Exploring the Olivine-Carbonate Association (OCA) in the Jezero Crater Region, Possible Serpentinization and its Astrobiological Potential

Last Mars Rover Workshop
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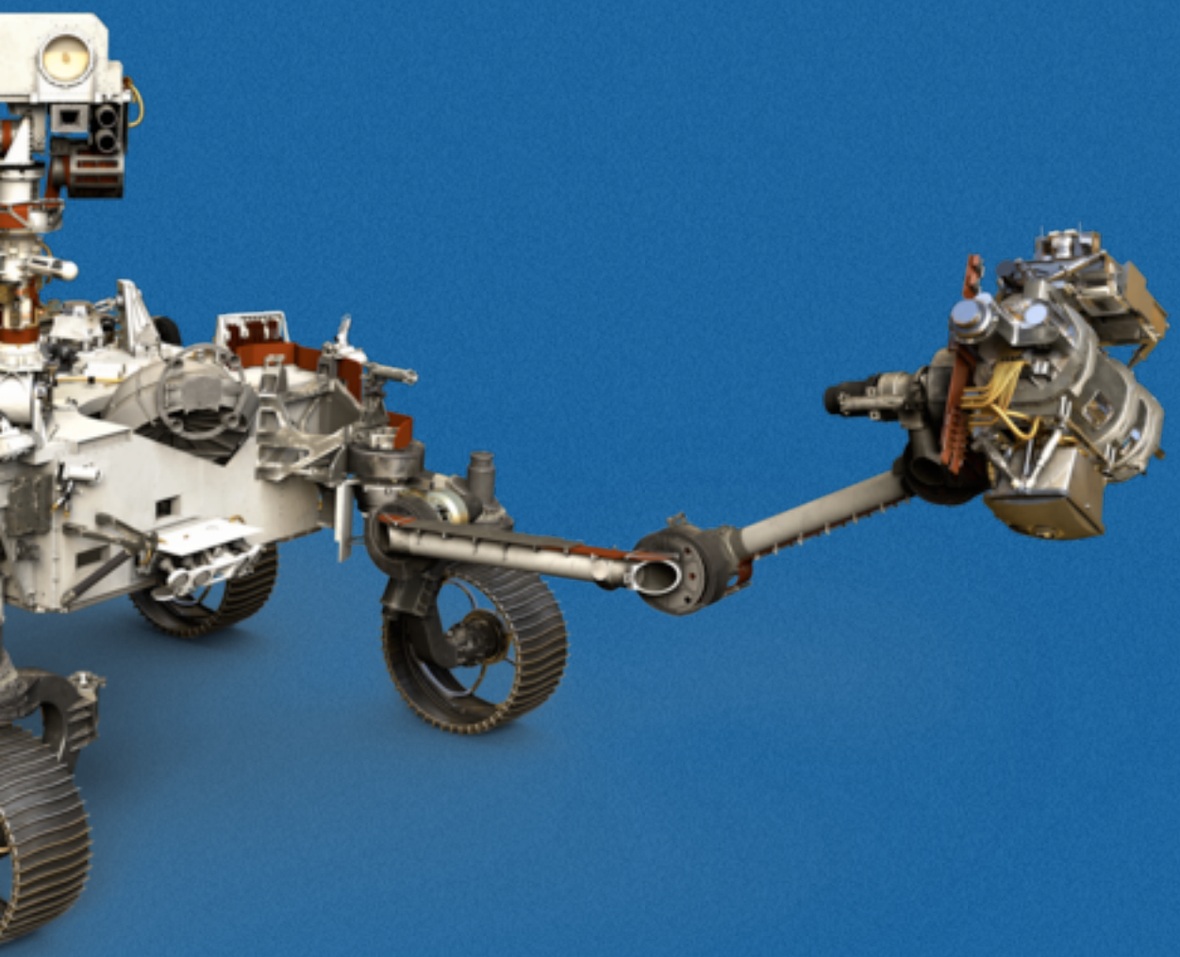
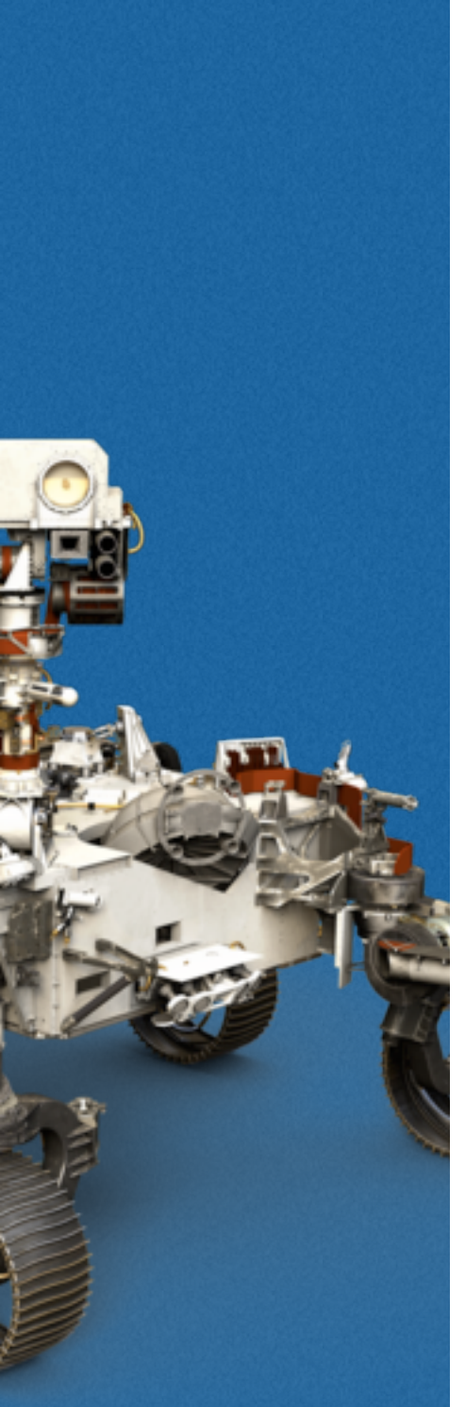
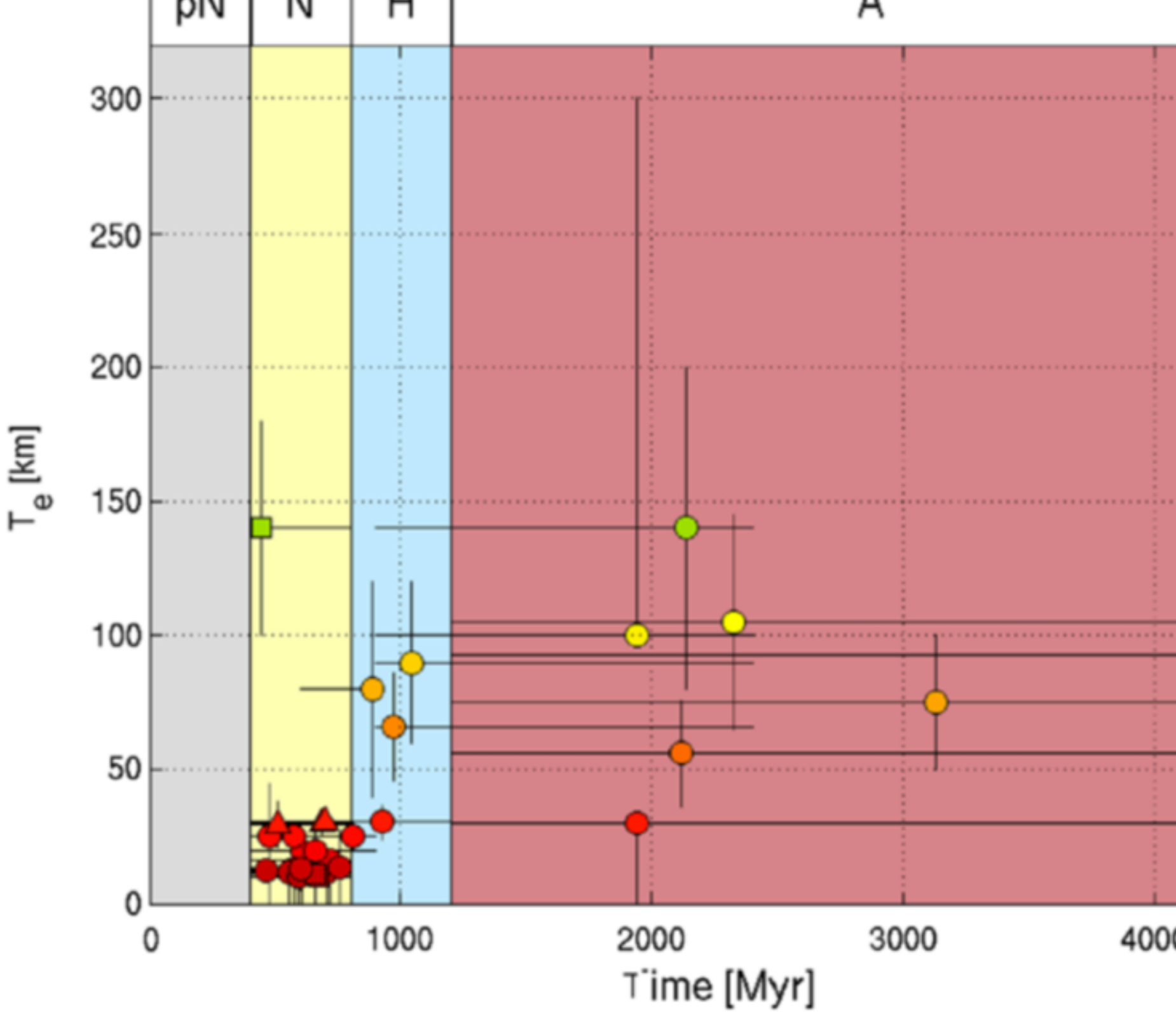
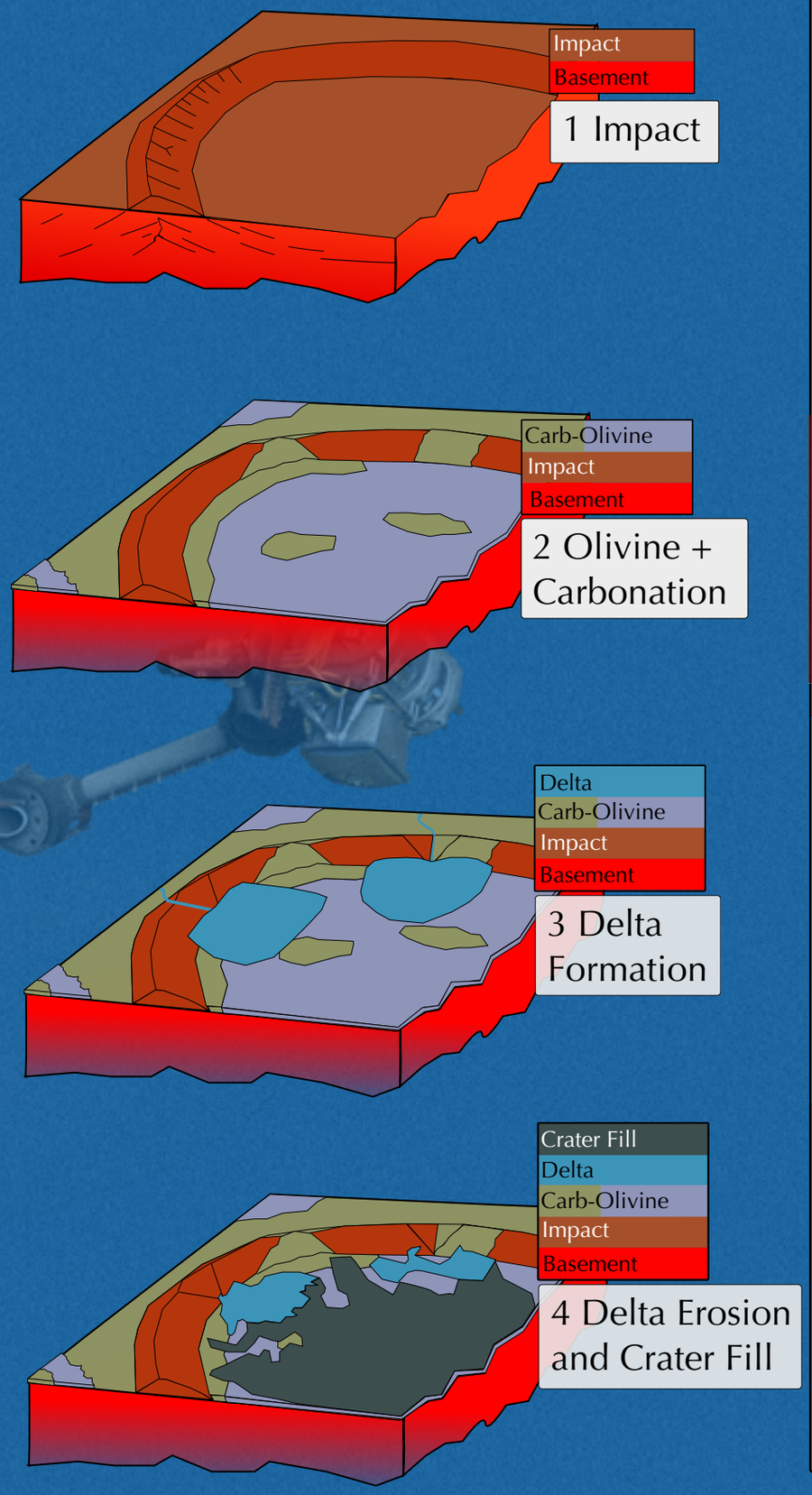
Possible Serpentinization and its Astrobiological Potential







