
EUROPLANET 2024
Research Infrastructure

Geology & Planetary Mapping
Winter School

Mapping Spectral Information by Means of Spectral Units

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871149.

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Outline

- Spectral unit retrieval
- Morphostratigraphic unit retrieval
- Geostratigraphic map

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Final Goal

Create a geostratigraphic map starting from spectral and morphological products.

We need two types of products:

1) Vectorial Spectral unit map;
2) Vectorial Morphostratigraphic map

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Definition of the Spectral Units

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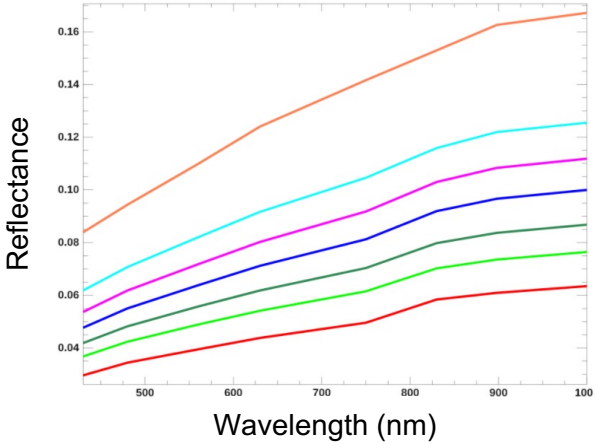
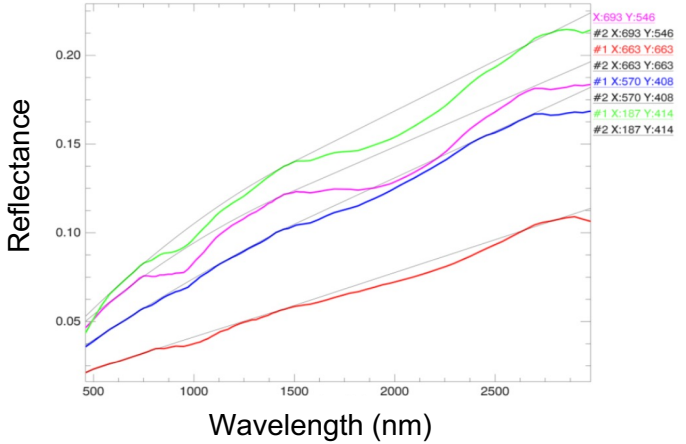
Spectral units

Spectral units summarize the spectral properties of a surface (Compositional variabilities, mineralogical information, physical properties), obtained by a simultaneously analysis of a set of spectral parameters, derived by multi-or hyperspectral datasets.

Multispectral data – tens of spectral channels



Hyperspectral data – Hundreds of spectral channels



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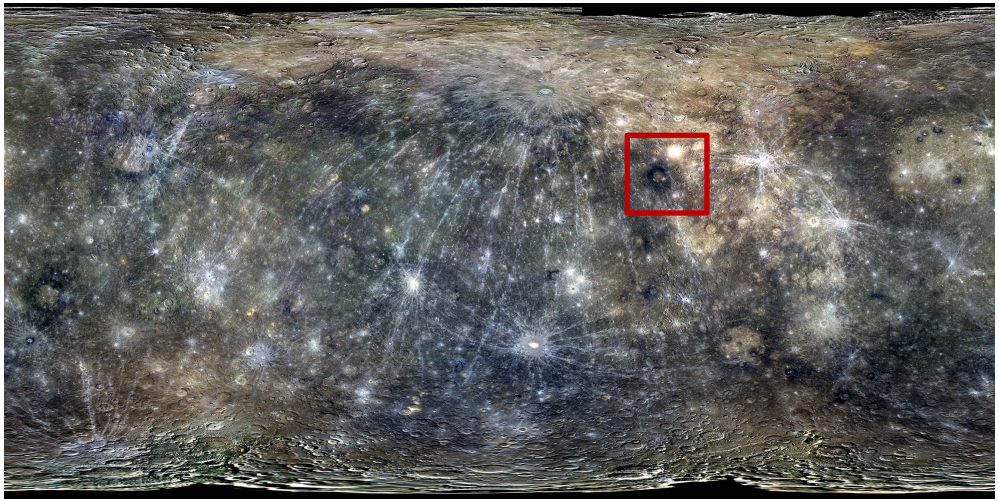
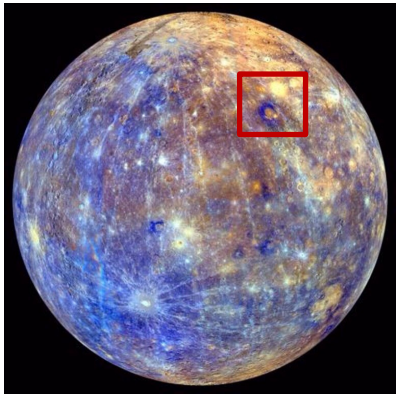
Region of study

Rachmaninoff and Nathair Facula regions on Mercury





MESSENGER – Mercury Dual Imaging System (MDIS)

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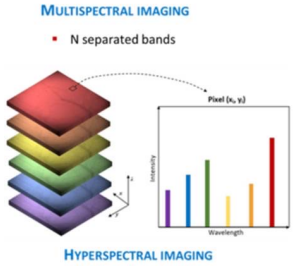
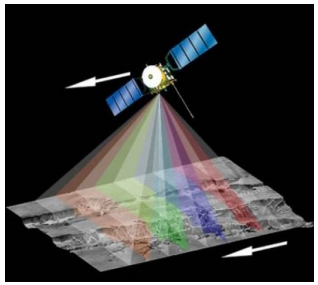
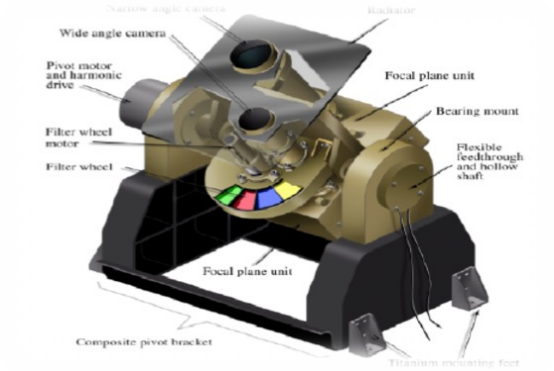




We considered the MESSENGER-MDIS Wide Angle Camera (WAC) and Narrow Angle Camera (NAC) datasets (https://ode.rsl.wustl.edu/mercury/).

