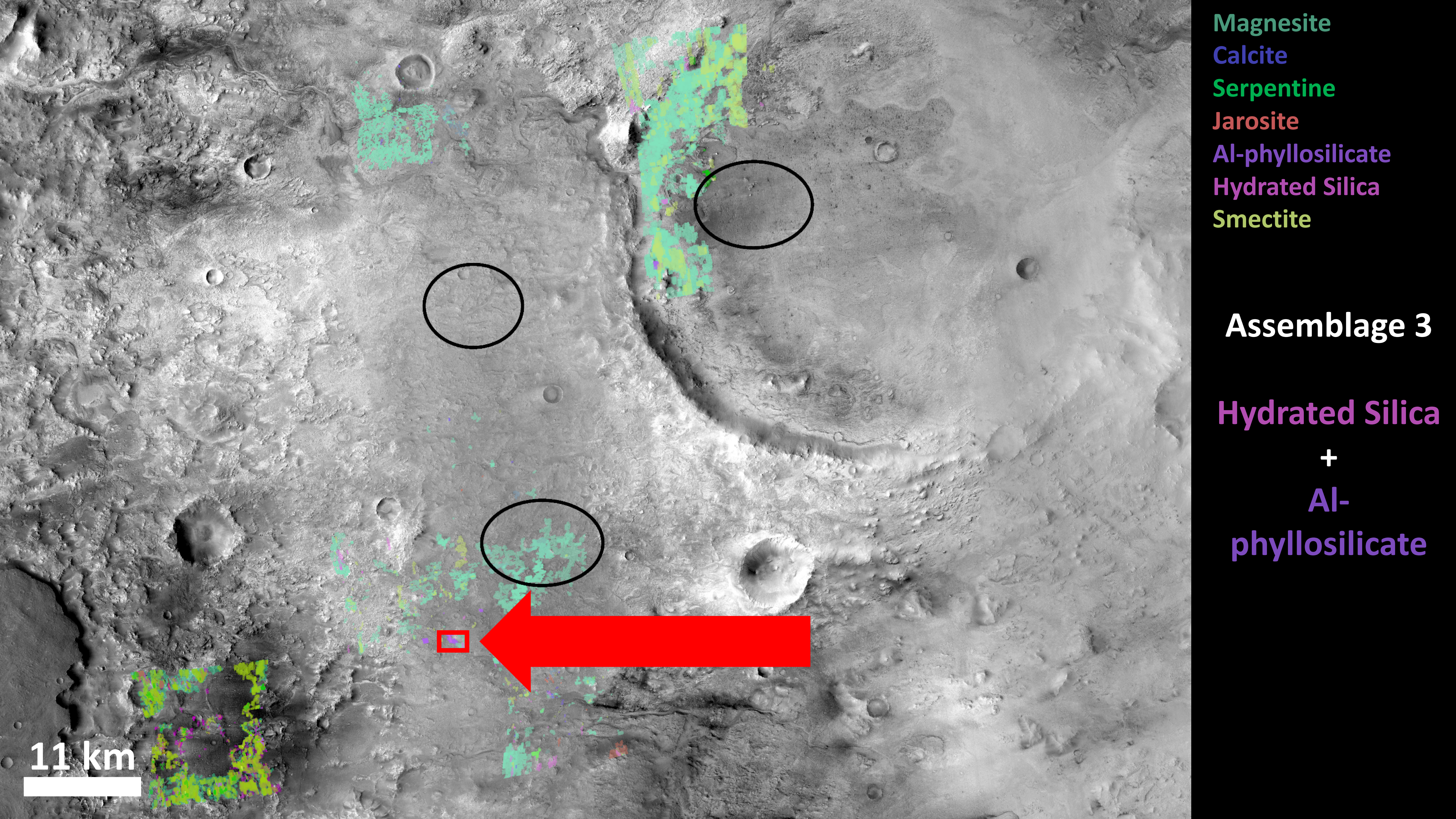
Library Spectrum

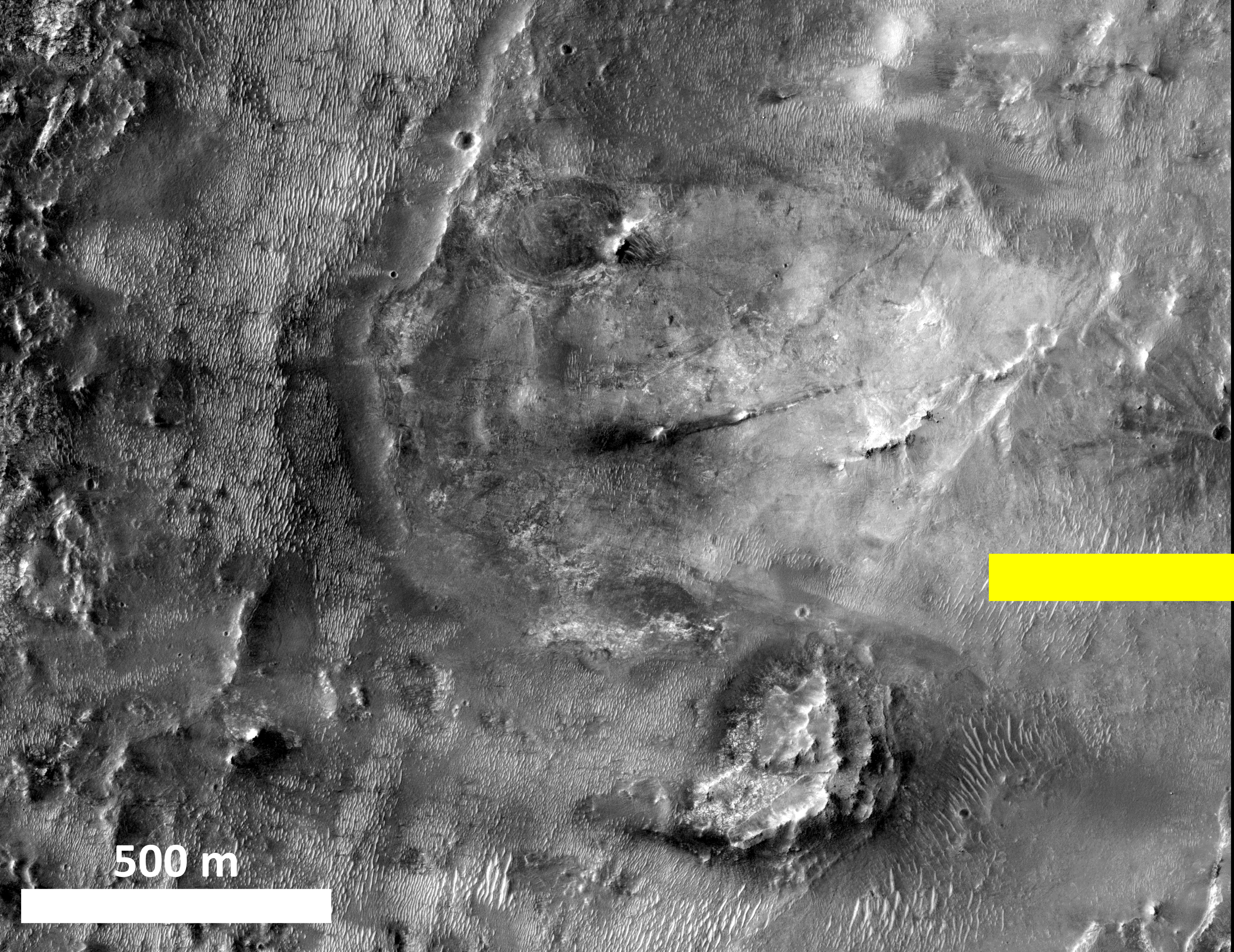
TT Fit

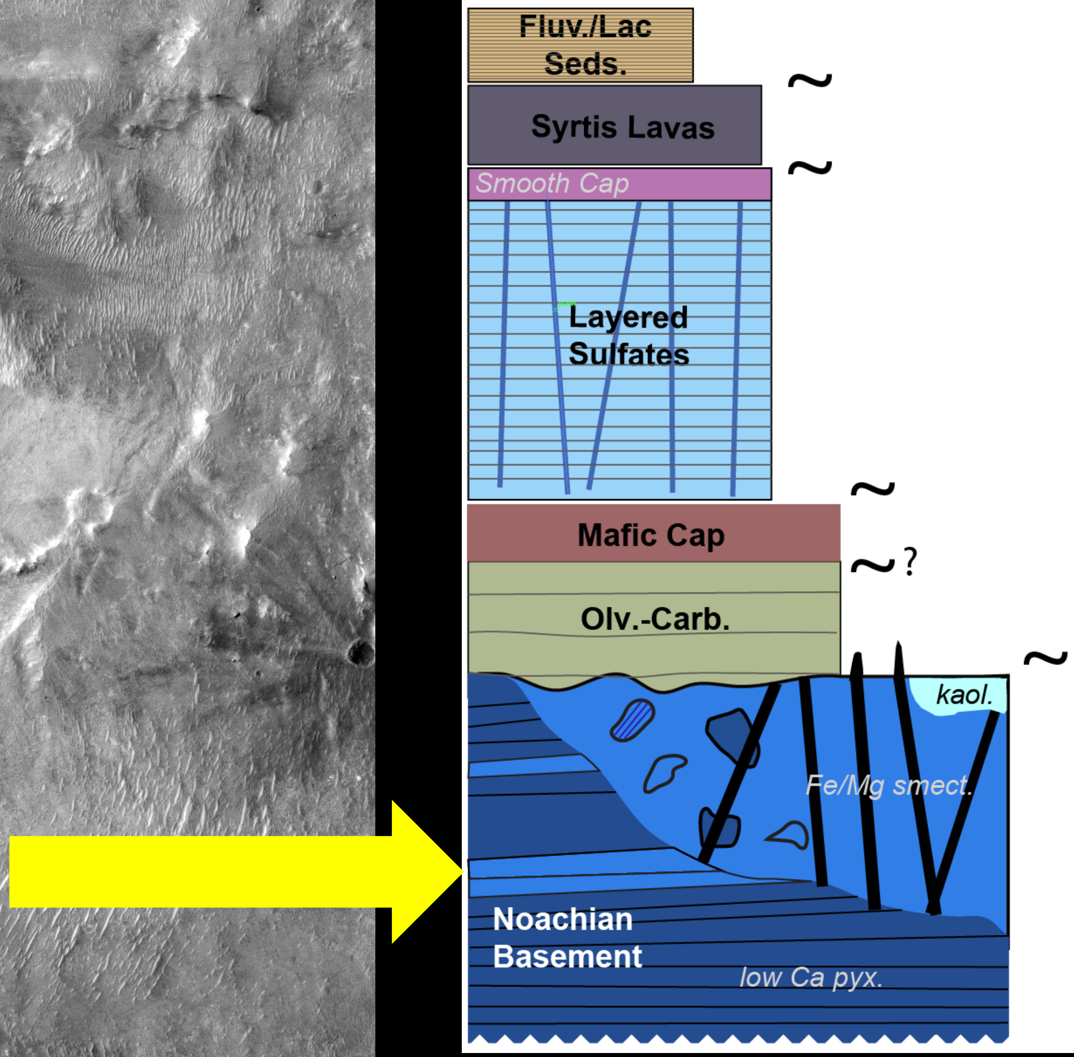
Hydrated Silica

Jarosite

