

Harvesting the fruits of a new spectral database: from hollows to explosive volcanism on Mercury

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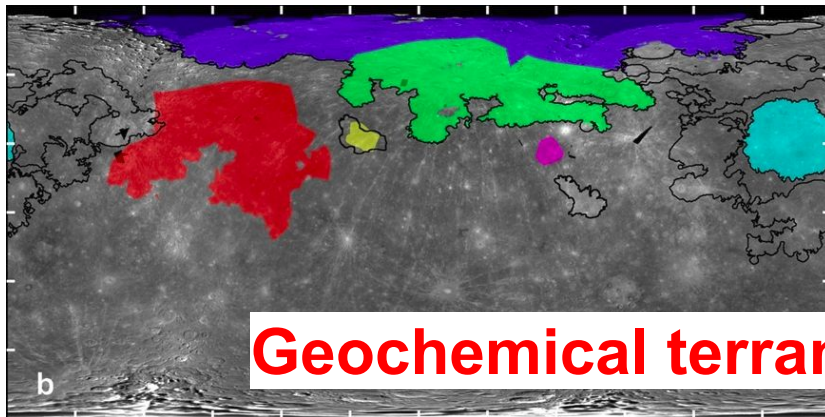
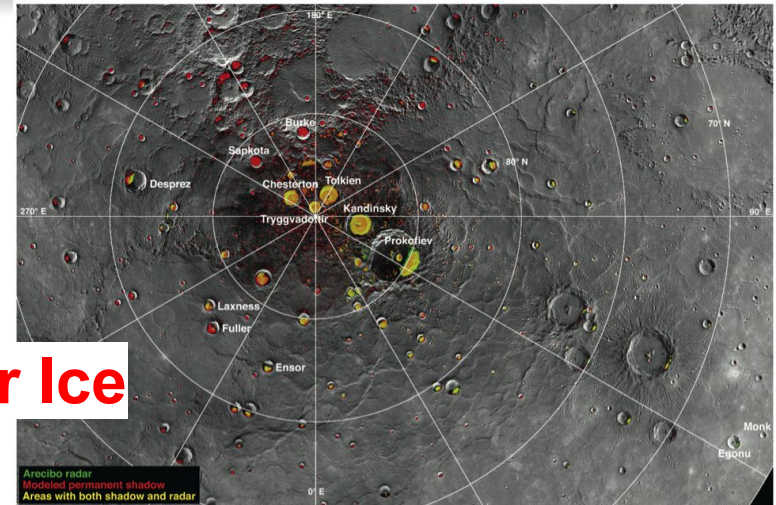


Why Mercury ?



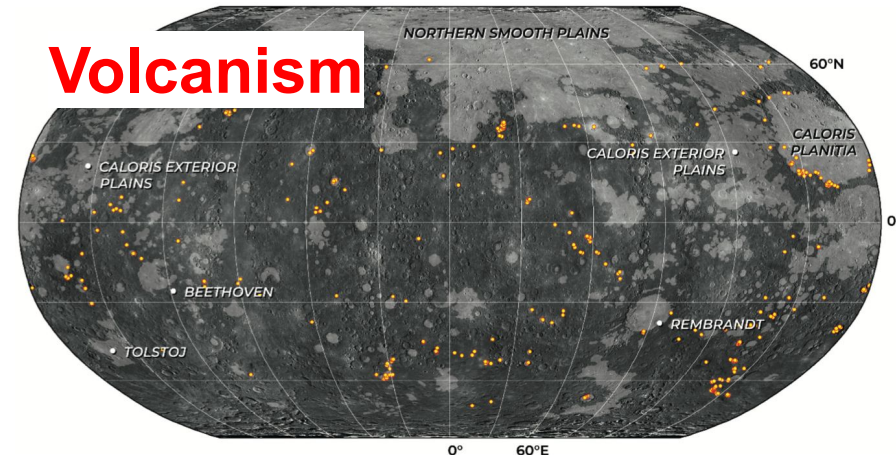
- High bulk density
- Magnetic field
- Volatile species
- Compressional features

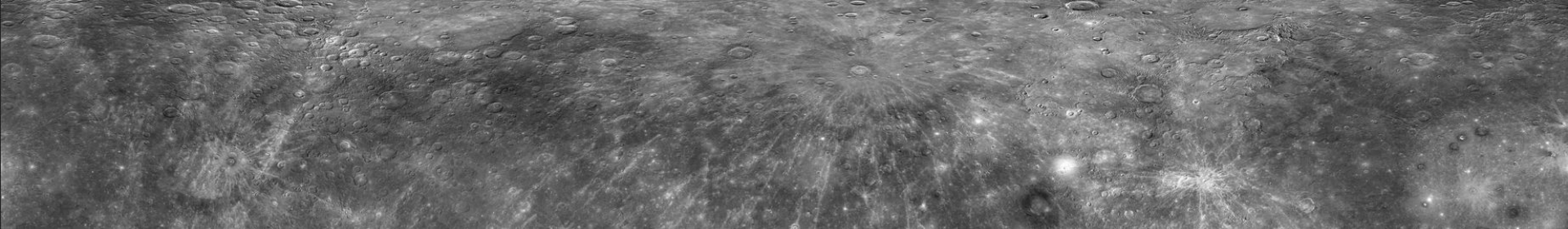
Water Ice



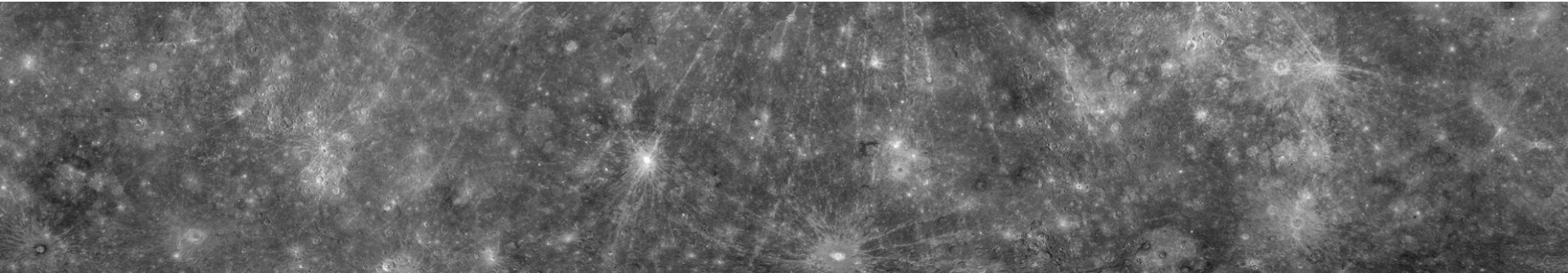
Geochemical terranes

Volcanism





What are hollows ?



Mercury Surface

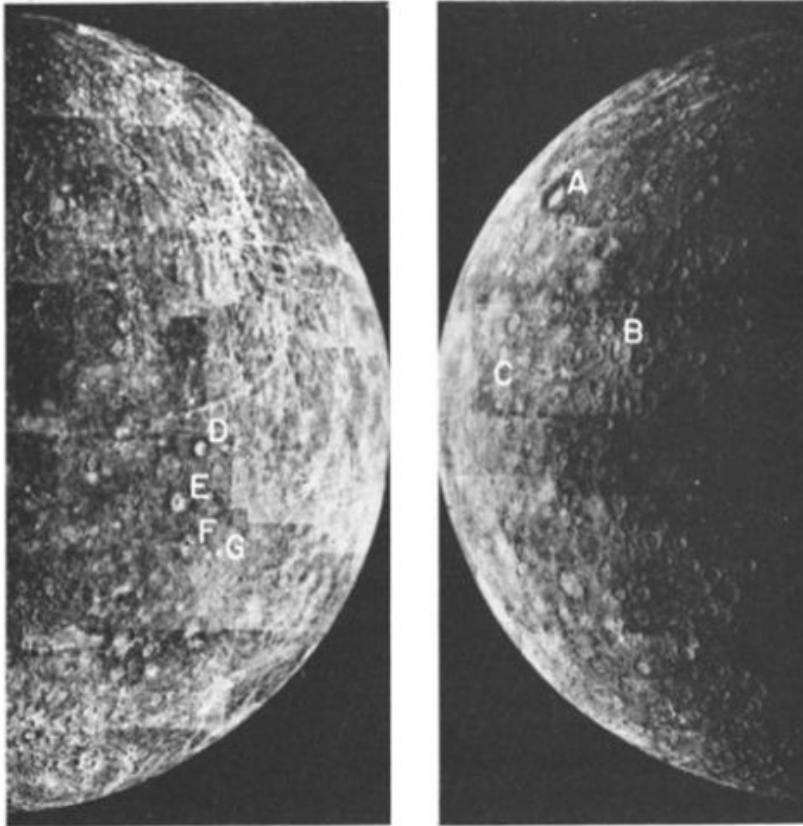


Fig. 1. Photomosaics of Mariner 10 Incoming (a) and Outgoing Quadrants (b) of Mercury, with letters marking locations of prominent bright patches.

