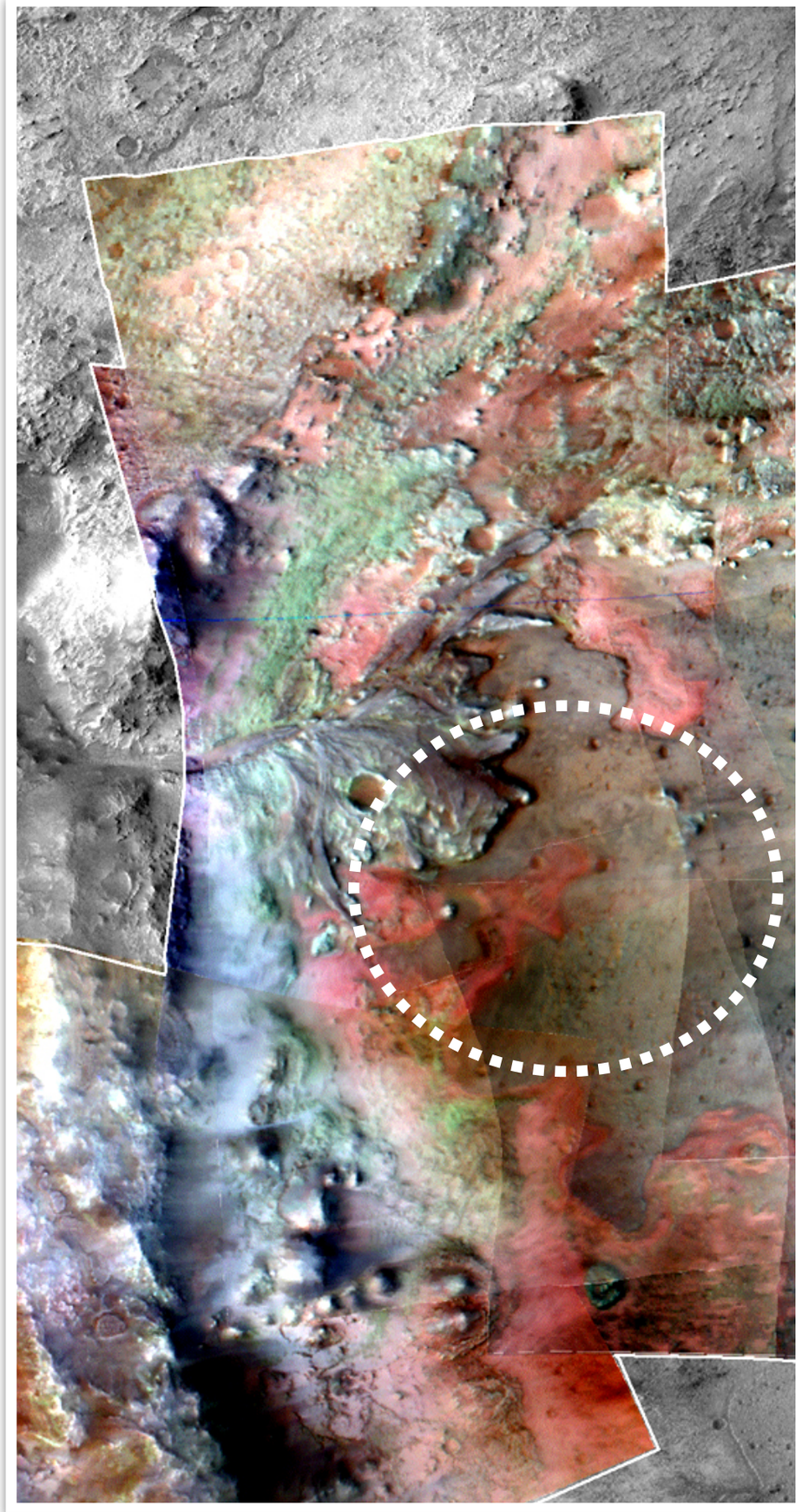
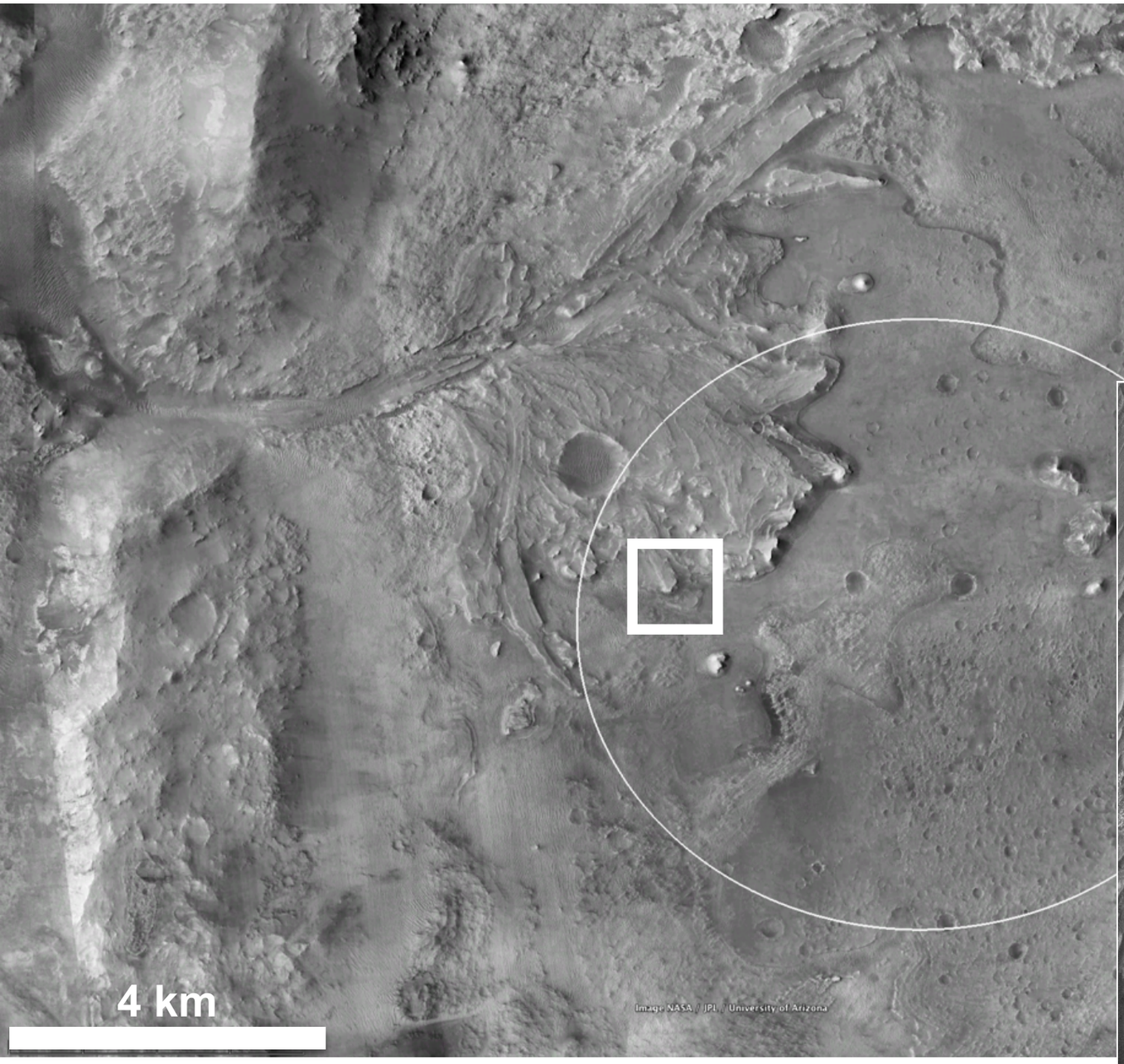


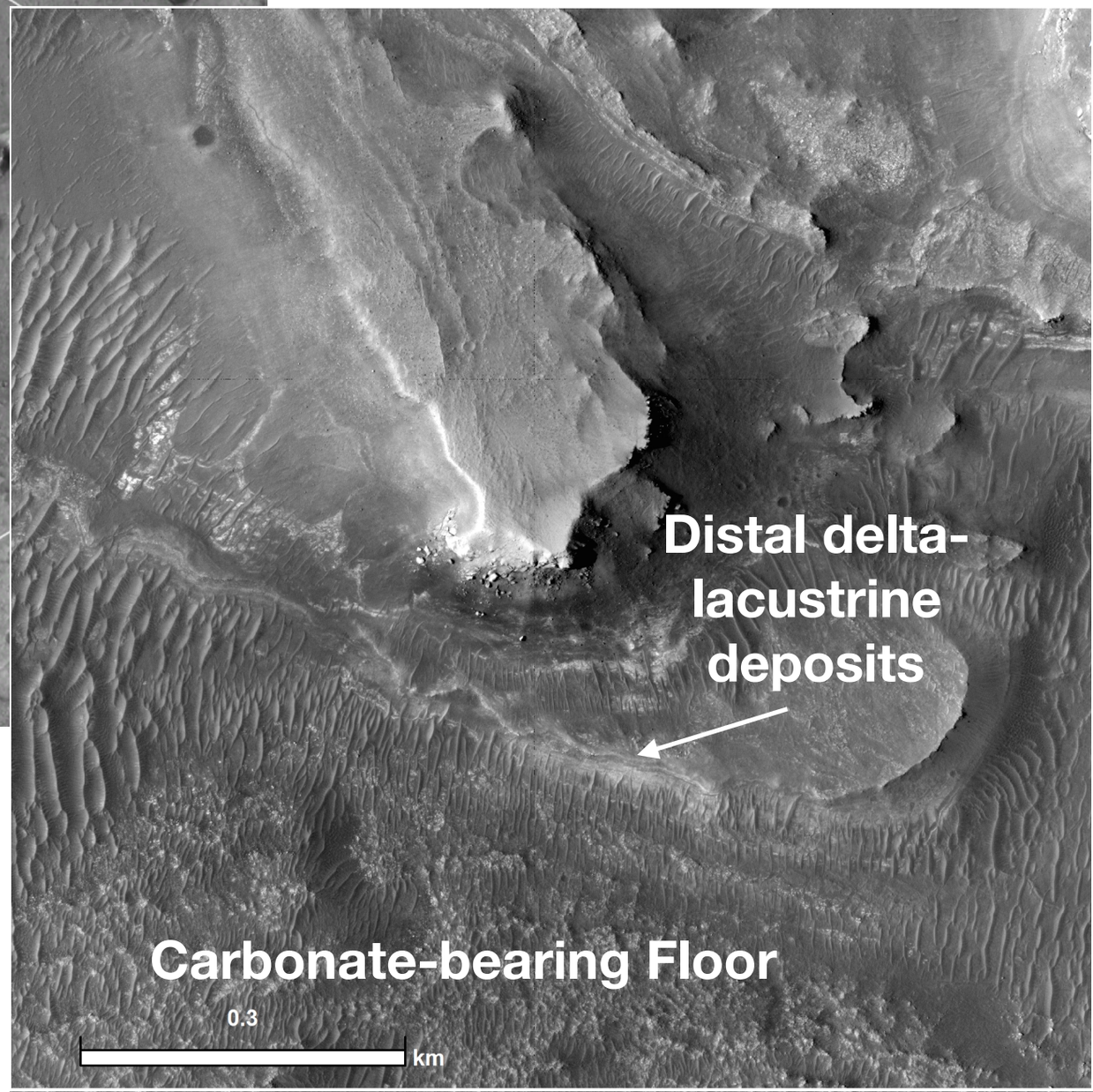
# The mineralogy of Jezero crater: Implications for fluvio-lacustrine history and biosignature preservation


Briony Horgan[1], Ryan Anderson[2], Gilles Dromart[3], Elena Amador[4], Melissa Rice[5]

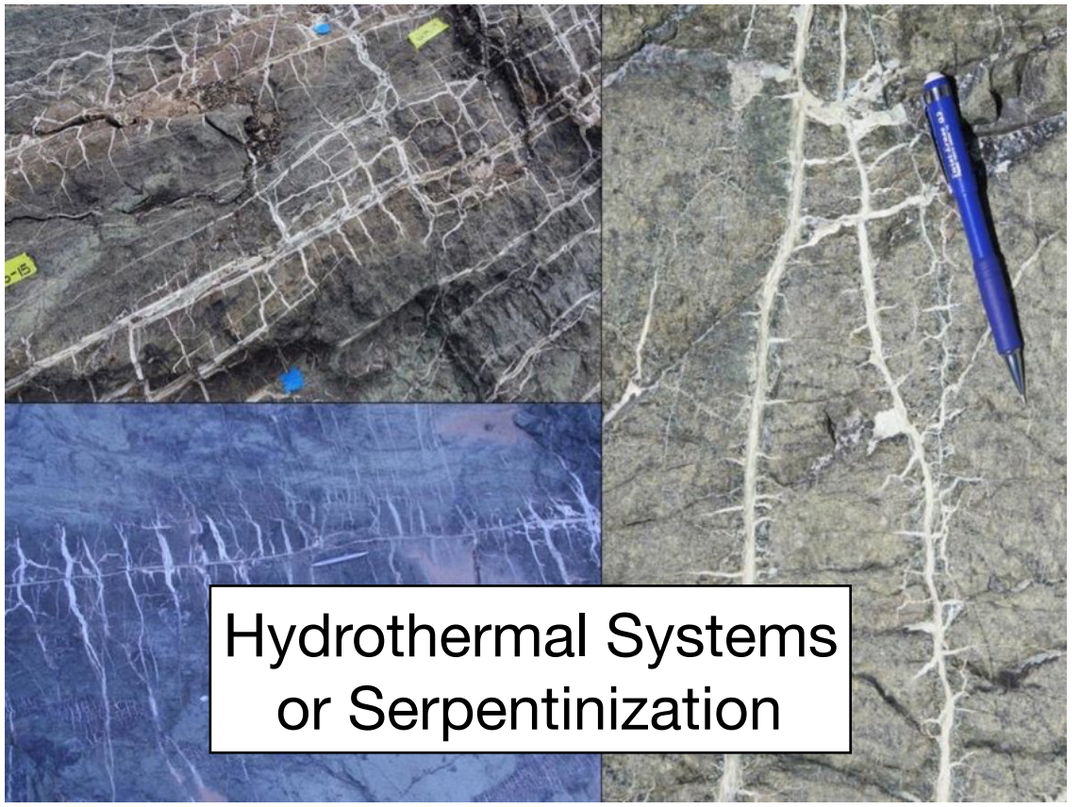
*[1]Purdue University*
*[2]USGS Astrogeology*
*[3]Université de Lyon*
*[4]Caltech*
*[5]Western Washington University*