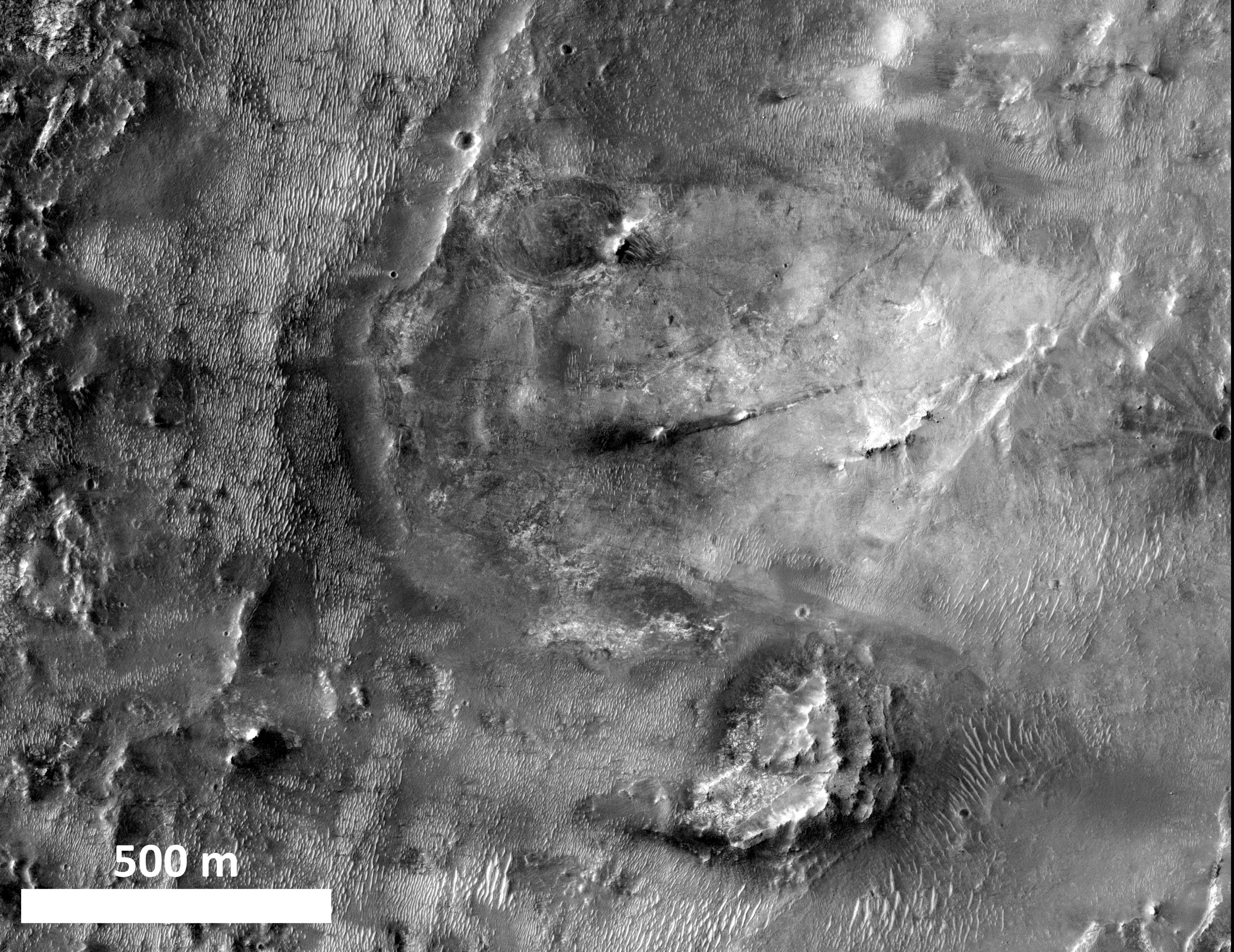
Monohydrated Sulfate


Magnesite
Calcite
Serpentine
Jarosite
Al-phyllosilicate
Hydrated Silica
Smectite
Assemblage 3
Hydrated Silica
+
Al-phyllosilicate
11 km

