EGU 2025
PS 1.4 Mars Science & Exploration

Supervised Spectral Parameter Learning

over Jezero Crater with the ESA ExoMars TGO CaSSIS Multiband Imager

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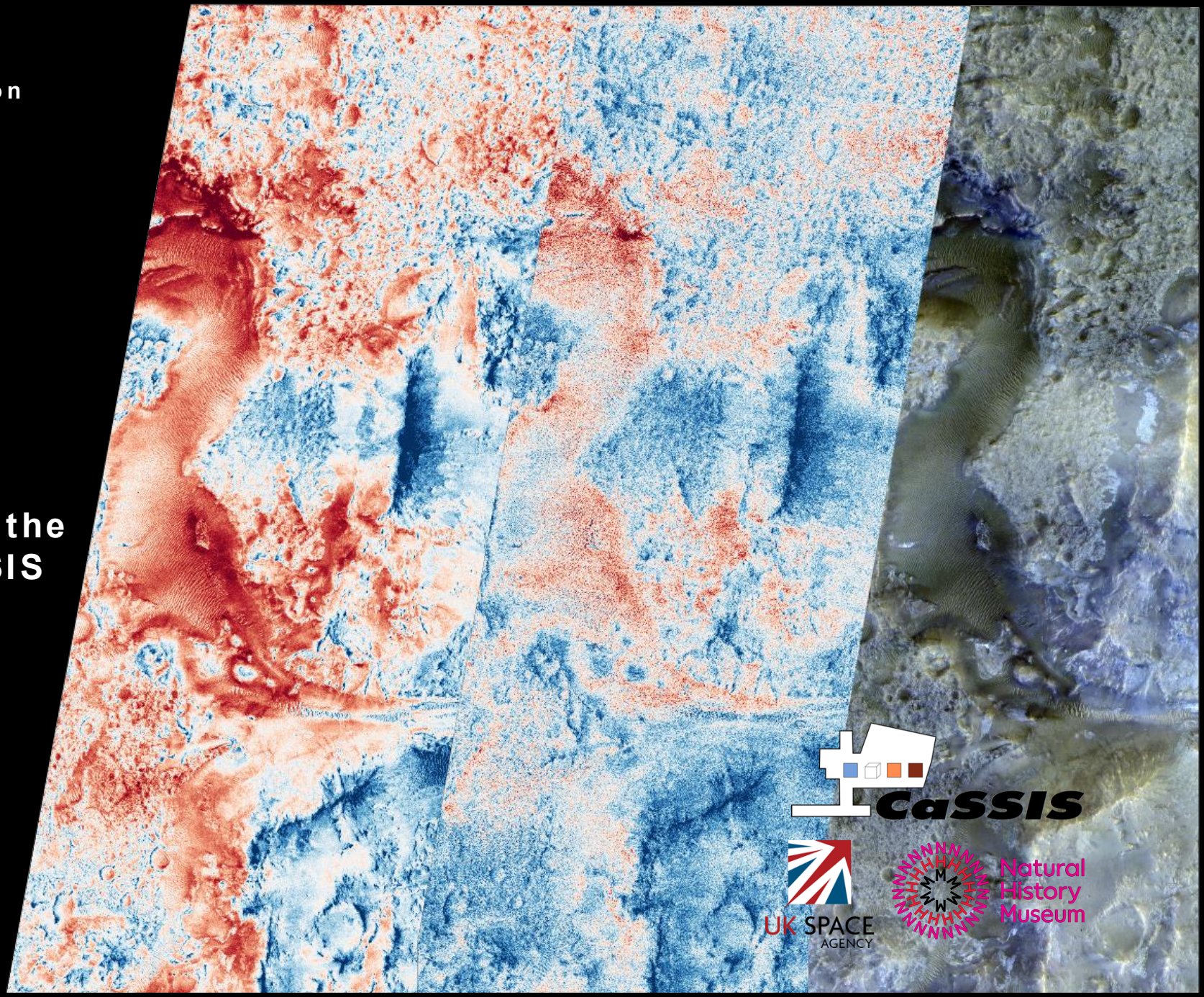
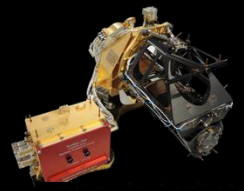
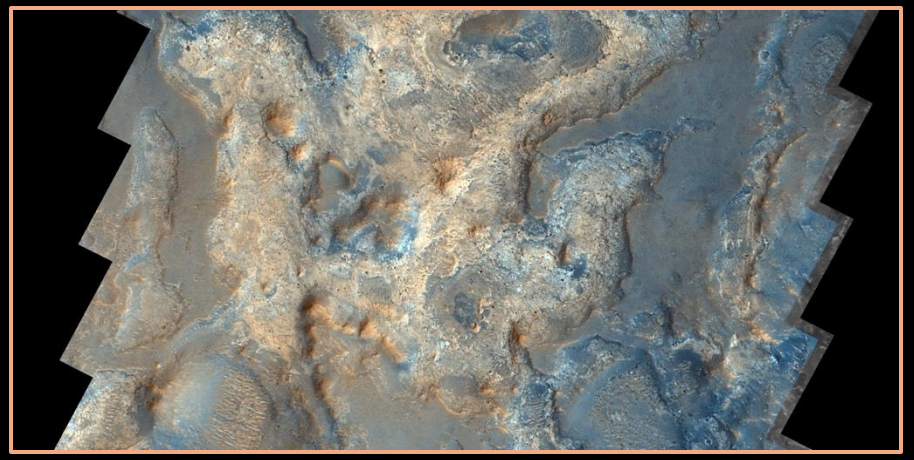
& Peter Grindrod
Natural History Museum, London, UK