D.Dzurisin (1977)

Mariner 10 highlighted bright patches on the surface of Mercury.

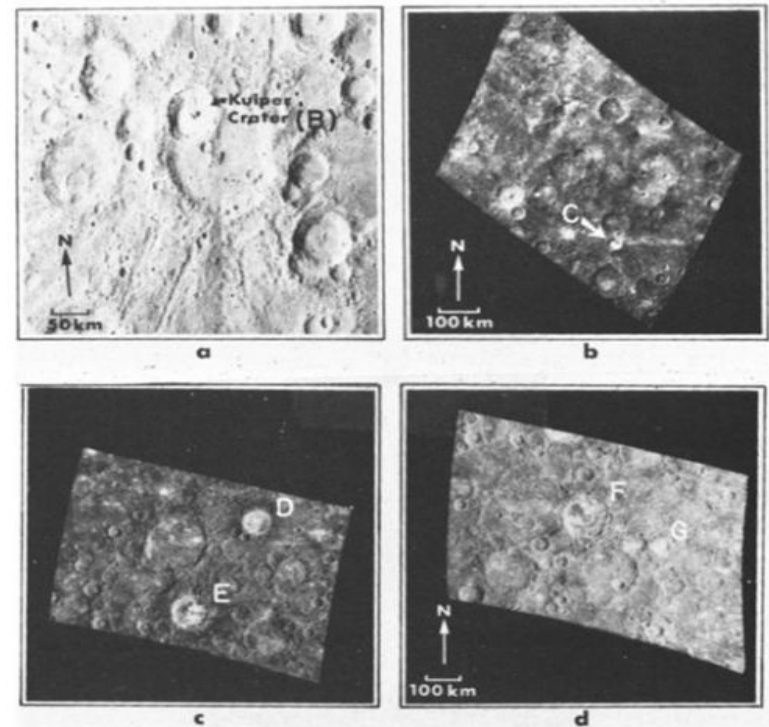
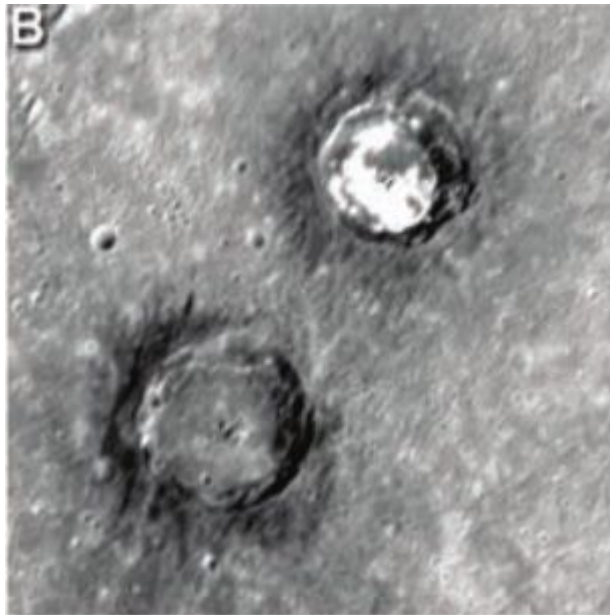


Fig. 2. Mercurian bright patches.

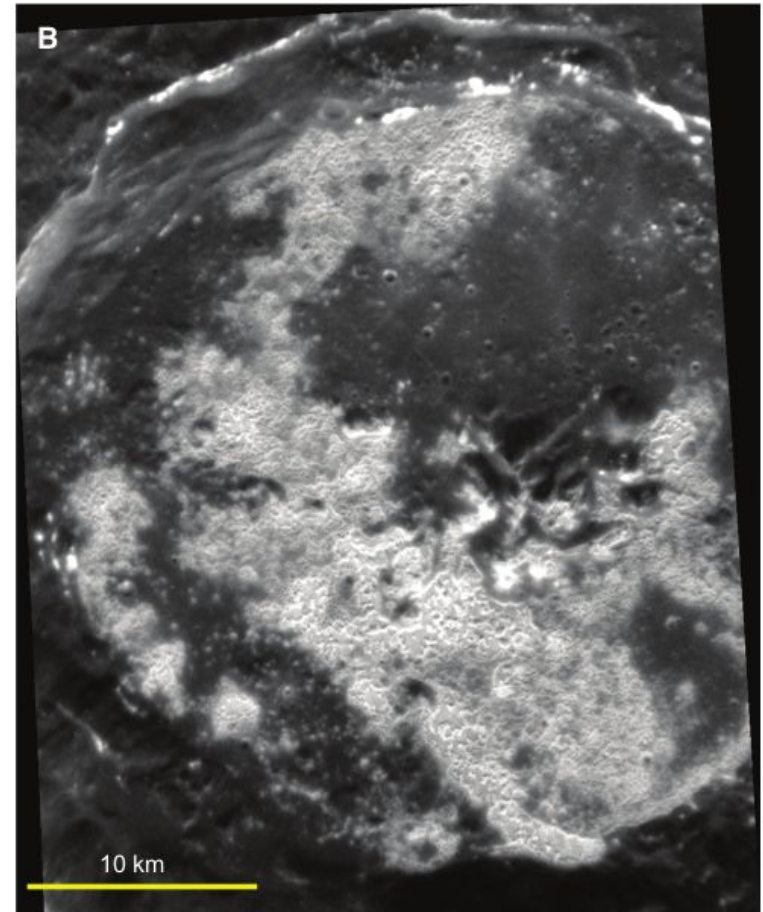
Bright crater floor deposit (BCFDs)



Robinson et al., (2008)

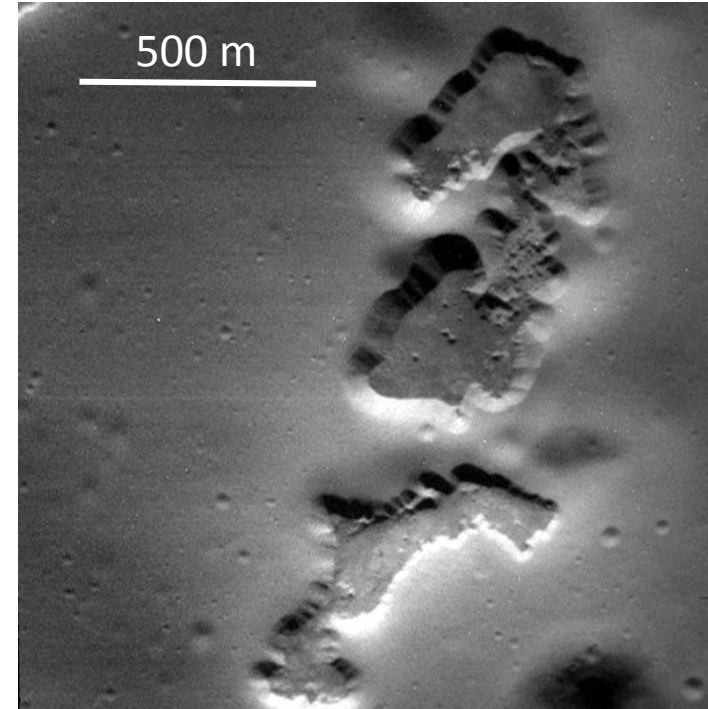
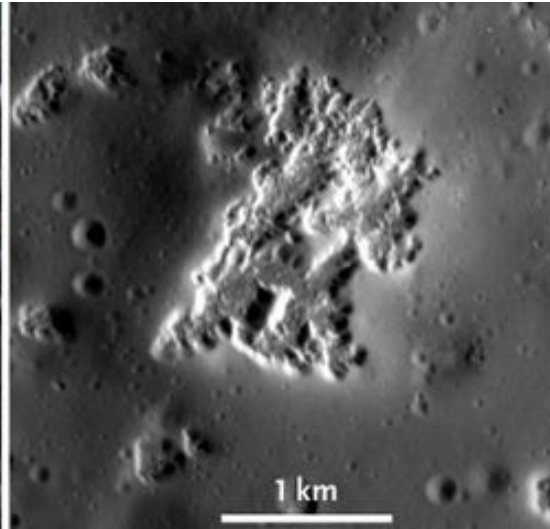