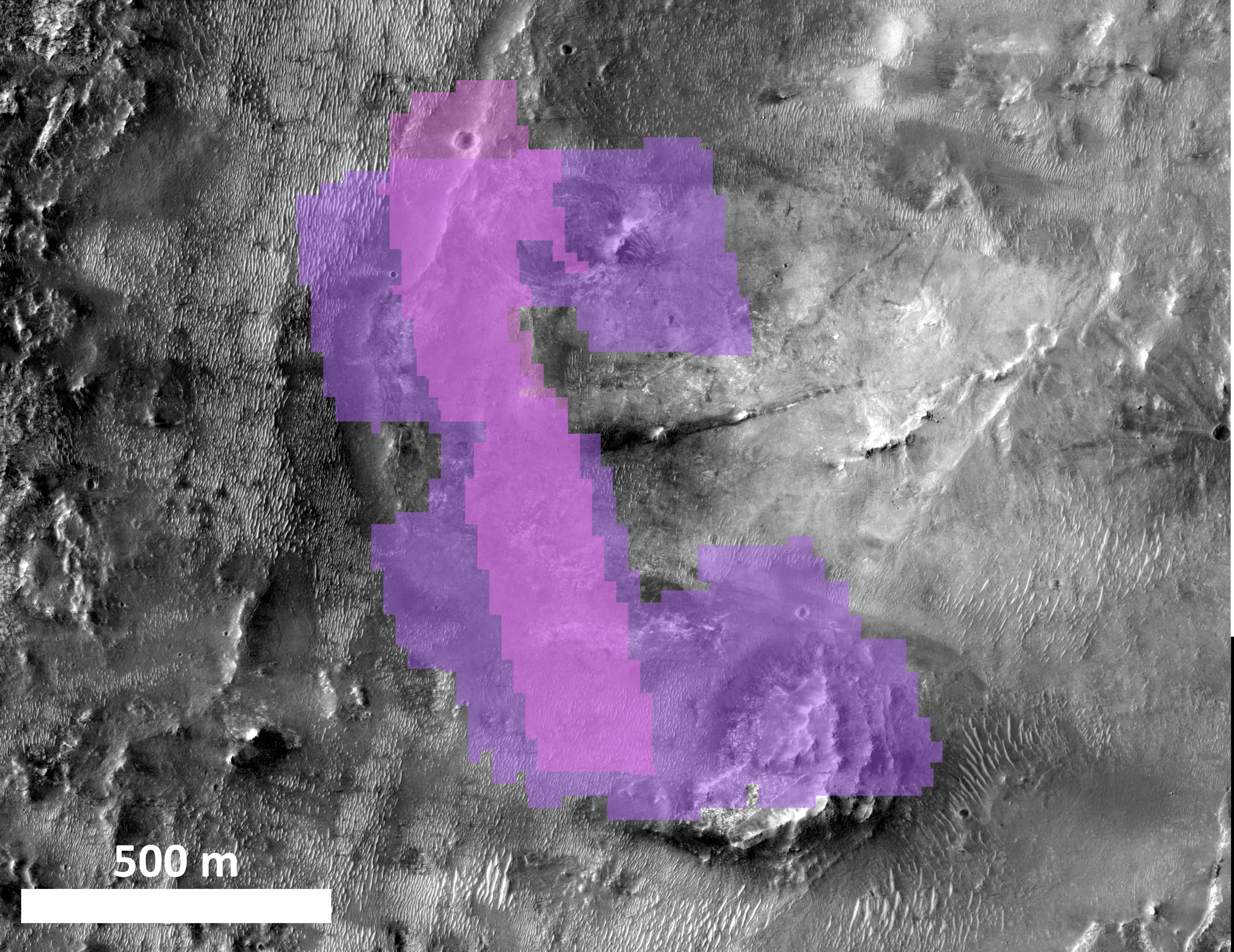


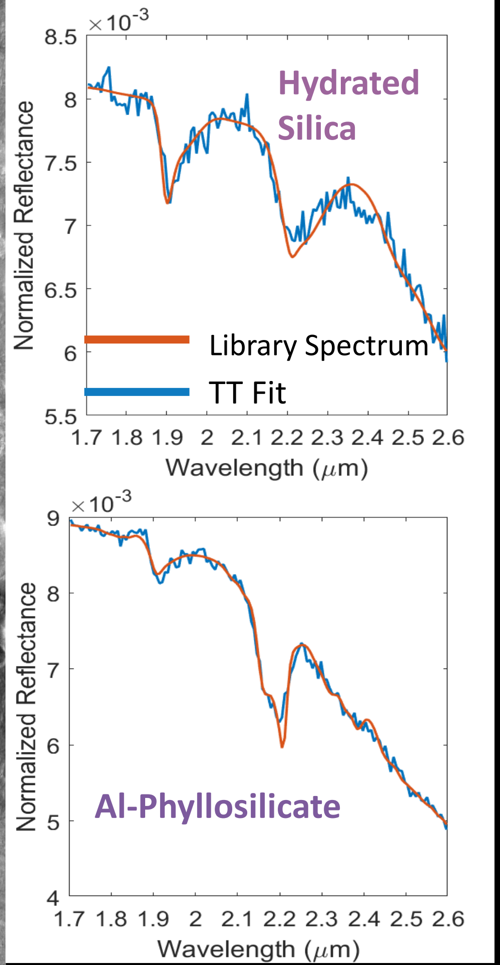


Associated with basement unit



Associated with
basement unit

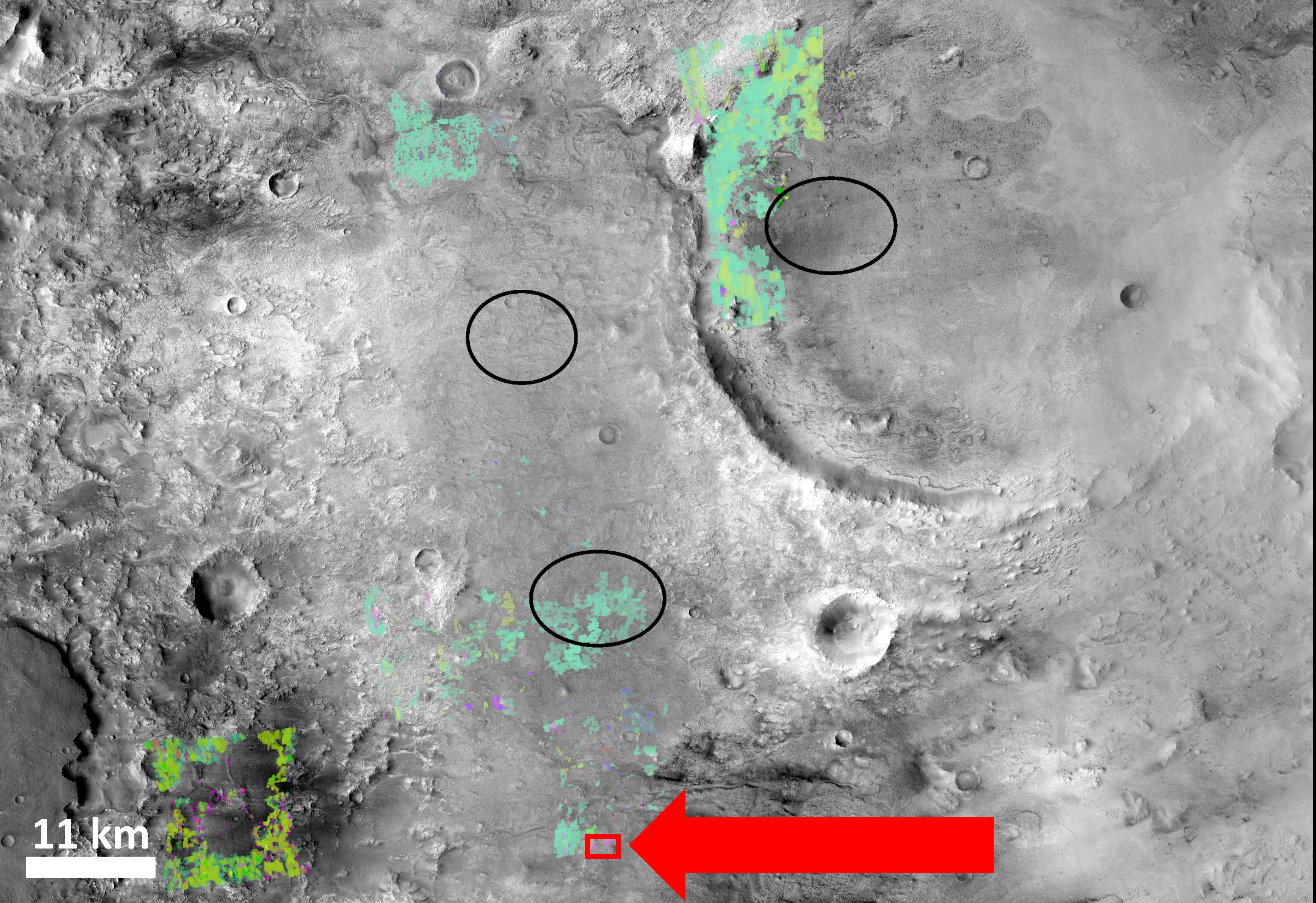




Hydrated Silica

Al-Phyllosilicate

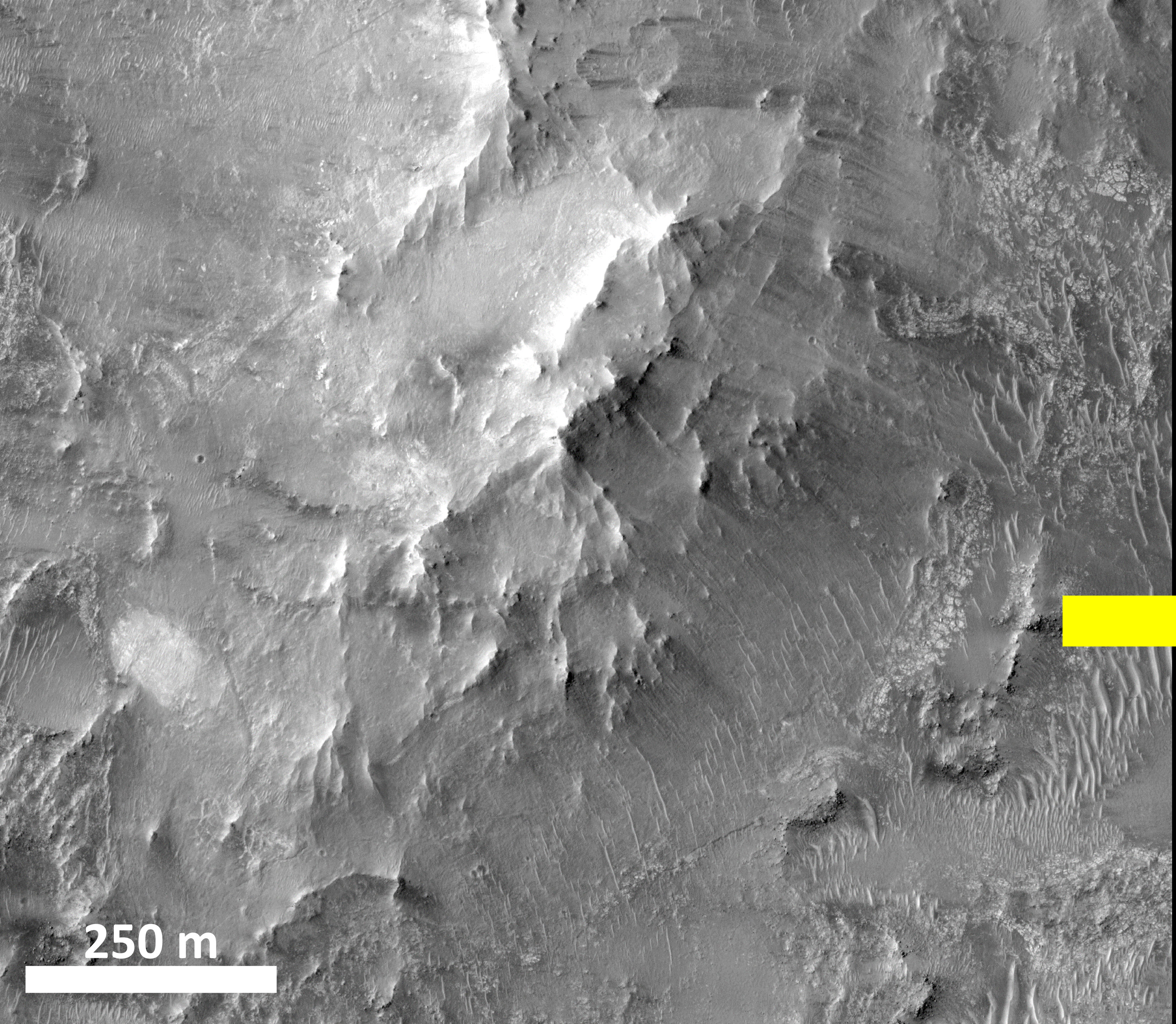