Grott+ 2013 Figure 9



Inferred Geological Timeline

0. Deposition of basement level olivine and variable alteration to Mg-phyllosilicates

1. Arrival of Jezero impactor

2. Emplacement of olivine lithology and variable carbonation/serpentinization of olivine lithology

3. Some erosion/wasting of olivine lithology

4. Commencement of open water conditions at Jezero

5. Emplacement of delta deposits

6. Channel incision and Erosion of crater walls

7. Cessation of open water at Jezero

8. Wasting/erosion of exposed delta deposits

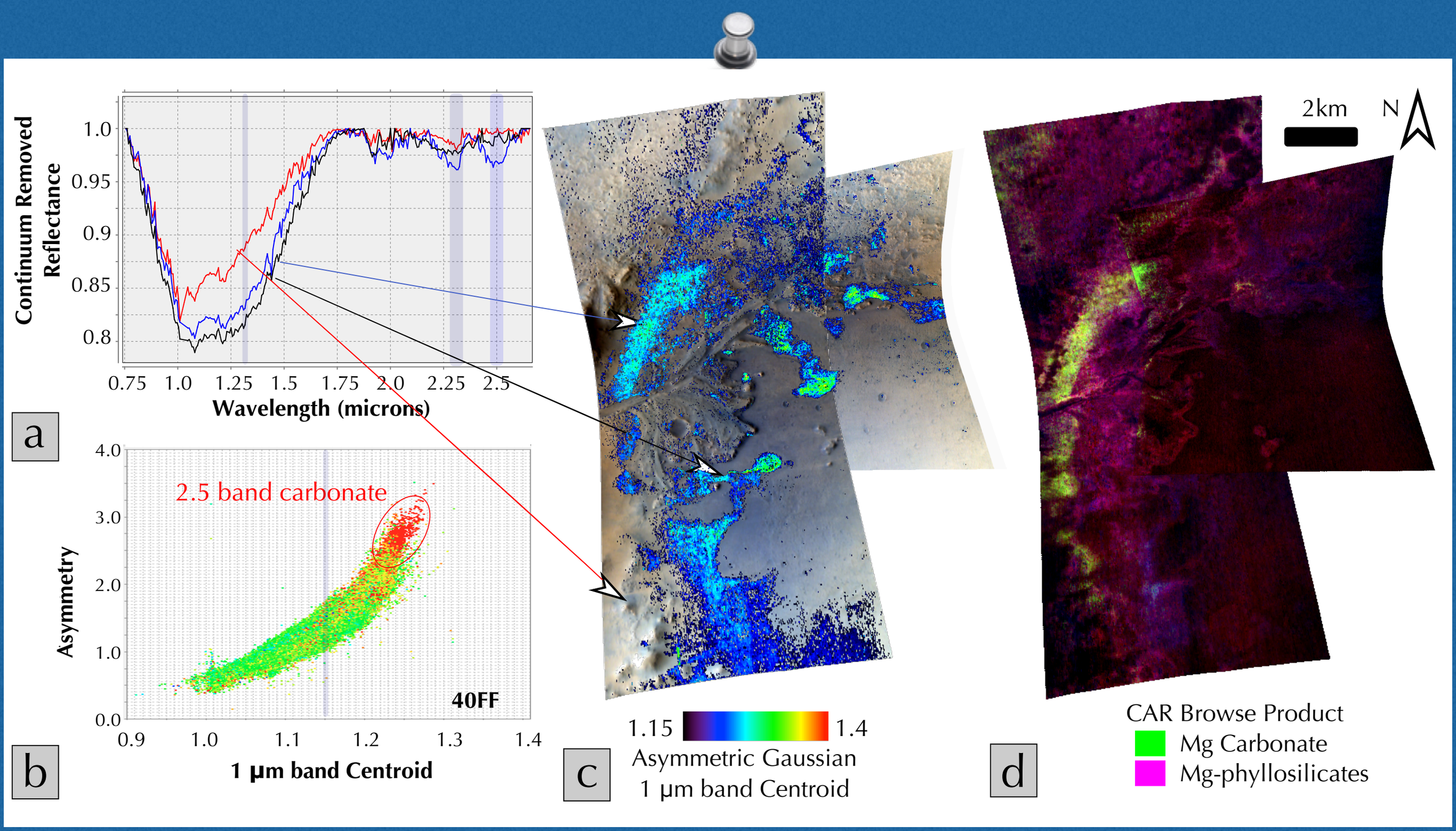
9. Emplacement/creation of crater fill unit over existing units in Jezero basin

NOACHIAN

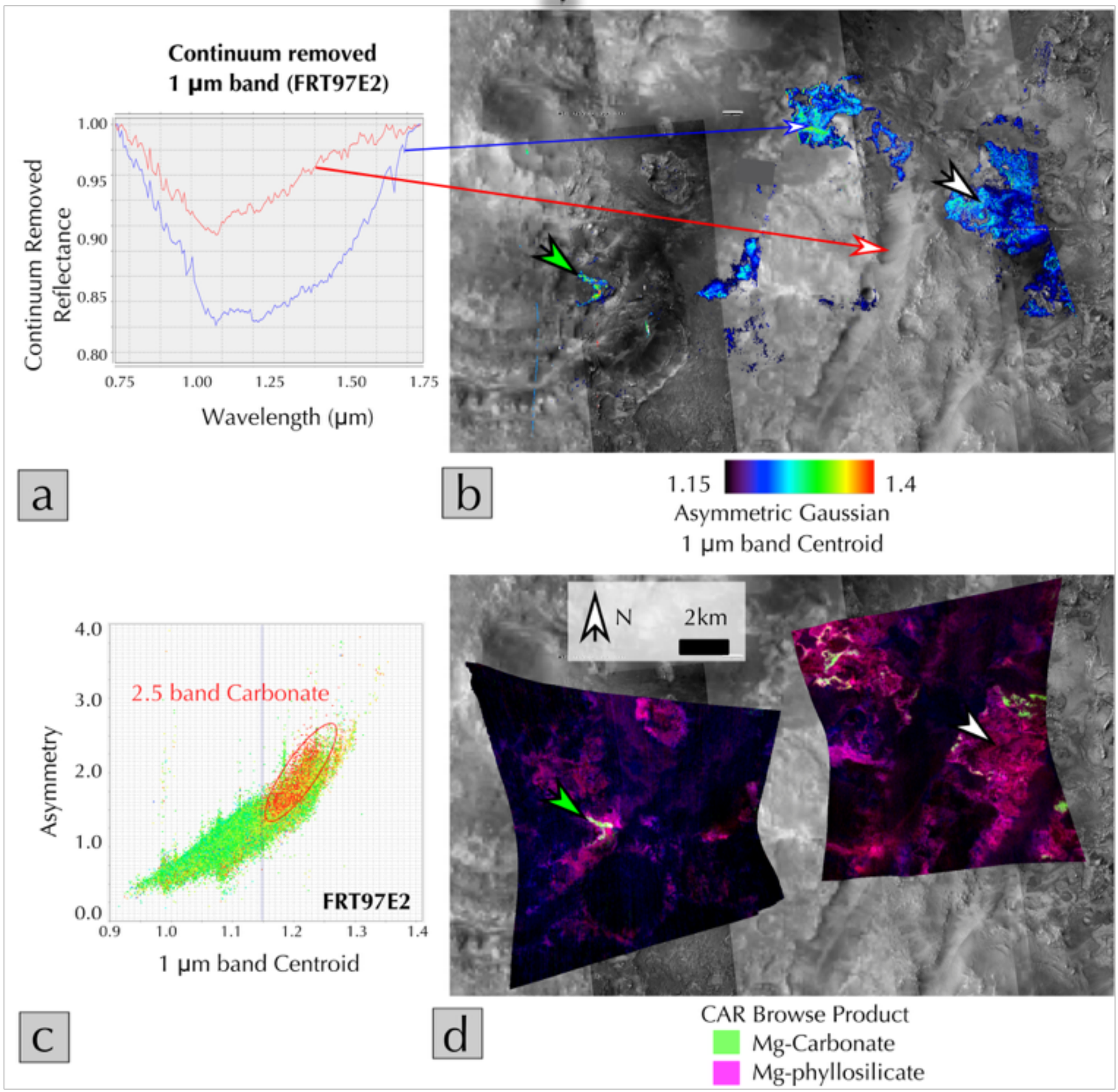
Open water (~10 million years)