High resolution images obtained by MESSENGER → BCFDs composed of several small depressions



Blewett et al., (2011)

Hollows



Figures: Hollows on Scarlatti impact crater ring.

NASA/Johns Hopkins University Applied Physics Laboratory /Carnegie Institution of Washington

- Fresh appearance
- Small depressions surrounded by bright halo
- Shallow with flat floor

Hollows



Geological settings:

- Low reflectance material
- Crater/basin floors, walls, terraces, central peaks, ejectas
- Close to explosive volcanism deposits

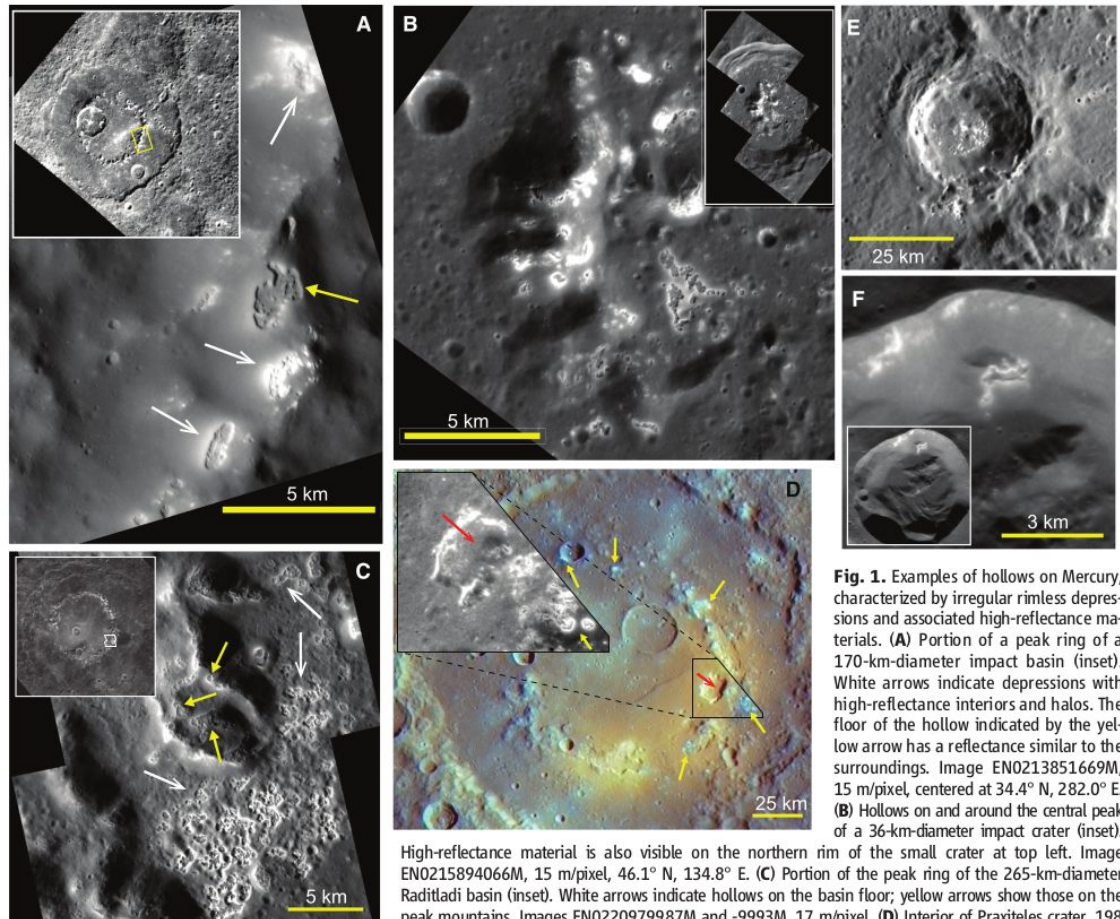
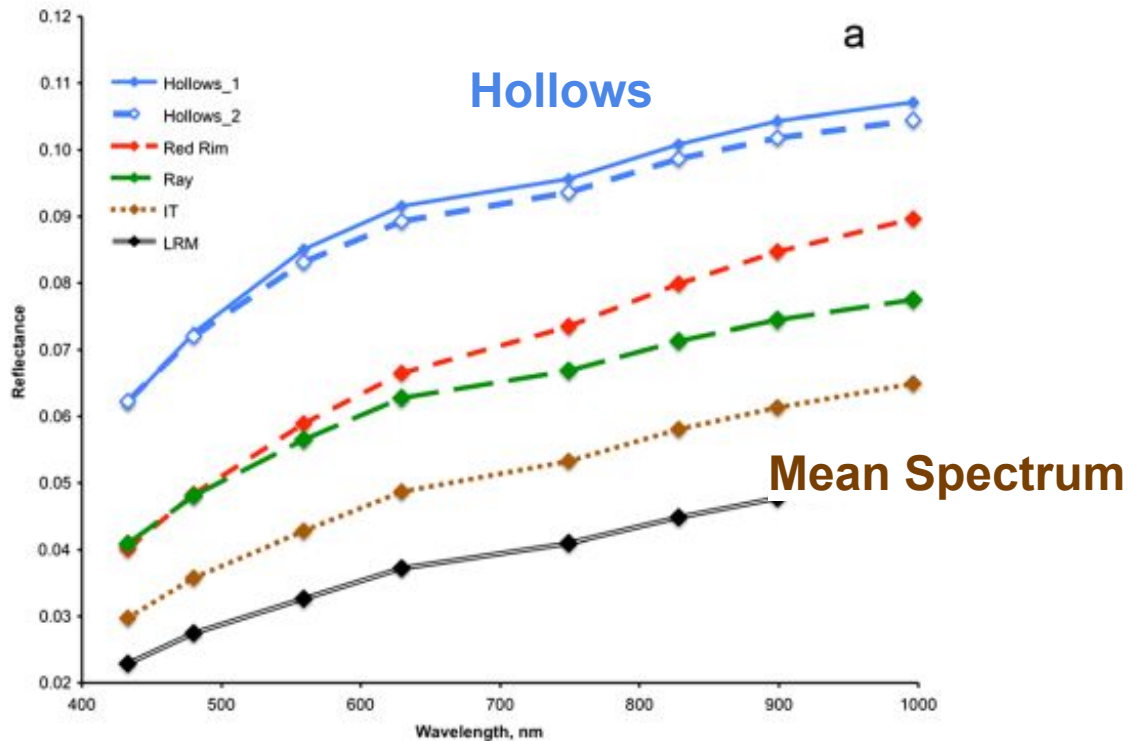