Associated with basement unit

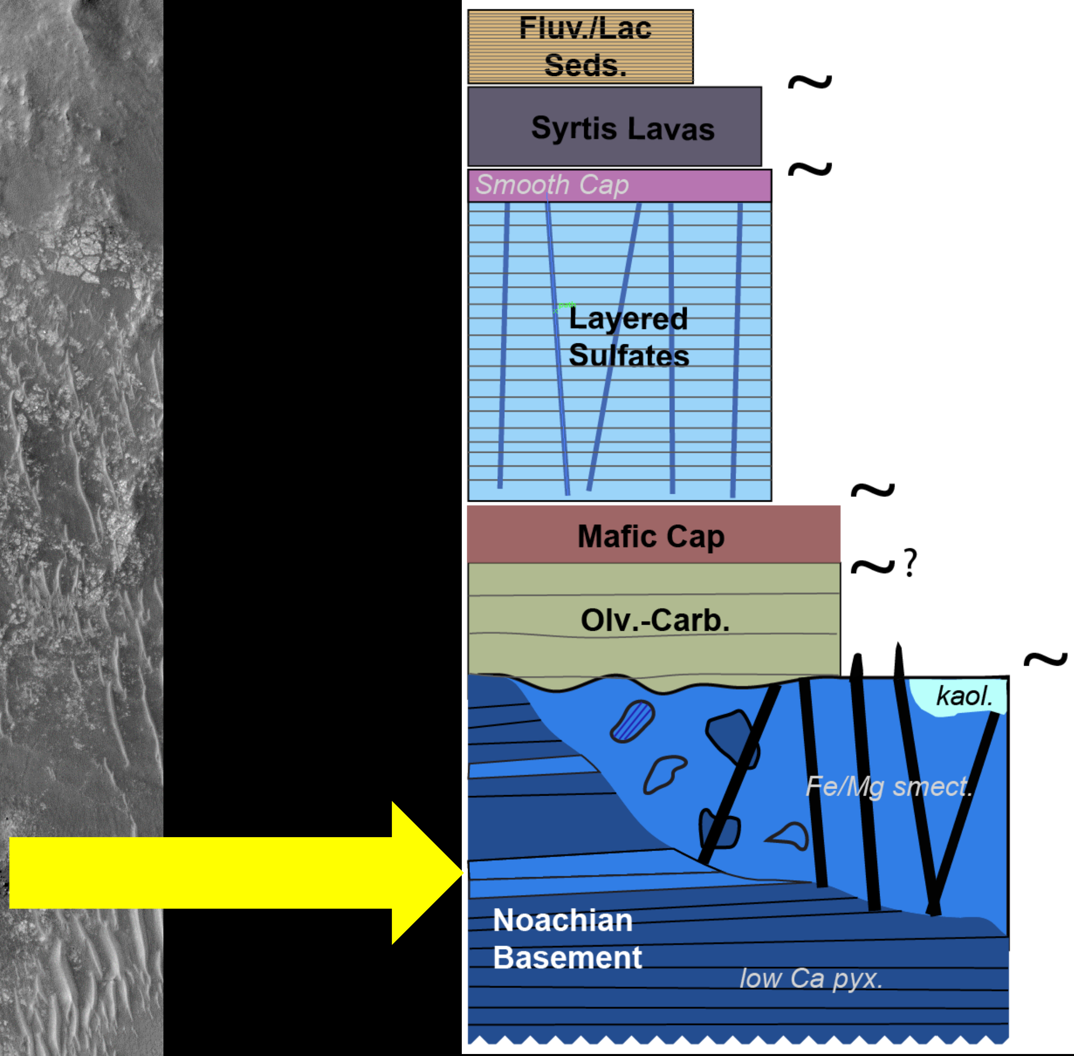


Magnesite
Calcite
Serpentine
Jarosite
Al-phyllosilicate
Hydrated Silica
Smectite

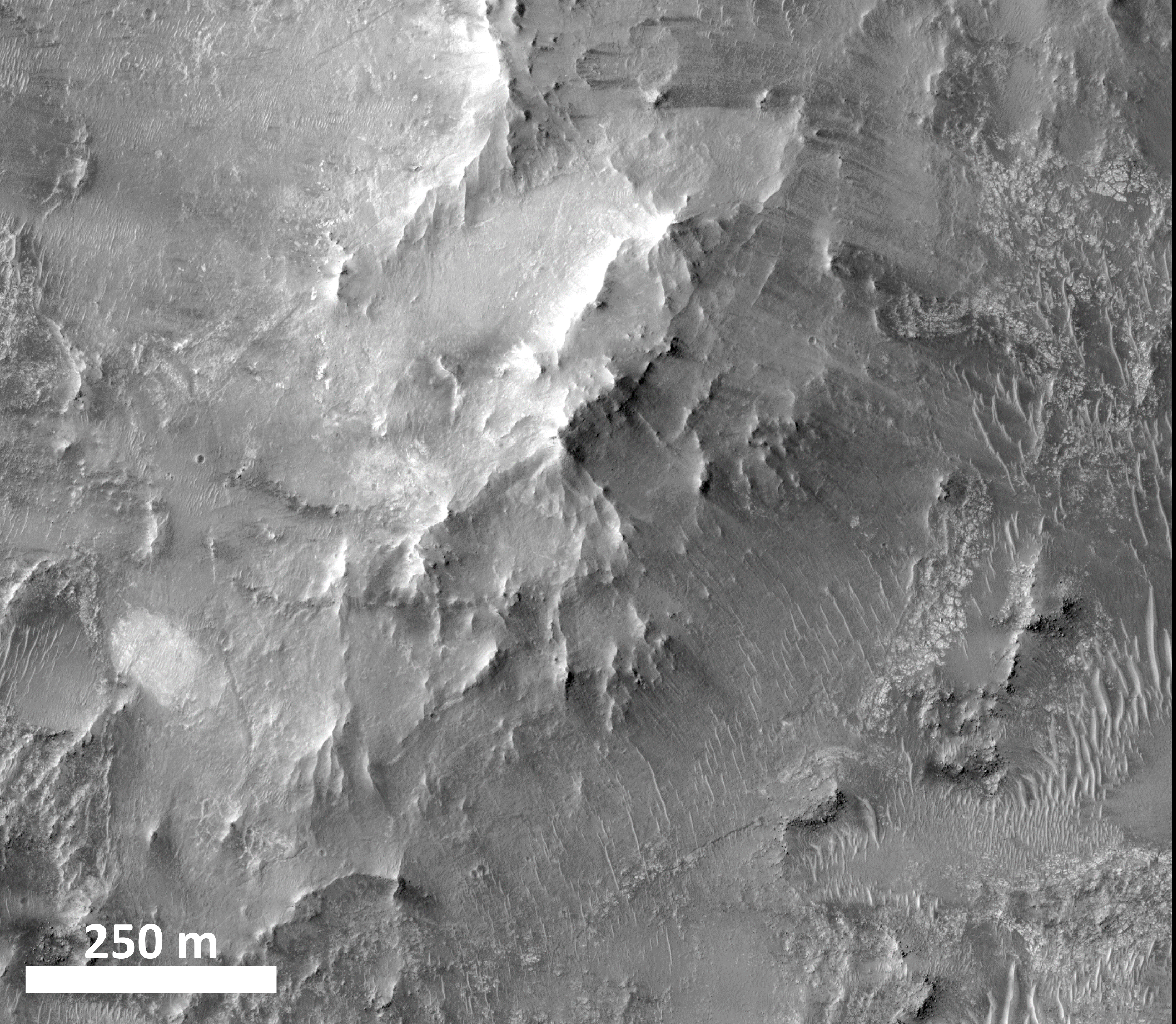
Assemblage 4

Isolated
Hydrated Silica