- MDIS-NAC is a monochrome camera centred at 748 nm.
- MDIS-WAC was equipped with a multi-filter rotating wheel (11 filters), the images were acquired one by one for each filter, therefore images captured in different moments do not exactly overlap each other.



MDIS-WAC filters used for Mercury global coverage

Filter	Wavelength (nm)	Bandwidth (nm)
F	430.0	18.0
C	480.4	8.9
D	559.2	4.6
E	628.8	4.4
G	749.0	4.5
L	828.6	4.1
J	898.1	4.3
I	996.8	12.0

Source: Nireos, Adapted from Giannoni et al 2018 J. Opt. 20 044009

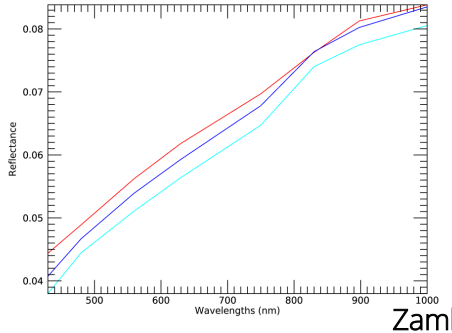
Definition of the Spectral Units: Dataset

We produced the 8-color mosaic of the region of study at 450 m/px.

The 8-color mosaic of the whole Mercury surface at 665 m/px is available at the following link: https://messenger.jhuapl.edu/Explore/Images.html#global-mosaics.

From the 8-color mosaic we obtain the spectral information.

Mercury spectra from MDIS-WAC



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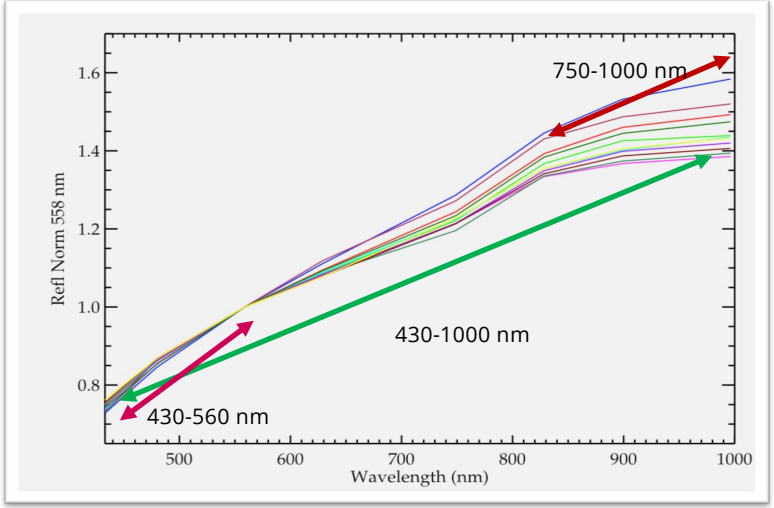
Spectral Units Retrieval: Step 1 – Spectral Parameters

Mercury spectra between 400 and 1000 nm at the MDIS-WAC spatial resolution do not show clear absorption bands, the most relevant indices in this case are the spectral slopes.



Global Slope 430-1000 nm → Terrain maturity

Spectral Slope 750-1000 nm → possible 1 μm absorption band

Spectral Slope 430-560 nm → Presence of opaque material, Mercury volcanic material

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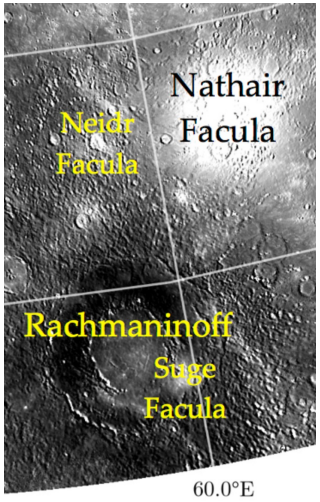
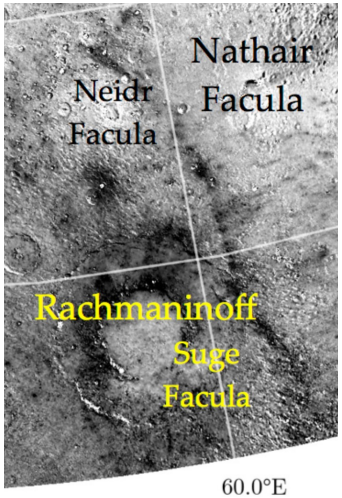
Spectral Units Retrieval: Step 1 – Spectral Parameters