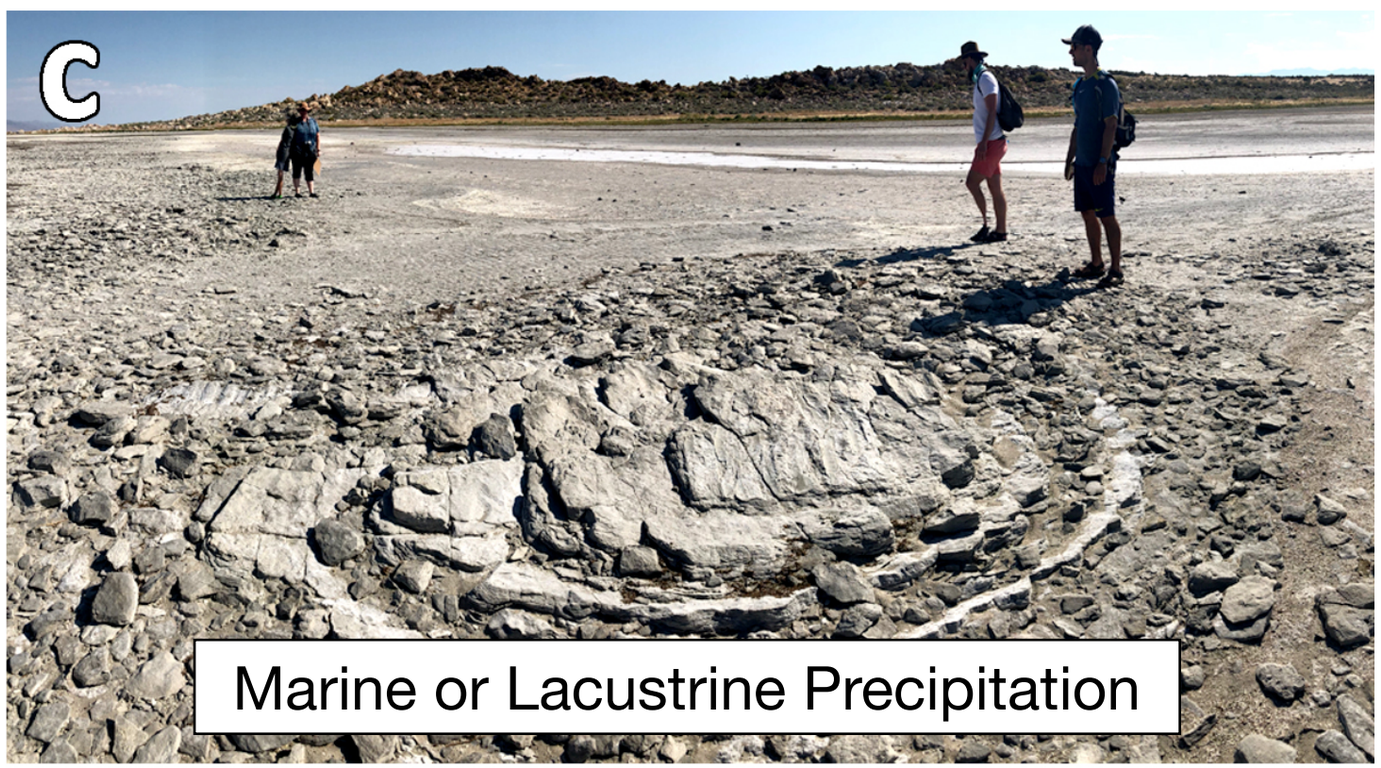
# The main targets for biosignature preservation in Jezero are distal fine-grained layers in the deltaic-lacustrine deposits, but what about the carbonates?



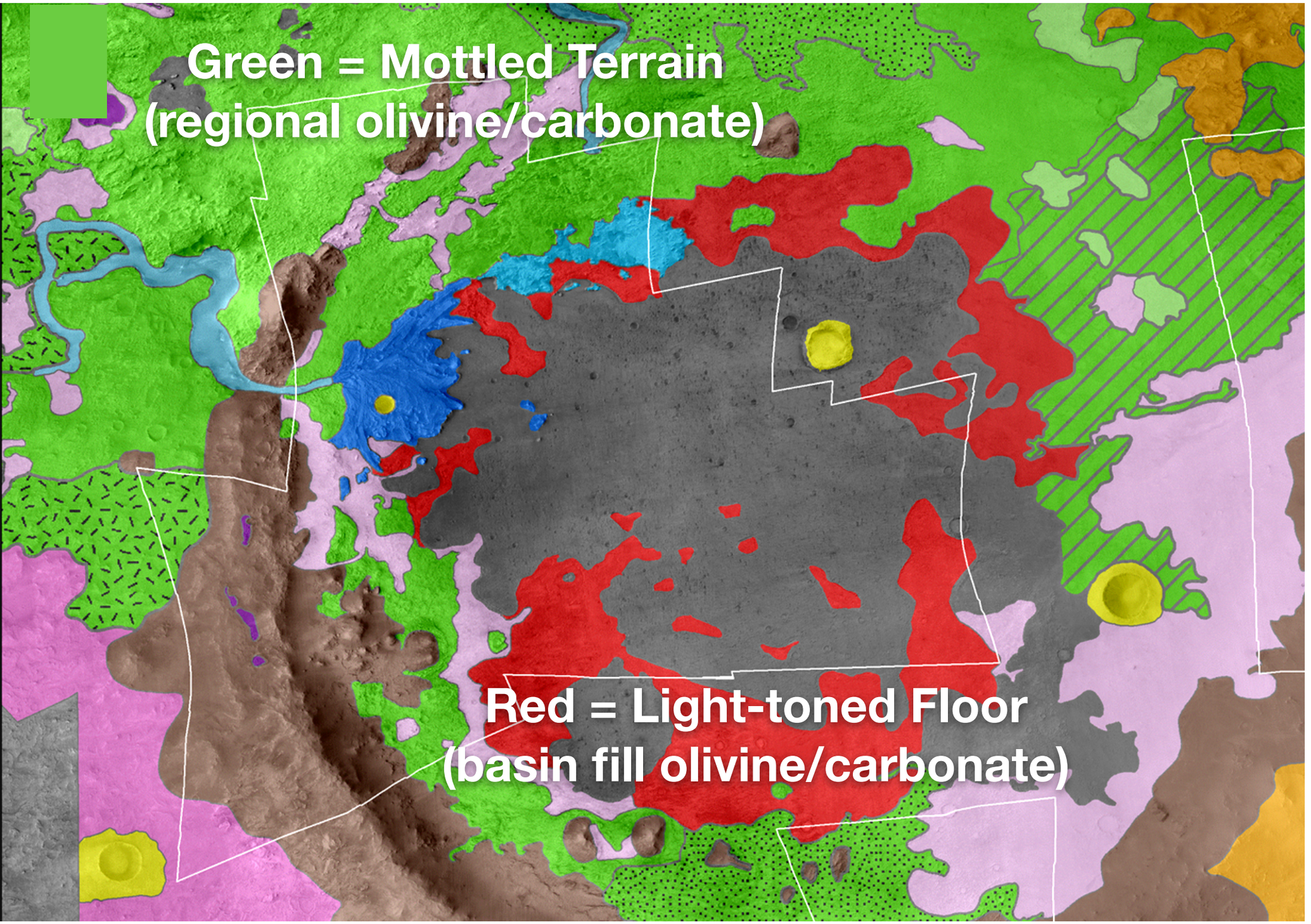
# Carbonates can form in many ways, but mechanisms and efficacy of biosignature preservation vary between environments

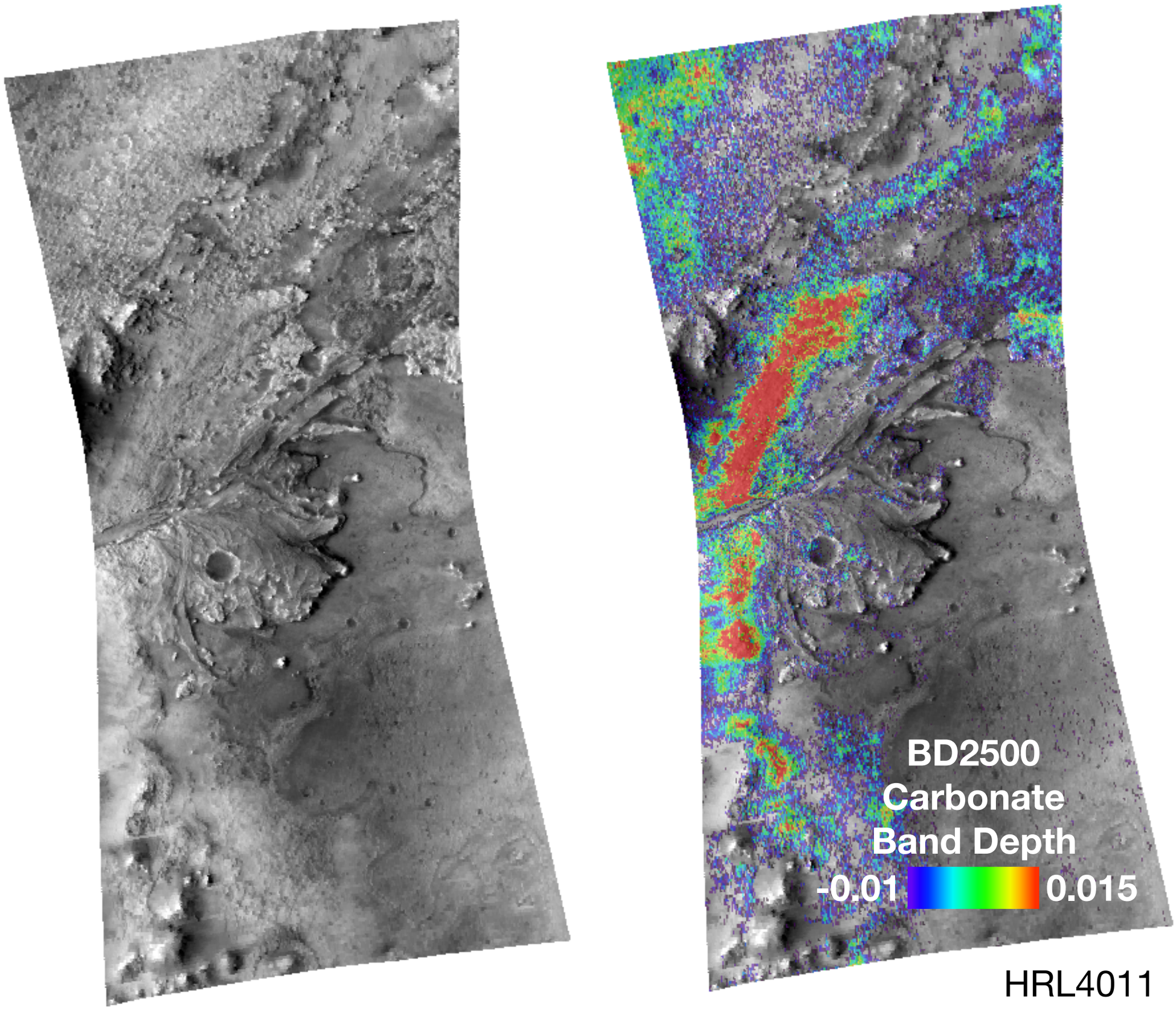

Carbonate in lake environments can preserve biosignatures at many scales, including features like microbialites that would be detectable by Mars 2020