CaSSIS *Colour & Stereo Surface Imaging System*



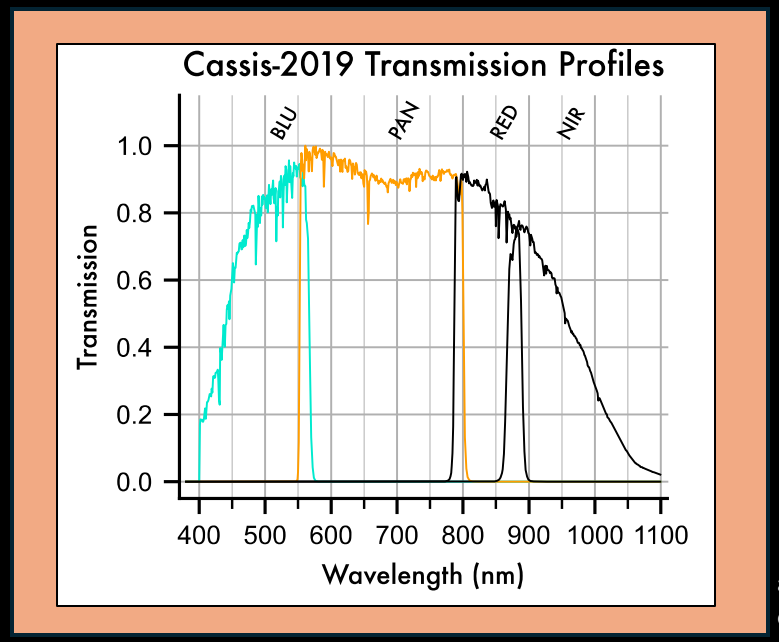
4 bands
4 m/px



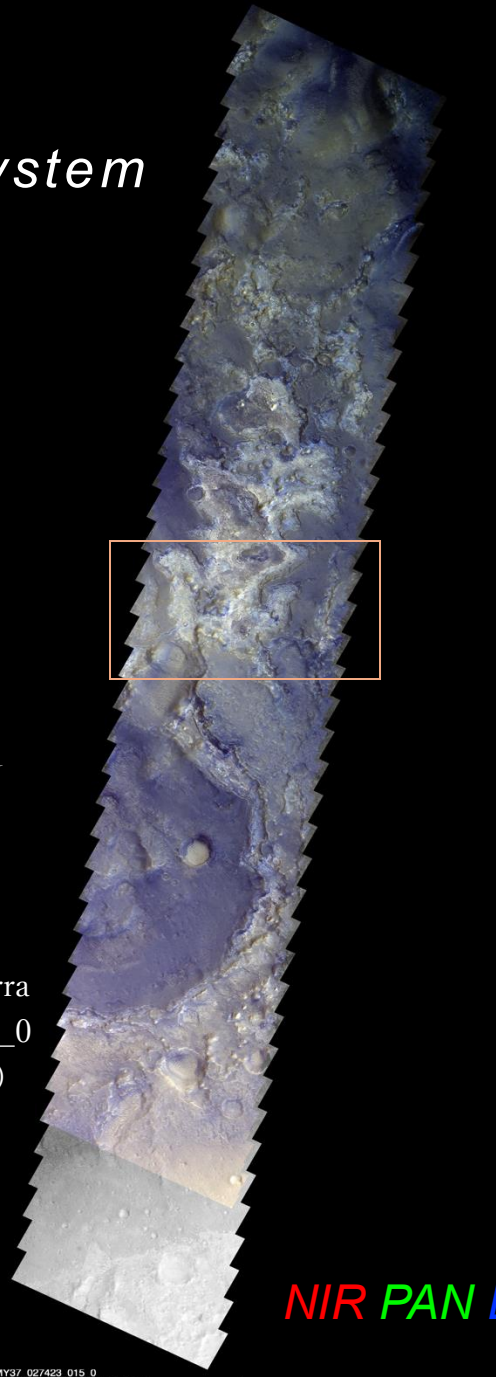
PAN BLU

sBLU = 0.3*BLU* - 2*PAN*

Perry et al. 2022 doi:10.1016/j.pss.2022.105581



after Pommerol et al 2022
doi: 10.1016/j.pss.2022.105580

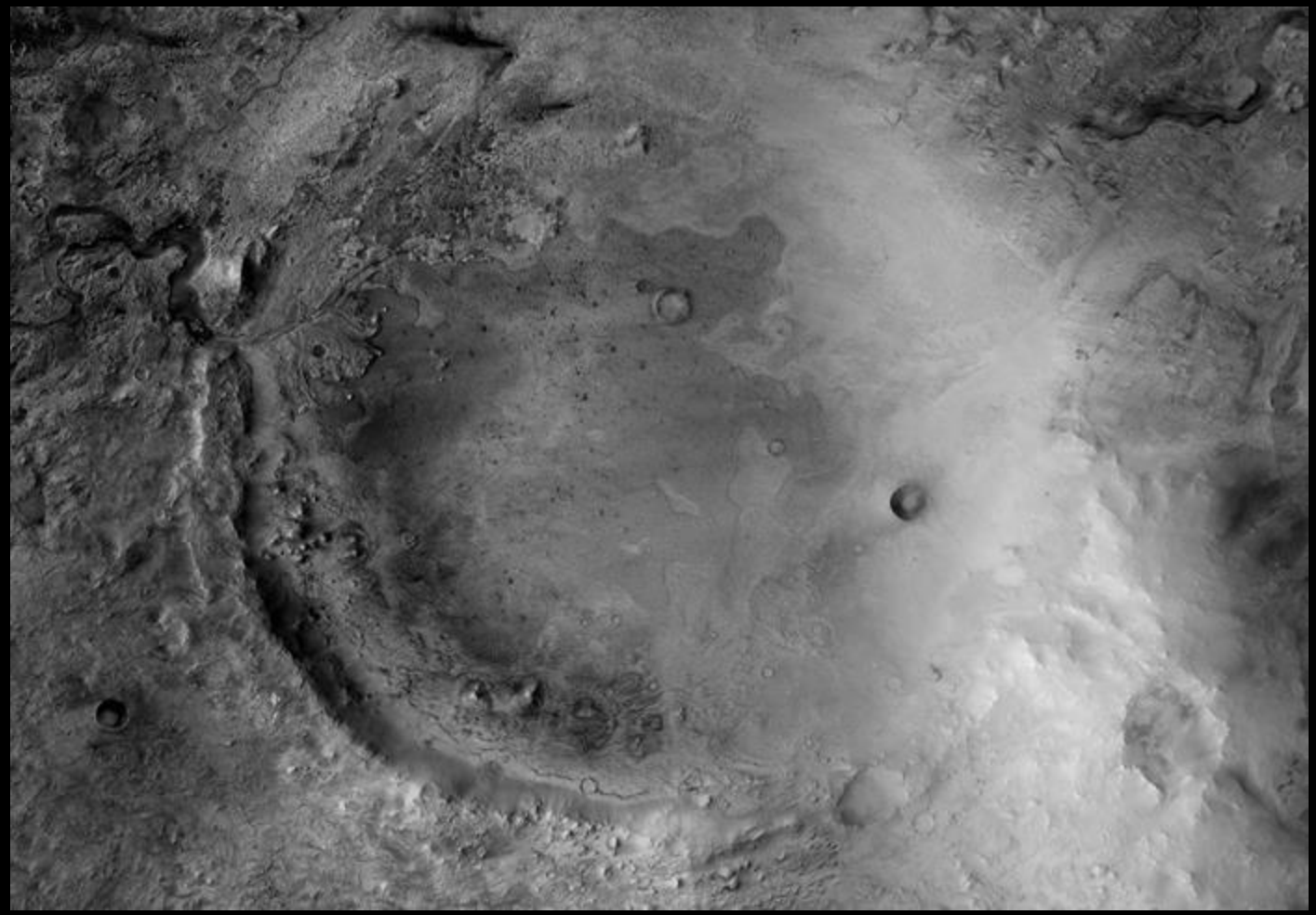


Western Arabia Terra
MY37_027423_015_0
(14.05° , 354.38°)
ϕ 39.1°
3/2/2024

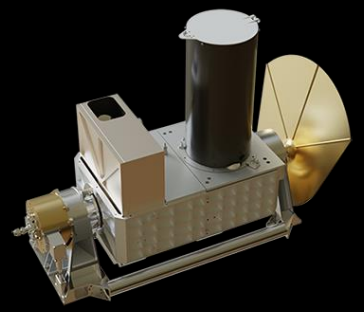
NIR PAN BLU

r.stabbins@nhm.ac.uk

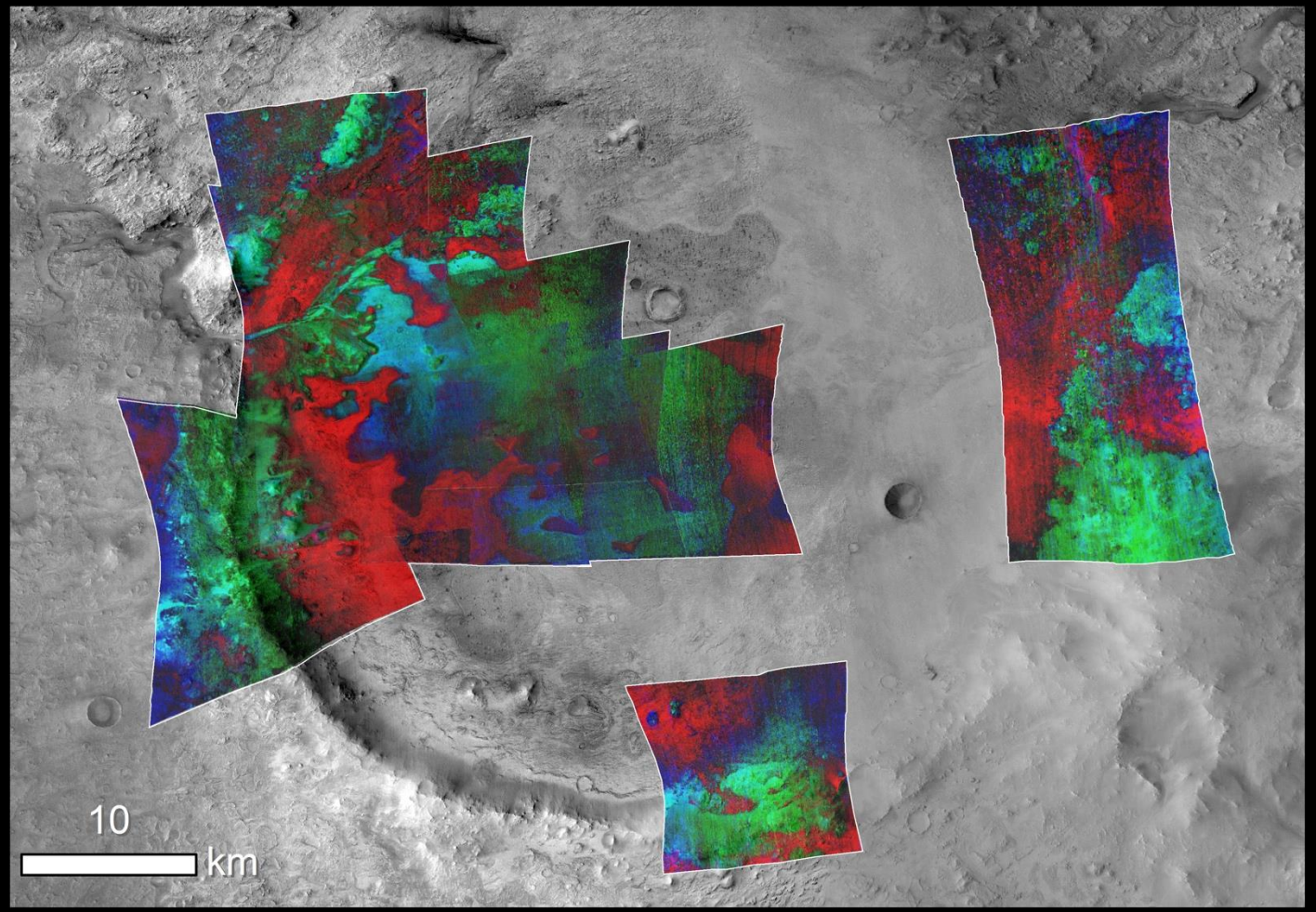
Jezero Crater *Mineralogical Diversity*



Jezero Crater *Mineralogical Diversity*



CRISM
544 *bands*
≥18 *m/px*



Mafic Minerals

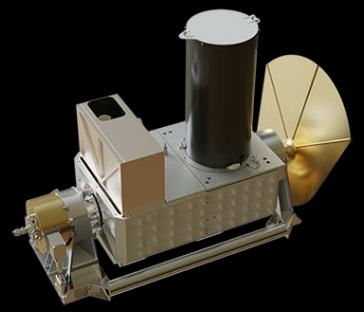