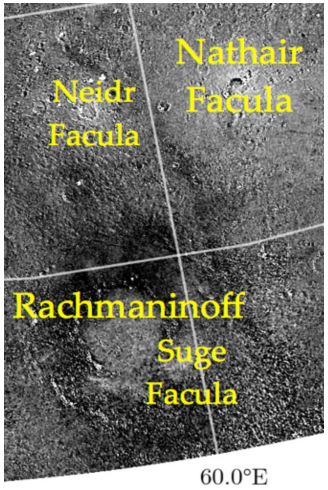
Reflectance at 750 nm



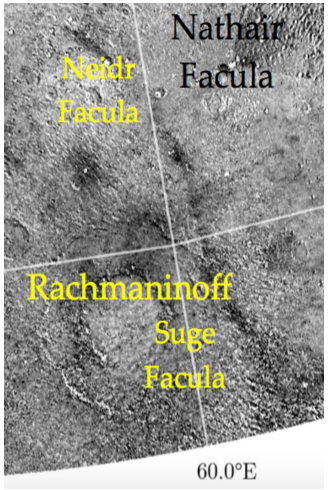
Global Slope 430-1000 nm



Spectral Slope 430-560 nm



Spectral Slope 750-1000 nm



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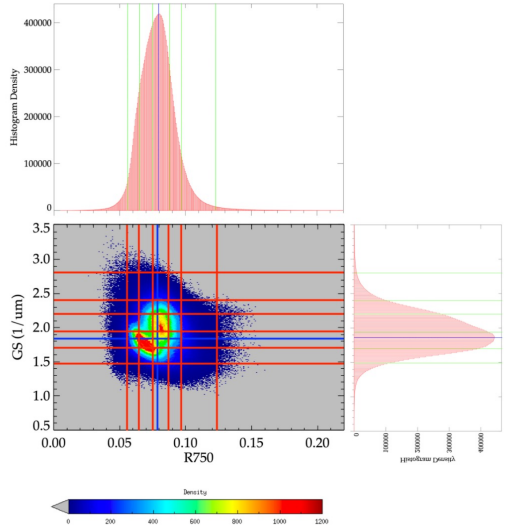
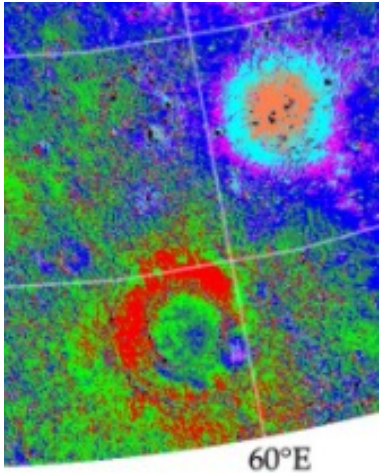
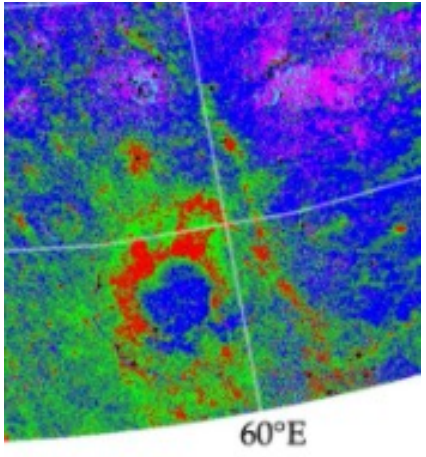
Spectral Units Retrieval: Step 2 – Thresholds Definition



Reflectance at 750 nm



Global Slope 430-1000 nm



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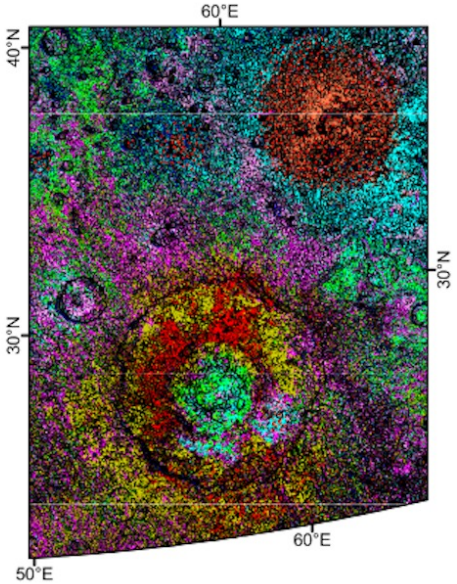
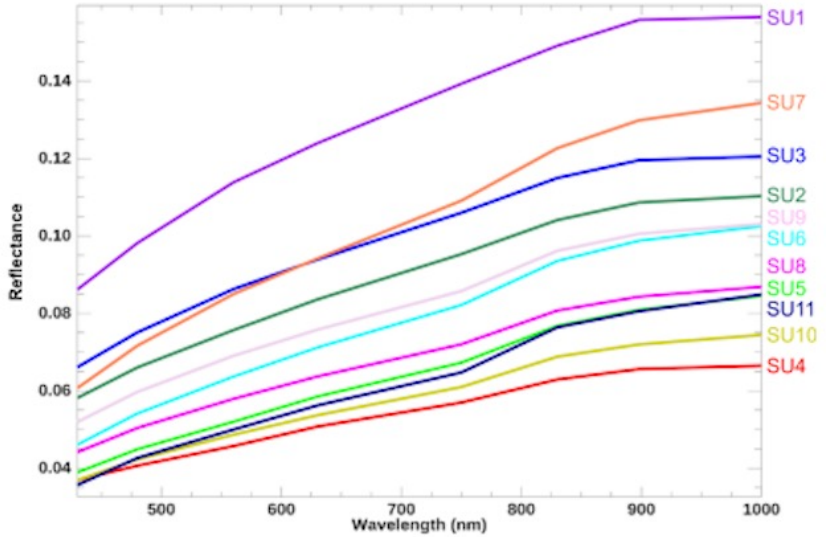
Spectral Units Retrieval: Step 3 – Definition of the Spectral Units





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Definition of the Morphostratigraphic Units And Integration with the Spectral Units