# Jezero is partially filled with carbonate-bearing units, some of which extend onto the surrounding plains.

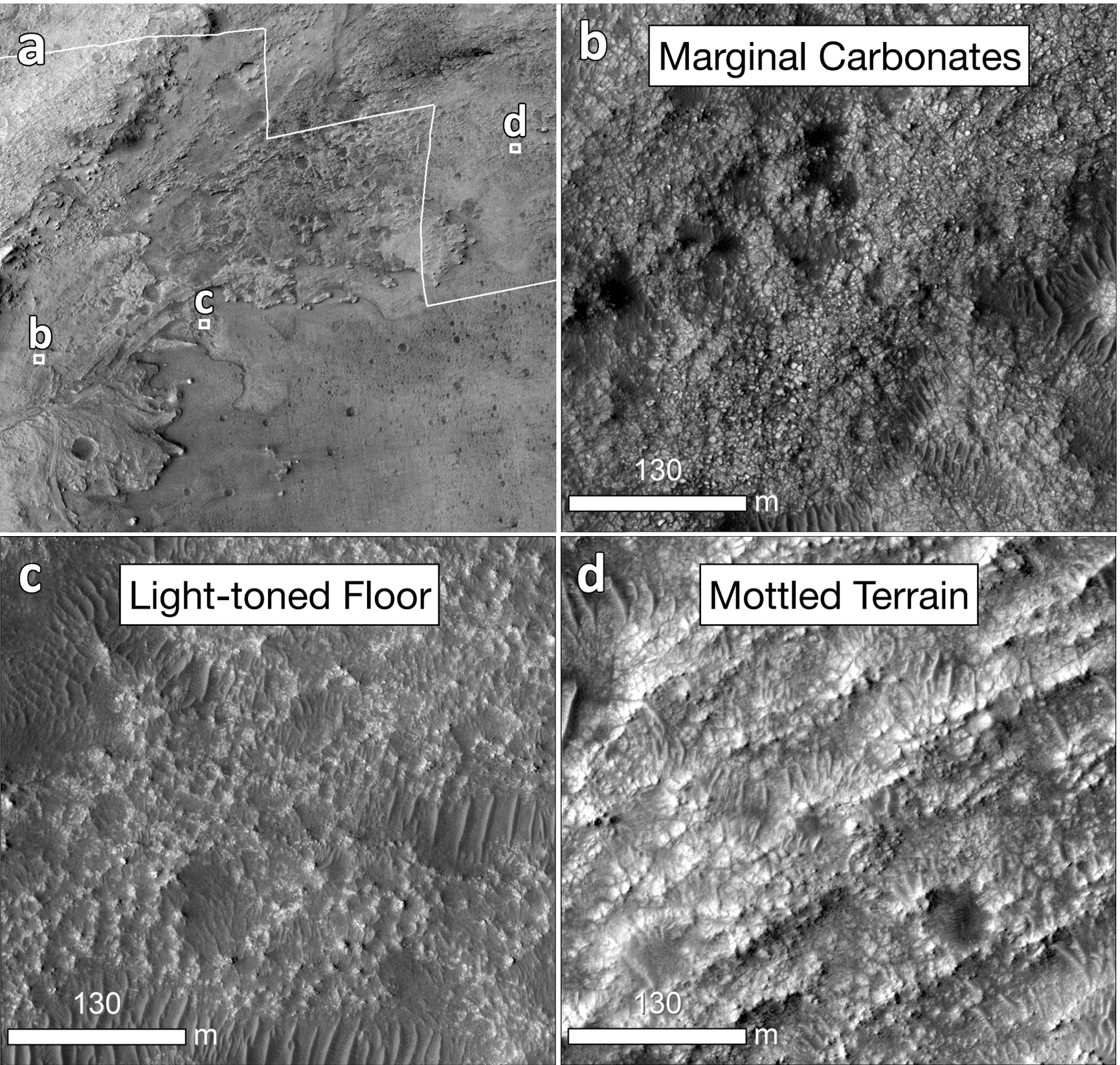



**This study: Are any of the carbonate-bearing units in Jezero related to the lake, and what is their biosignature preservation potential?**

# The strongest carbonate signatures in the crater are restricted to the inner margin of the rim - are these “Marginal Carbonates” a distinct unit?

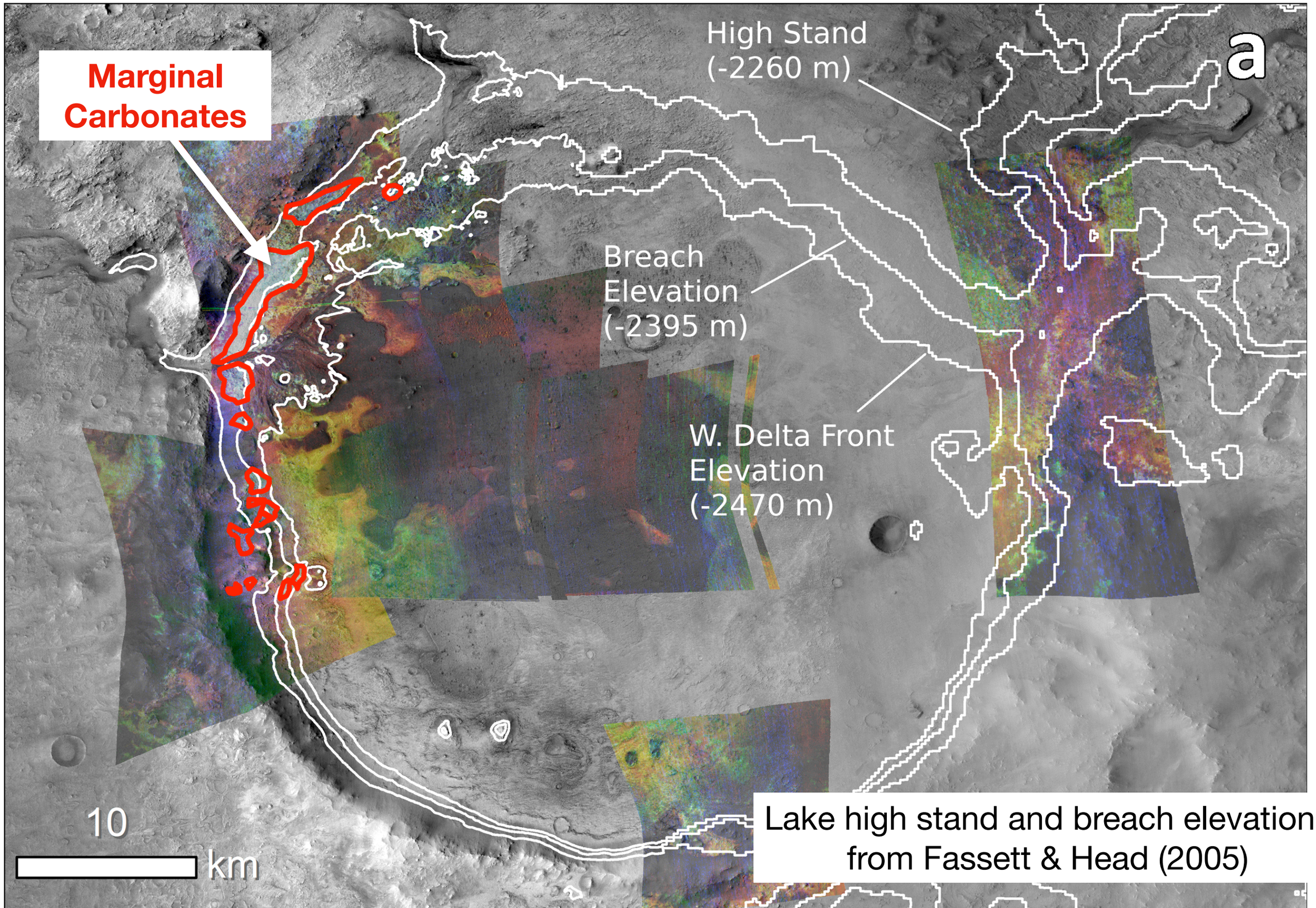


# **Texture**: All three carbonate-bearing units are light-toned and fractured, but exhibit different smaller scale surface textures



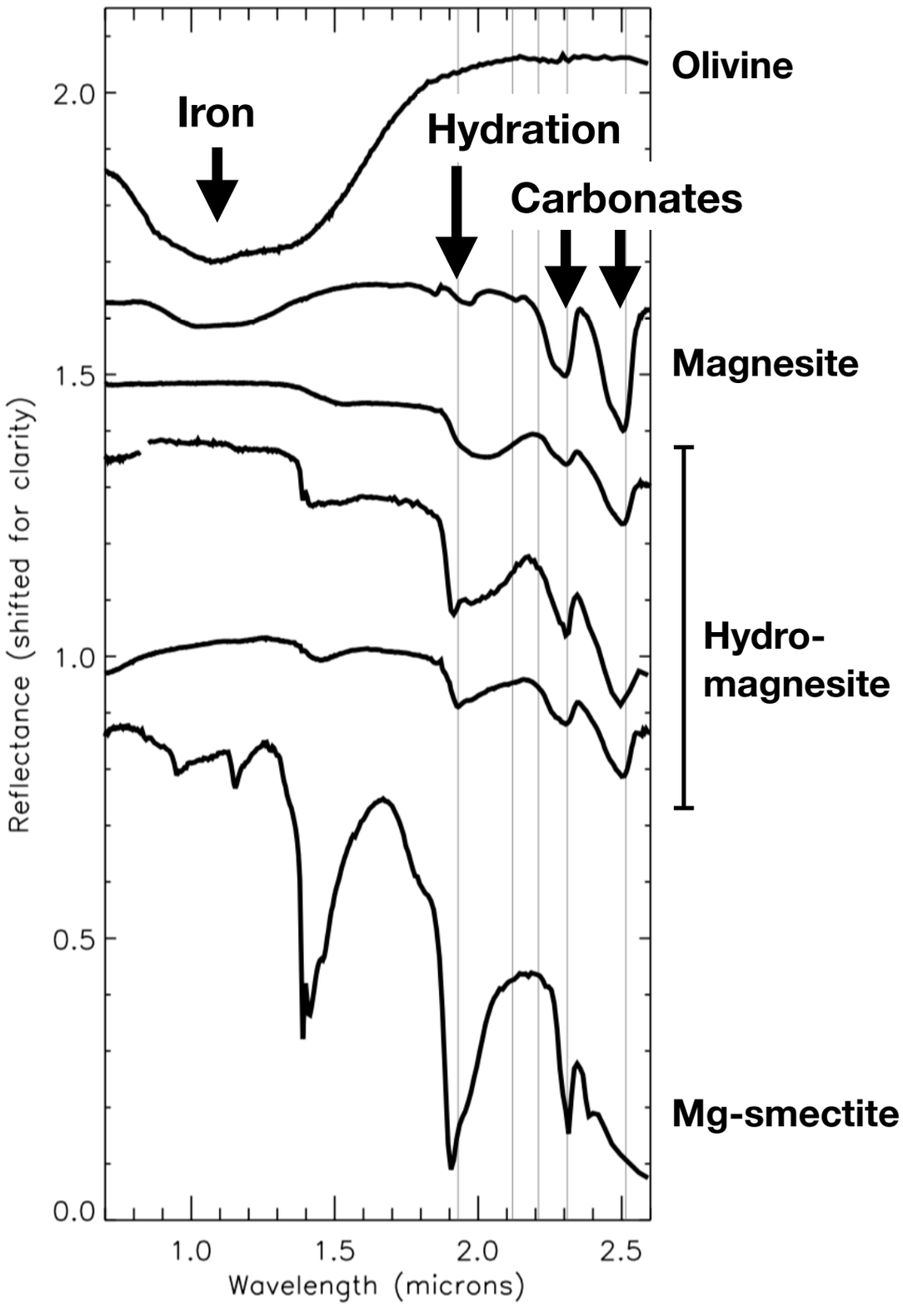

These textural differences suggest that these terrains experienced different origin, alteration, or erosional processes, but the nature of the difference is unclear from texture alone