Fig. 1. Examples of hollows on Mercury, characterized by irregular rimless depressions and associated high-reflectance materials. (A) Portion of a peak ring of a 170-km-diameter impact basin (inset). White arrows indicate depressions with high-reflectance interiors and halos. The floor of the hollow indicated by the yellow arrow has a reflectance similar to the surroundings. Image EN0213851669M, 15 m/pixel, centered at 34.4° N, 282.0° E. (B) Hollows on and around the central peak of a 36-km-diameter impact crater (inset). High-reflectance material is also visible on the northern rim of the small crater at top left. Image EN0215894066M, 15 m/pixel, 46.1° N, 134.8° E. (C) Portion of the peak ring of the 265-km-diameter Raditladi basin (inset). White arrows indicate hollows on the basin floor; yellow arrows show those on the peak mountains. Images EN0220979987M and -9993M, 17 m/pixel. (D) Interior of Praxiteles crater, 198 km in diameter. Enhanced-color image in which red-to-blue variations indicate relative color; the green channel is a measure of overall albedo (34). Hollows (yellow arrows) appear bright blue; the large depression (red arrow) is a likely volcanic vent and the source of the reddish pyroclastic deposit. Inset is image EN0211416219M (53 m/pixel), showing details of the bright depressions. (E) High-reflectance depressions on the floor, walls, and rim of a partially degraded 25-km-diameter impact crater. Image EN0213154023M, 149 m/pixel, 23.3° N, 179.4° E. (F) Portion of a morphologically fresh 15-km-diameter crater (inset) with bright material on the upper wall and hollows on a wall slump. Image EN0218374376M, 18 m/pixel, 66.5° N, 153.2° E.

Blewett et al., (2011)

Hollows spectral features



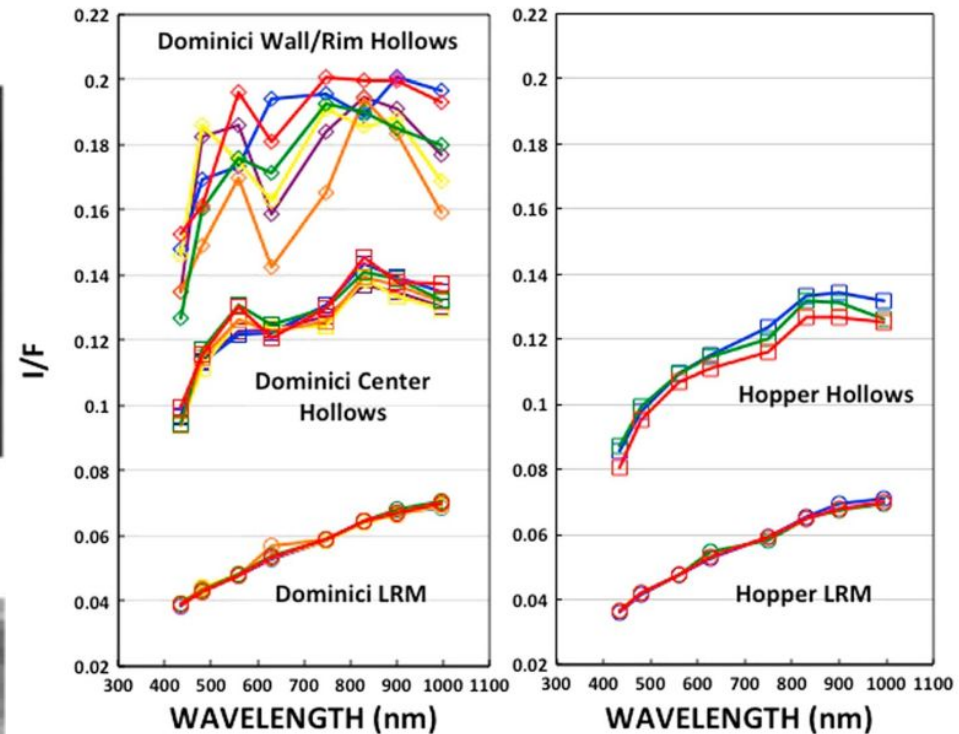
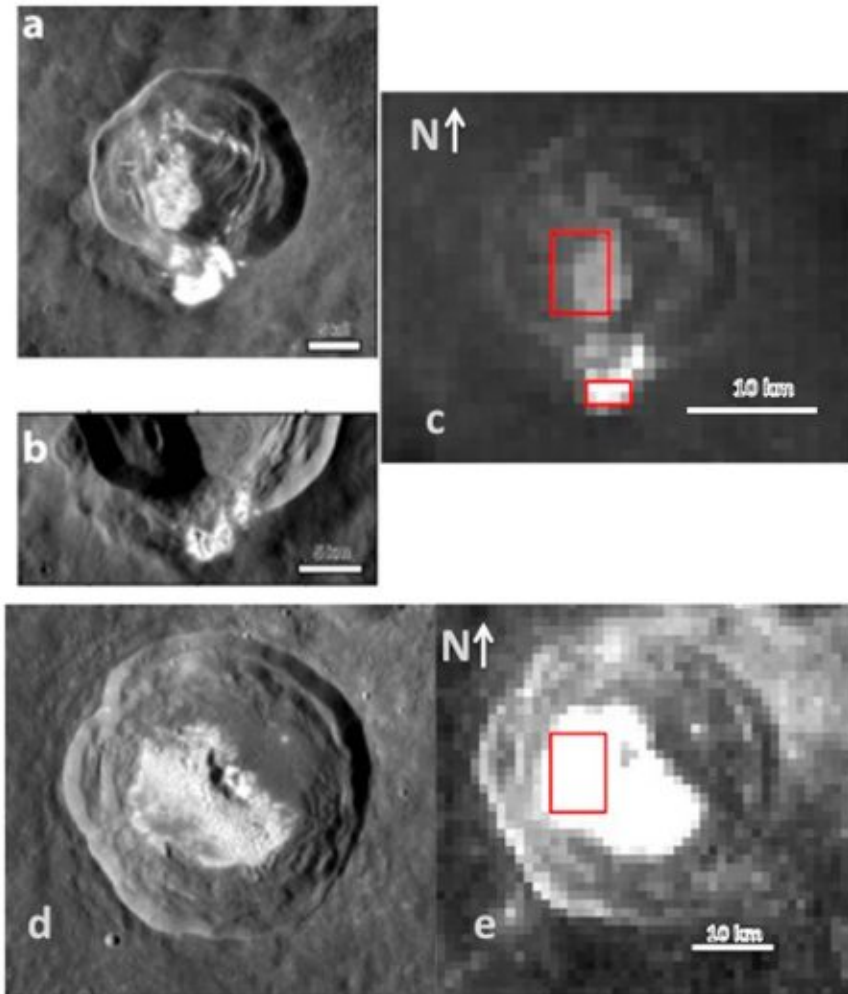
Blewett et al., (2013)

Multispectral camera with 12 filters : Mercury Dual Imaging System (MDIS) onboard MESSENGER

→ 395 to 1040 nm

- Hollows have a reflectance twice higher than the Mercury mean spectrum

Hollows spectral features



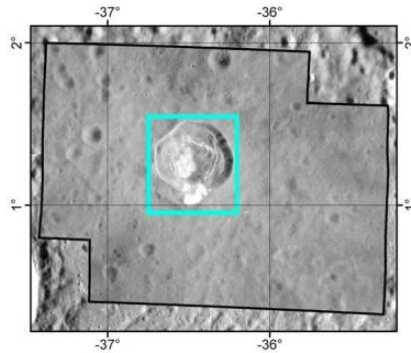
Vilas et al., (2016)

- None expected absorption band between 558 and 828 nm.