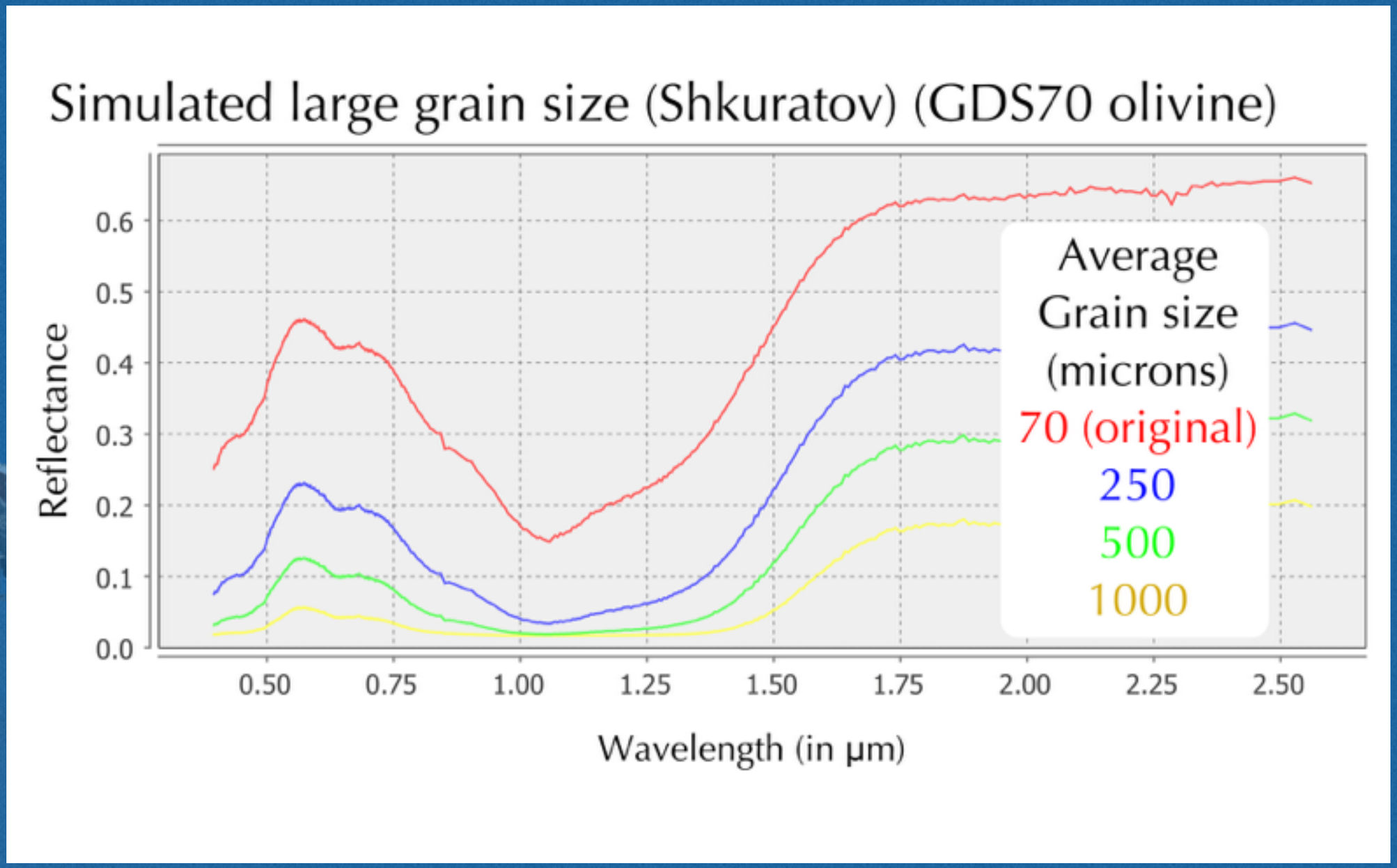
Fasset and Head 2005, Schon et al. 2012

Goudge+ 2015

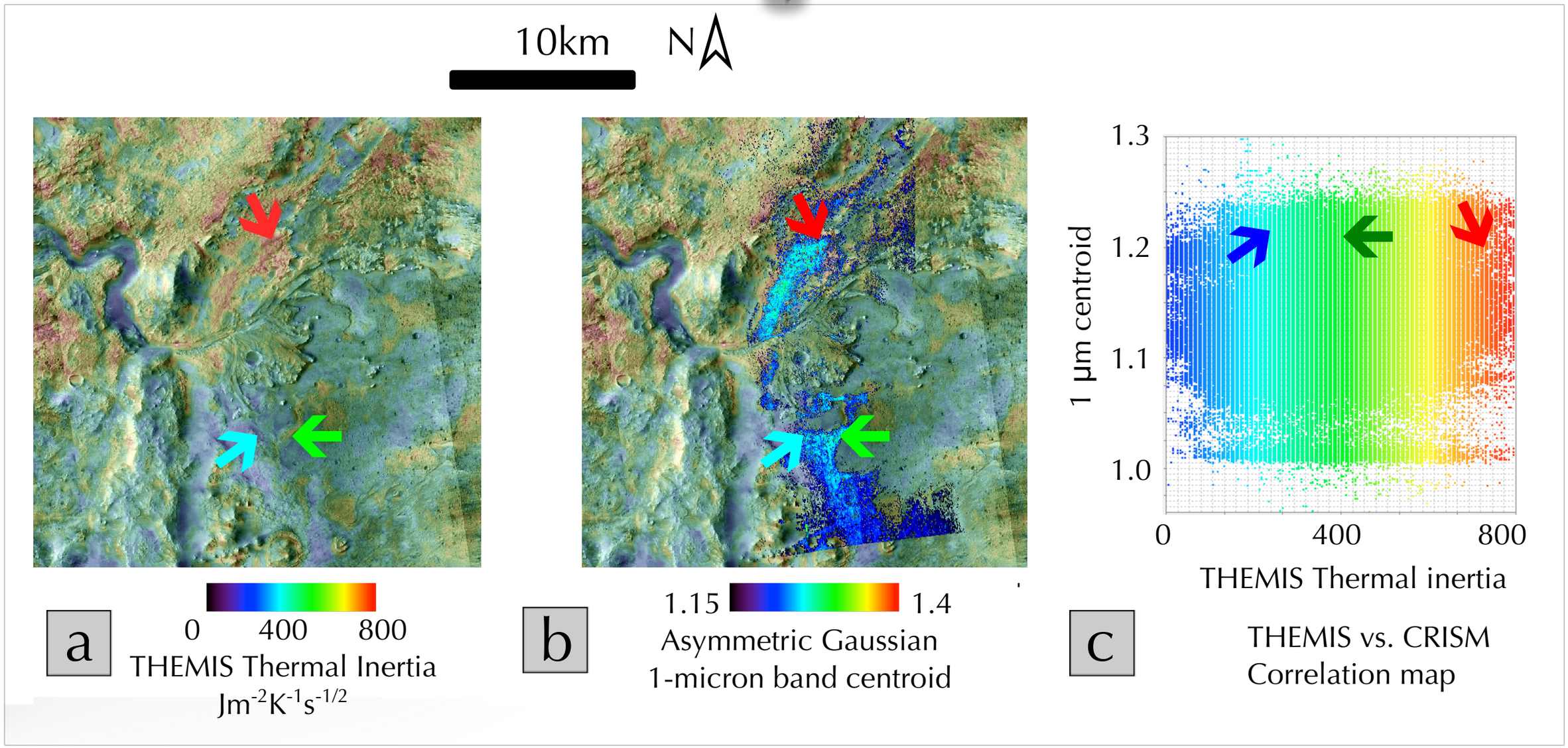


Correlations between Fe-olivine and Mg-carbonate at Nili Fossae (in a nutshell)


Continuum removed
1 µm band (FRT97E2)
Continuum Removed Reflectance
1.00
0.95
0.90
0.85
0.80
0.75
1.00
1.25
1.50
1.75
Wavelength (µm)
a
b
1.15
1.4
Asymmetric Gaussian
1 µm band Centroid
4.0
3.0
2.0
1.0
0.0
Asymmetry
2.5 band Carbonate
FRT97E2
0.9
1.0
1.1
1.2
1.3
1.4
1 µm band Centroid
c
N
2km
d
CAR Browse Product
Mg-Carbonate
Mg-phyllosilicate