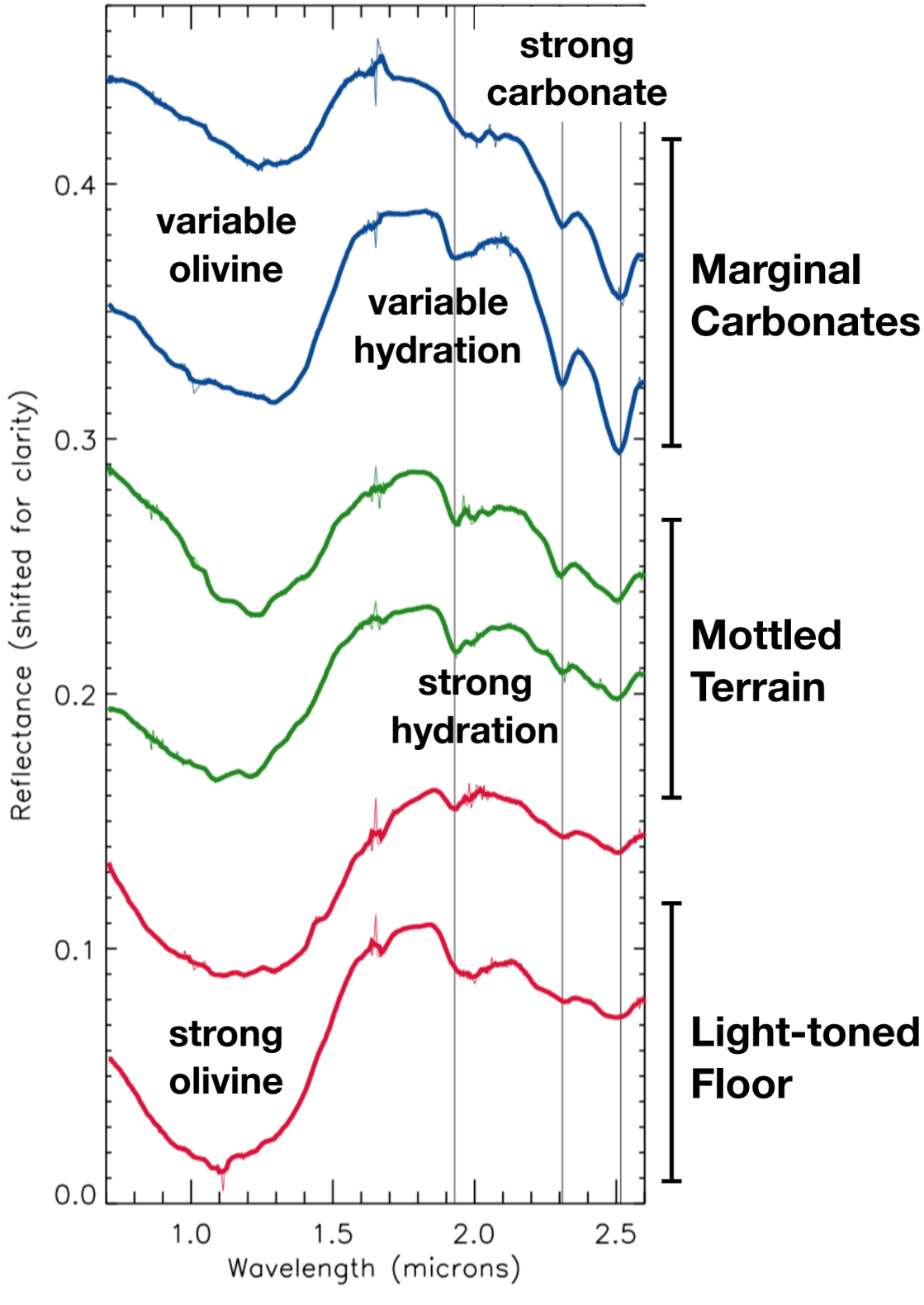
# **Topography**: The marginal carbonates are restricted to elevations between the lake high stand and the outlet breach



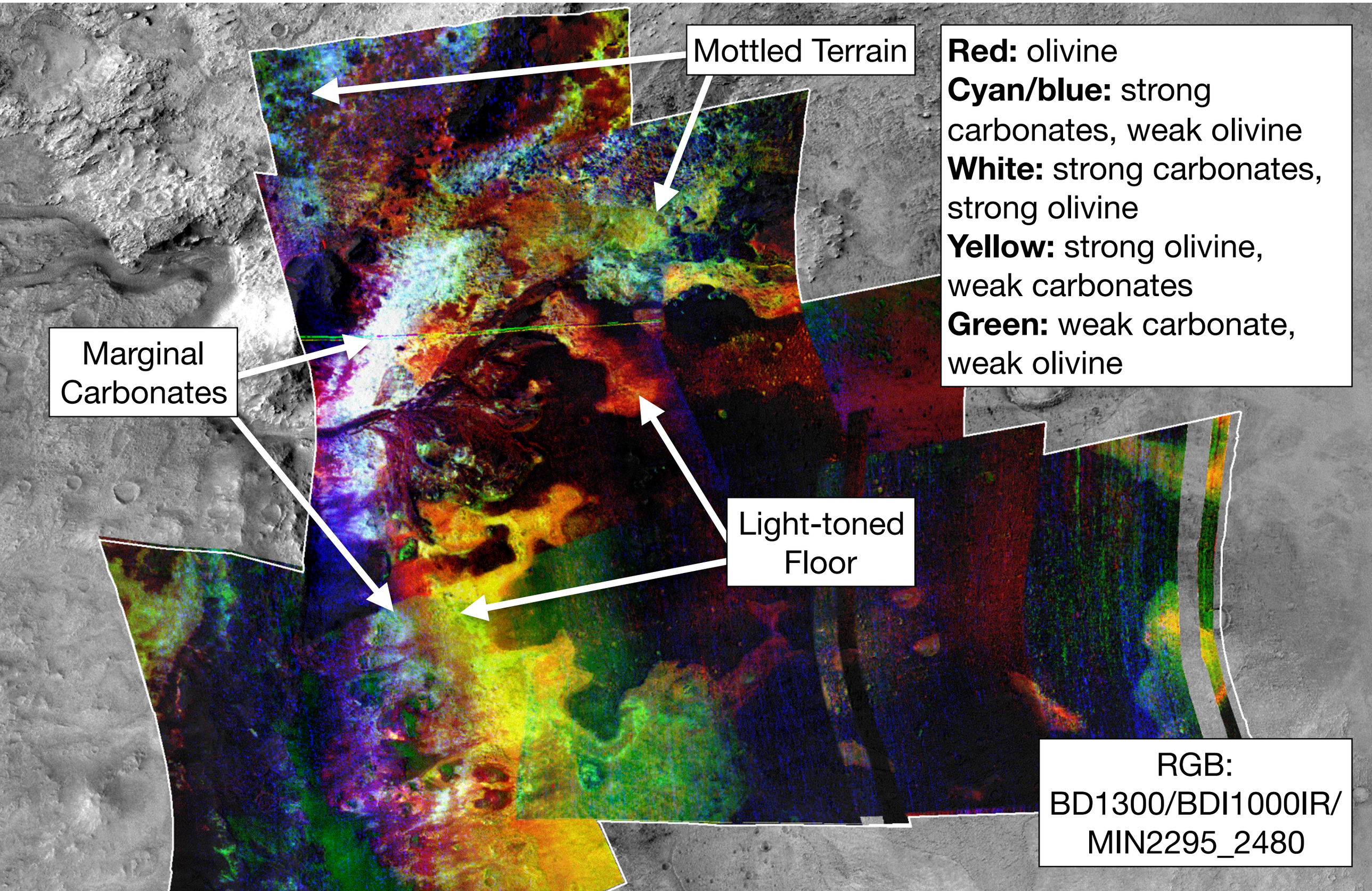

Lake high stand and breach elevations from Fassett & Head (2005)

**Mineralogy**: All three units exhibit spectral signatures of Mg-carbonate, hydrated minerals, and olivine, but the relative strengths vary