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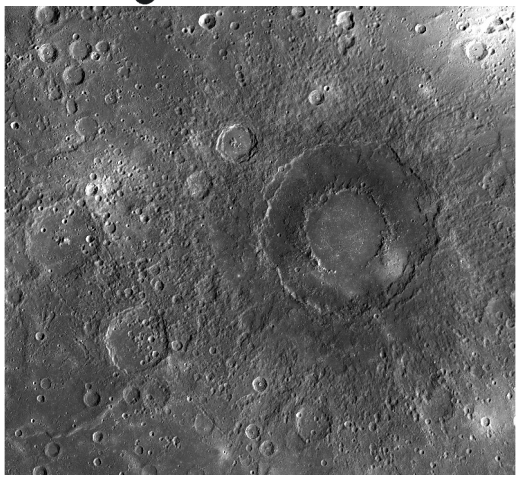
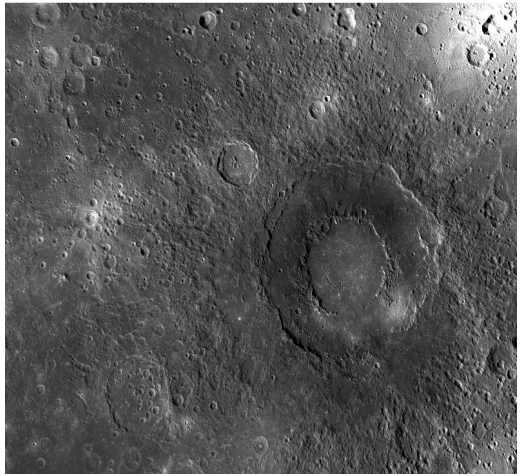
Datasets

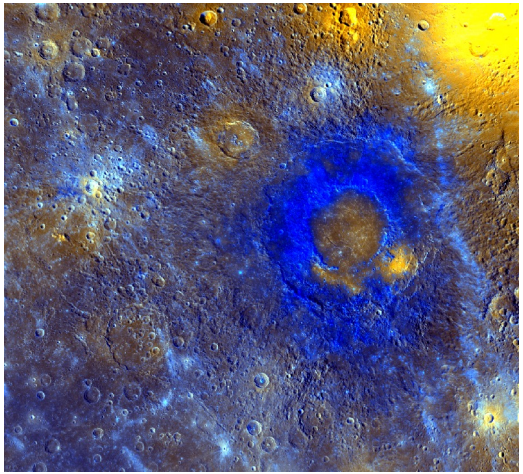


166 m/pixel monochrome
eastern illumination



Data Gap!!!

166 m/pixel monochrome
western illumination



665 m/pixel enhanced colour

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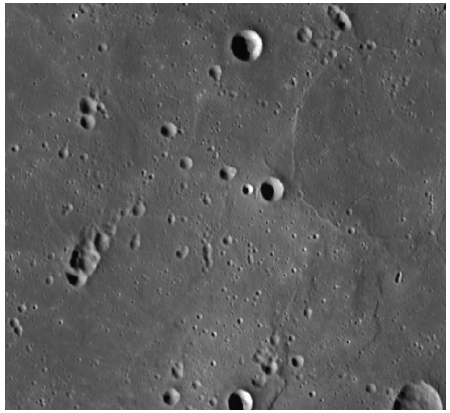
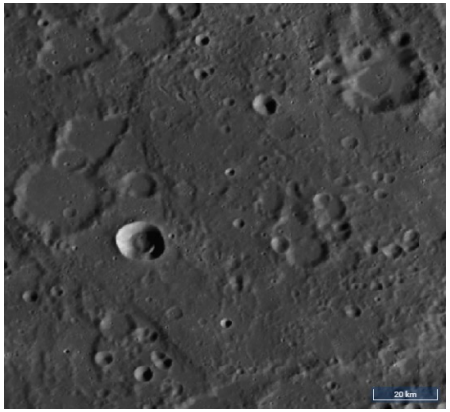
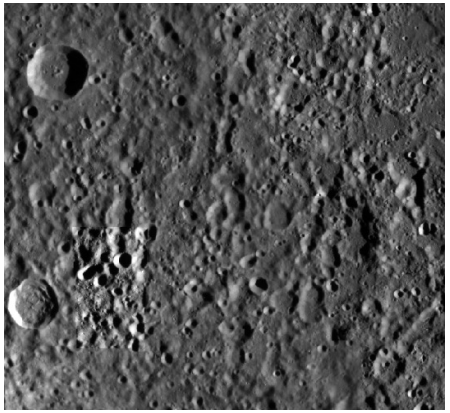
Geomorphic units – Plains



smooth plains



intermediate plains



intercrater plains

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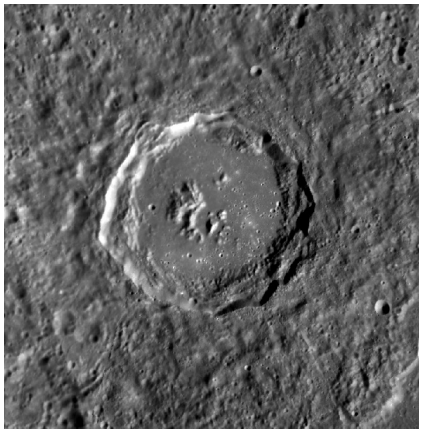
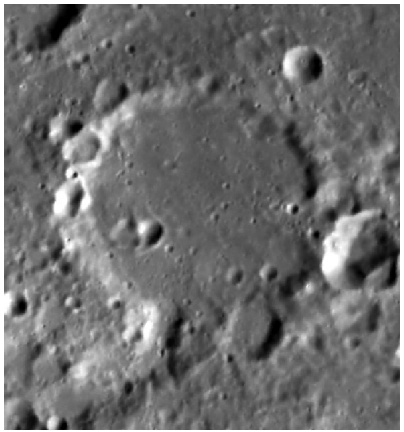
Geomorphic units - Crater materials