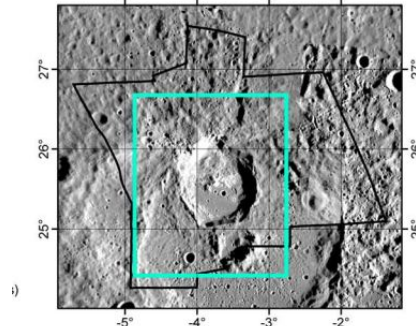
Hollows spectral features



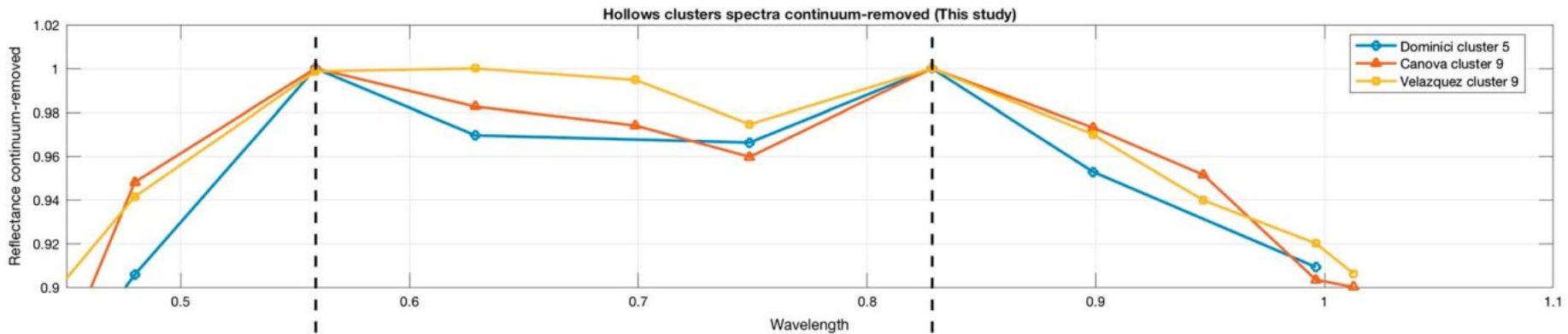
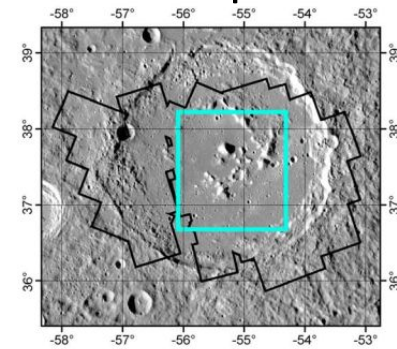
Dominici



Canova

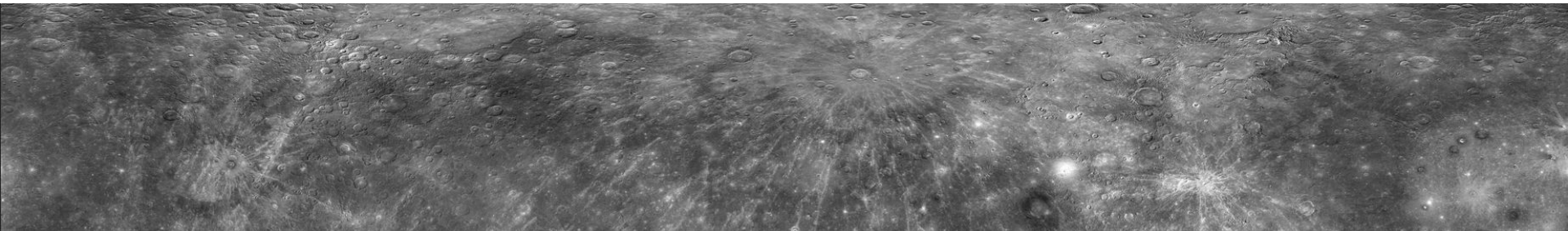


Velazquez



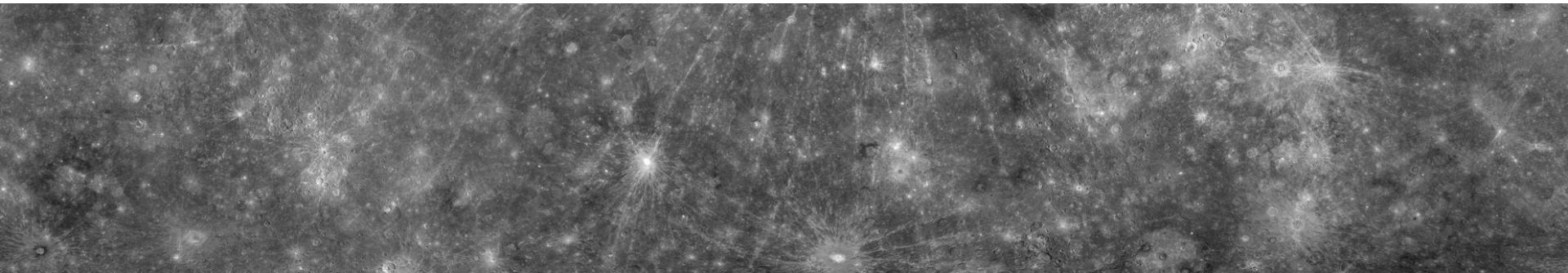
Lucchetti et al., (2018)

- Possible absorption band between 558 and 828 nm (4%)
- Presence of sulfides ?



Our Analysis

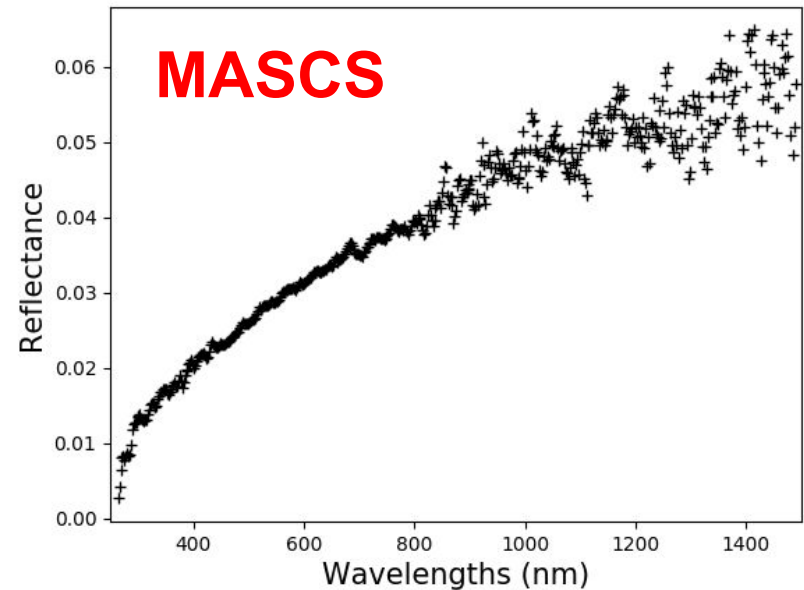
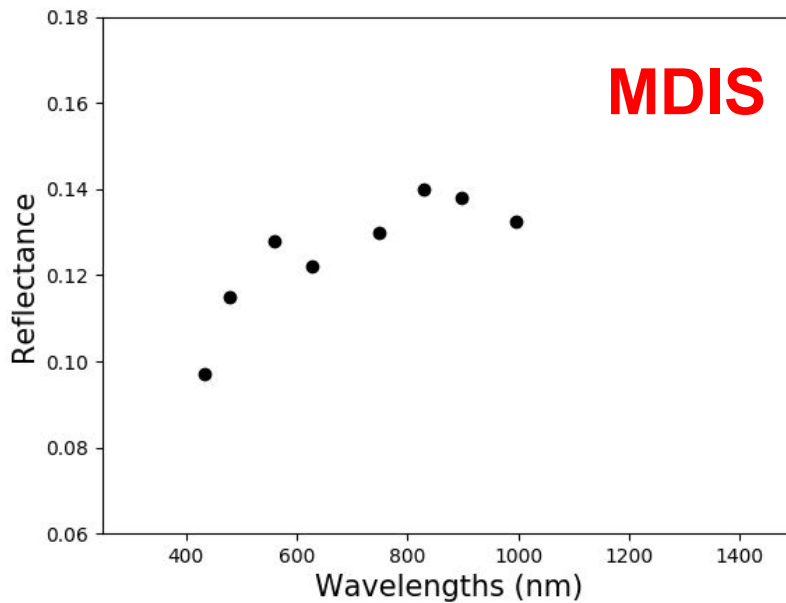
1. Search for absorption band and spectral analysis
2. Investigation of the geological context