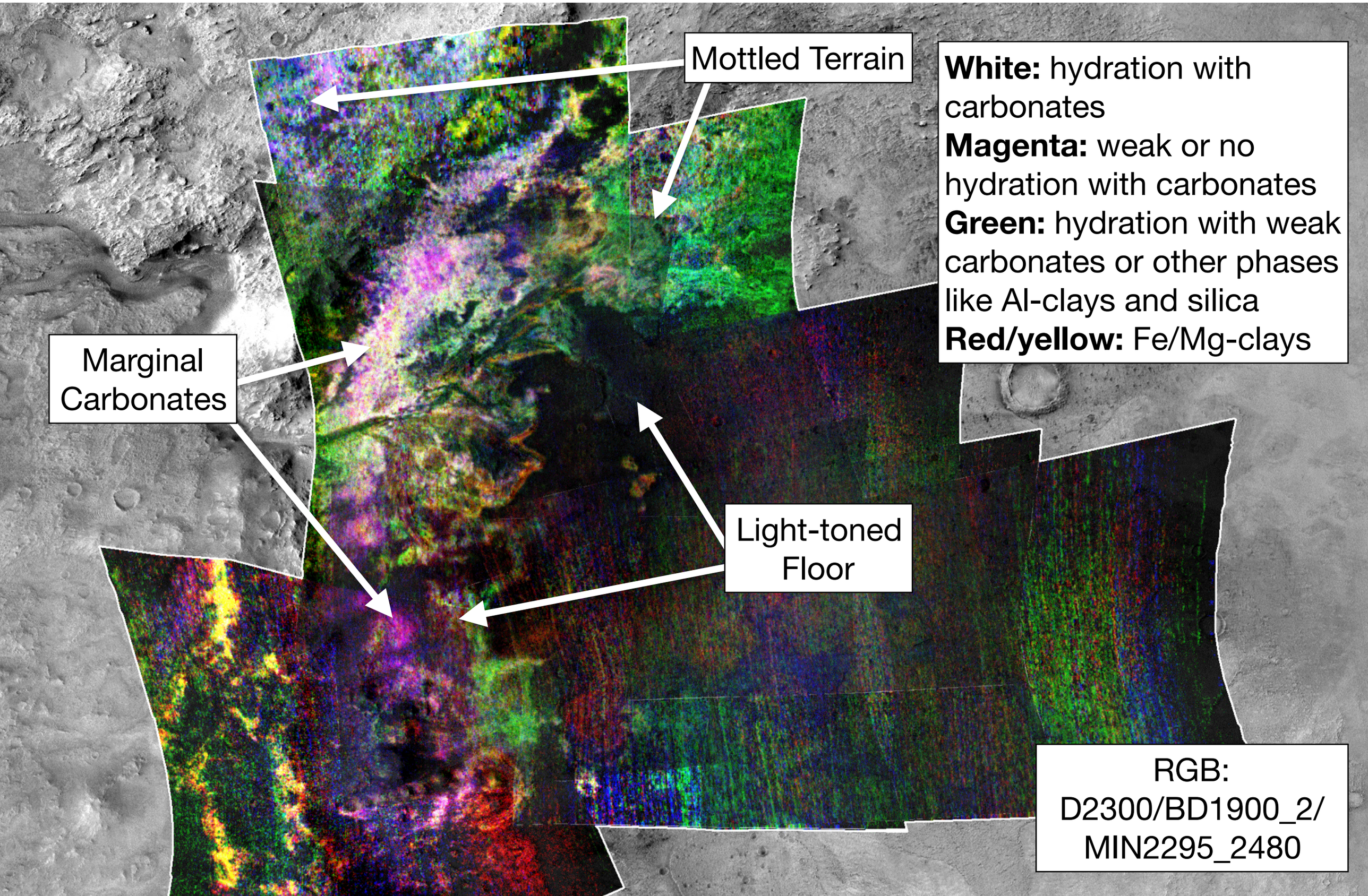


# These spectral differences between the carbonate units show clear spatial correlations across the crater

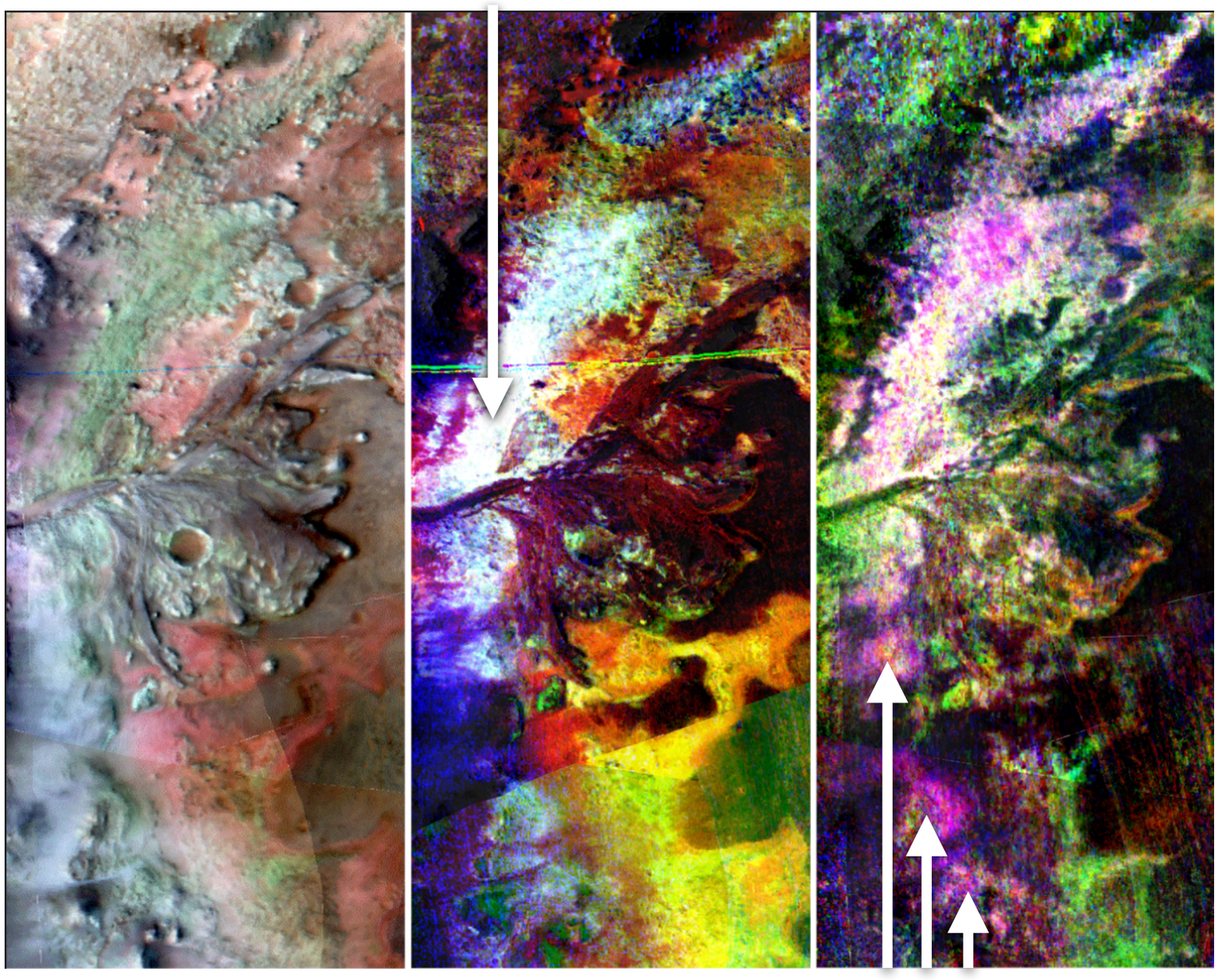


# Hydration varies independently of carbonates between and within units, suggesting another hydrated phase - Fe/Mg-clay?

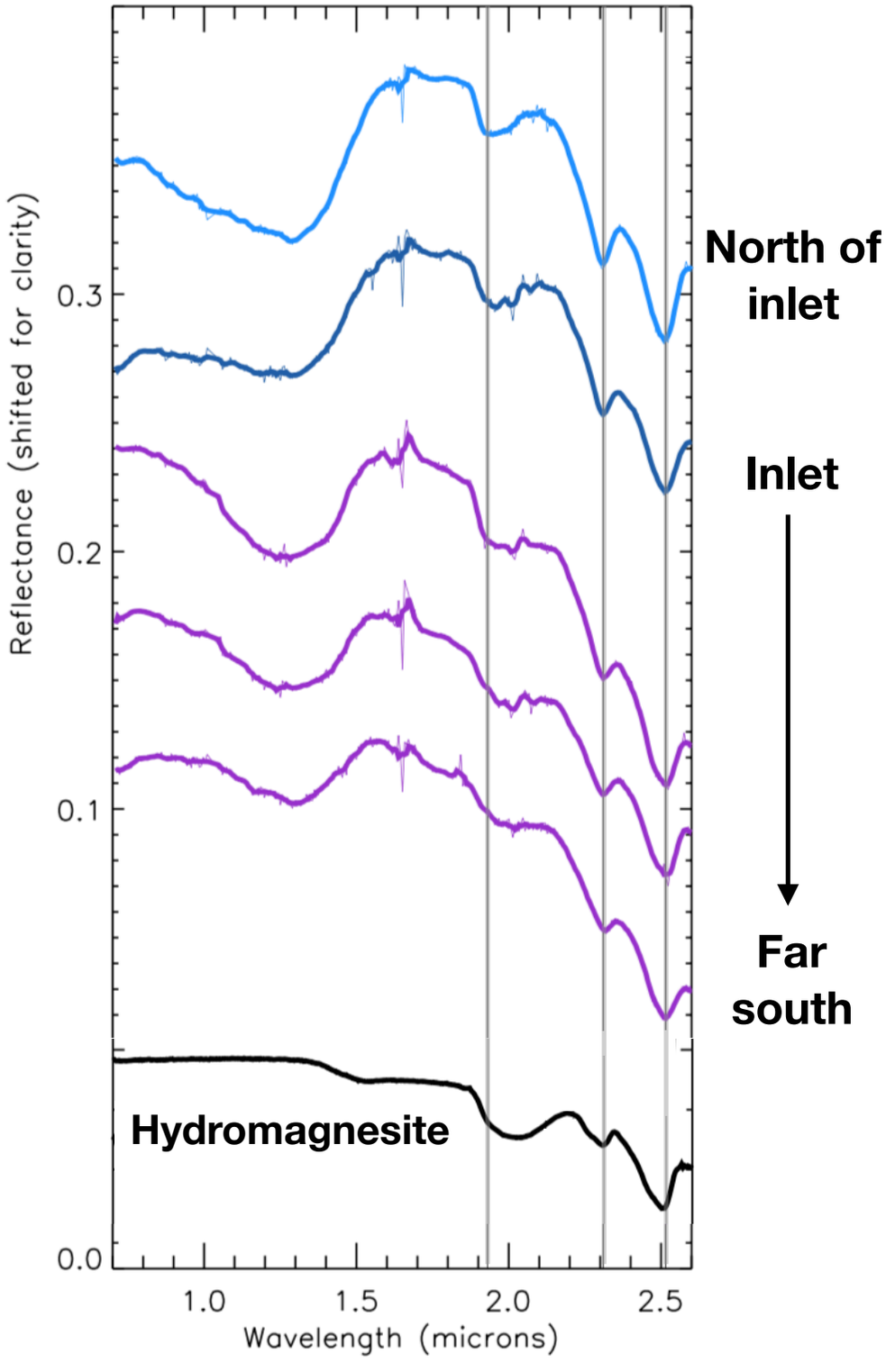


# The Marginal Carbonates vary spectrally with distance from the western inlet, with more isolated carbonates to the south

**<u>A mix of phases:</u>** Near the channel, strong olivine/ carbonate/clay signatures, effectively a more carbonate-rich version of the surrounding plains



**<u>Carbonate dominated:</u>** Away from the channel (especially south), carbonates dominate the spectra (pink)



## Taken together, the properties of the marginal carbonates could be consistent with precipitation at the margin of a paleolake

(1) **Location:** Found near the western and northern inlets, where dissolved bicarbonate and cations from weathering would have entered the lake

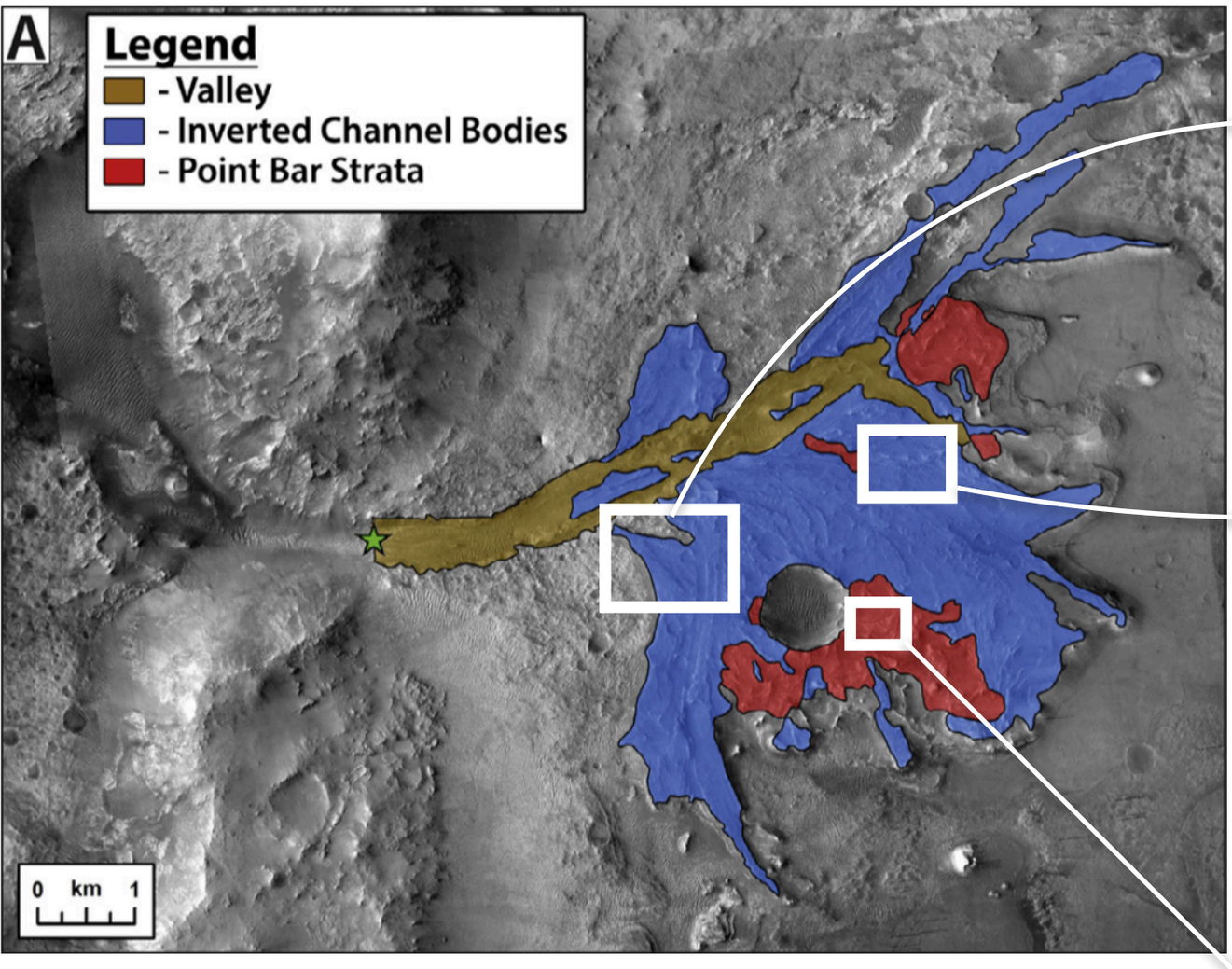
(2) **Elevation:** Found at the highest possible lake levels for a closed basin lake in Jezero, consistent with precipitation in the shallowest warm waters along the shore of a closed and thus alkaline lake

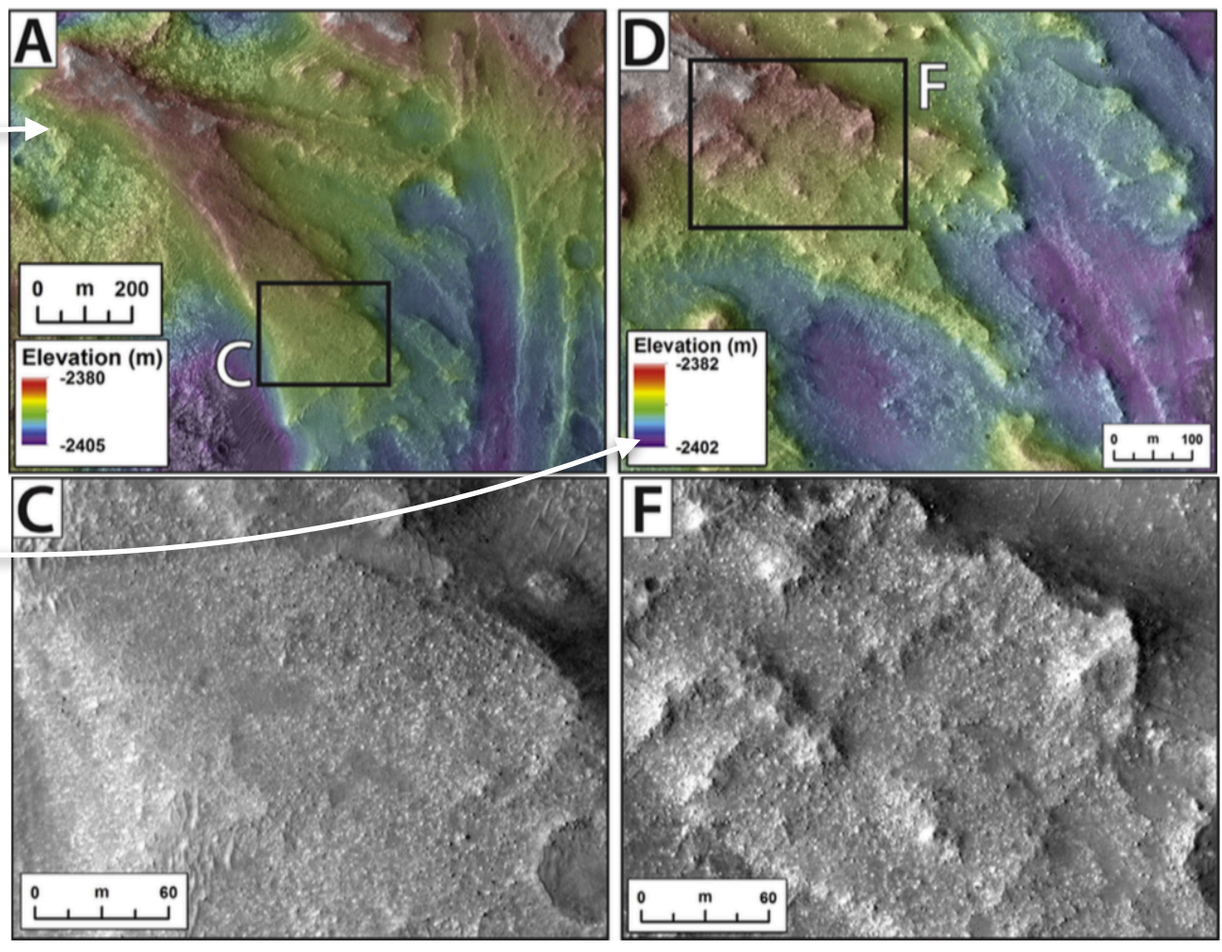
(3) **Spectral properties:** Exhibits the strongest carbonate spectral signatures in the crater, consistent with additional carbonate precipitation