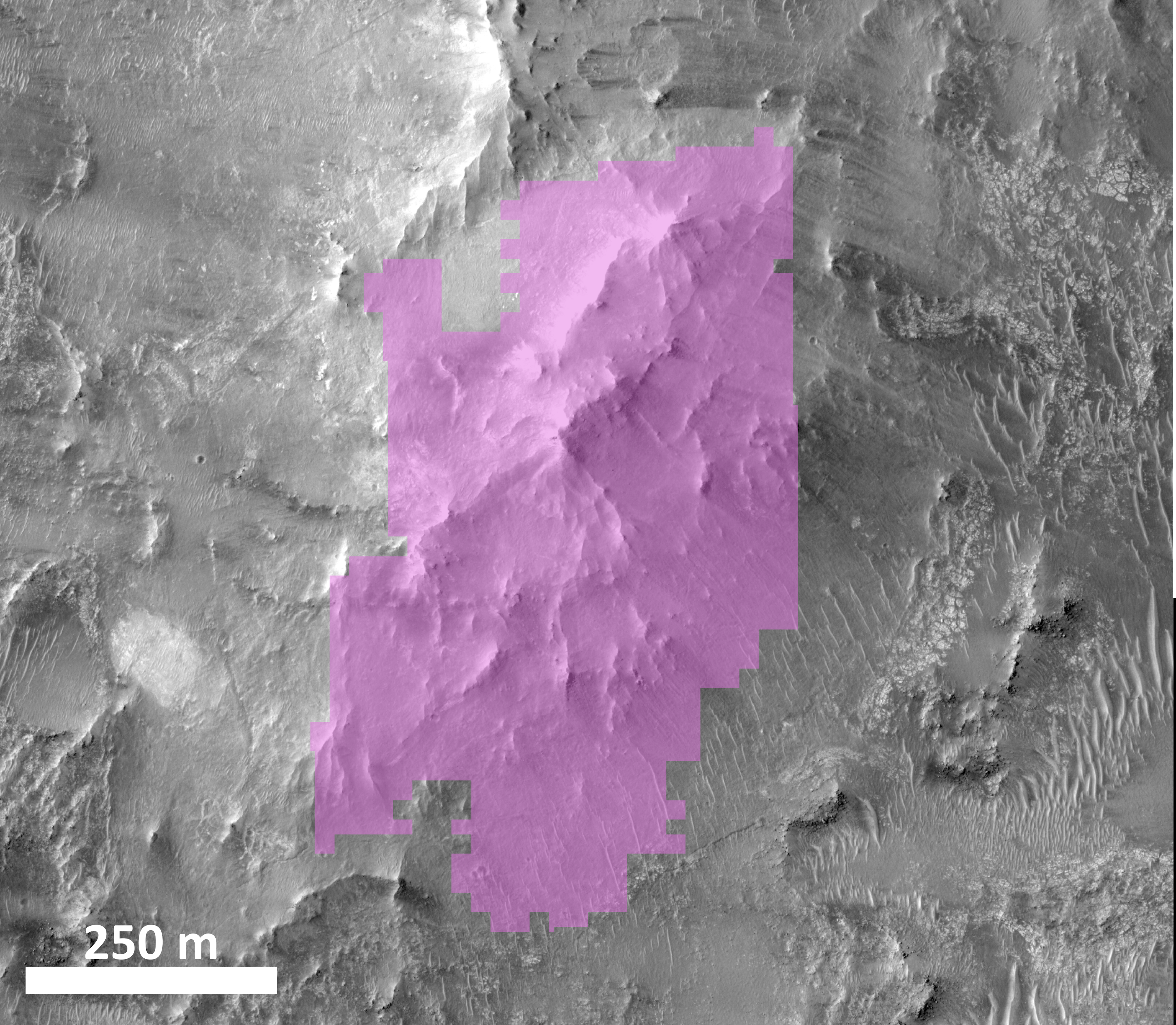


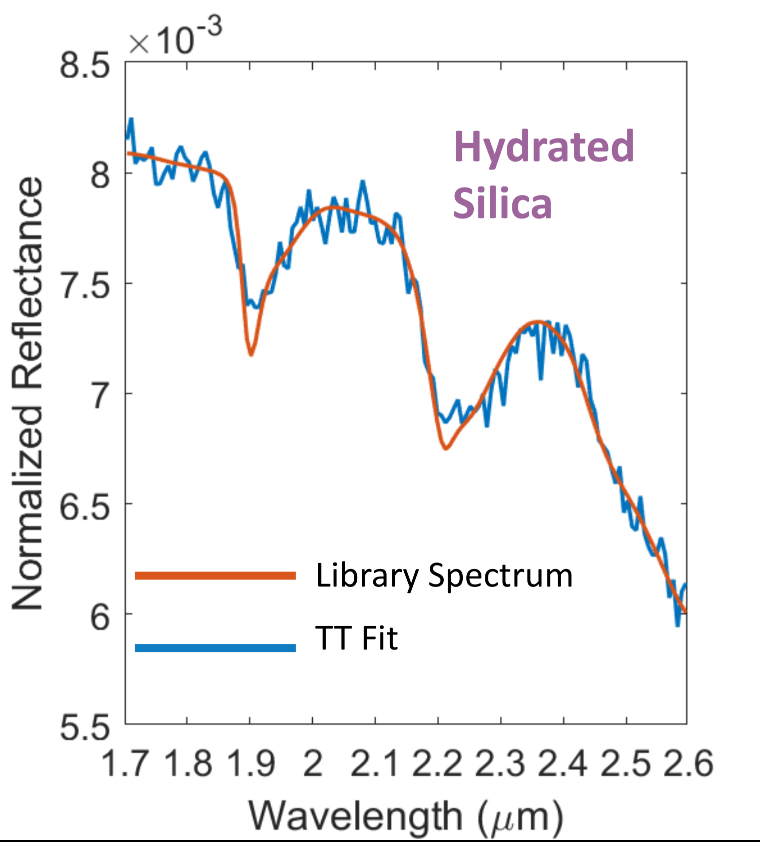


Associated with basement unit



Associated with basement unit





Hydrated Silica

Associated with basement unit

Conclusions

- Hydrated silica is detected in the western Jezero delta.