Red
Olivine & Fe-carbonates

Green
Low-Ca Pyroxene

Blue
High-Ca Pyroxene

Horgan et al. 2020. *The mineral diversity of Jezero crater: Evidence for possible lacustrine carbonates on Mars,* Icarus, doi:10.1016/j.icarus.2019.113526

Jezero Crater *Mineralogical Diversity*



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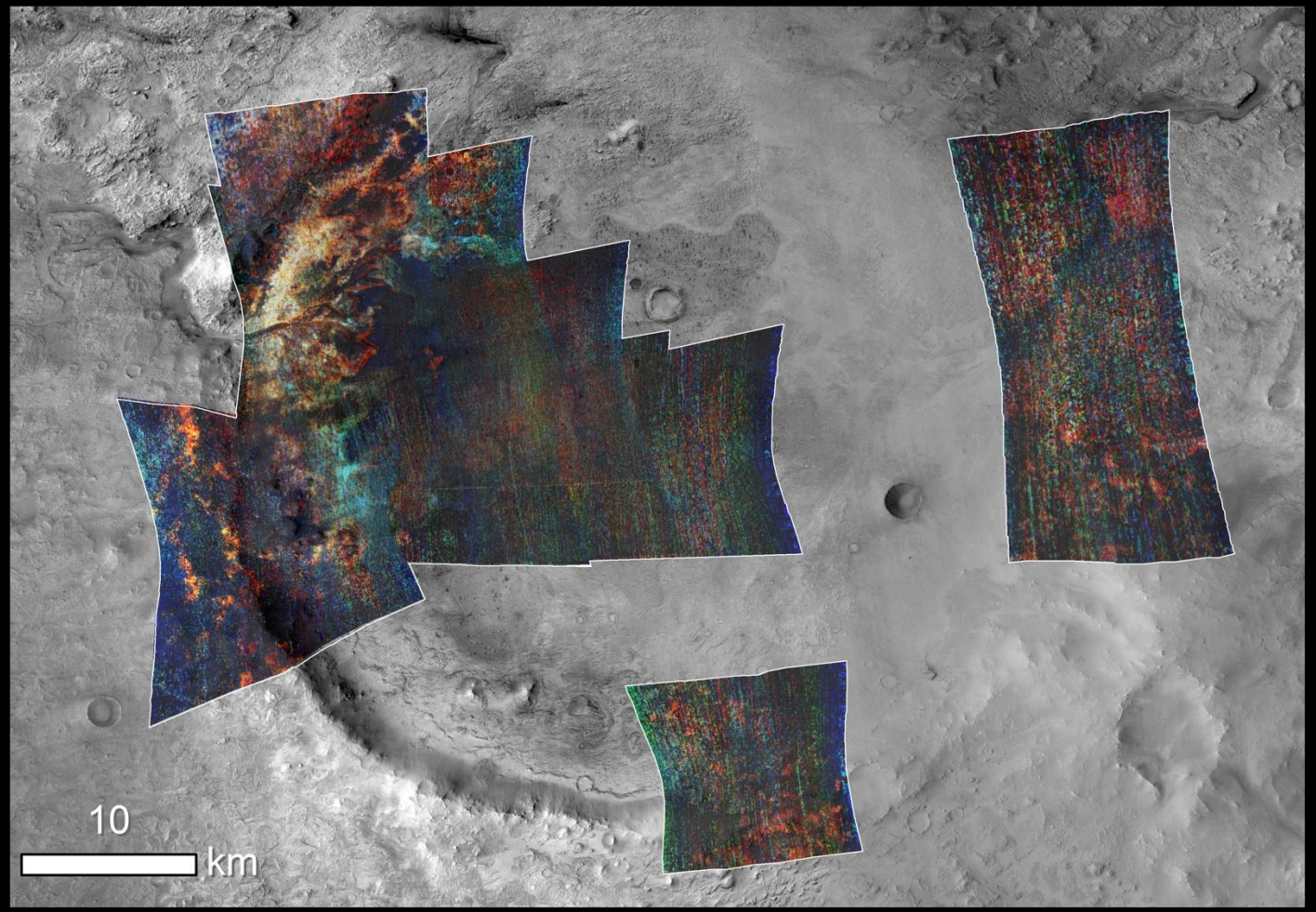


Phyllosilicates

Red/Yellow
Fe/Mg-clays or carbonates

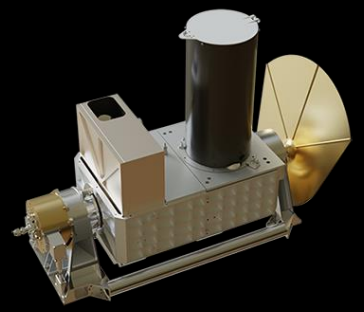
Green
Al-clays

Cyan
Opal or hydrated silica

Blue
Opal or hydrated silica

Horgan et al. 2020. *The mineral diversity of Jezero crater: Evidence for possible lacustrine carbonates on Mars,* Icarus, doi:10.1016/j.icarus.2019.113526