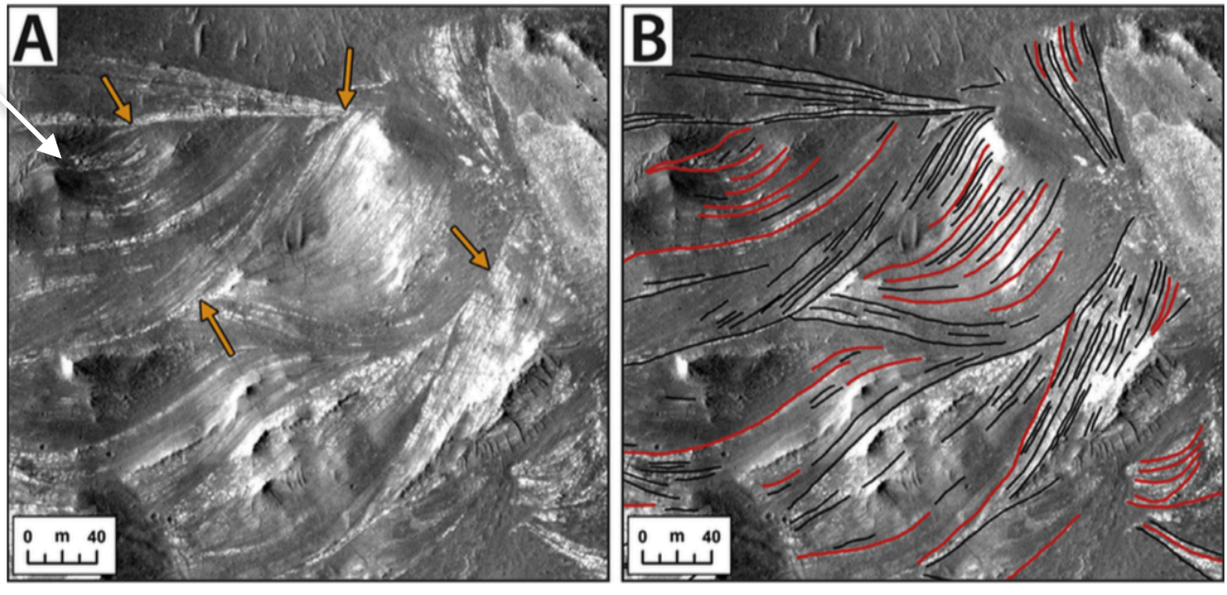
(4) **Texture:** Distinct blocky texture compared to other carbonate units

(5) **Distribution:** Isolated hydromagnesite spectral signatures far to the south of the channel are consistent with precipitation on a quiescent shoreline, whereas strong olivine/hydration/carbonate near the inlet is consistent with fluvial deposition of detrital phases.

# Western delta fluvial facies suggest changing depositional environments over time. **Can mineralogy provide insight into the fluvio-lacustrine history?**




Goudge et al. (2018) suggest that these structures are consistent with increasing lake depths over time, until the crater breached and lake levels stabilized

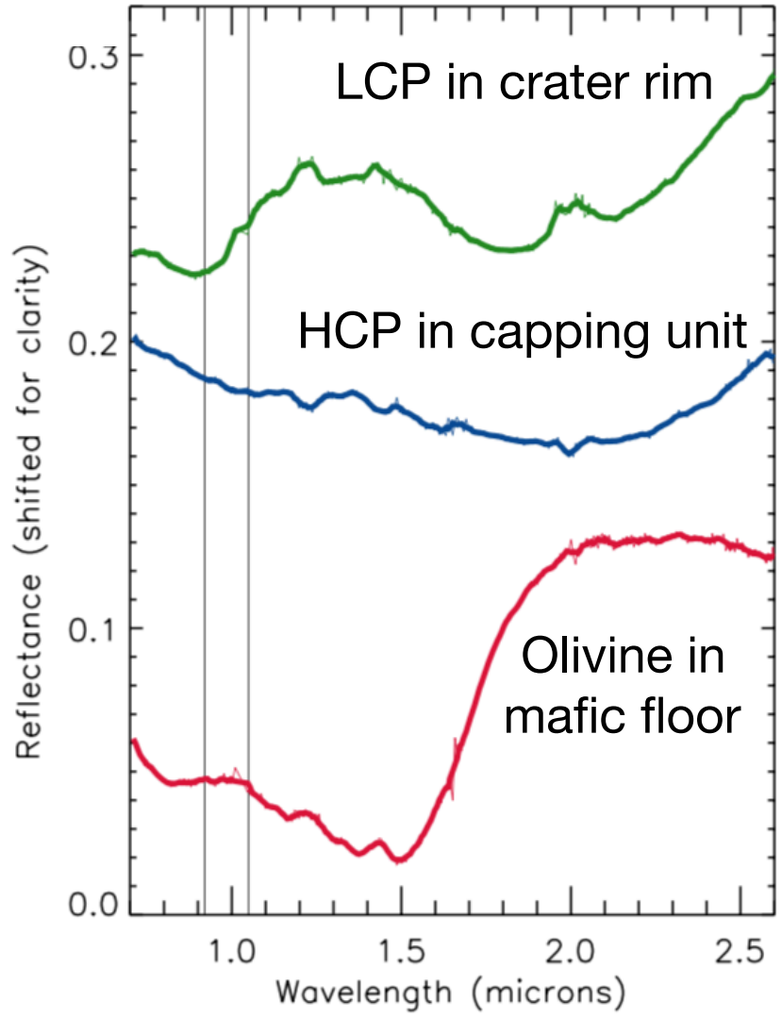
# Primary mineralogy is the best discriminator between regional units in Jezero and on the plains

Olivine in carbonate units

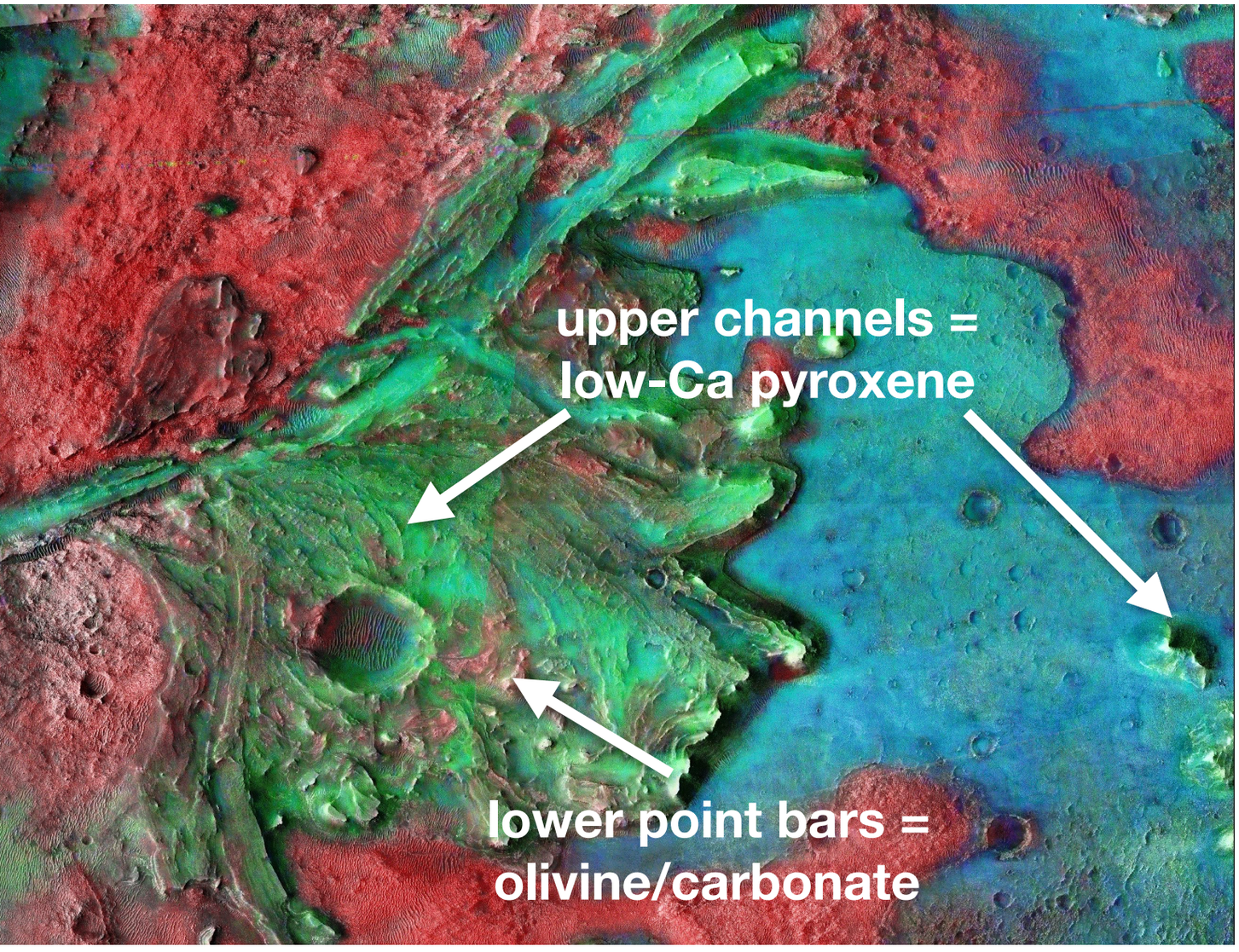
LCP in basement and rim

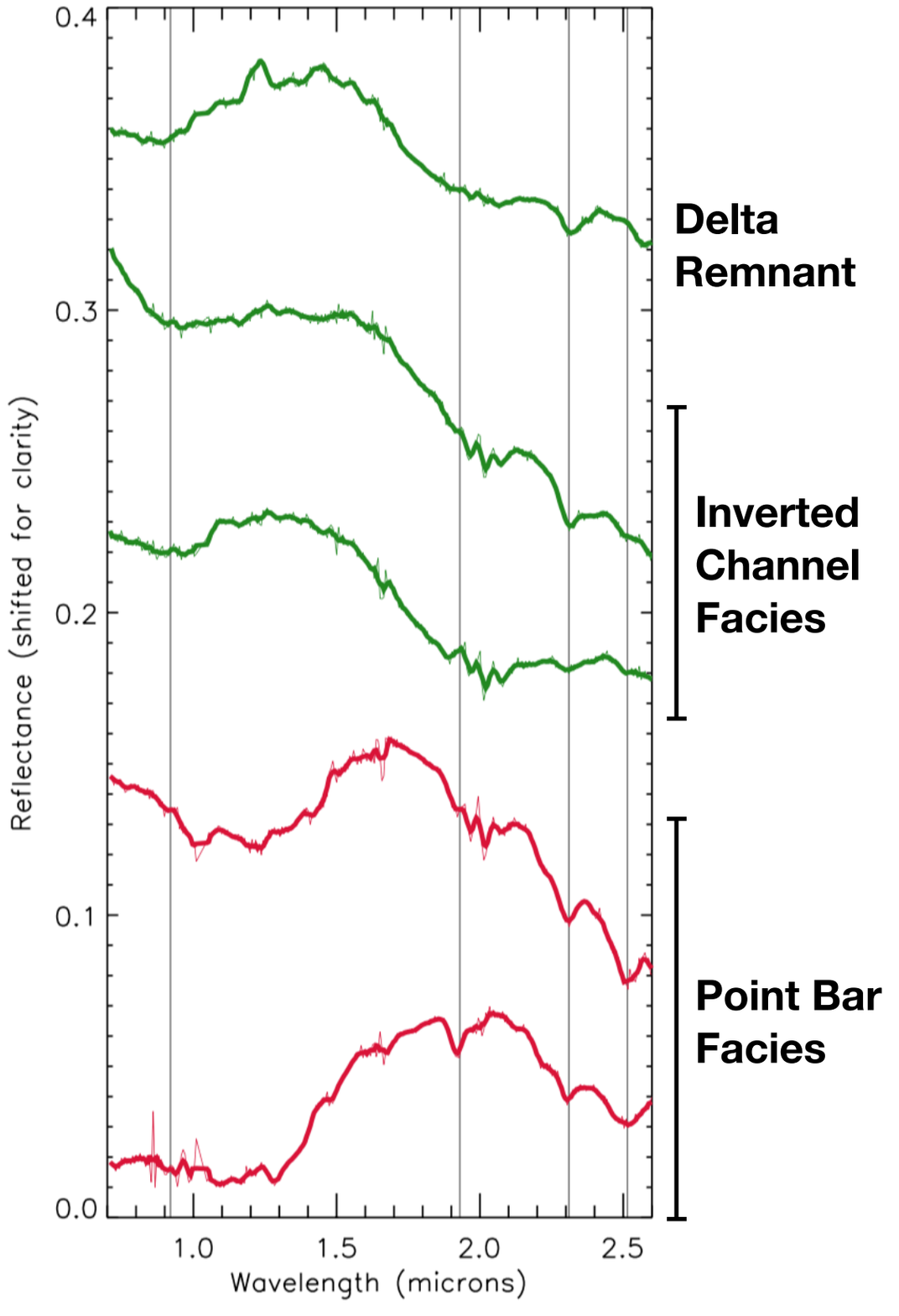
HCP in Mafic Floor and regional capping unit

**Red:** Olivine
**Green:** Low-calcium pyroxene
**Blue:** High-calcium pyroxene



# The Western delta shows distinct mineralogies associated with the specific fluvial facies




Mineral stratigraphy is reversed compared to surrounding plains

**LCP/Smectite Inverted Channel Facies**

**Olv/Carbonate Point Bar Facies**

**Olv/Carb Light-Toned Floor**

# The lower and upper portions of the Jezero delta may have been produced during different fluvio-lacustrine phases

**Early phase:**

(1) Fluvial erosion of regional olivine/ carbonates on surrounding plains

(2) Deposited in gradually infilling closed-basin lake to form lower delta strata