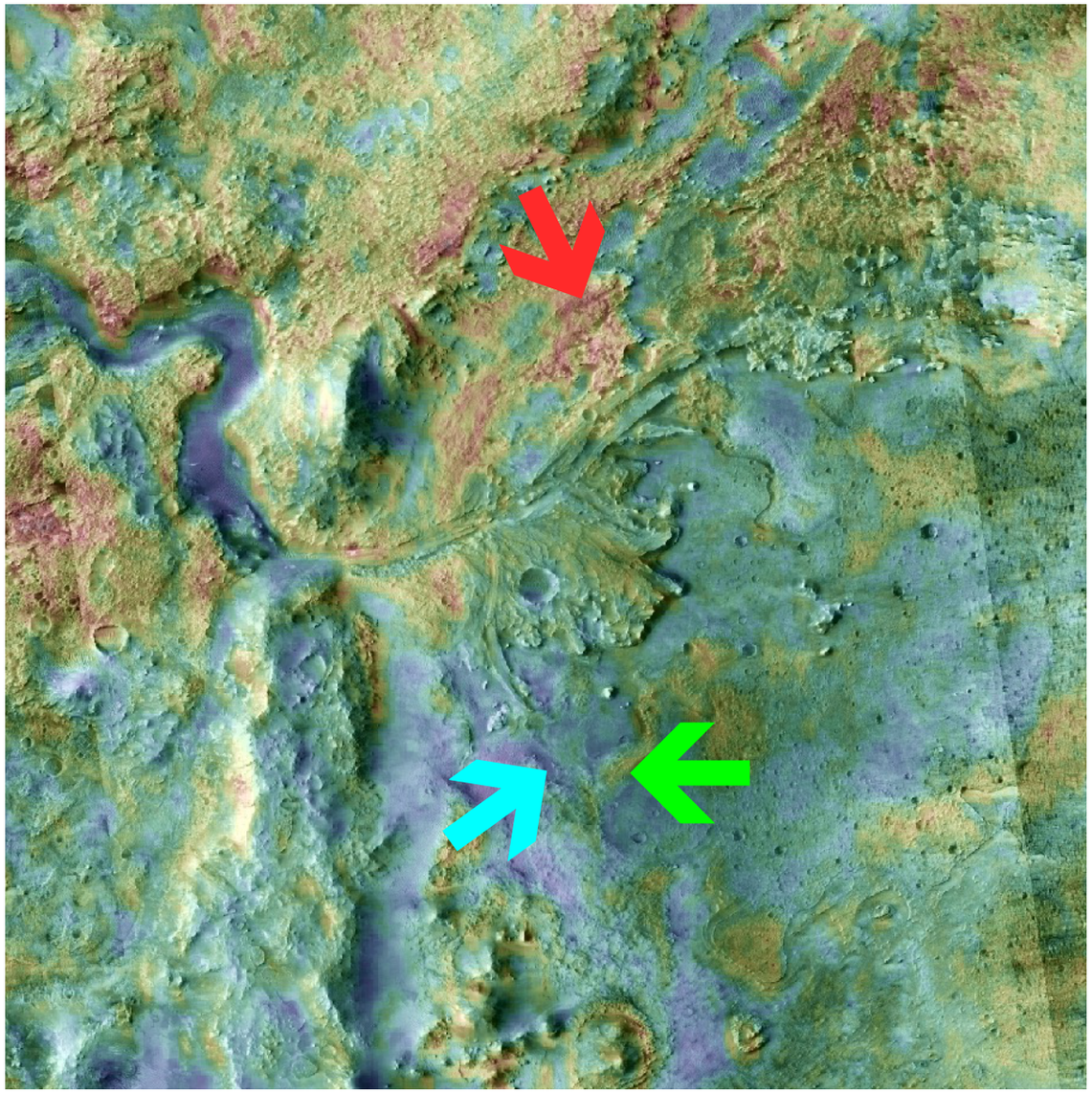


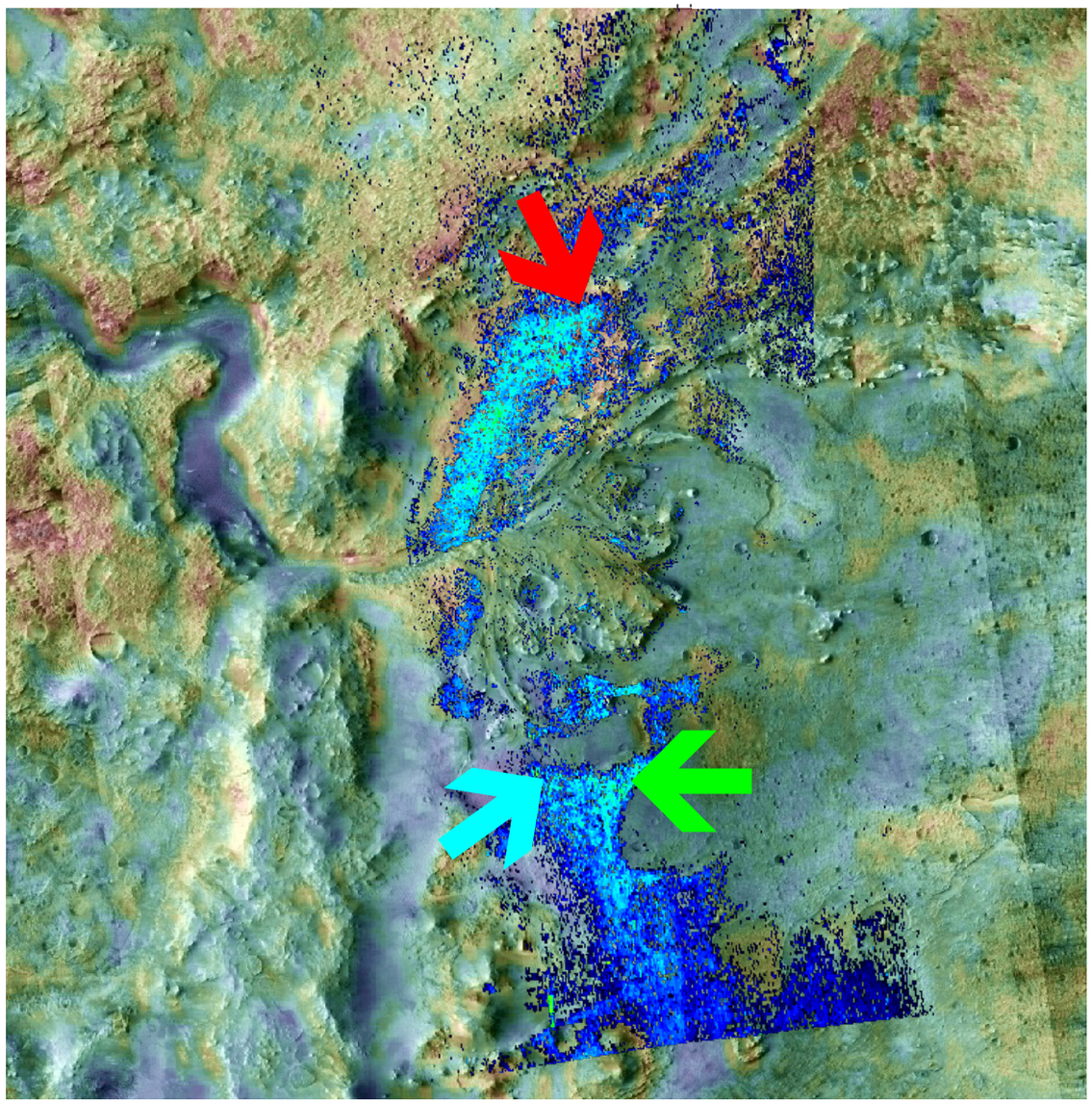
Shkuratov model to constrain movement of 1 micron band due to increasing grain size



The Thermal Inertia problem

[redacted]