Jezero Crater *Mineralogical Diversity*



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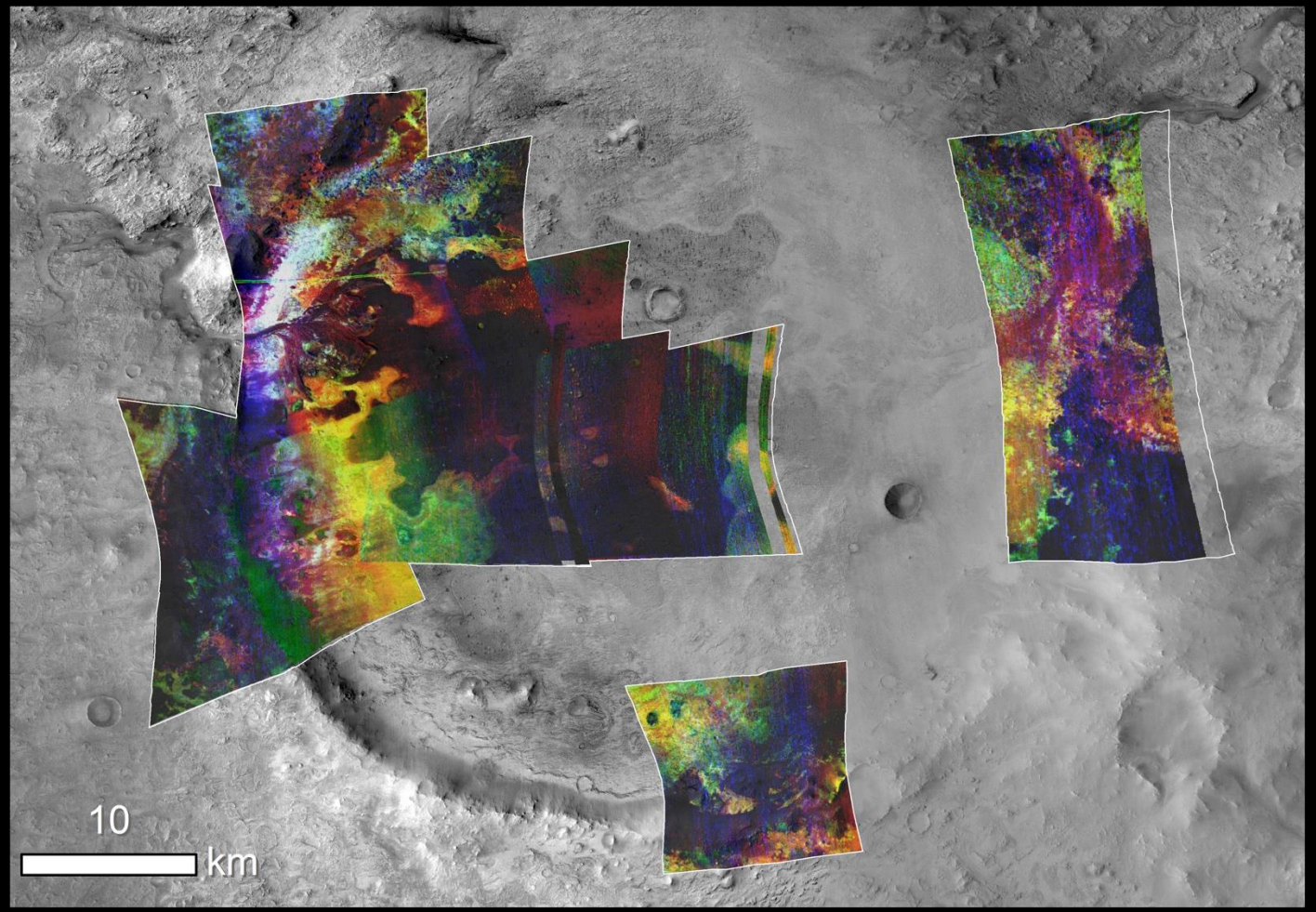


Carbonates

Red
Olivine-dominated

Cyan/Blue
Strong carbonates/weak olivine

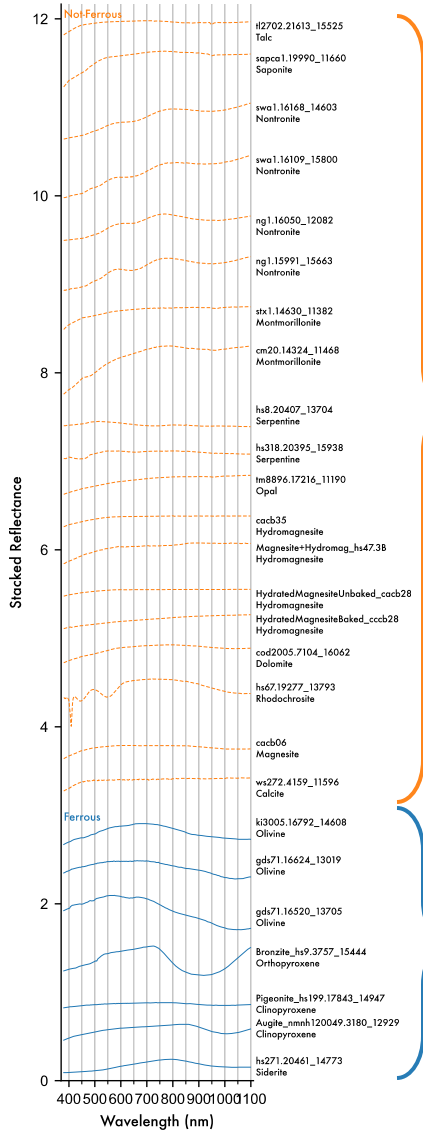
Yellow/White
Strong carbonates/olivine

Green
Weak olivine/clays/carbonates

Horgan et al. 2020. *The mineral diversity of Jezero crater: Evidence for possible lacustrine carbonates on Mars,* Icarus, doi:10.1016/j.icarus.2019.113526

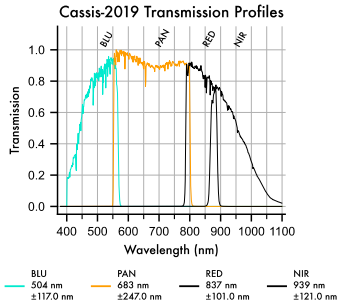
SSPL *Supervised Spectral Parameter Learning*

Stabbins et al. 2024. Earth & Space Science,
doi:10.1029/2023EA003398



Background

Target



Filter Profiles

SSPL

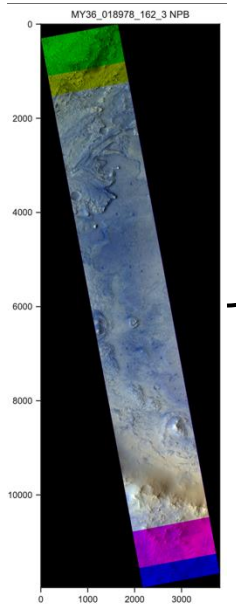
Spectral Parameter Pair Linear Combinations

spc_id	Rank	Fisher Ratio	sp_0	sp_1	lda_a_0_1	lda_a_1_1
83	1.0	3.324786	R_683_504	R_939_837	-0.057214	-0.998362
146	2.0	3.224047	R_837_504	R_939_837	-0.036606	-0.999330
233	3.0	3.195297	R_939_837	S_504_837	0.996207	0.087012

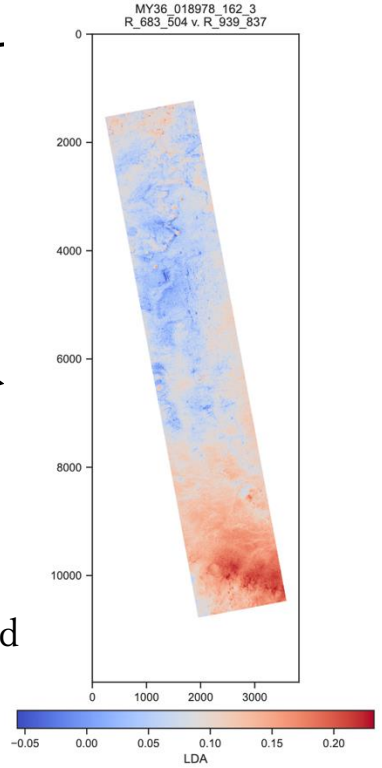
ranked by separation (Fisher Ratio) of target from background

...