C3—fresh

C2—degraded



C1—very degraded

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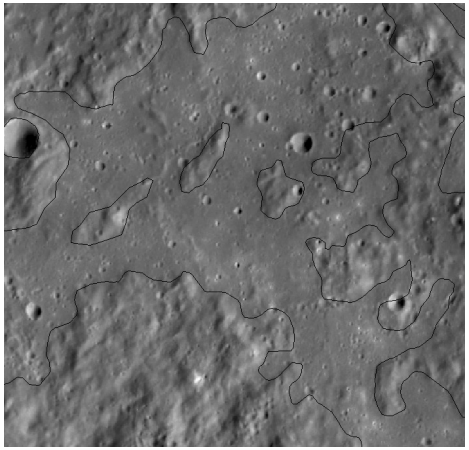
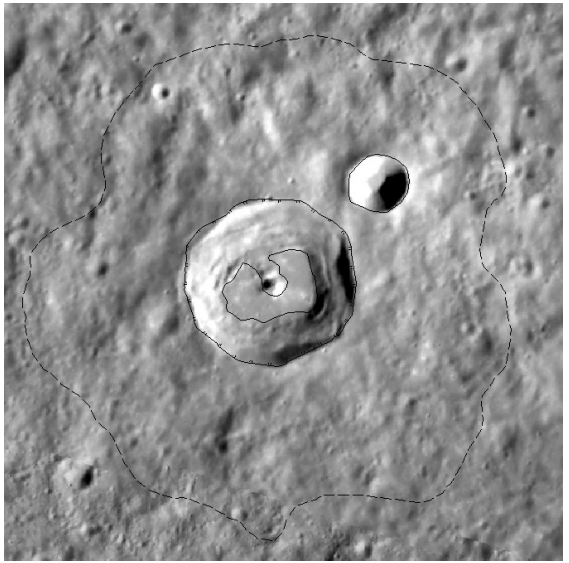
Mapping



certain contacts

linear features



approximate contacts

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Mapping

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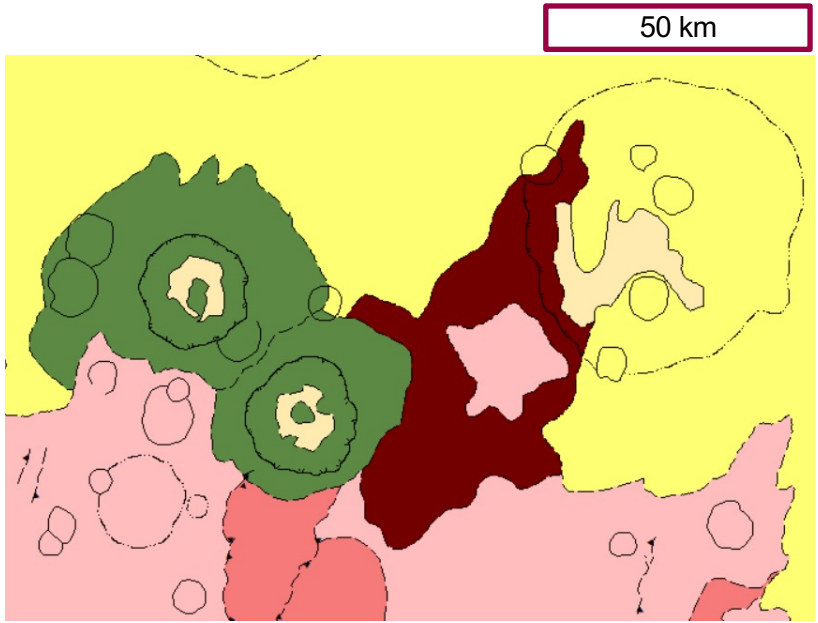
- smooth plains
- intermediate plains
- intercrater plains
- C3—fresh crater materials
- C2—degraded crater materials
- C1—extremely degraded crater materials
- smooth crater floor
- hummocky crater floor

Contacts
- certain
- approximate

Faults
- thrust fault, certain
- thrust fault, uncertain

Crater rims
- crater, large
- crater, small
- crater, buried
- pit



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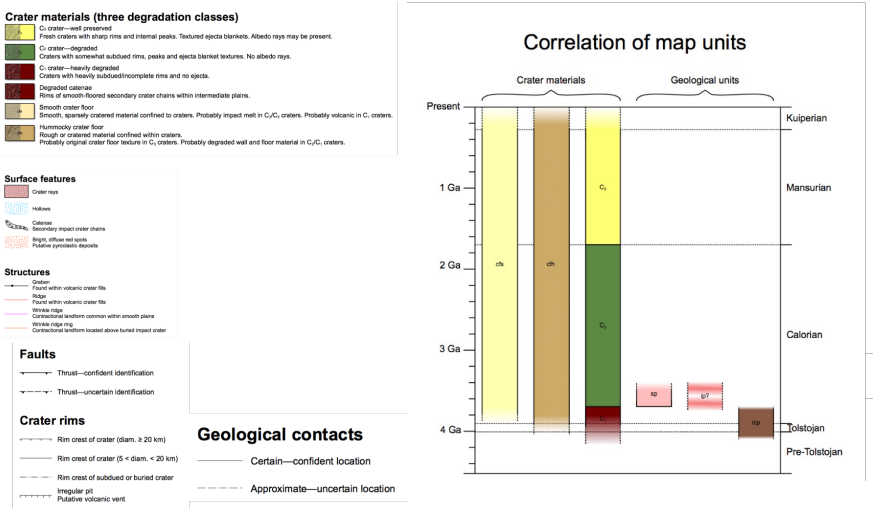