a

0 400 800

THEMIS Thermal Inertia

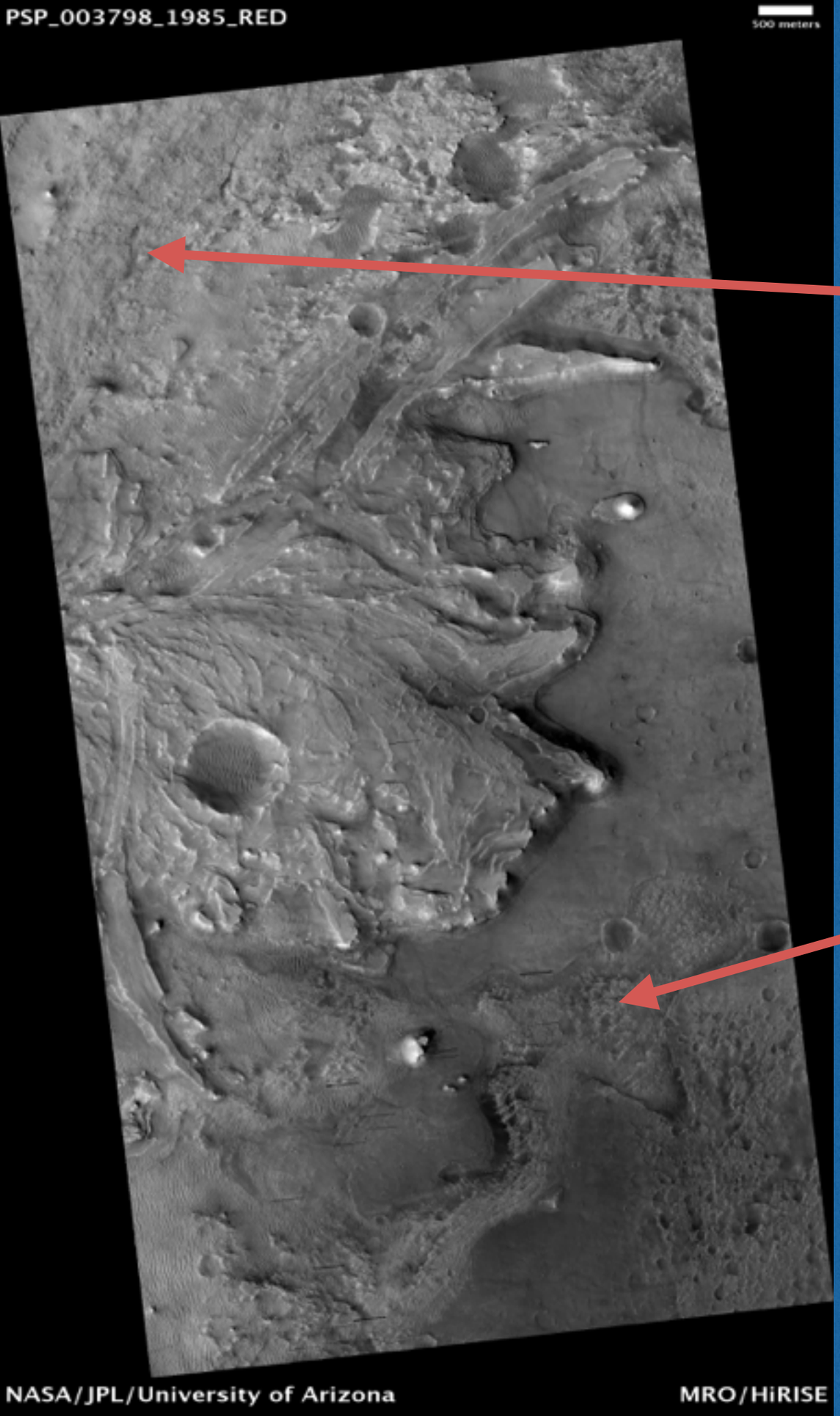
$Jm^{-2}K^{-1}s^{-1/2}$

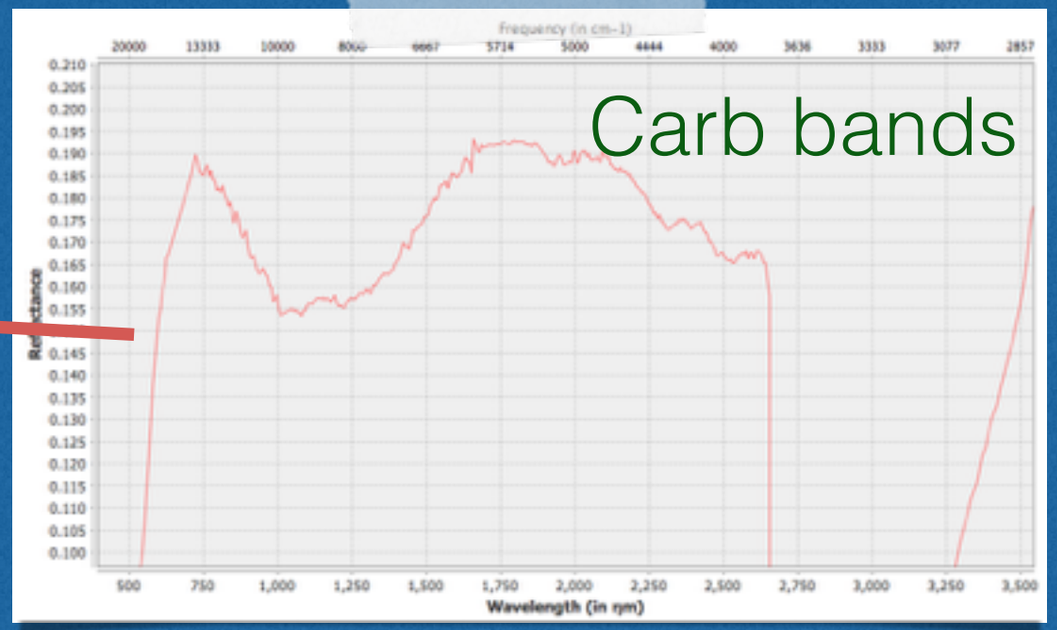
b

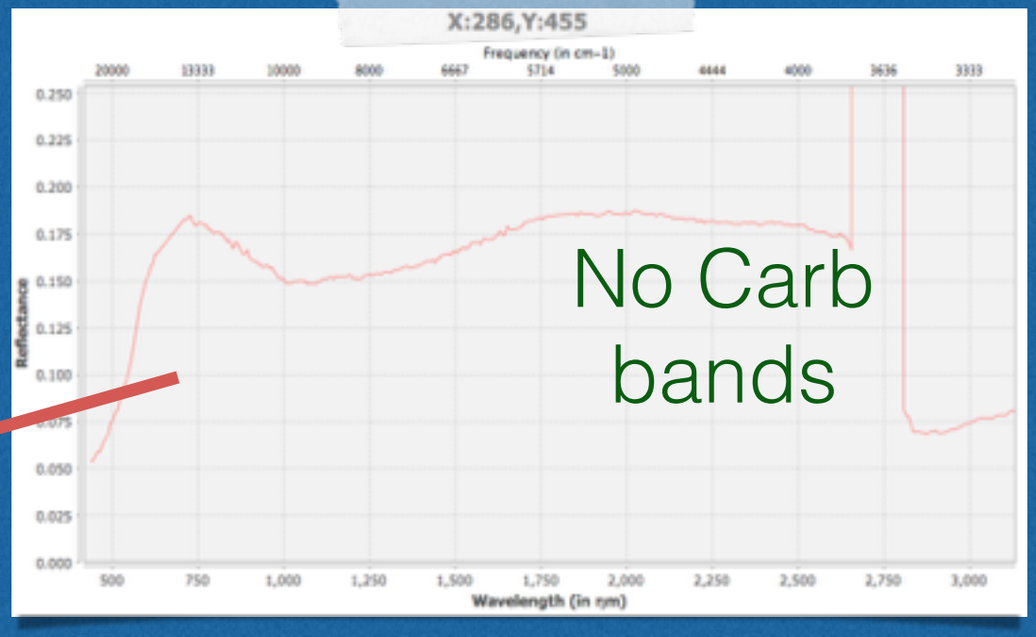
1.15 1.4

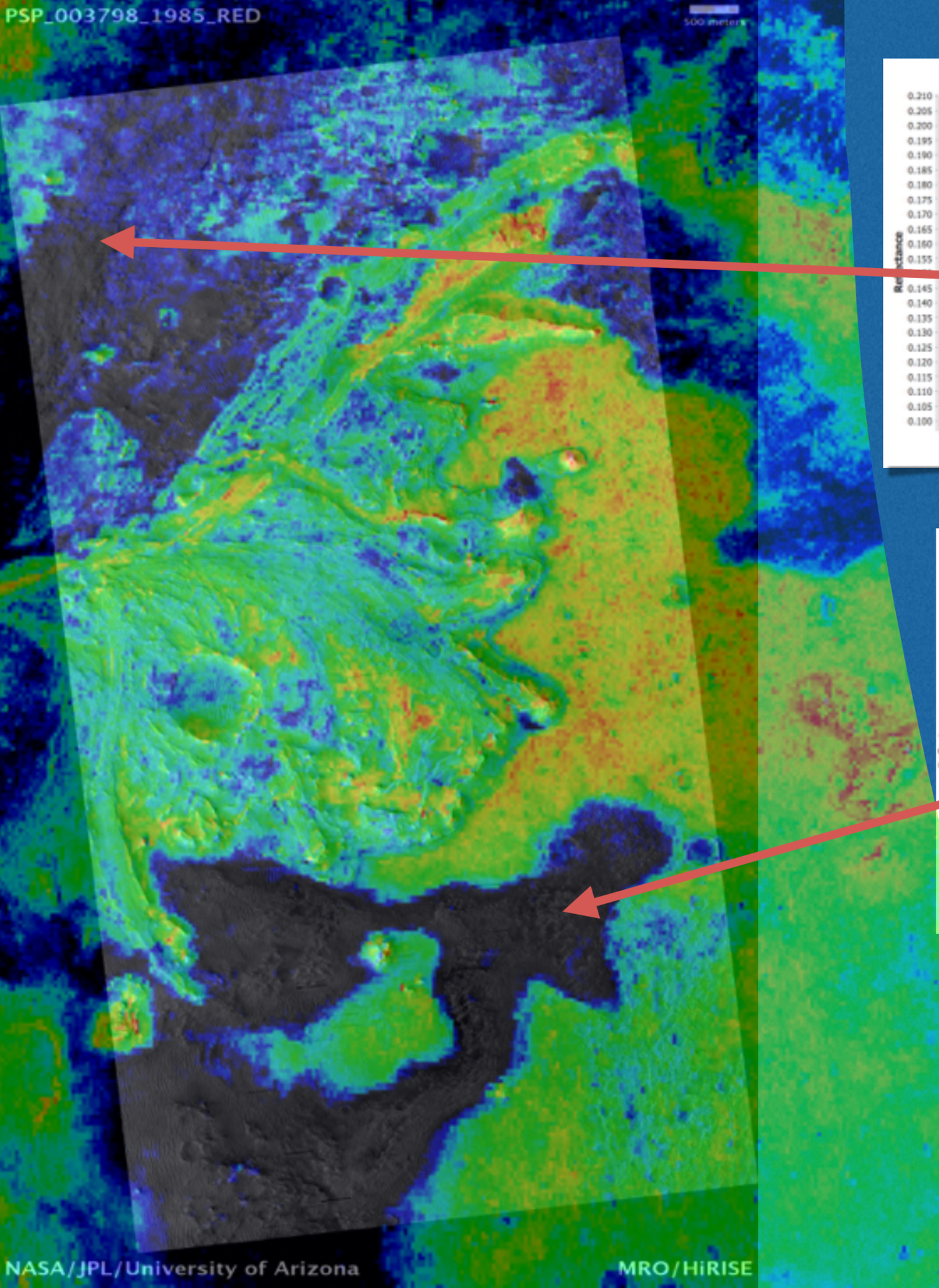
Asymmetric Gaussian

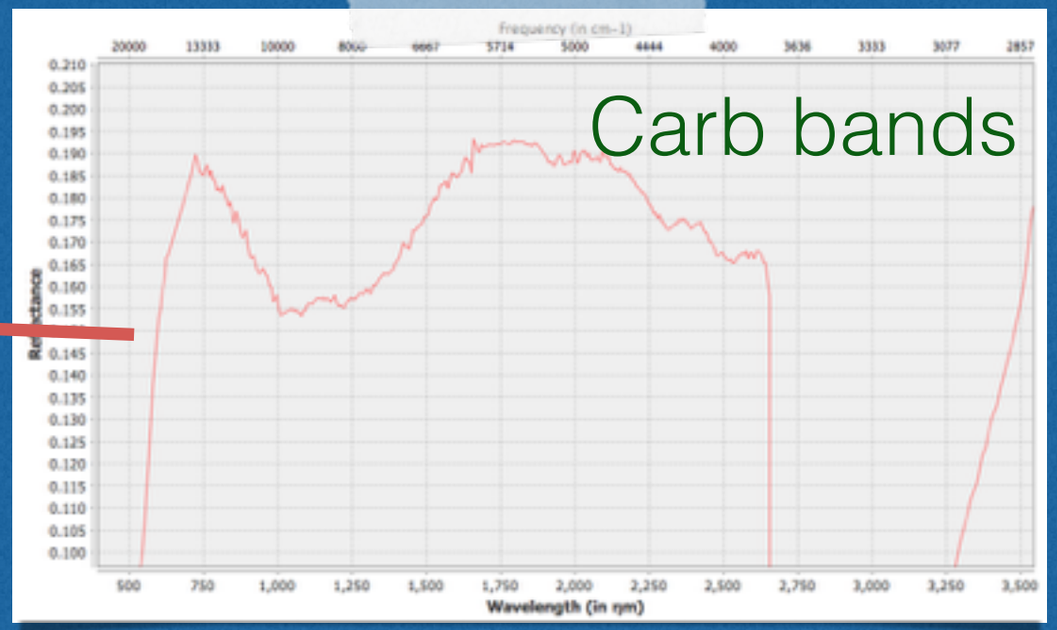
1-micron band centroid

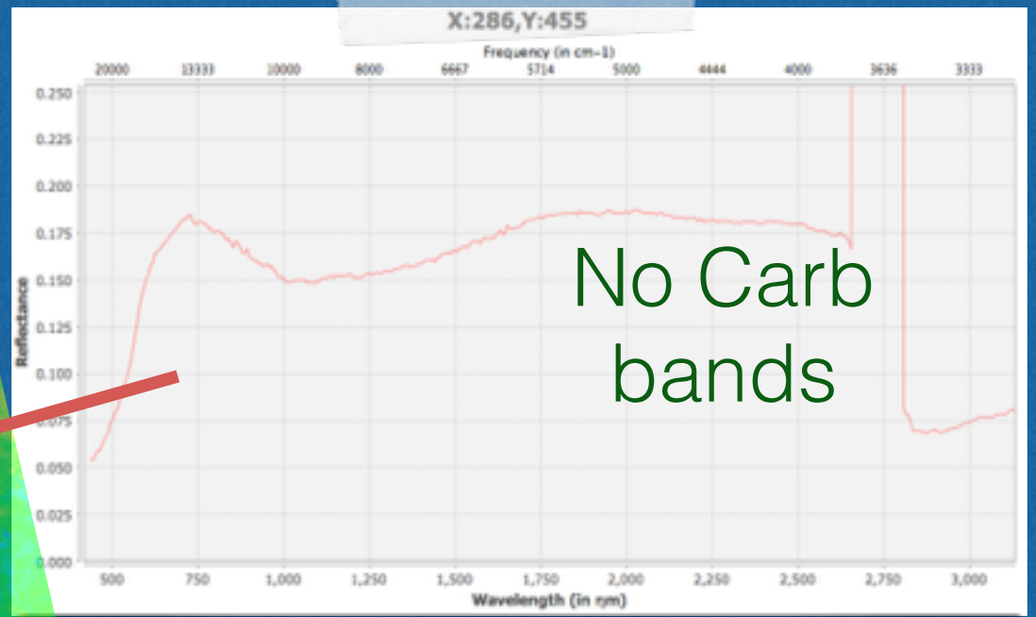

PSP_003798_1985_RED
500 meters
NASA/JPL/University of Arizona
MRO/HiRISE

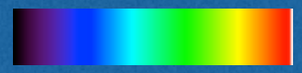

Carb bands
Frequency (in cm-1)
Reflectance
Wavelength (in nm)


X:286,Y:455
Frequency (in cm-1)
No Carb bands
Reflectance
Wavelength (in nm)