Limitation of the spectral analysis



	Spatial resolution	Spectral resolution	Spectral range
MDIS*	8 m to 7 km per pixel	around 60 nm	433 - 1012 nm
MASCS**	0.1*3 km to over 6*7 km	5 nm	300 - 1400 nm



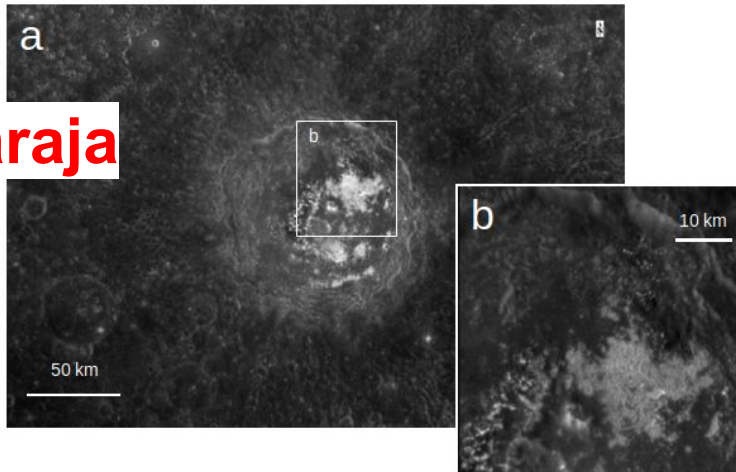
*MDIS: Mercury Dual Imaging System

**MASCS: Mercury Atmospheric and Surface Composition Spectrometer.

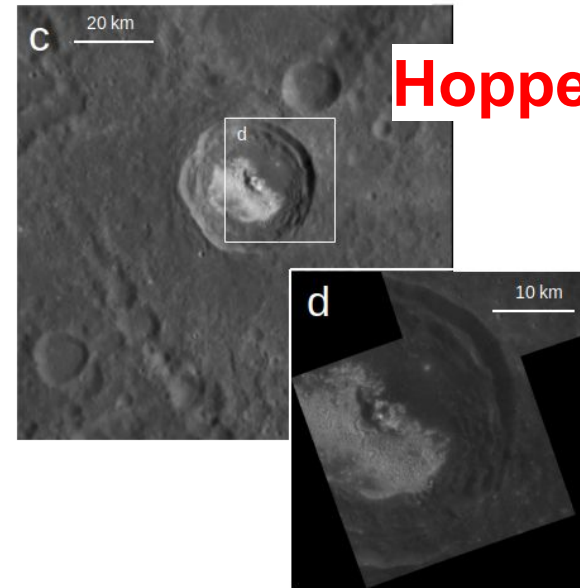
Hollows observations with MASCS



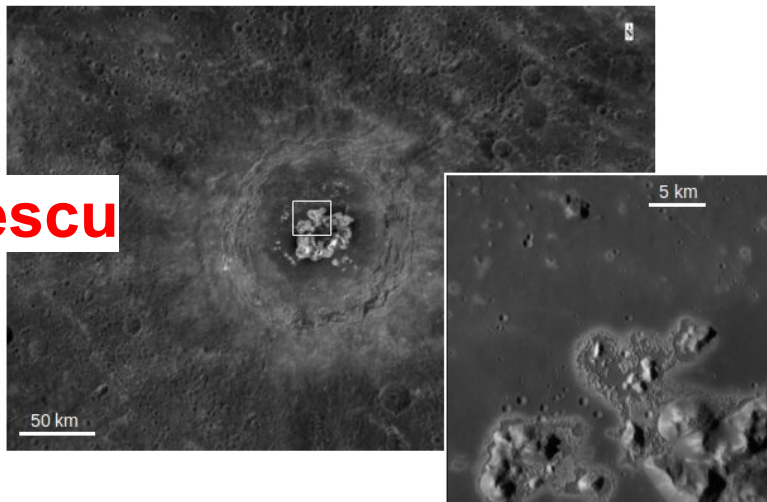
Tyagaraja



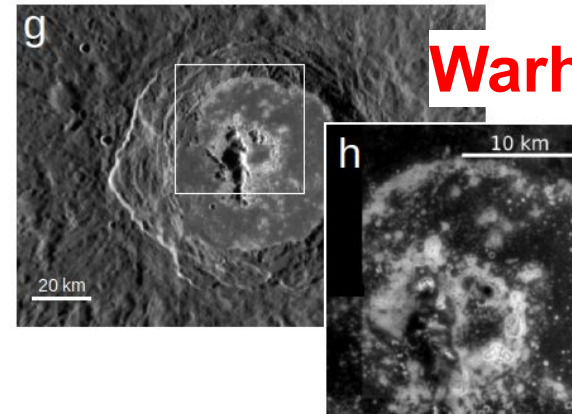
Hopper



Eminescu



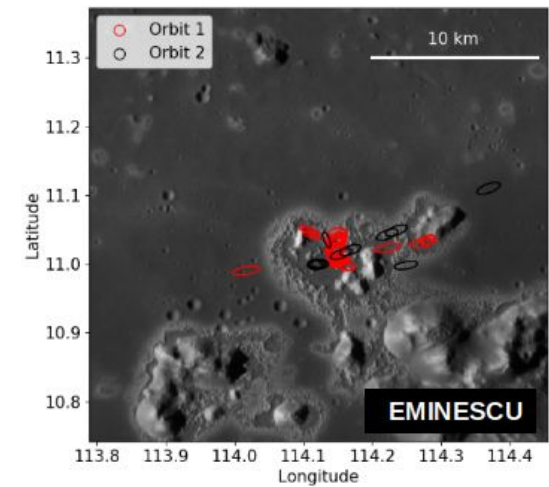
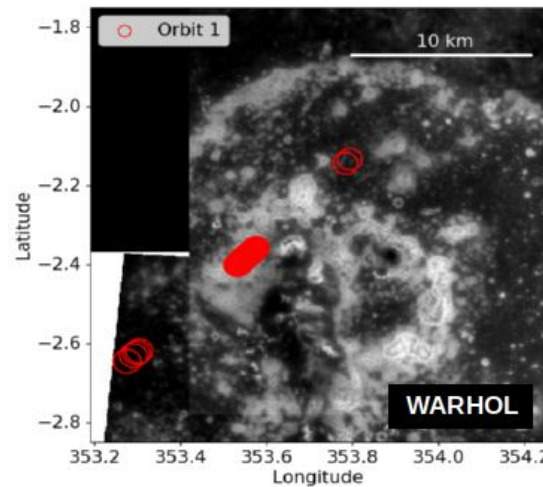
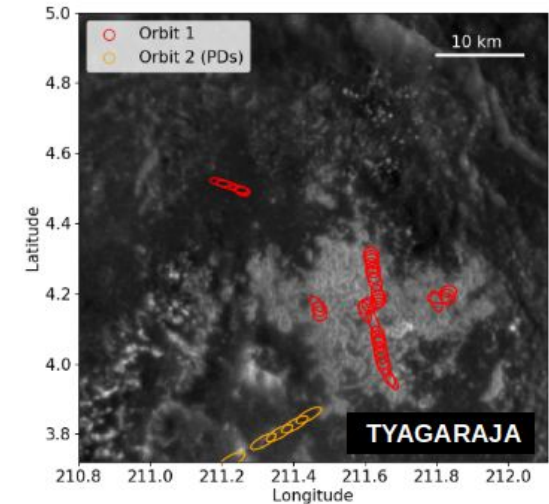
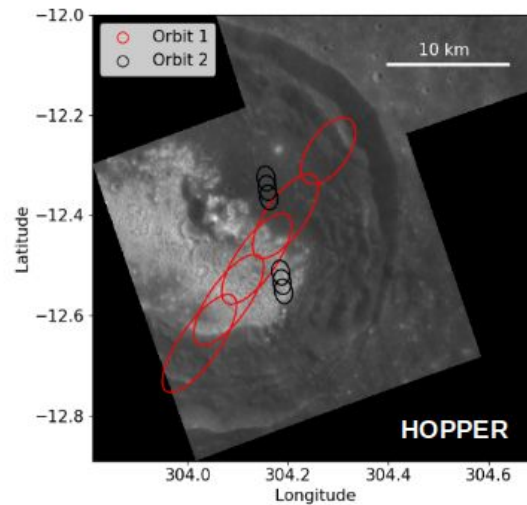
Warhol