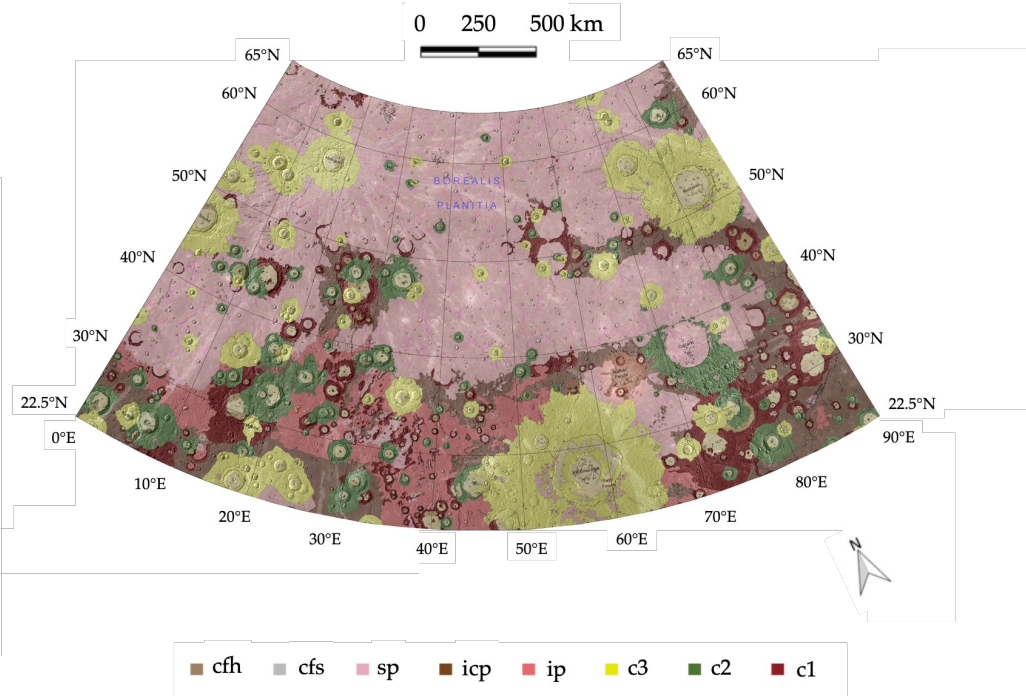

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Digitisation of spectral units – Interpretation of spectromorphic contacts

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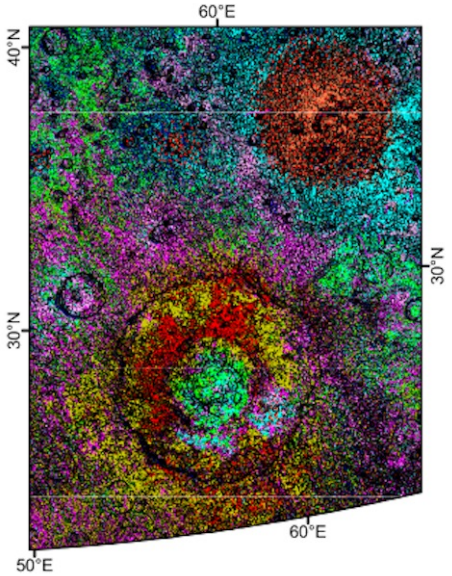

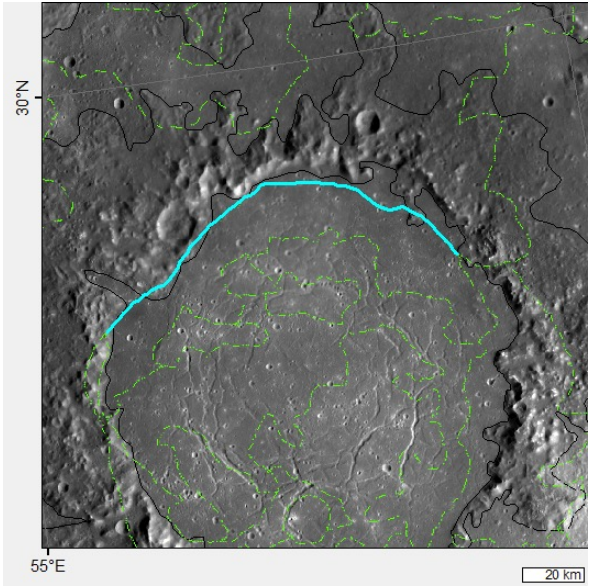

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Digitisation of Spectral Units

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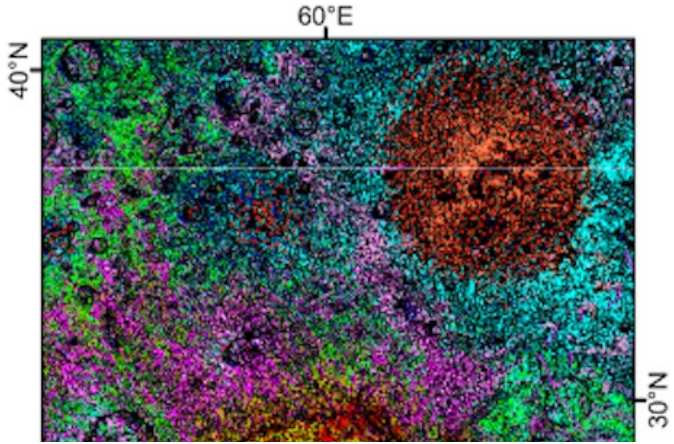
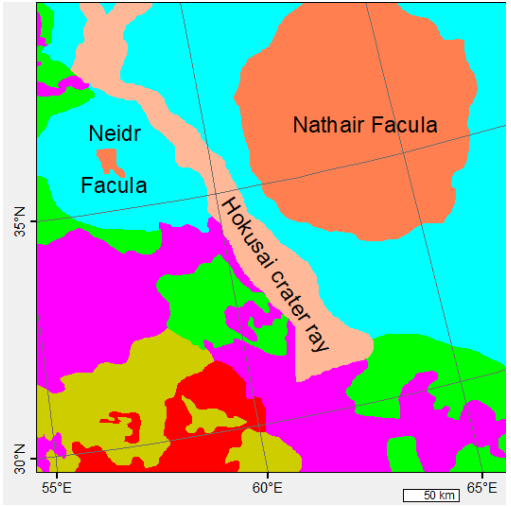
Spectral units within the Rachmaninoff subregion that correspond to named surficial textures rather than geomorphic ("bedrock") geology.