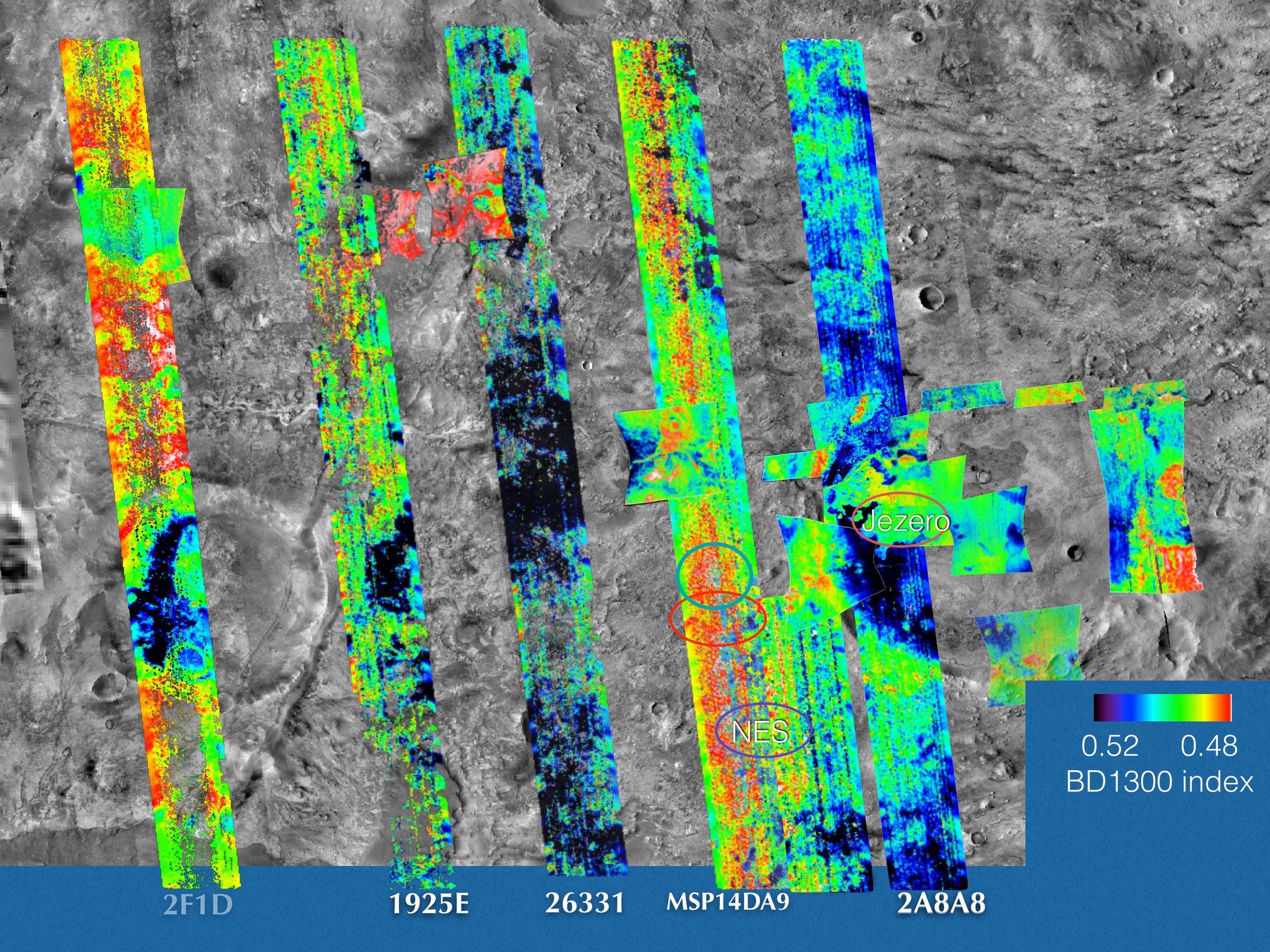




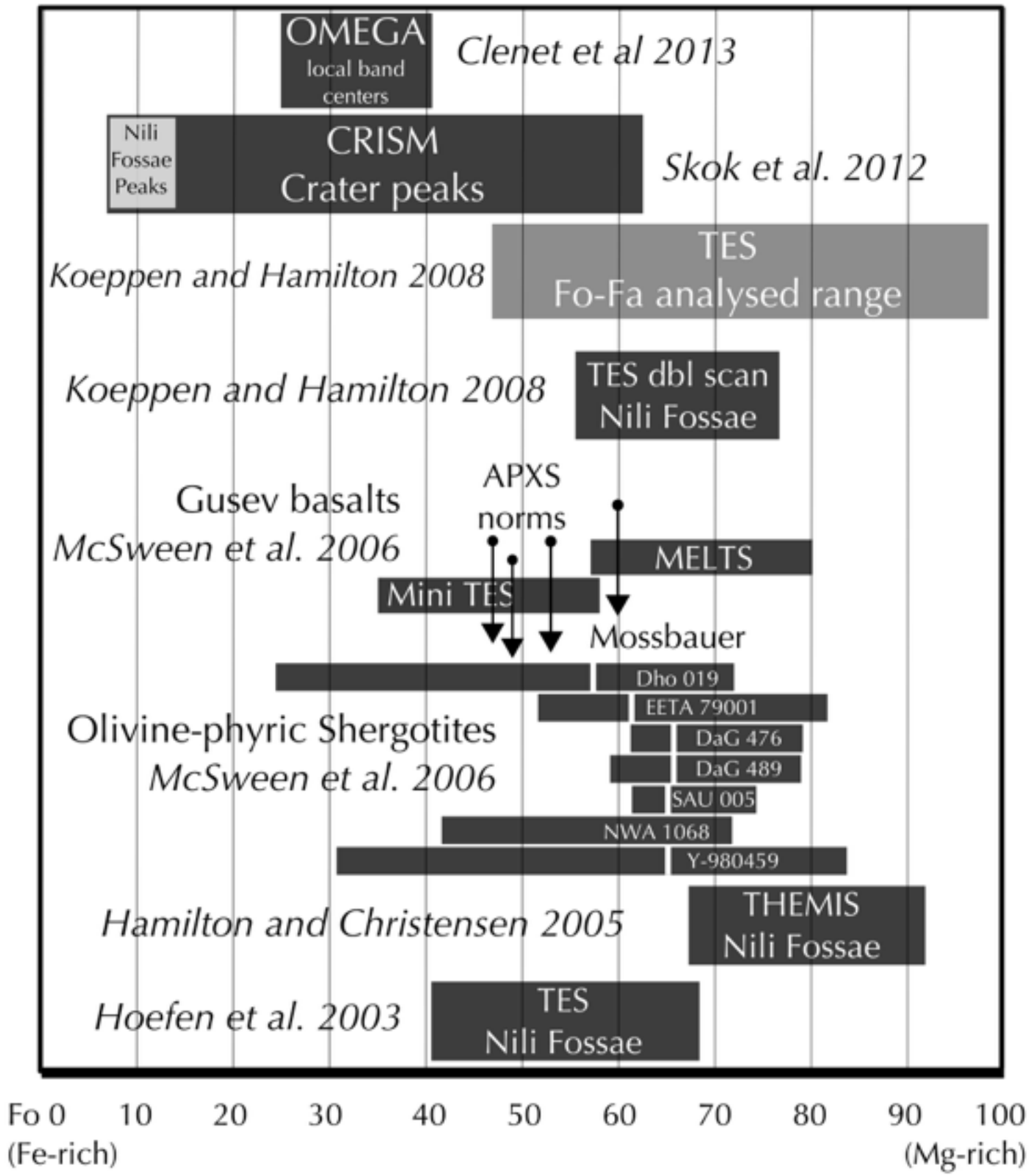


0.52 0.48

BD1300 index


Jezero
NES
0.52
0.48
BD1300 index
2F1D
1925E
26331
MSP14DA9
2A8A8

40FF/97E2



Previous studies Olivine composition results

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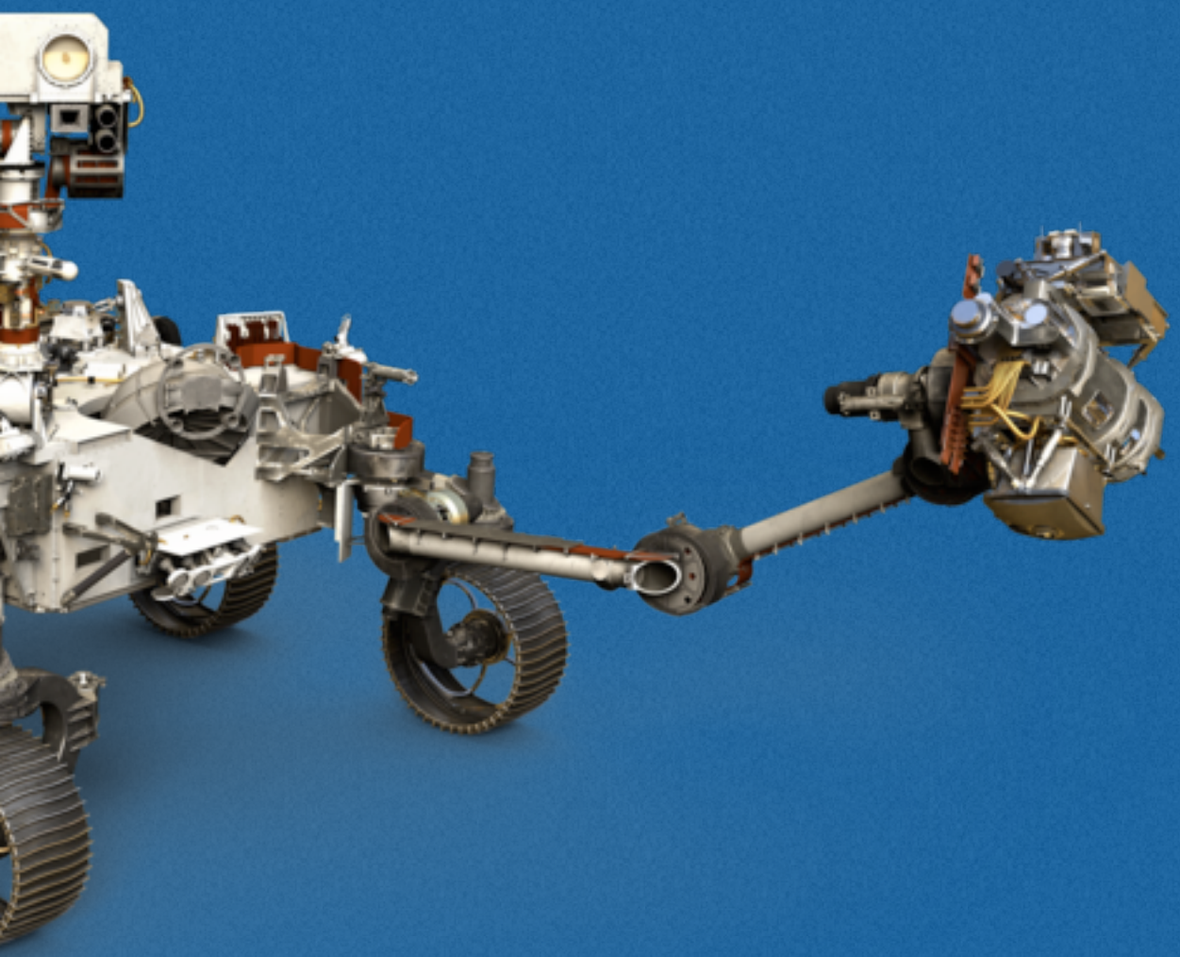


Serpentinization

$$3\,\underset{\textit{forsterite}}{Mg_2SiO_4} + \underset{\textit{aqueous silica}}{SiO_2} + 2H_2O \Rightarrow \underset{\textit{serpentine}}{2Mg_3Si_2O_5(OH)_4}$$

vs. (or in addition to)

$$\underset{\textit{serpentine}}{2Mg_3Si_2O_5(OH)_4} + 3CO_2 \Rightarrow \underset{\textit{talc}}{Mg_3Si_4O_{10}(OH)_2} + H_2O + \underset{\textit{magnesite}}{3MgCO_3}$$

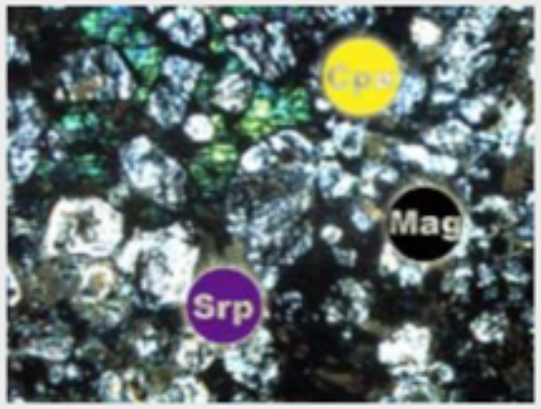
Talc-Carbonatization

1. Hydrothermal alteration reaction to produce talc-carbonate

Ref. AJB+ 2010

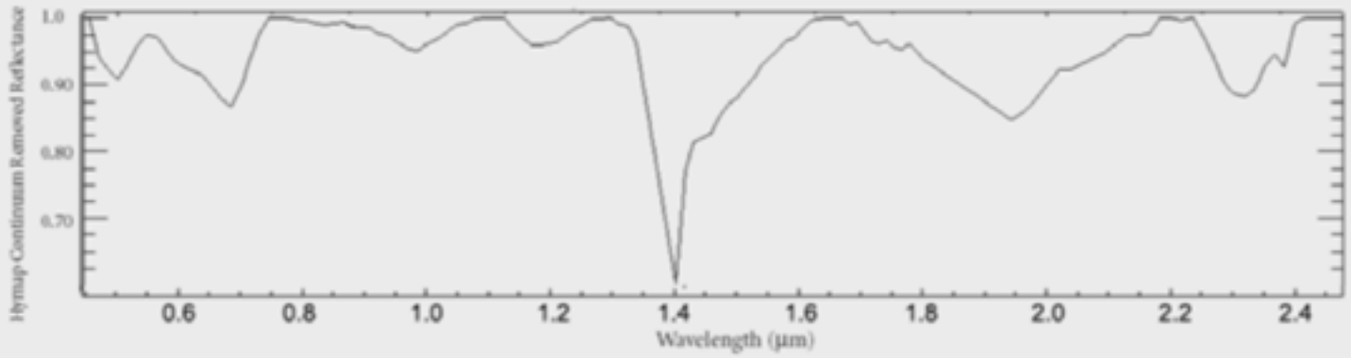
Both processes probably occurred, e.g. Viviano+ 2013, Amador+ 2017 key question is where and why