- Hydrated silica detected in the NE Syrtis region is associated with different mineral assemblages in two different geologic units:
  - Fractured unit: magnesite+silica –neutral-alkaline aqueous environment
  - Fractured unit: jarosite+monohydrated sulfate+silica— acidic aqueous environment
  - Basement outcrops of silica
- Each formation environment has significantly different implications for habitability.

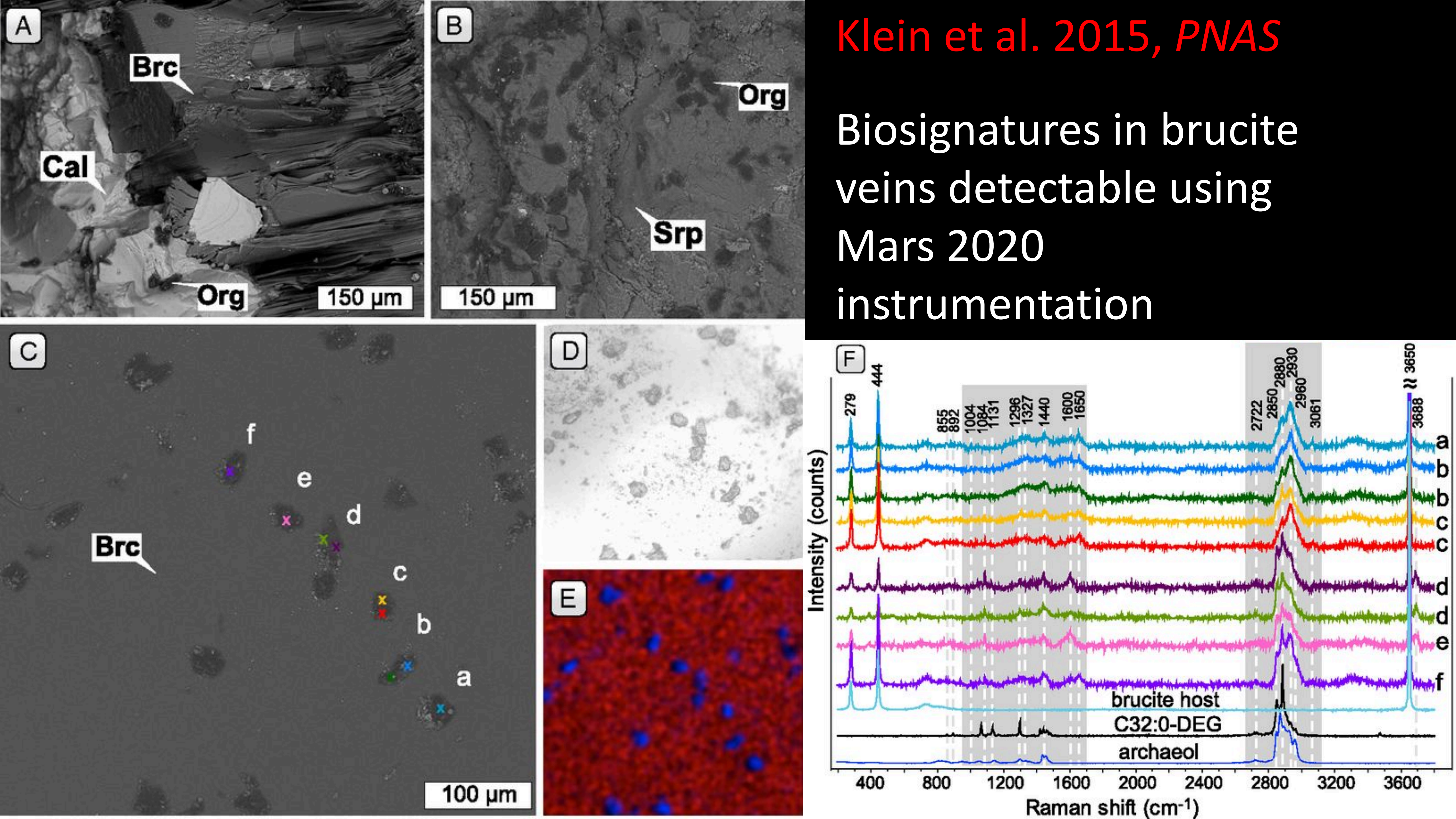
Implications for biosignature preservation potential