Hollows observations with MASCS



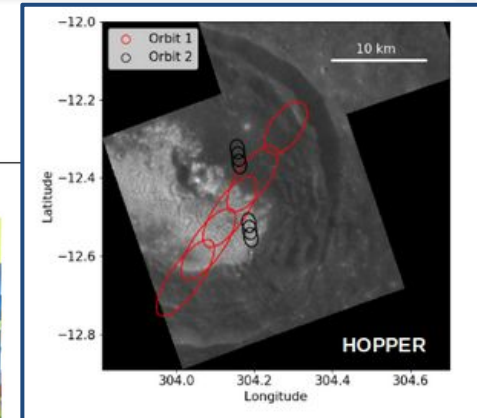
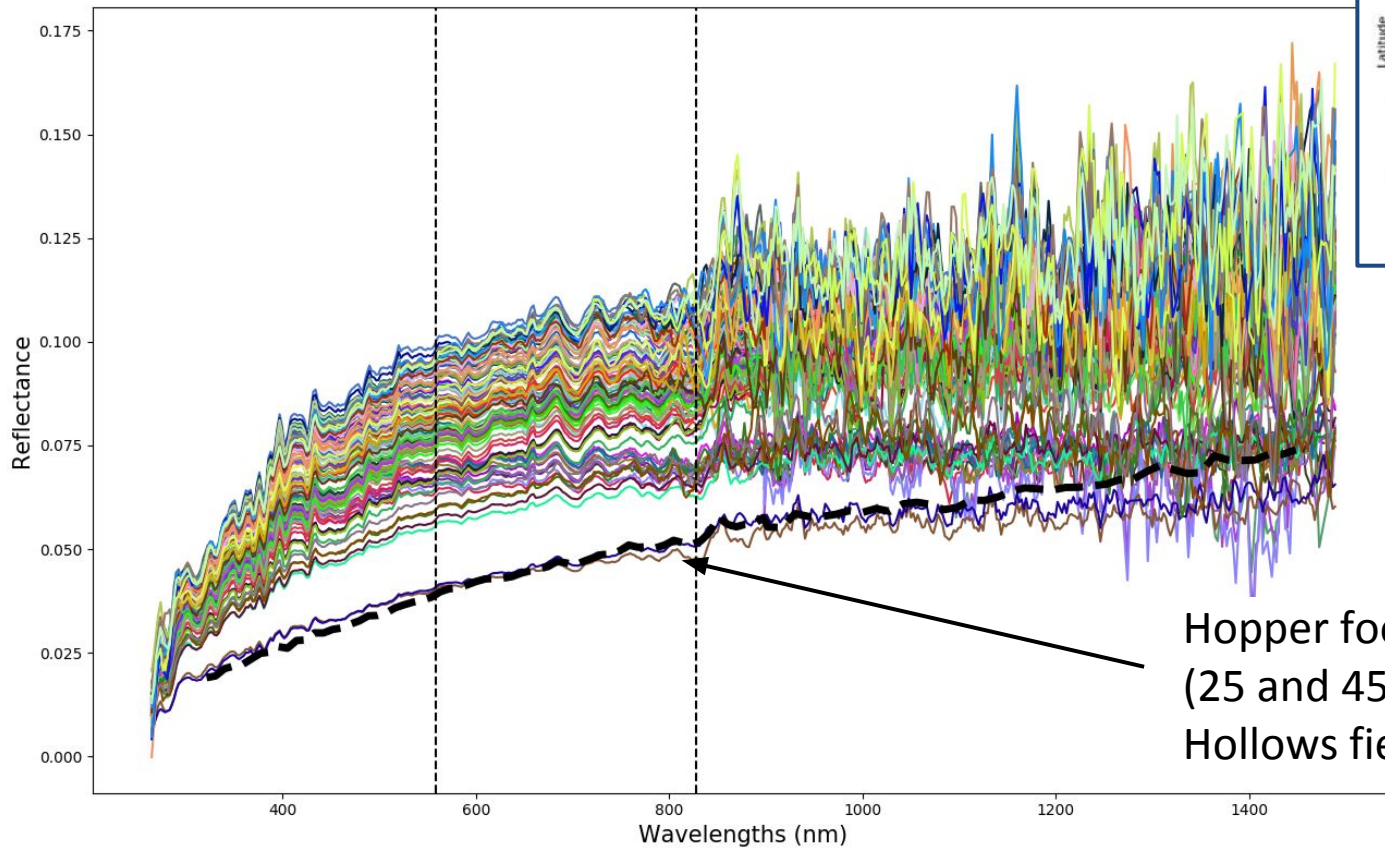
- Spatially resolved hollows



Hollows spectra



- 113 spectra of hollows

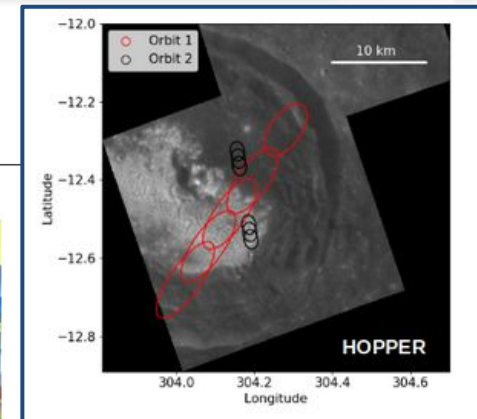
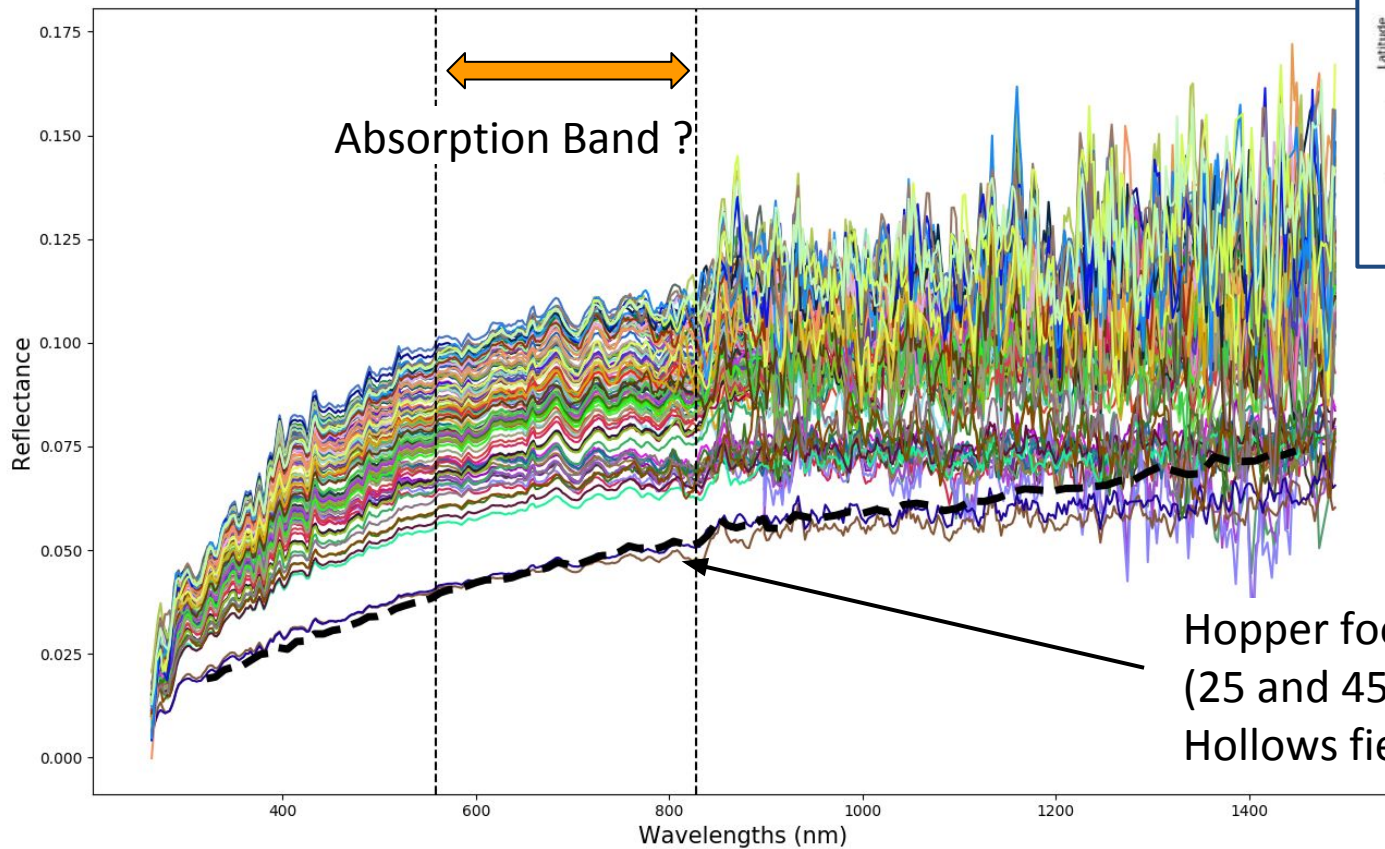