Sample ID	AJB0503098
Location	754679E 7663523N
Unit	AWak
Description	Peridotitic komatiite
Alteration Zone	SERPENTINITIC PROPYLITIC



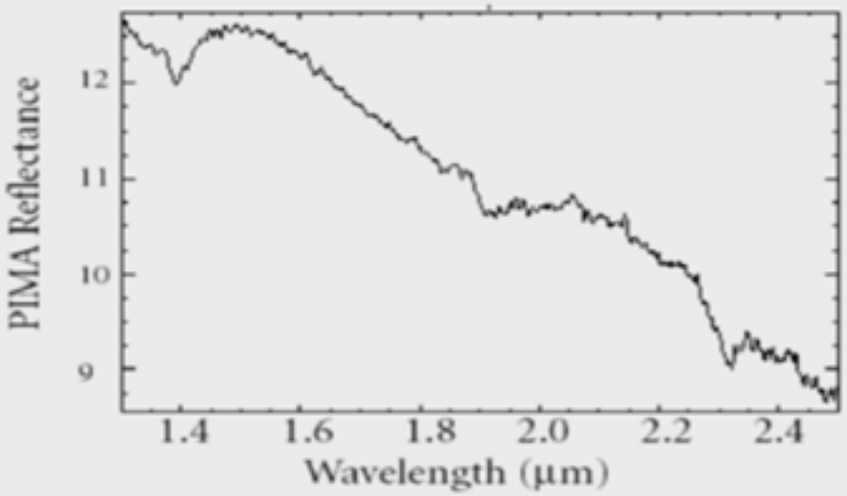
PTS Summary: Cumulate serpentine after olivine with interstitial (green) pyroxene and magnetite (black). XPL.

HyMap Summary: A right asymmetric band is present around 2.38µm probably indicative of surficial talc. Fe signature apparent in VNIR. Bands at 0.9 and 1.0 µm also attributable to minor Fe oxides.

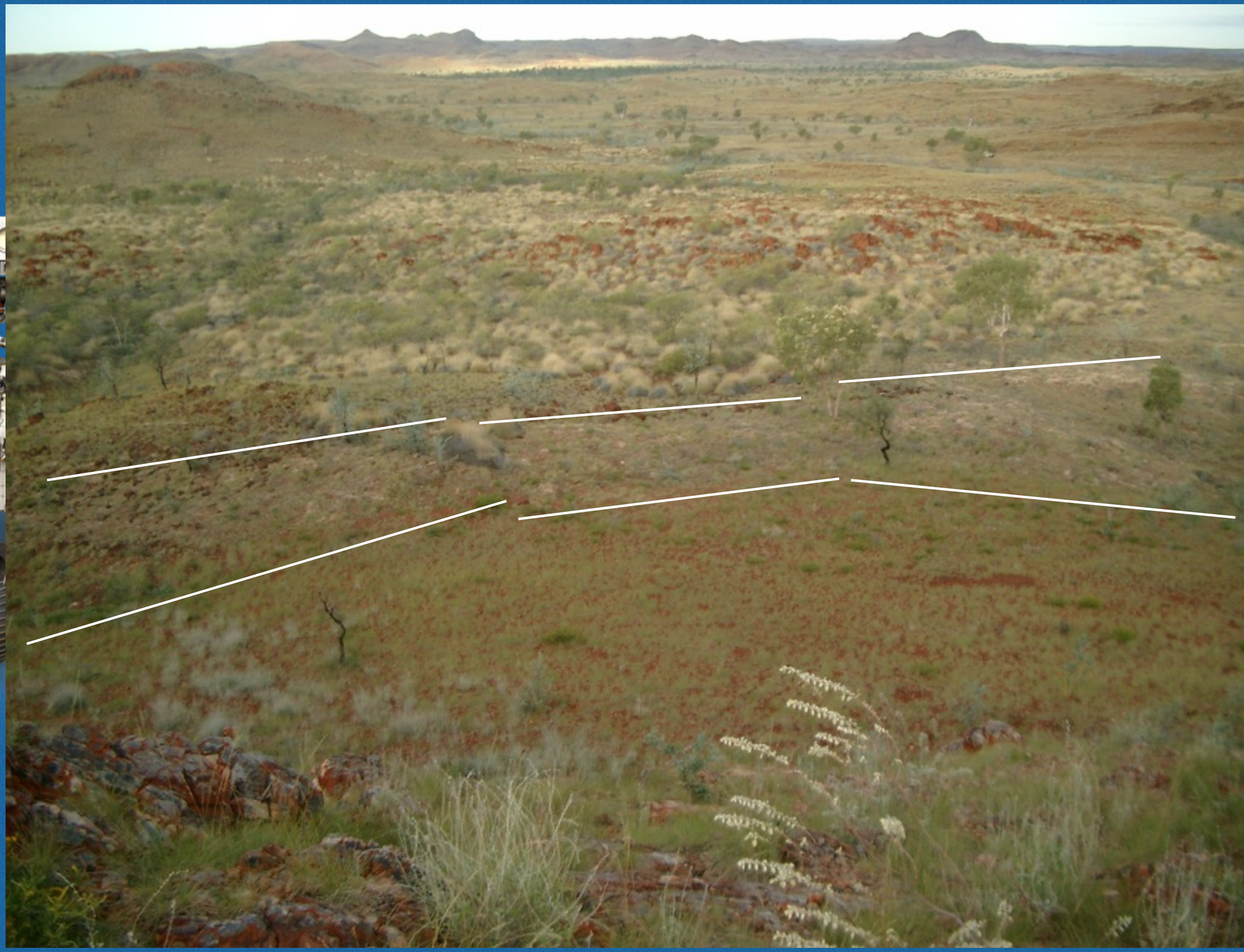


PIMA Absorption Bands

λ (µm)	Depth	FWHM (ηm)	Assignment
2.314	0.066	21.047	Mg-OH υ+δ
1.912	0.064	23.659	H_2O
1.394	0.048	18.398	*Al-OH 2υ*
1.836	0.039	25.717	*H_2O*
1.986	0.035	38.212	H_2O
1.766	0.029	28.189	
2.372	0.022	15.795	*Mg-OH υ+δ*
2.448	0.020	15.795	
1.708	0.019	28.163	

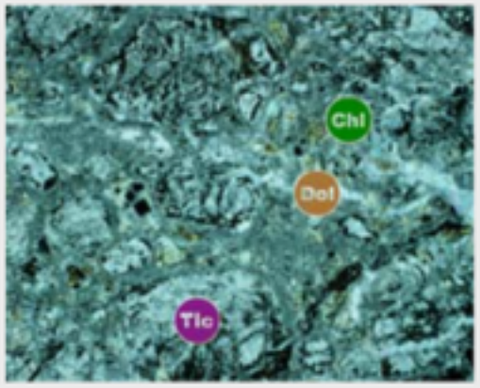


Summary: Sample is noisy and absorption bands are weak due to the low reflectance of serpentine. In the SWIR region of the PIMA spectra there is an indication of a band at 2.372µm. The band is stronger in the HyMap spectrum, but may be due to talc.



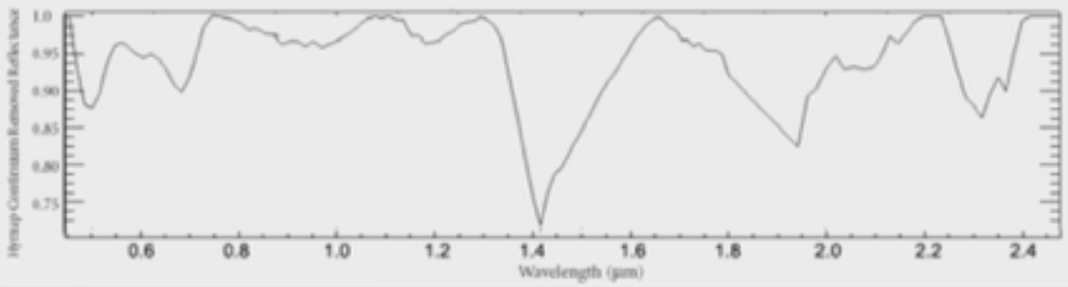
Sample 100 -

Sample ID	AJB0504100
Location	754702E 7663703N
Unit	AWak
Description	Carbonated ultramafic
Alteration Zone	TALC-CARBONATE PROPYLITIC



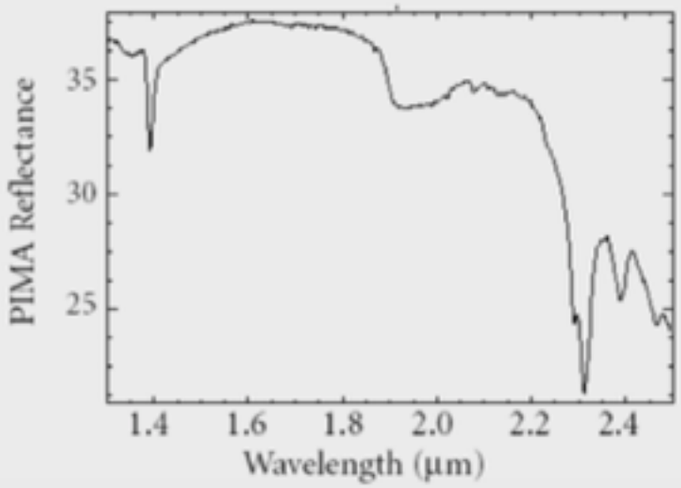
PTS Summary: Orbicular blebs of talc replacing olivine surrounded by carbonate in veins. XPL.

HyMap Summary: Possible band at 2.14 due to overlapping spinifex grass. Strong band present around 2.34µm with minor sharp band at 2.38µm indicative of talc or actinolite – here due to talc. Band at 0.9 attributable to Fe oxides.