SPC



CaSSIS I/F cube

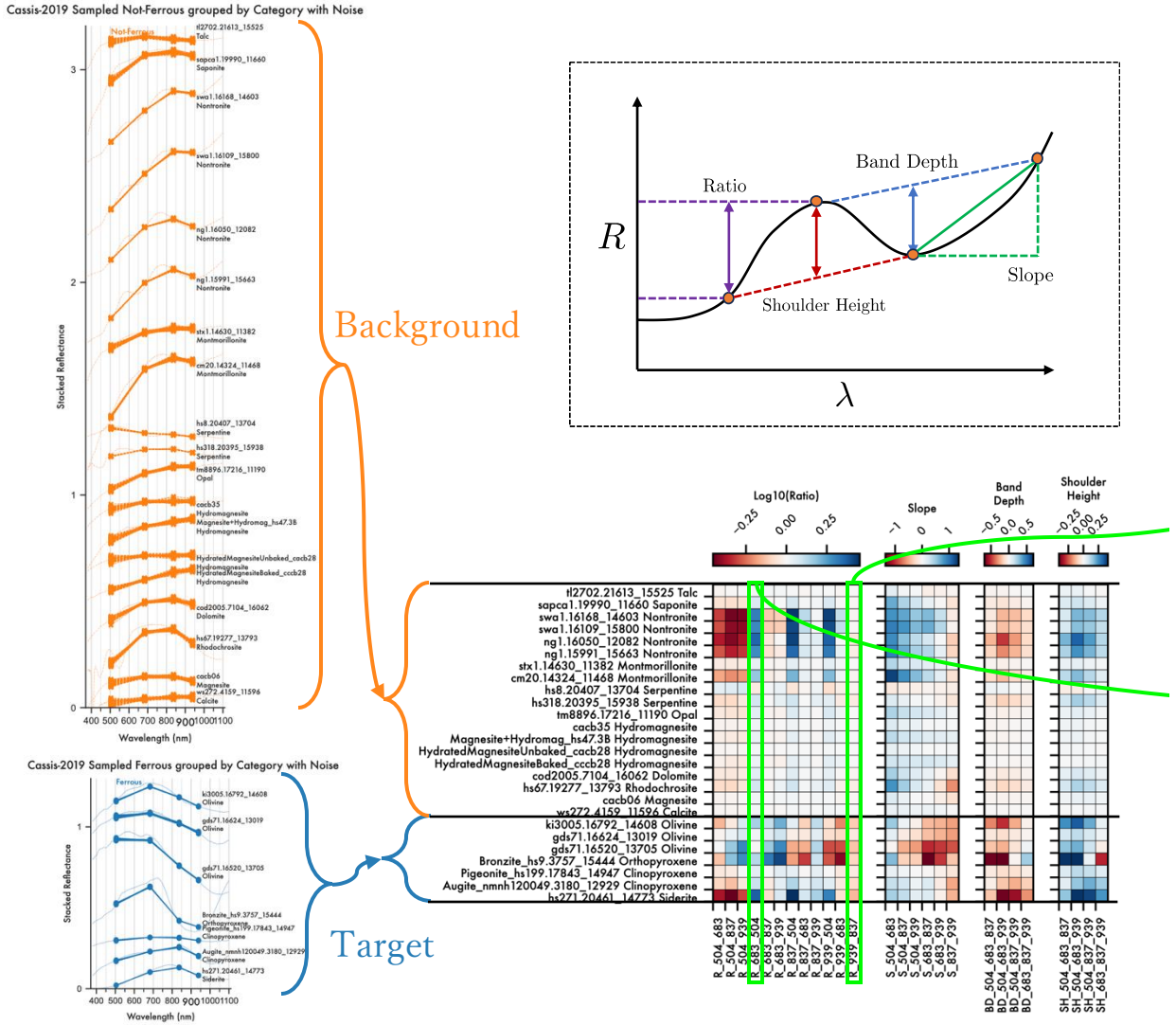


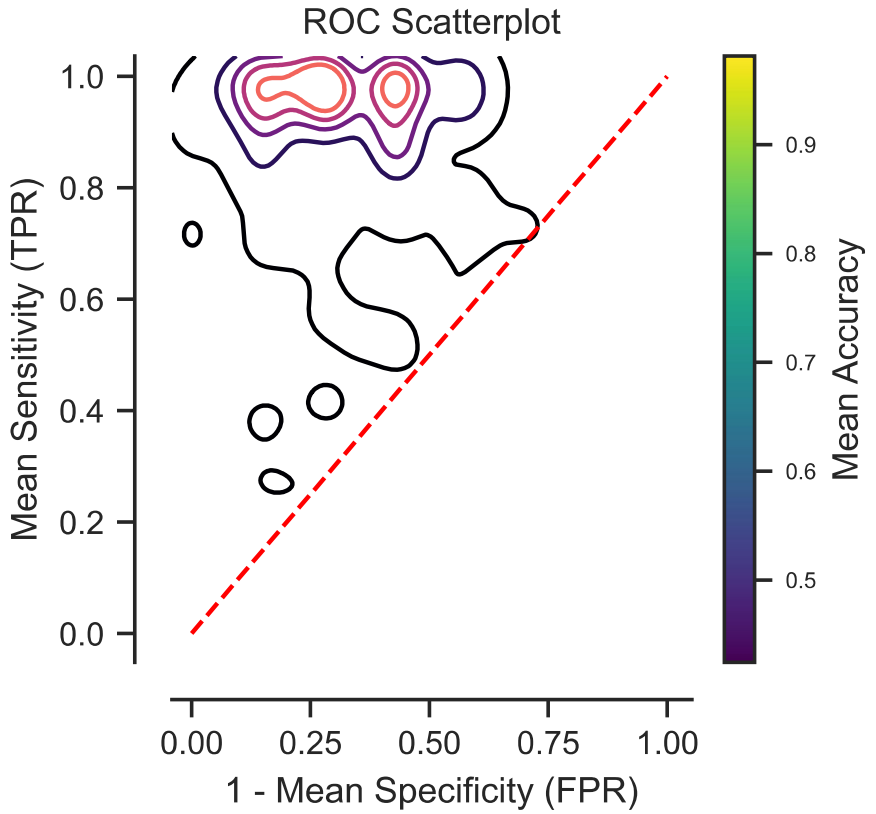
SPC Stretched Product

PLDA *Parallel Linear Discriminant Analysis*

Inside Supervised Spectral Parameter Learning

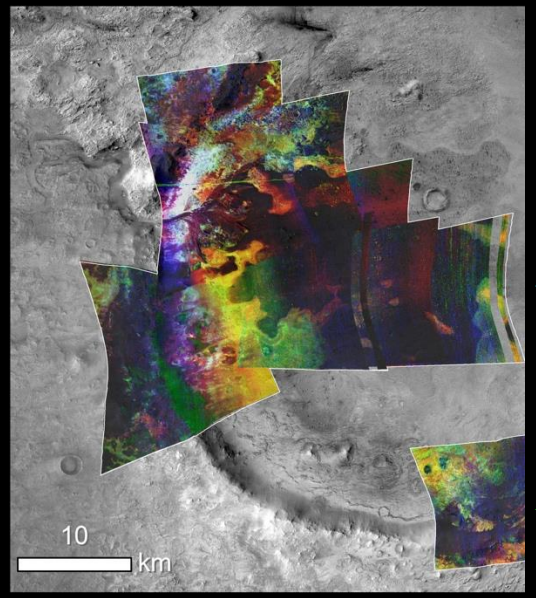
Stabbins et al. 2024. Earth & Space Science,
doi:10.1029/2023EA003398





$$\text{Fisher Ratio} = \frac{\text{Between-Class Scatter}}{\text{Within-Class Scatter}}$$

Jezero Crater *Training Spectral Library*



Carbonates

Red
Olivine-dominated

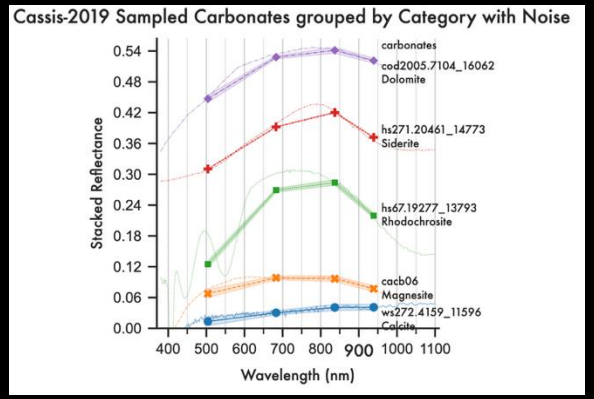
Cyan/Blue
Strong carbonates/ weak olivine