(3) Marginal carbonates form along shore of closed basin due to precipitation of dissolved carbonate

**— — — Unconformity? — — —**

**Later phase:**

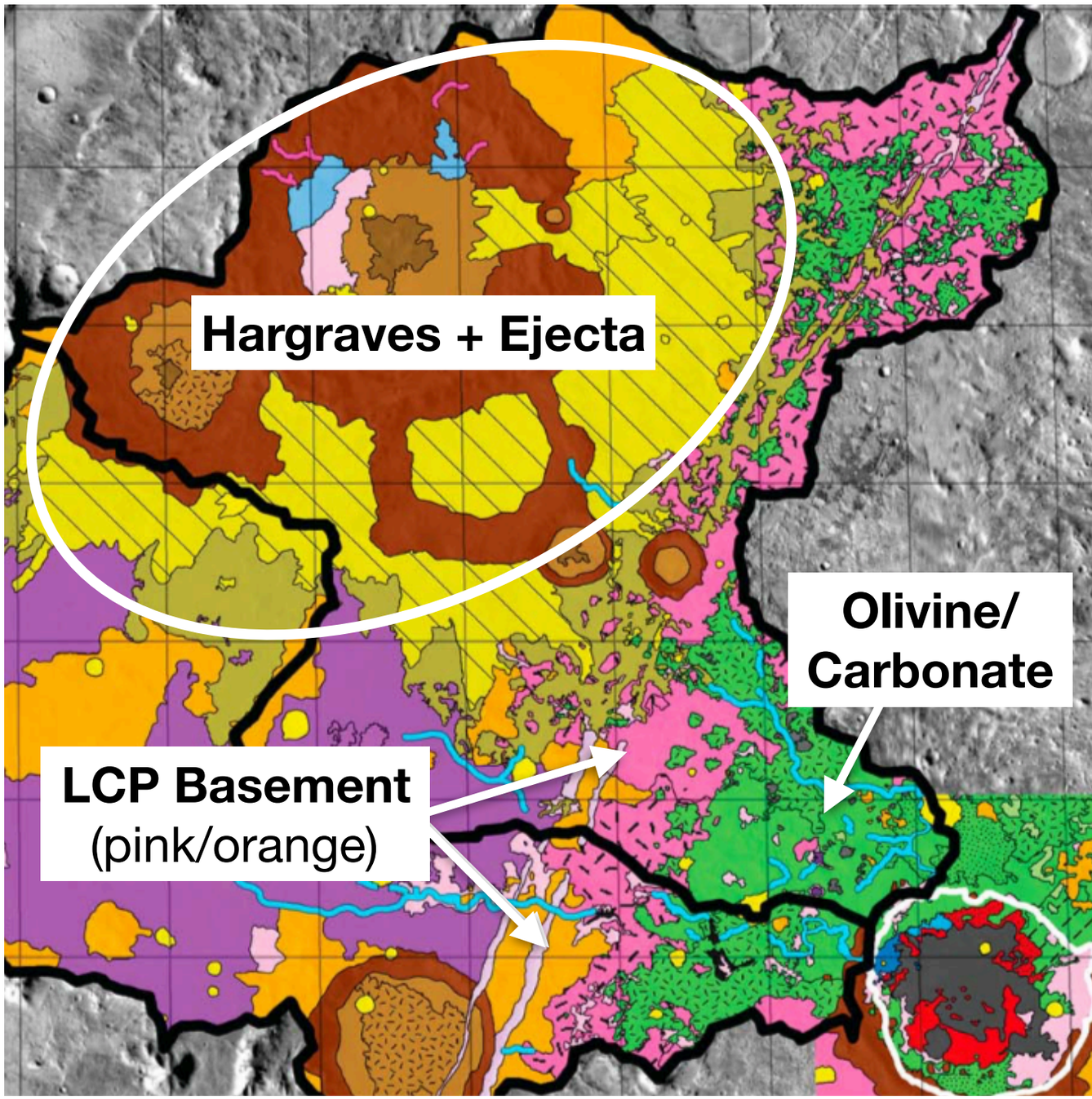
(1) Olivine/carbonates are sufficiently eroded to allow additional erosion of LCP/clay in basement unit

*OR*

Hargraves impact creates new sediment source - basement ejecta

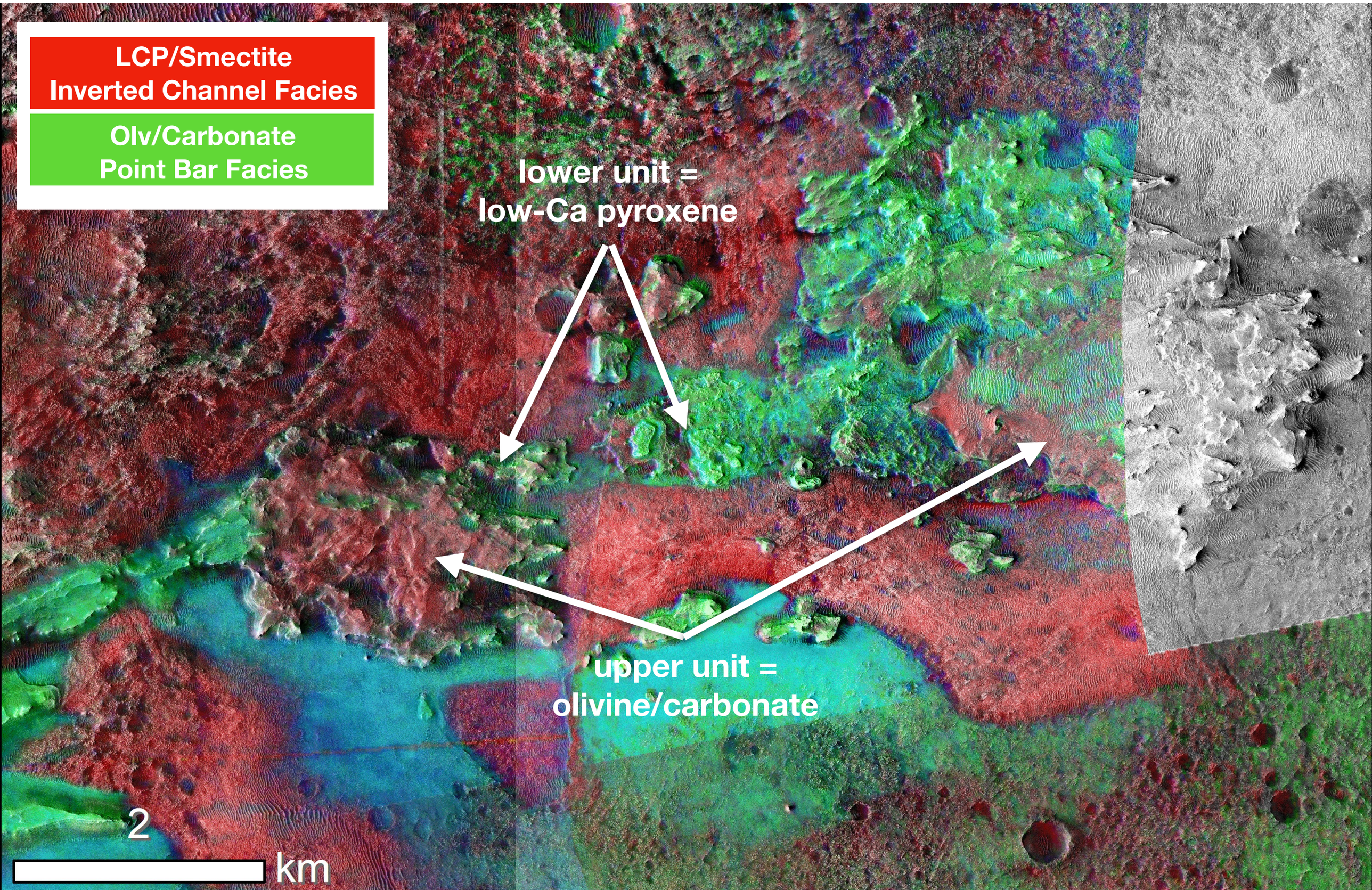
(2) Deposited in upper delta strata

(?) Basin overflows, open-basin lake




Goudge et al. (2015)

# The nothern fans are more eroded and have LCP/clay underlying olivine/carbonates - do these represent even earlier fluvial activity?