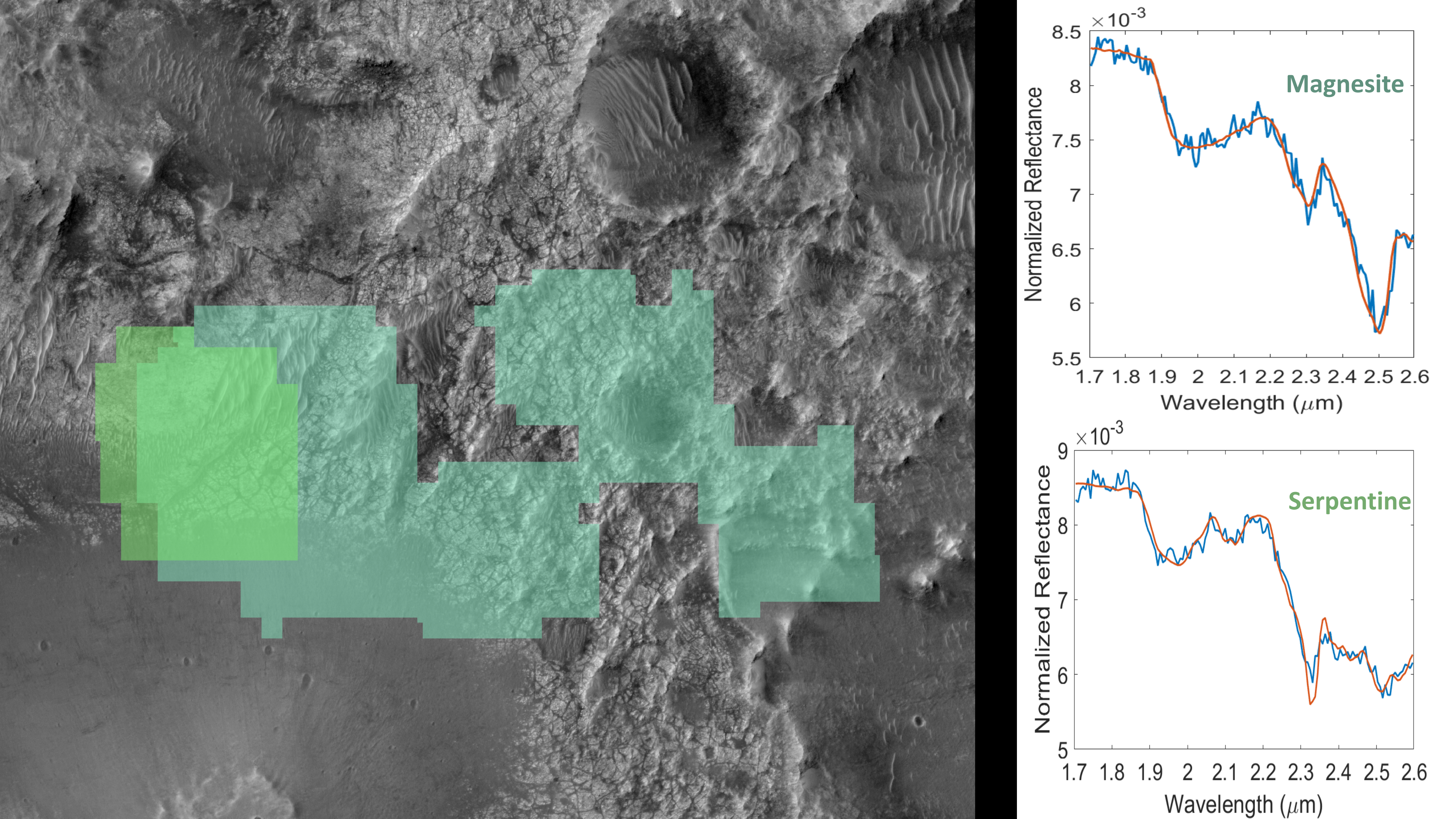
- If Jezero delta hydrated silica is authigenic, it likely either formed during deposition of the delta or via later diagenetic event, as seen in Gale crater.
- If Jezero delta hydrated silica is detrital, its formation environment is key to determining biosignature preservation potential.
- Formation environment of carbonate-hydrated silica assemblage is more favorable for habitability and biosignature preservation than formation environment of jarosite-hydrated silica assemblage.

Bonus Slides

Klein et al. 2015, *PNAS*

Biosignatures in brucite veins detectable using Mars 2020 instrumentation




×10^-3
Magnesite
Normalized Reflectance
8.5
8
7.5
7
6.5
6
5.5
1.7 1.8 1.9 2 2.1 2.2 2.3 2.4 2.5 2.6
Wavelength (μm)
×10^-3
Serpentine
Normalized Reflectance
9
8
7
6
5
1.7 1.8 1.9 2 2.1 2.2 2.3 2.4 2.5 2.6
Wavelength (μm)