Yellow/White
Strong carbonates/ olivine

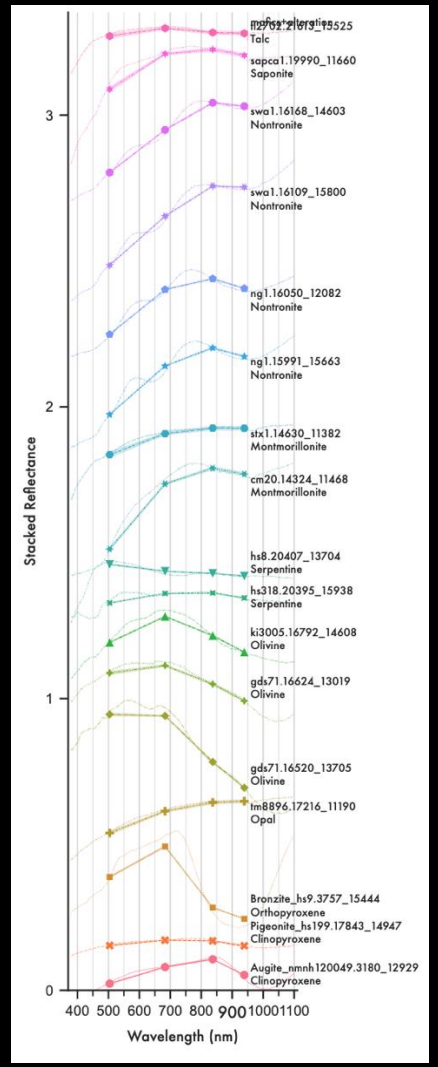
Green
Weak olivine/clays/ carbonates

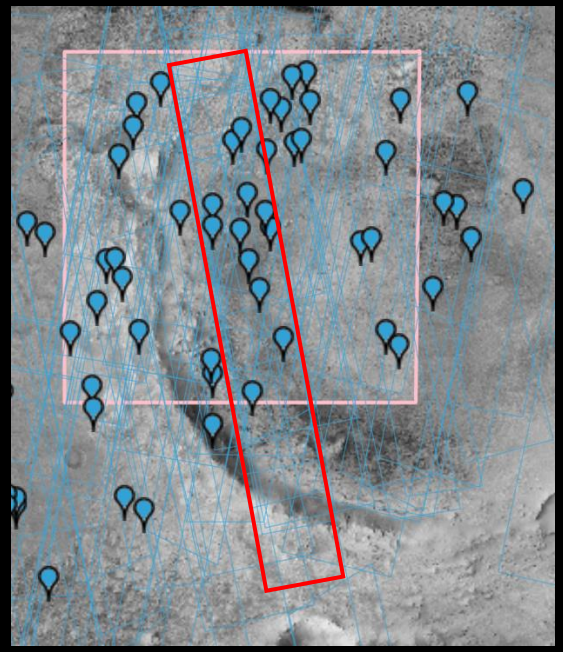
Horgan et al. 2020. doi:10.1016/j.icarus.2019.113526