PIMA Absorption Bands

λ (ηm)	Depth	FWHM (ηm)	Assignment
2.312	0.276	18.201	Mg-OH υ+δ
1.394	0.099	13.153	Al-OH 2υ
2.388	0.085	13.056	
2.288	0.077	15.630	Fe-OH υ+δ
1.920	0.070	26.280	H_2O
1.984	0.044	41.971	*H_2O*
2.462	0.031	13.060	*Mg-OH υ+δ*
1.438	0.022	21.019	H_2O
1.348	0.016	15.500	*Mg-OH υ+δ*



Summary: Sharp (13-18ηm) peaks of PIMA spectra at 2.312

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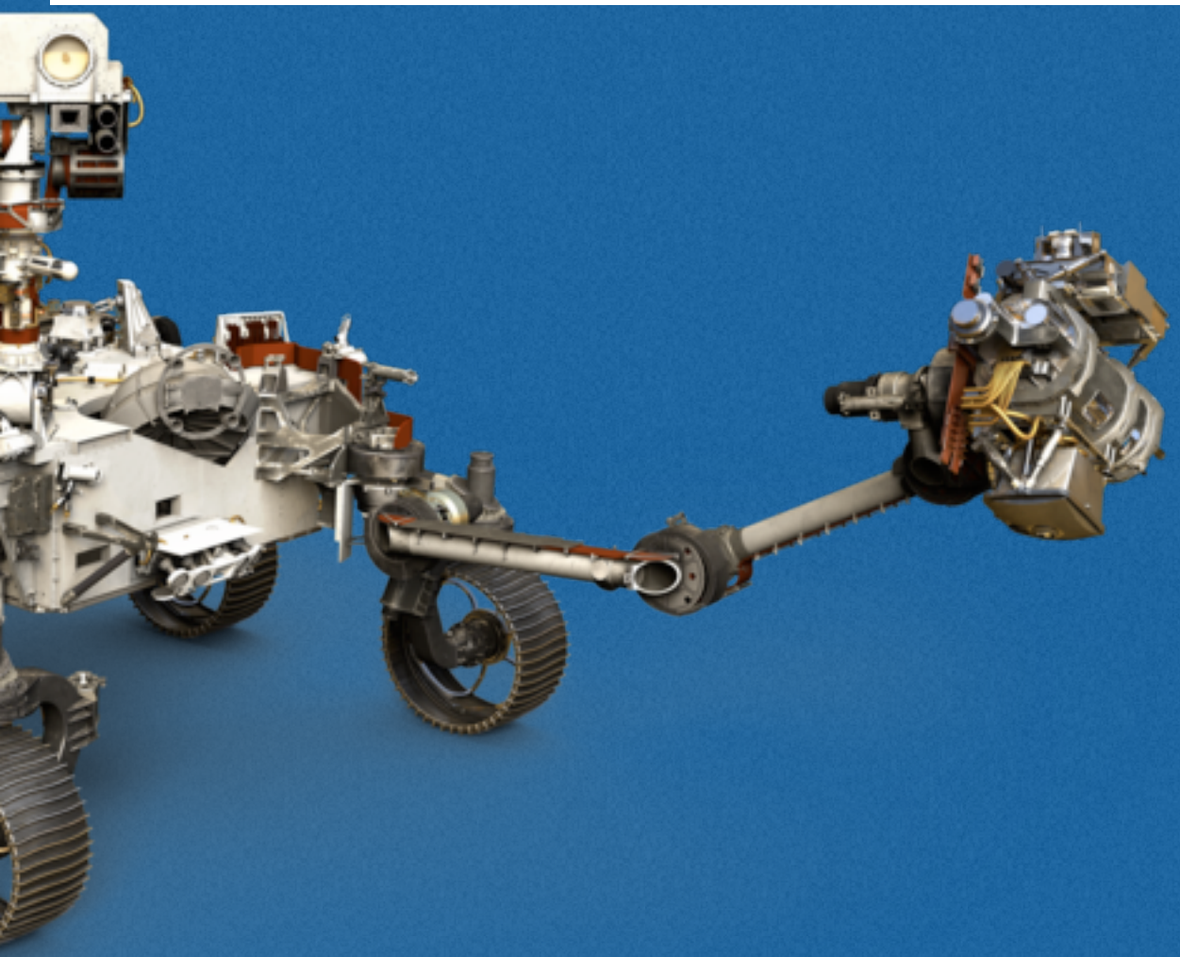

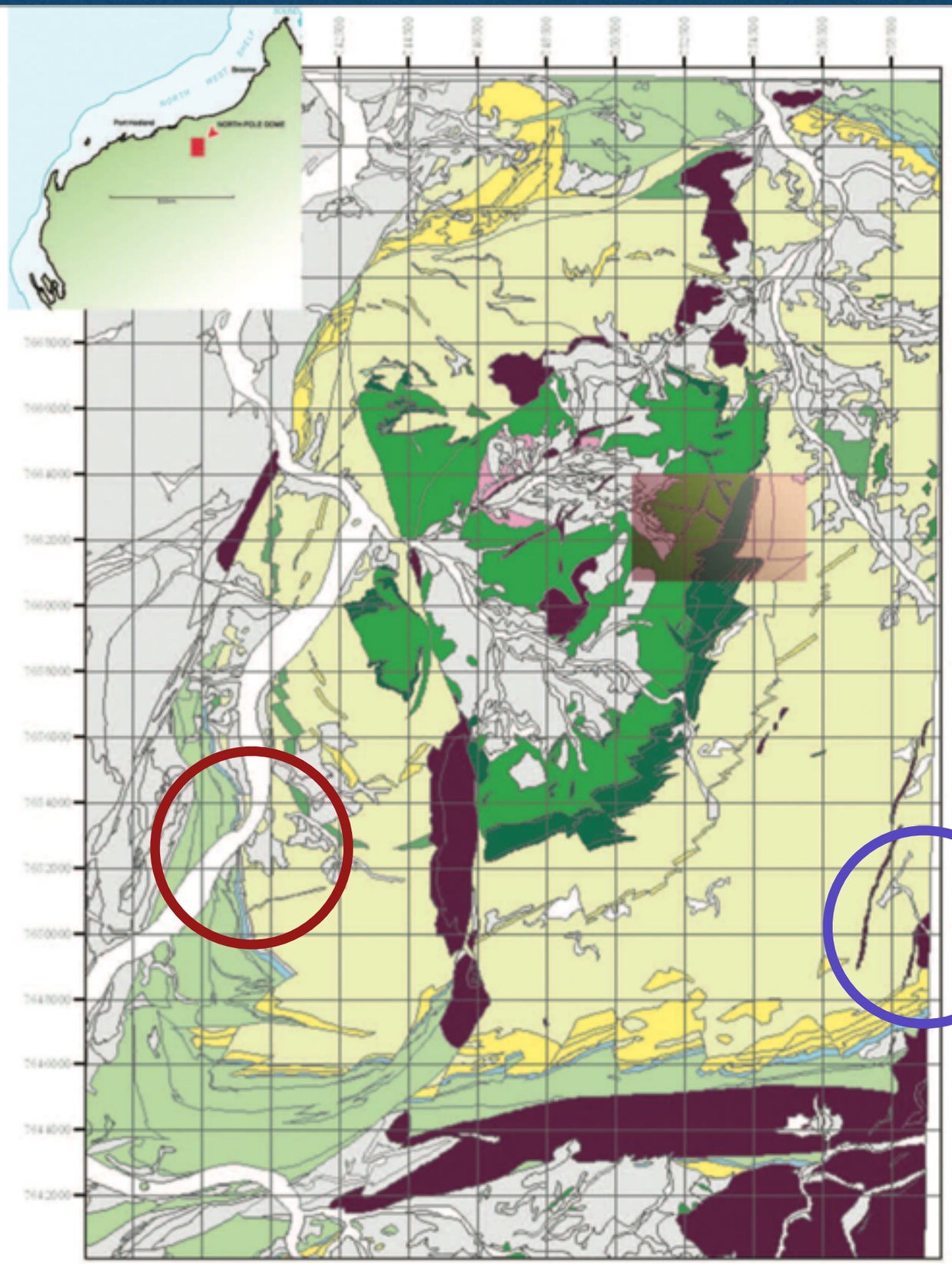

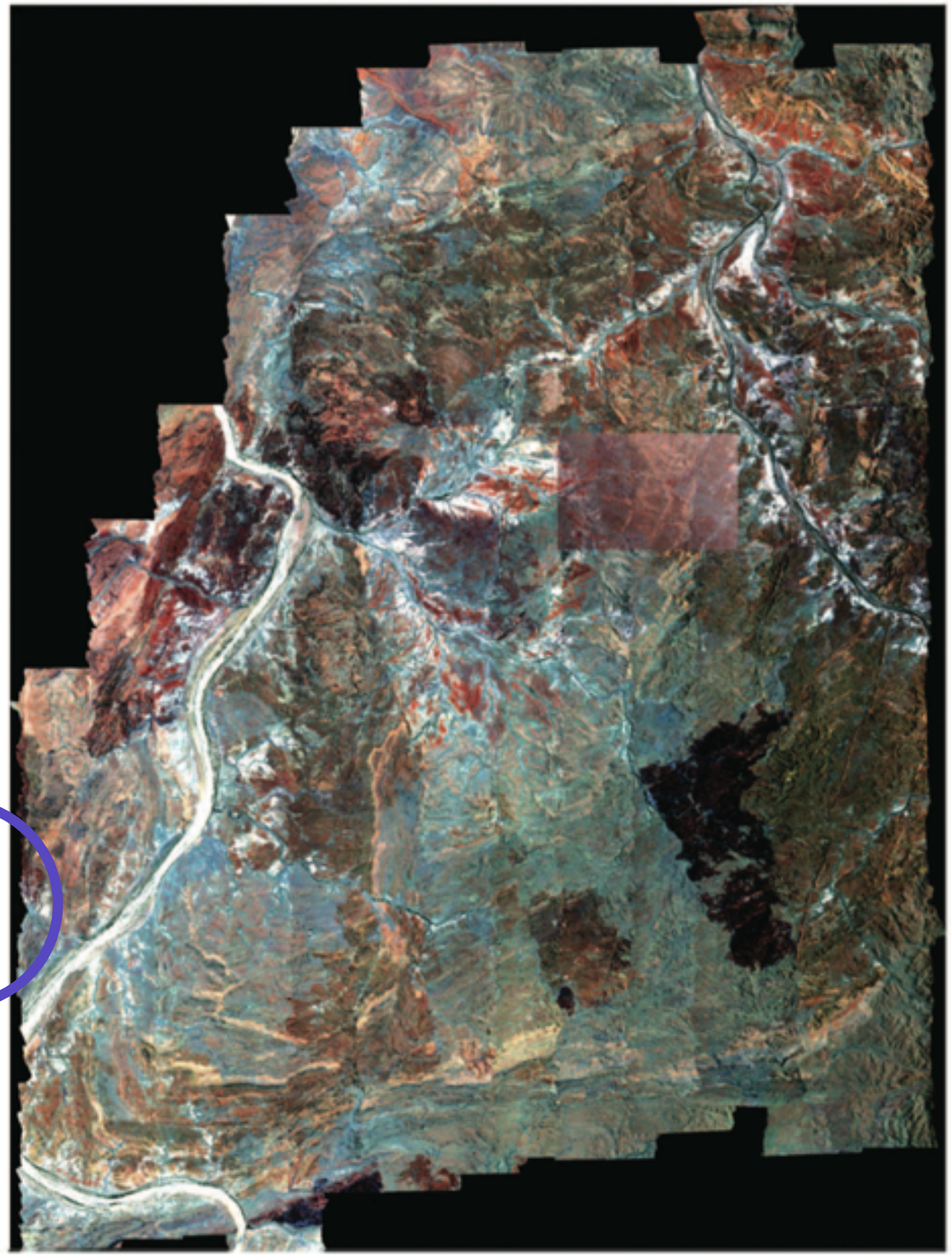

Legend (in stratigraphic order youngest to oldest)

- Alluvial units
- Fortescue Group
- Euro Basalt
- Strelley Pool Chert
- Panorama Formation
- Apex Basalt
- Dresser Chert
- Dresser Formation
- Mt Ada Basalt
- North Pole Monzogranite
- Other units

Grid lines are Australian Map Grid Zone 50
Each grid is 2km across.

N