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Digitisation of Spectral Units

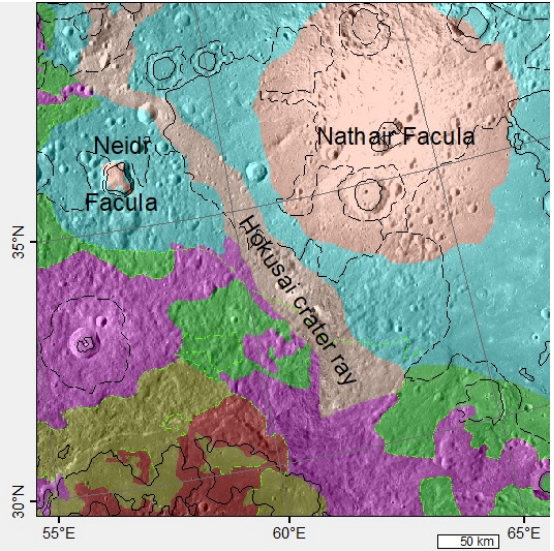

Illustration of how spectral units were inferred for spectromorphic units whose original spectral unit was attributable to surficial textures, such as faculae and crater rays.

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Digitisation of Spectral Units

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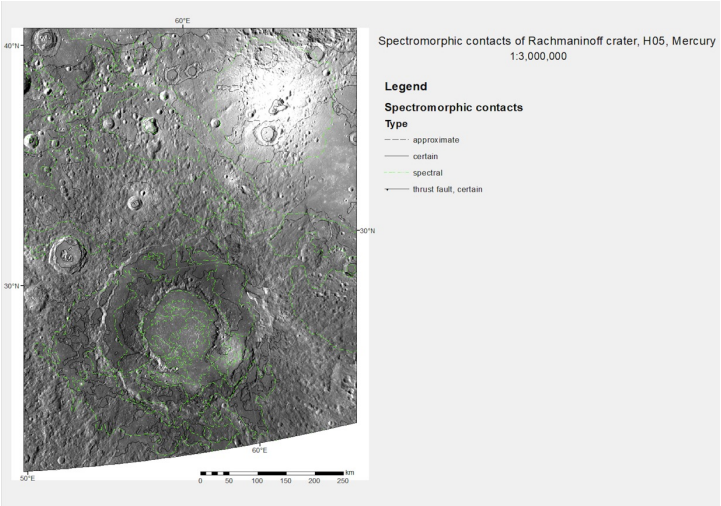
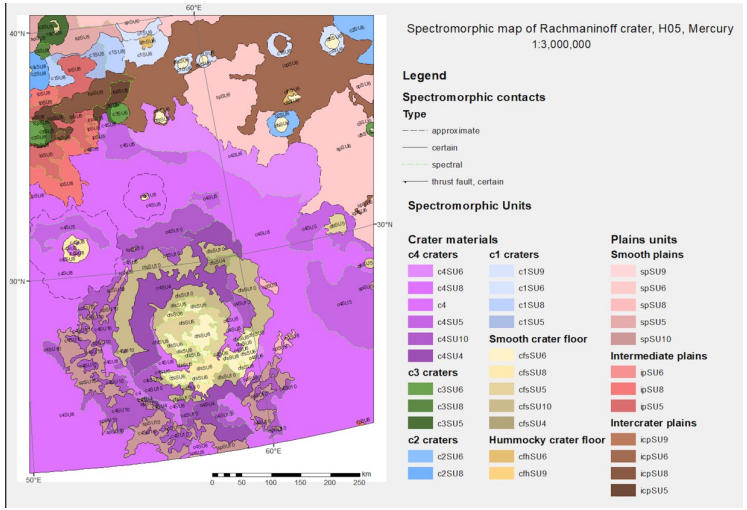
Merging of geomorphic and spectral contacts