Target

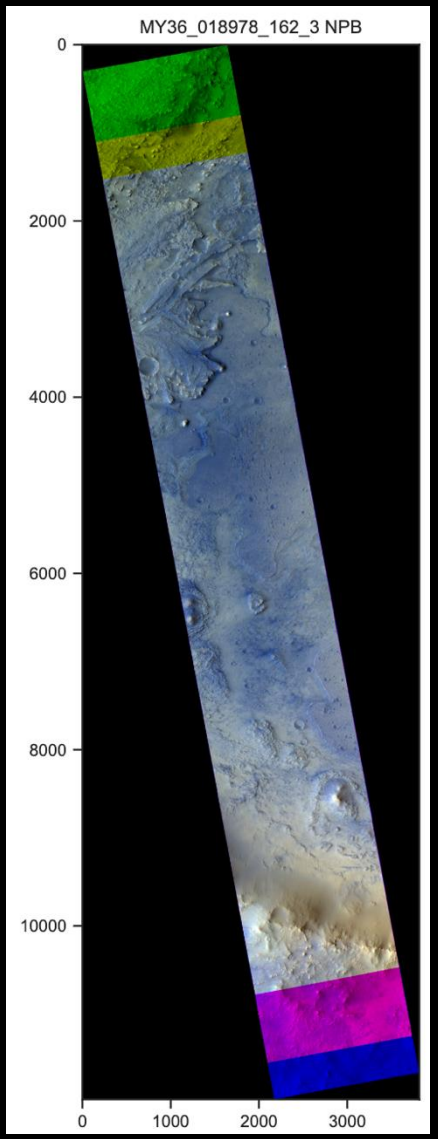


Background

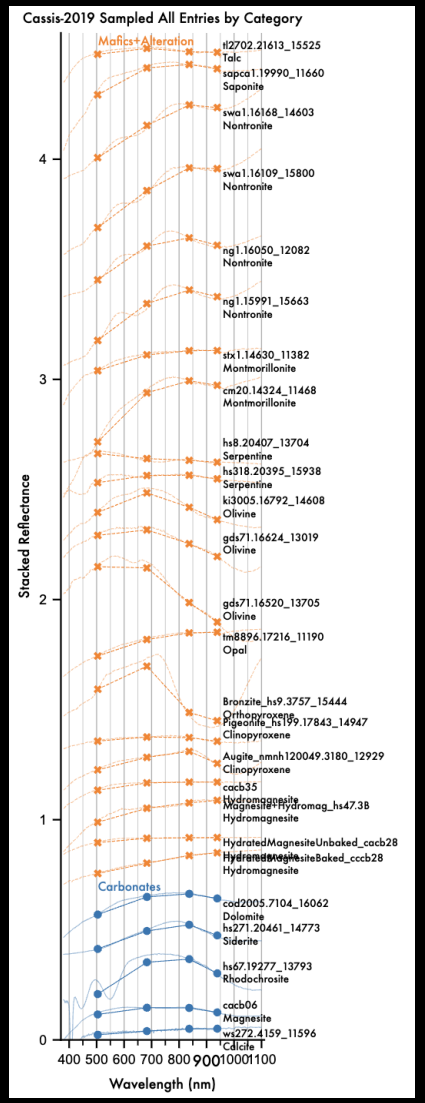


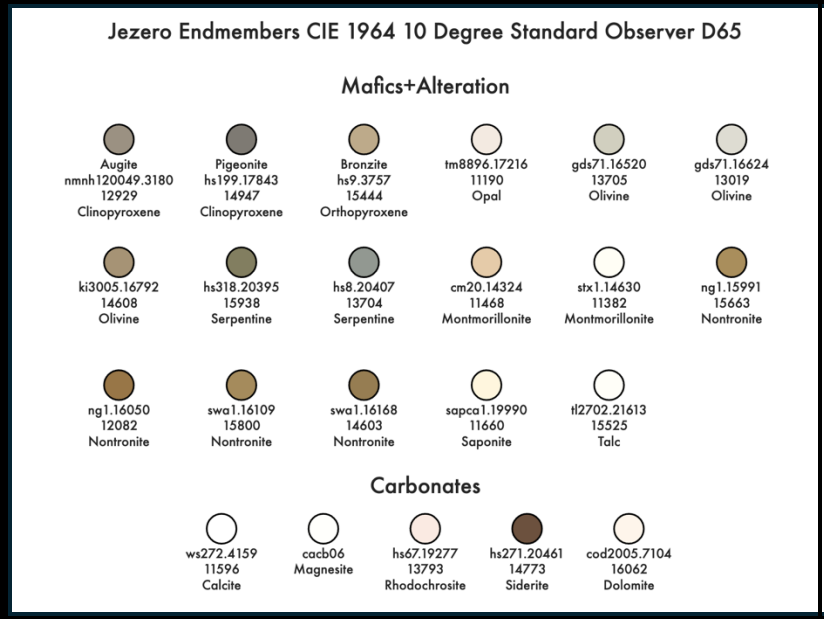


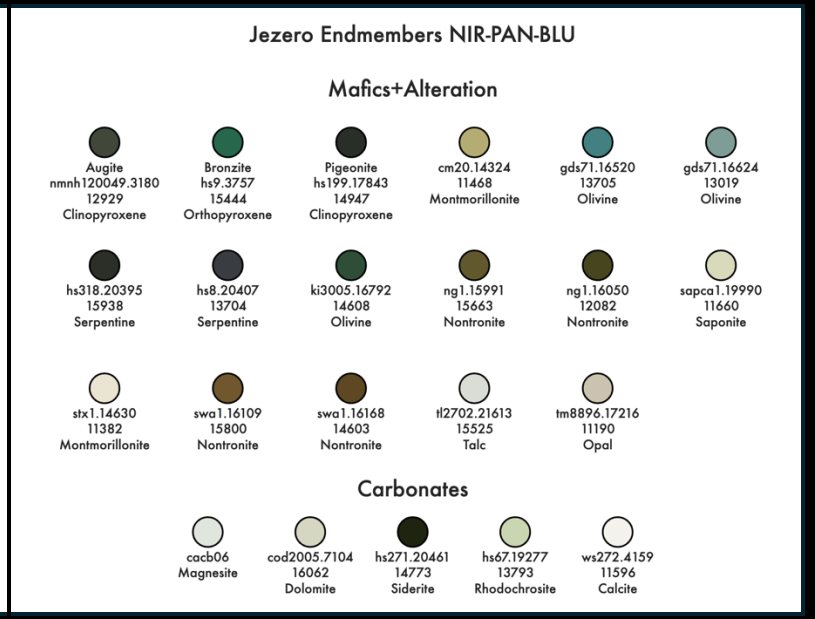
Jezero Crater
MY36_018978_162_3
77.470E, 18.349N
(18.35° , 77.47°)
ϕ 63.0°
23/2/2022



Results *Expected Natural & NPB Colours*



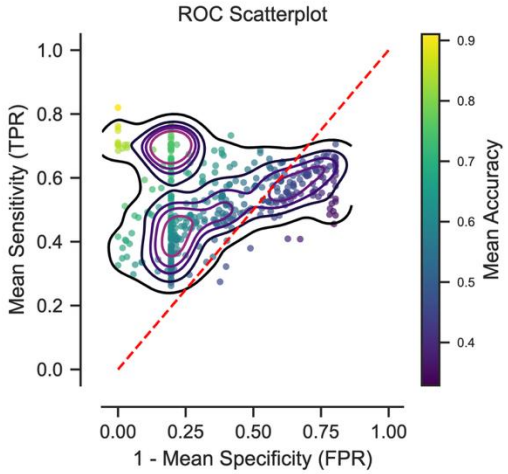




Carbonates have low colour contrast in natural lighting simulations,

as well as expected NPB (*NIR PAN BLU*) CaSSIS Browse products

Results *Learned Spectral Parameter Combinations*

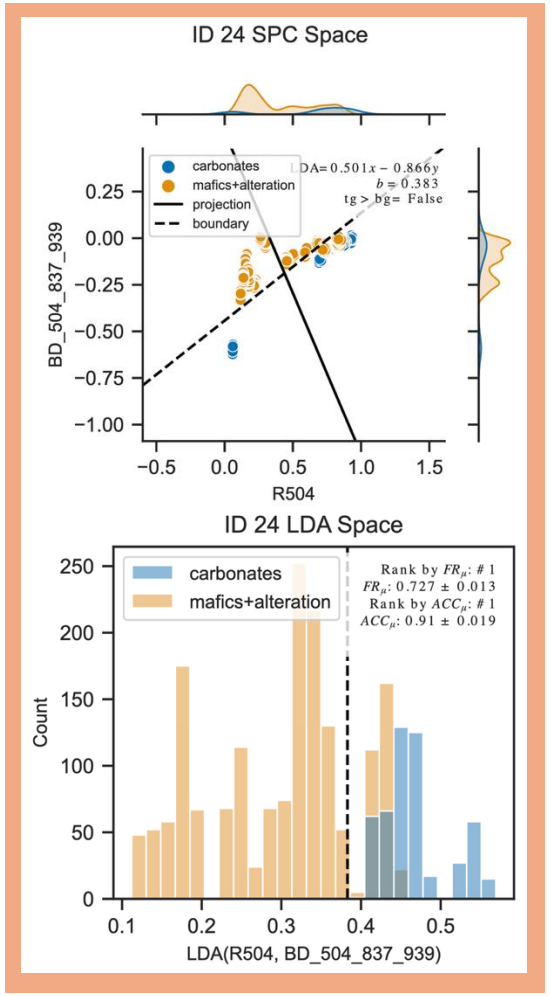


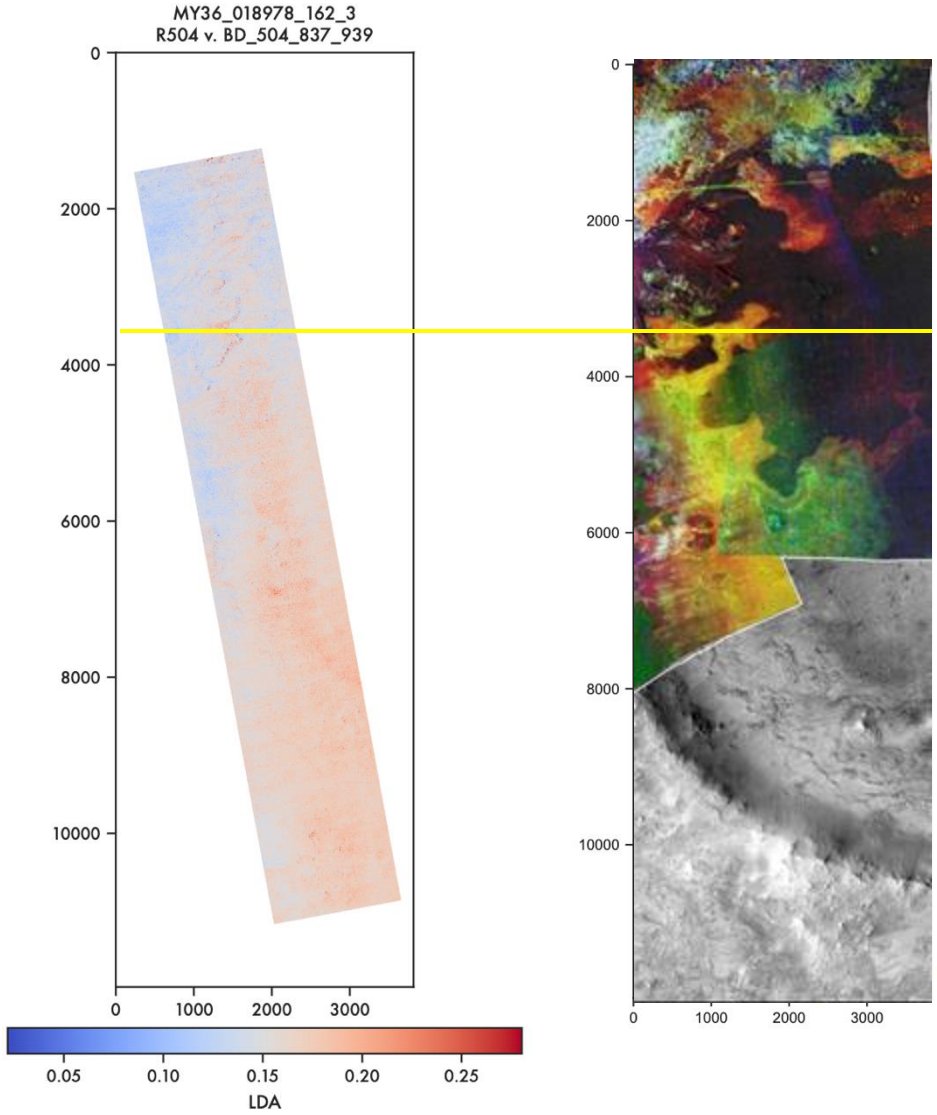
Low True Positive Rate

Individual Spectral Parameters have poor target separation,

but Spectral Parameter Combination achieves separation with ~90% accuracy.