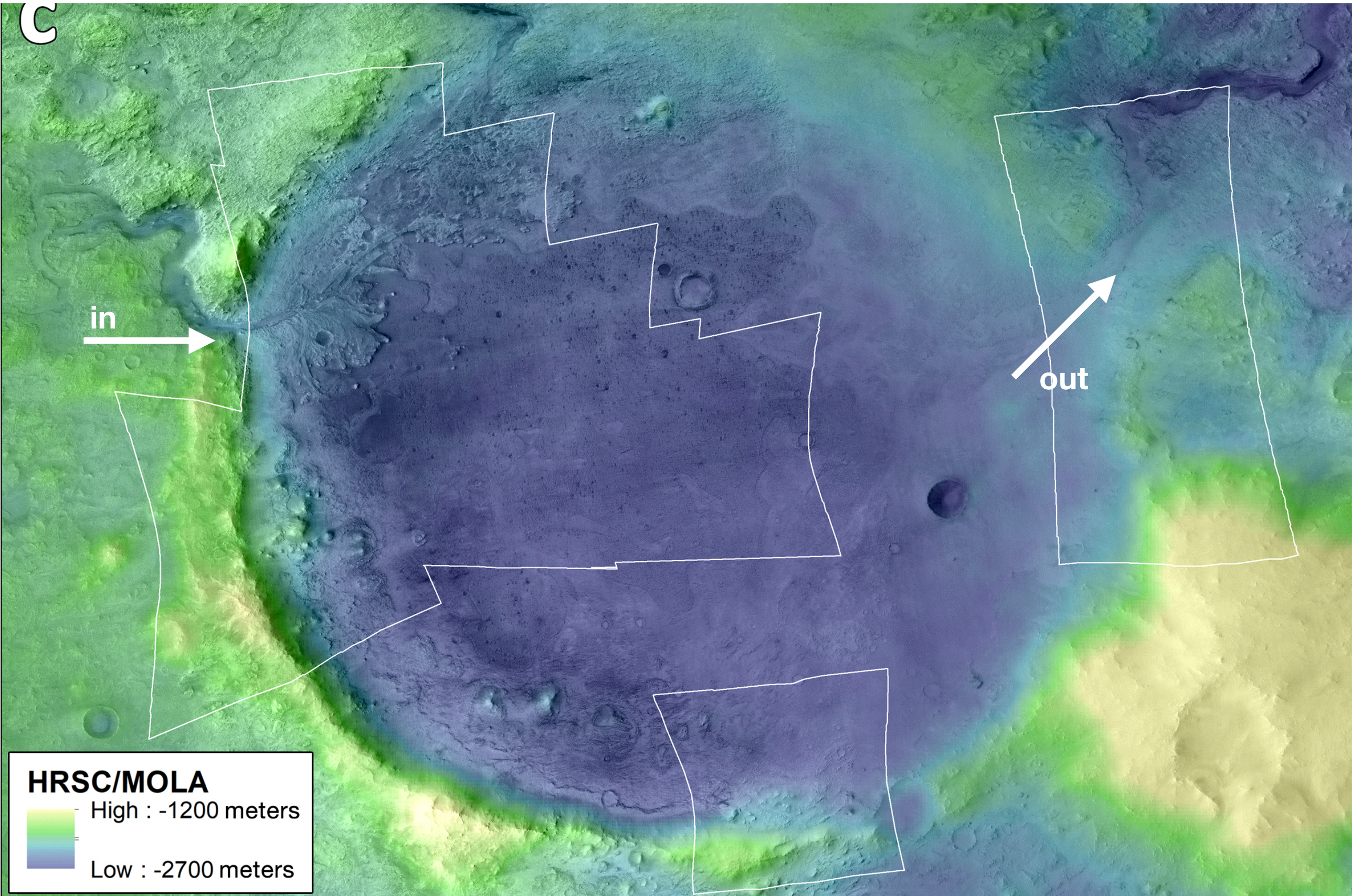


# **Conclusions**: The mineralogy of Jezero crater is diverse, suggesting a complex fluvial and lacustrine history

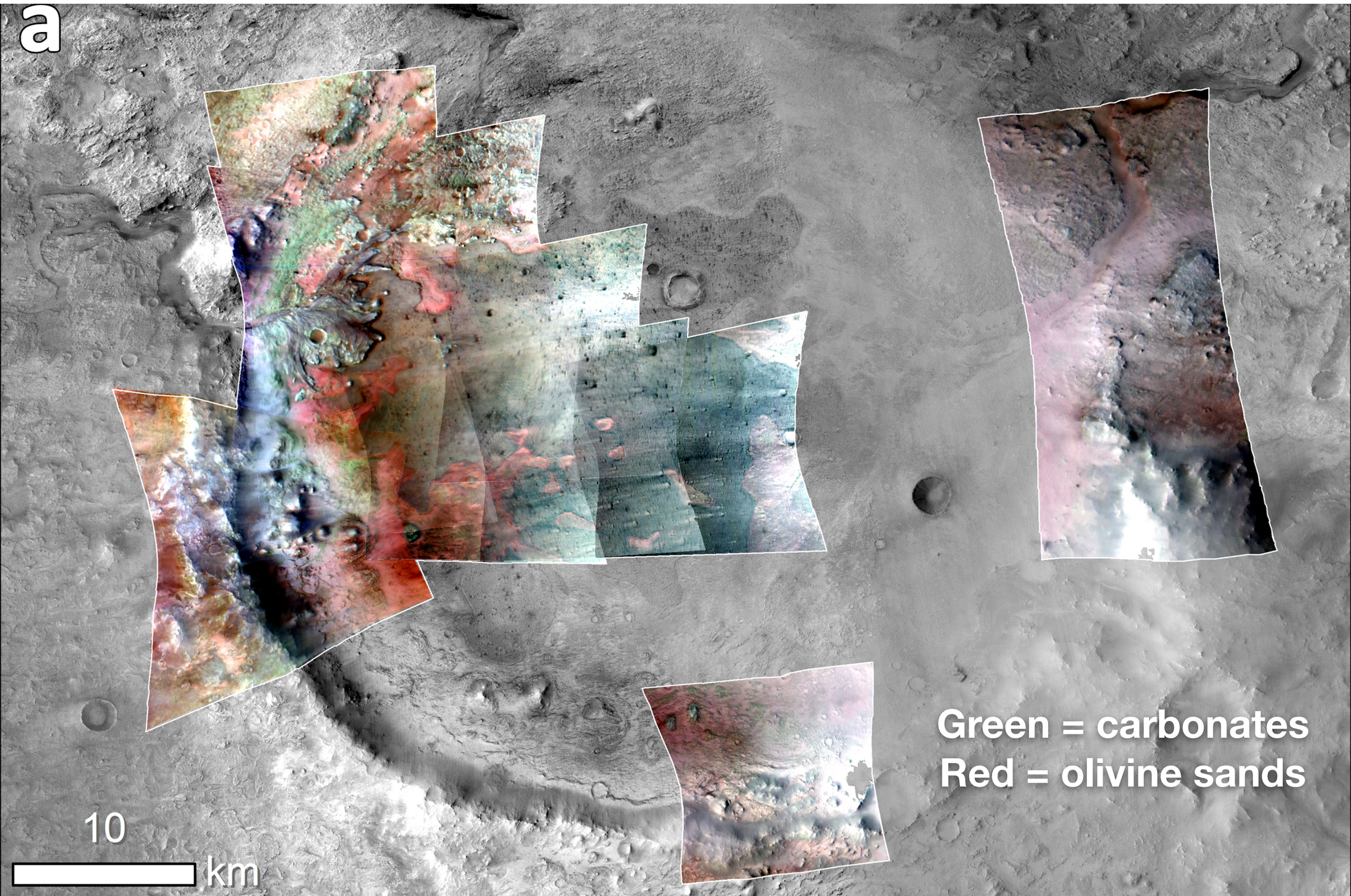
- There are carbonate-bearing terrains around the inner margin of the crater that may be consistent with near-shore lacustrine precipitates.
- These “Marginal Carbonates” may be associated with a closed basin lake, which also may have laid down the lower point bar and distal facies of the western delta
- Both of these targets have high biosignature preservation potential - distal delta strata could preserve organics, and near-shore carbonates could preserve microbialite textures, both detectable by Mars 2020

# Backup Slides

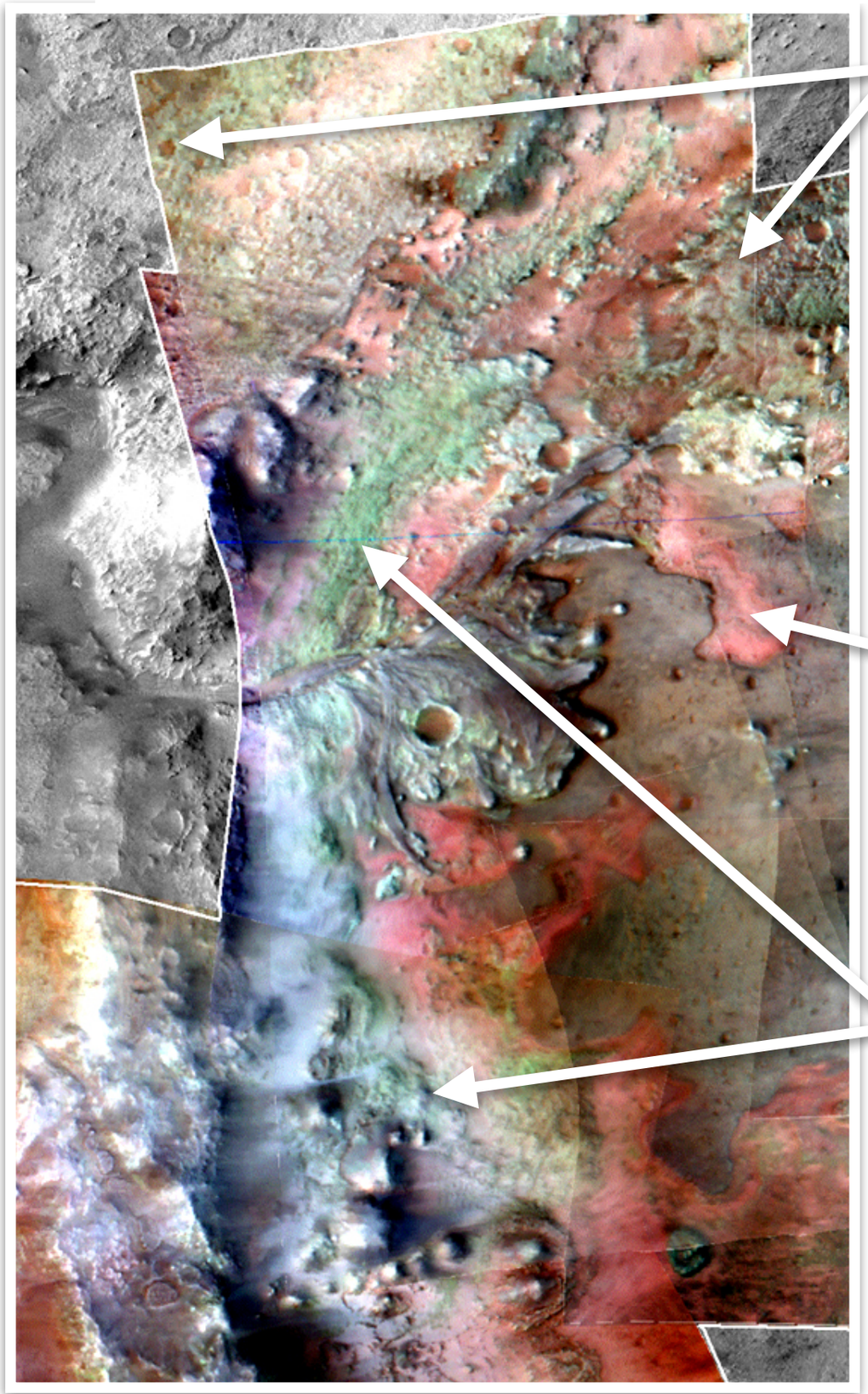
# An extensive watershed to the NE and a breach on the NW rim suggests that Jezero was an open-basin lake for some time



# These units are distinctive in VNIR/SWIR false color from CRISM



# This study: Are any of the three carbonate-bearing units in Jezero related to the lake?



**Mottled Terrain:**

- Regional olivine/carbonate-bearing unit
- Mantles topography
- Rare serpentine detections
- Postdates Jezero impact and some fluvial activity
- Isidis impact melt (no) or ultramafic tephra?
- Carbonate from weathering, subsurface groundwater/serpentinization, other??

**Light-toned Floor:**

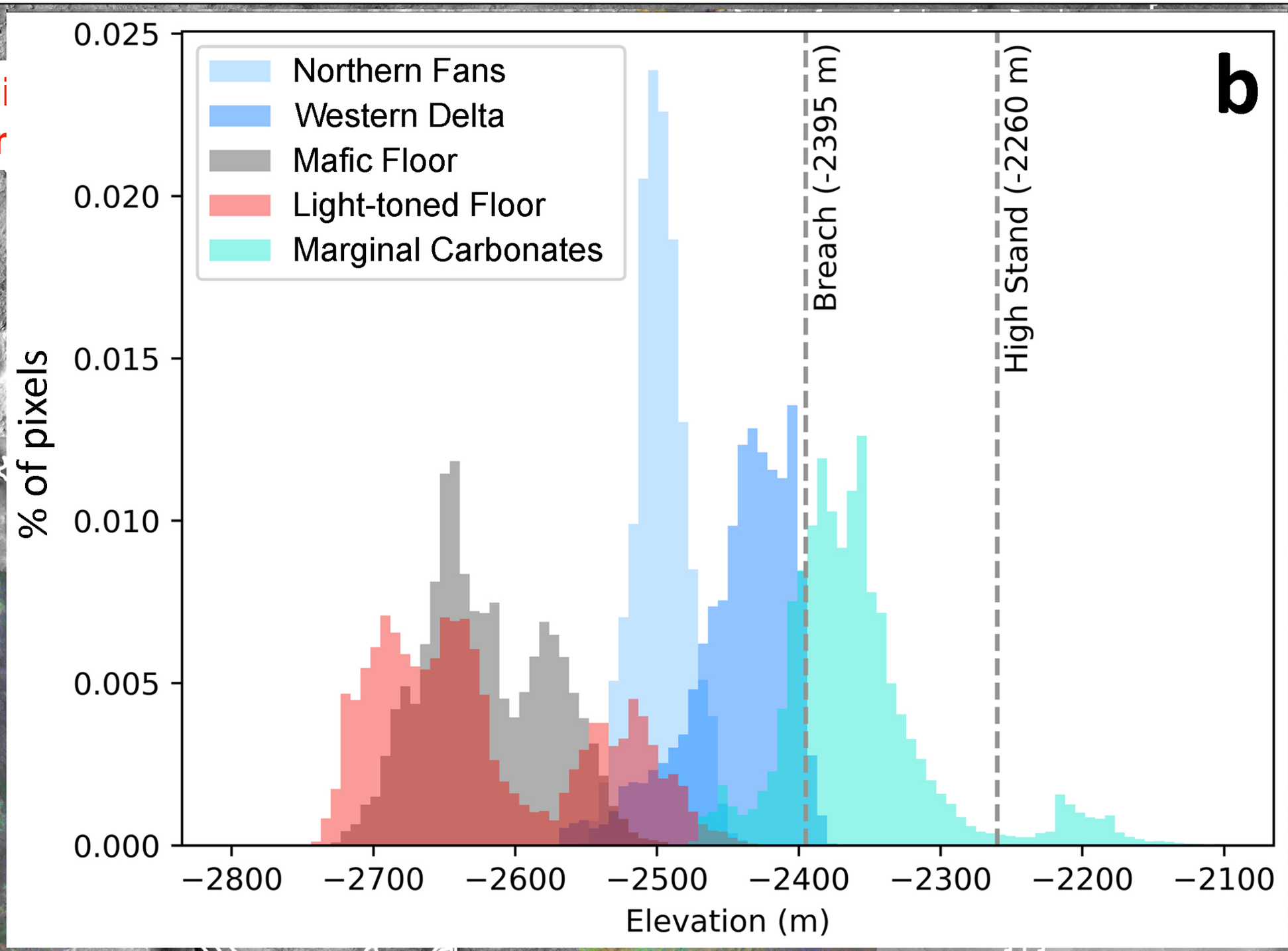
- Also olivine/carbonate-bearing
- Major source of olivine sand
- Lake deposit or extension of Mottled Terrain?

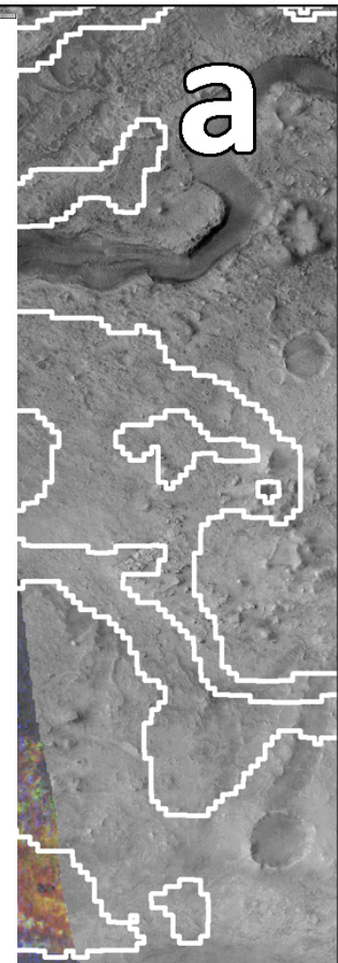
**Marginal Carbonates:**

- Strongest carbonate signatures in crater
- Restricted to inner margin of crater
- Could these be a lake deposit??

# <u>Topography</u>: The marginal carbonates are restricted to elevations between the lake high stand and the outlet breach

Margi
Carbor




Lake high stand and breach elevations from Fassett & Head (2005)