Spectromorphic (geostratigraphic) map of the Rachmaninoff subregion



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Geostratigraphic Map

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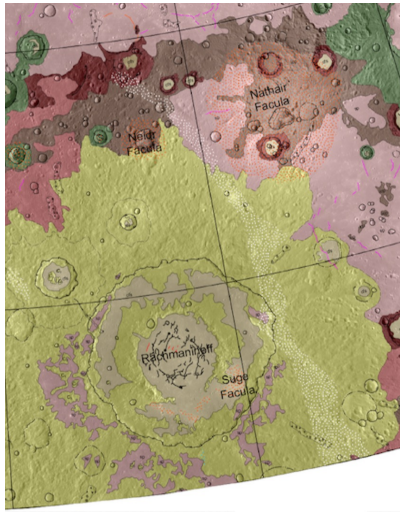
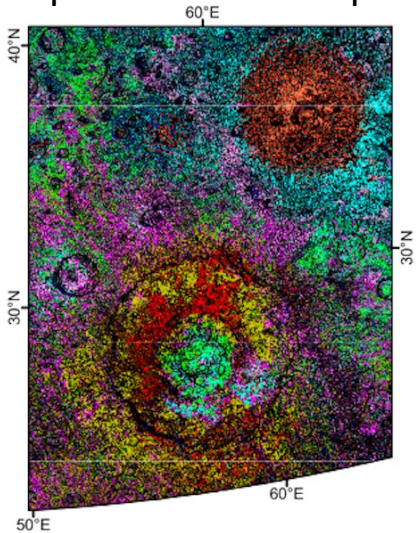
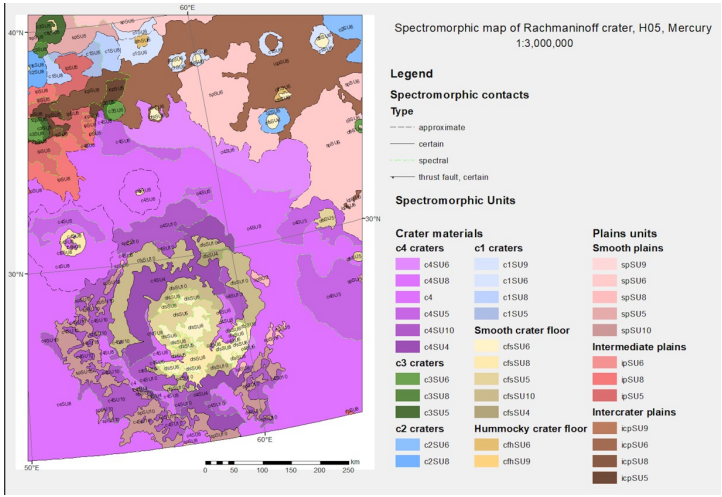
Morphostratigraphic map



Spectral unit map



Spectromorphic (geostratigraphic) map



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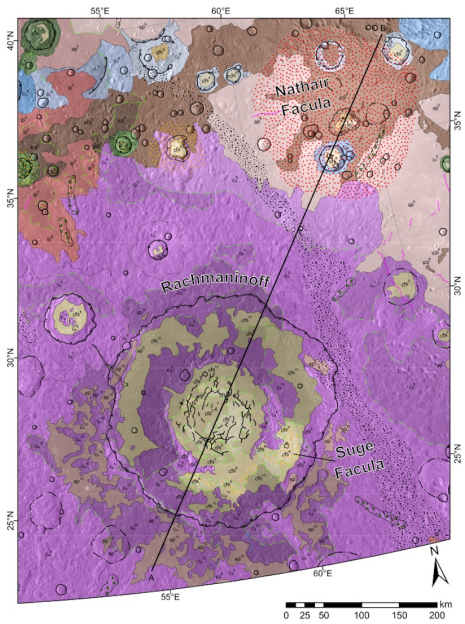
Final Geostratigraphic Map

Geostratigraphic map



Geostratigraphic units

Crater materials

c_4 craters

Well-preserved crater materials. Sharp rims and internal peaks. Textured ejecta blankets. Albedo rays absent. c_4^{10} is interpreted as Rachmaninoff ejecta mixed with melt. c_4^4 is low-reflectance material excavated from Mercury's lower crust.

c_3 craters

Degraded crater materials. Muted rims and internal peaks. Ejecta blankets present but not stongly textured.

c_2 craters

Heavily degraded crater materials. Rims mostly complete, but subdued. Peaks and distal ejecta rare.

c_1 craters

Extremely degraded crater materials. Rims highly incomplete or absent. Ejecta present in largest examples only.

Smooth crater floor

Smooth, sparsely cratered material confined to craters. Either ponded impact melt or volcanic crater fill. cfs^5 and cfs^6 are post-impact volcanic infill of Rachmaninoff.

Hummocky crater floor

Rough or cratered material confined within craters. Either original floor texture or mass-wasted wall material.

Geostratigraphic units are labelled with their original geomorphic unit symbol from Wright et al. (2019) followed by a superscript of their spectral unit number from Zambon et al. (in prep.). Geostratigraphic units of the same original geomorphic unit are symbolised in shades of their original symbol from Wright et al. (2019). Darker shades are used for geostratigraphic units with spectral units with lower overall reflectance. Spectral units uniquely correlated with surface features such as crater rays (SU9) and Nathair Facula (SU7), rather than 'bedrock' geology are shown by surface feature symbols.

Plains materials

Smooth plains

Sparsely cratered plains. Probably volcanic where areally extensive. Small patches within impact crater terraces/ejecta probably impact melt. sp^{10} is probably ponded Rachmaninoff impact melt.

Intermediate plains

Patches of smooth material confined by high-standing plains intermediate in roughness between smooth and intercrater plains. Probably intercrater plains that has been partially inundated by smooth material of volcanic/impact origin.

Intercrater plains

Heavily cratered plains with a rough, hummocky texture. Probably akin to smooth plains but older and thus more heavily cratered.

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Papers and Links

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Papers:

- Wright et al., 2019, Journal of Maps.
  Doi: https://doi.org/10.1080/17445647.2019.1625821

- Zambon et al., 2022, Journal of Geophysical Research (Planets).
  Doi: https://doi.org/10.1029/2021JE006918

- Wright et al., 2024, Earth & Space Science, in press.

Links:

- PLANMAP: https://planmap.eu/
- Mercury spectral units map: Doi: https://doi.org/10.5281/zenodo.4772274, https://data.planmap.eu/pub/mercury/PM-MER-C-H05/, https://data.planmap.eu/pub/mercury/PM-MER-C-H05_SU/
- Mercury morphostratigraphic maps: https://data.planmap.eu/pub/mercury/PM-MER-MS-H05_3cc/, https://data.planmap.eu/pub/mercury/PM-MER-MS-H05_5cc/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871149.

Thanks for your attention!