Image shows some noisy change in target signal.





sptk *the Spectral Parameters Toolkit*

sptk provides a simple Python interface for:

- instrument spectral response simulation
- instrument spectral library sampling
- instrument spectral reconstruction error evaluation
- instrument spectral parameter evaluation
- spectral parameter and spectral parameter combination material discrimination evaluation and ranking

Available via pip:

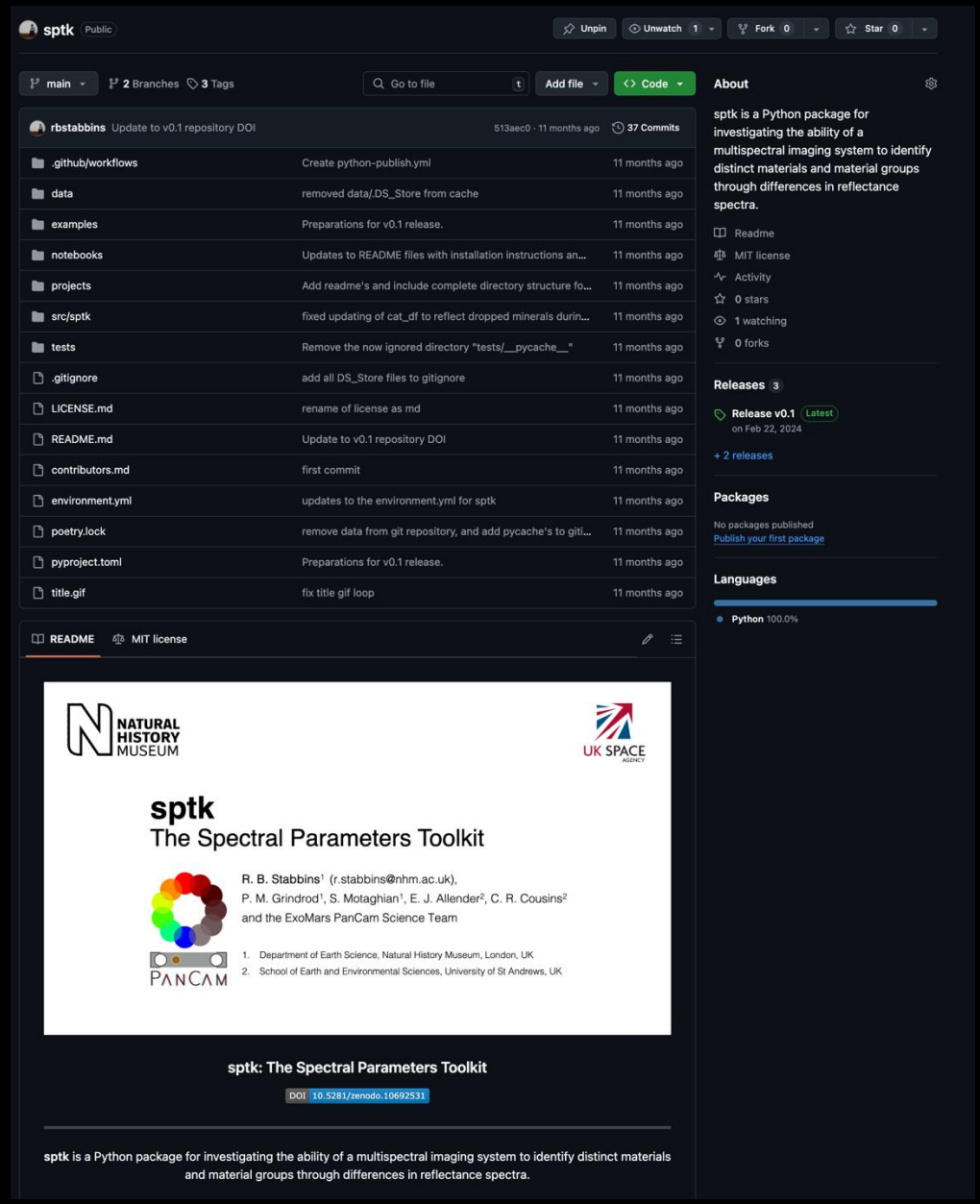
pip install sptk=0.1

DOI:10.5281/zenodo.10694286

Git: https://github.com/rbstabbins/sptk

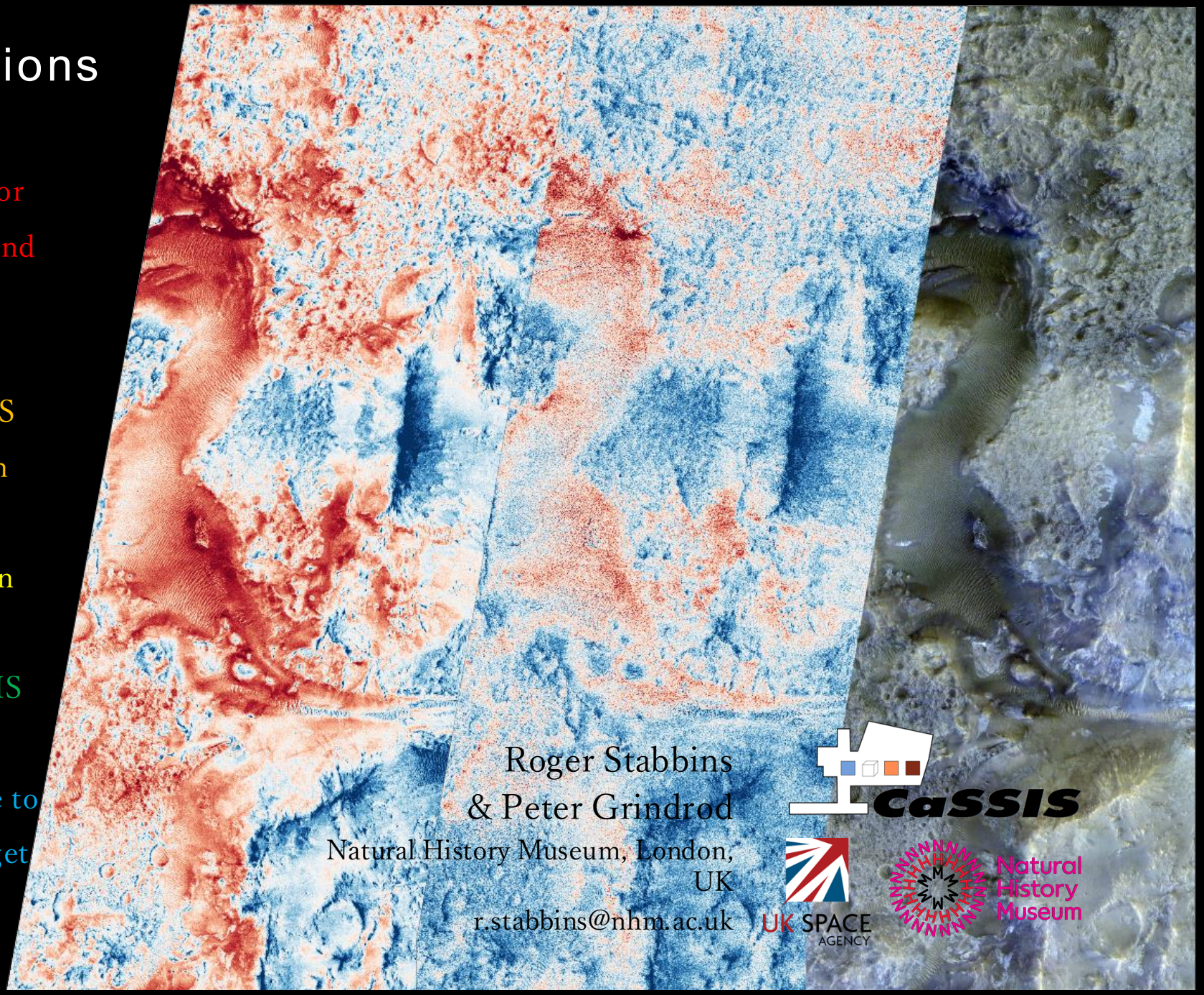
'Main' branch for PanCam (v0.1 Release 2/2024)

'cassis_development' branch for CaSSIS, WIP



Summary & Conclusions

- Supervised Spectral Parameter Learning gives a novel method for investigating target vs. background separation tasks for a given multiband imager
- SPTK can generate novel CaSSIS Spectral Parameter Combination Products
- Carbonates are still hard to see in
- VNIR…
- Photometric correction of CaSSIS I/F products will likely help
- Further CaSSIS Jezero Coverage to be explored, as well as other target vs. background tasks.



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CaSSIS

UK SPACE AGENCY

Natural History Museum

1/5/2025