Hopper footprints
(25 and 45 %) of
Hollows field.

Hollows spectra



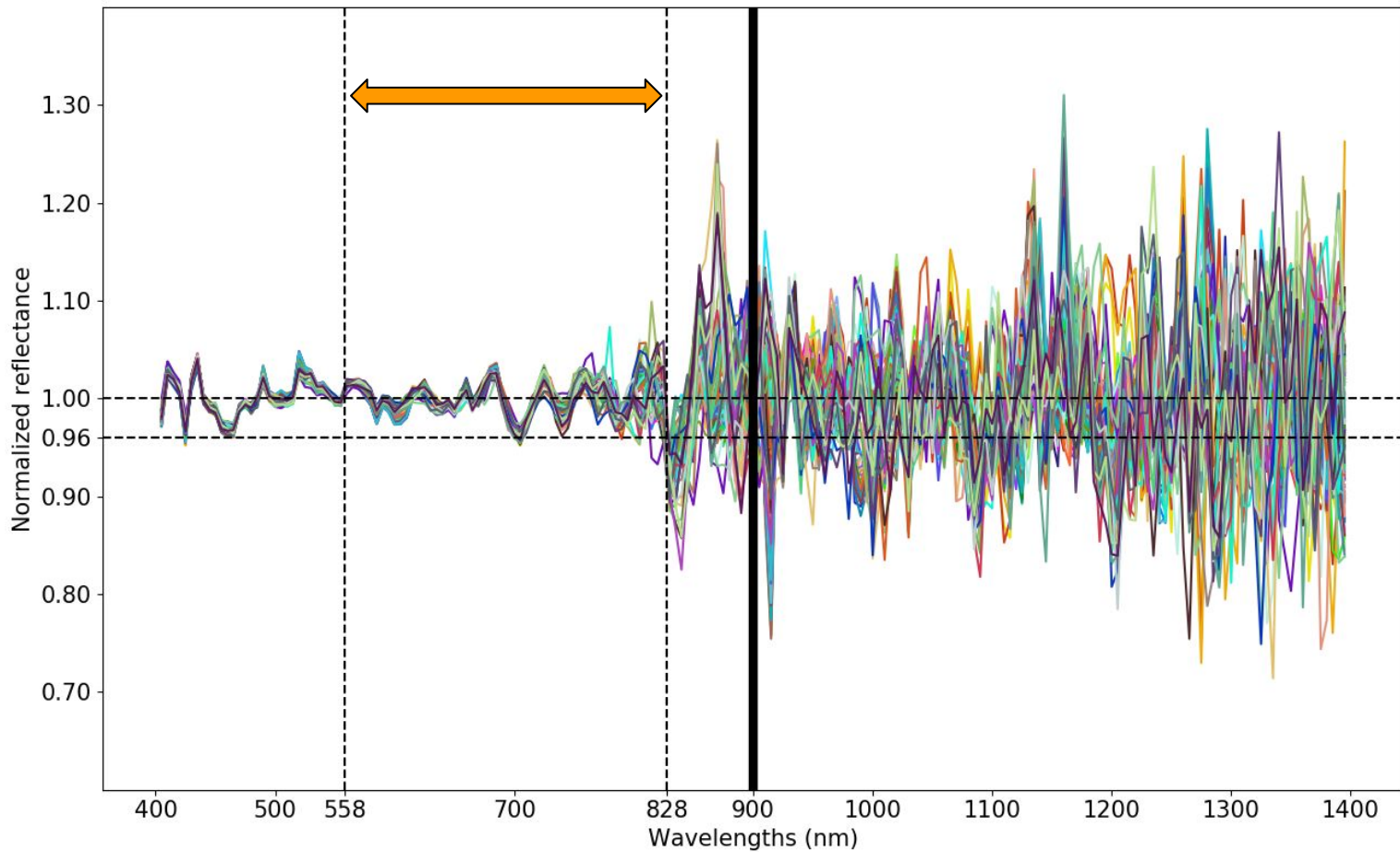
- 113 spectra of hollows



Hollows spectral features ?



- Continuum removed spectra (113)



Lack of absorption bands



1. Calibration errors

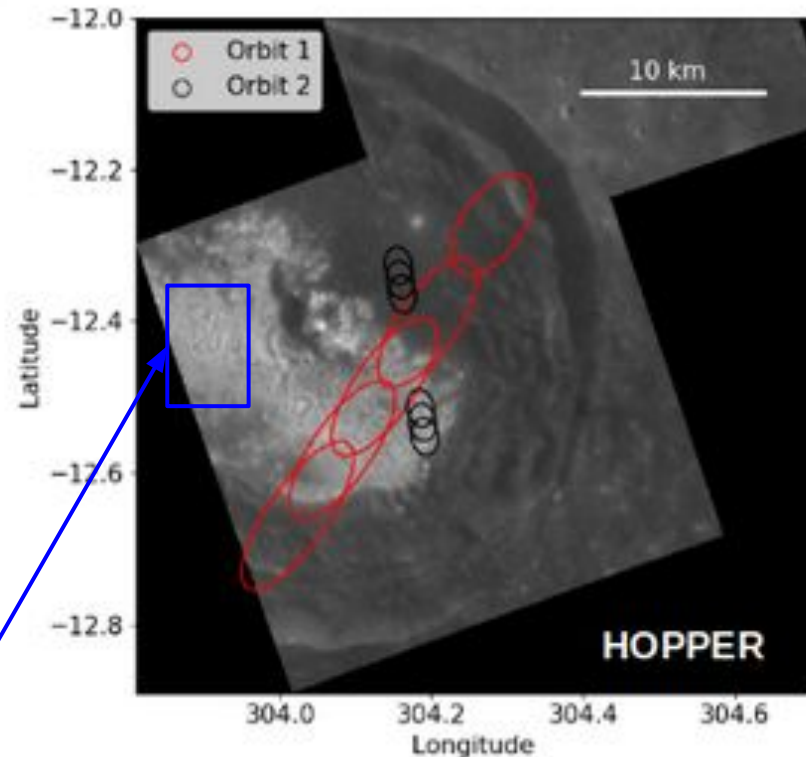
In MDIS or in MASCS

2. No sufficient concentration of pure sulfides

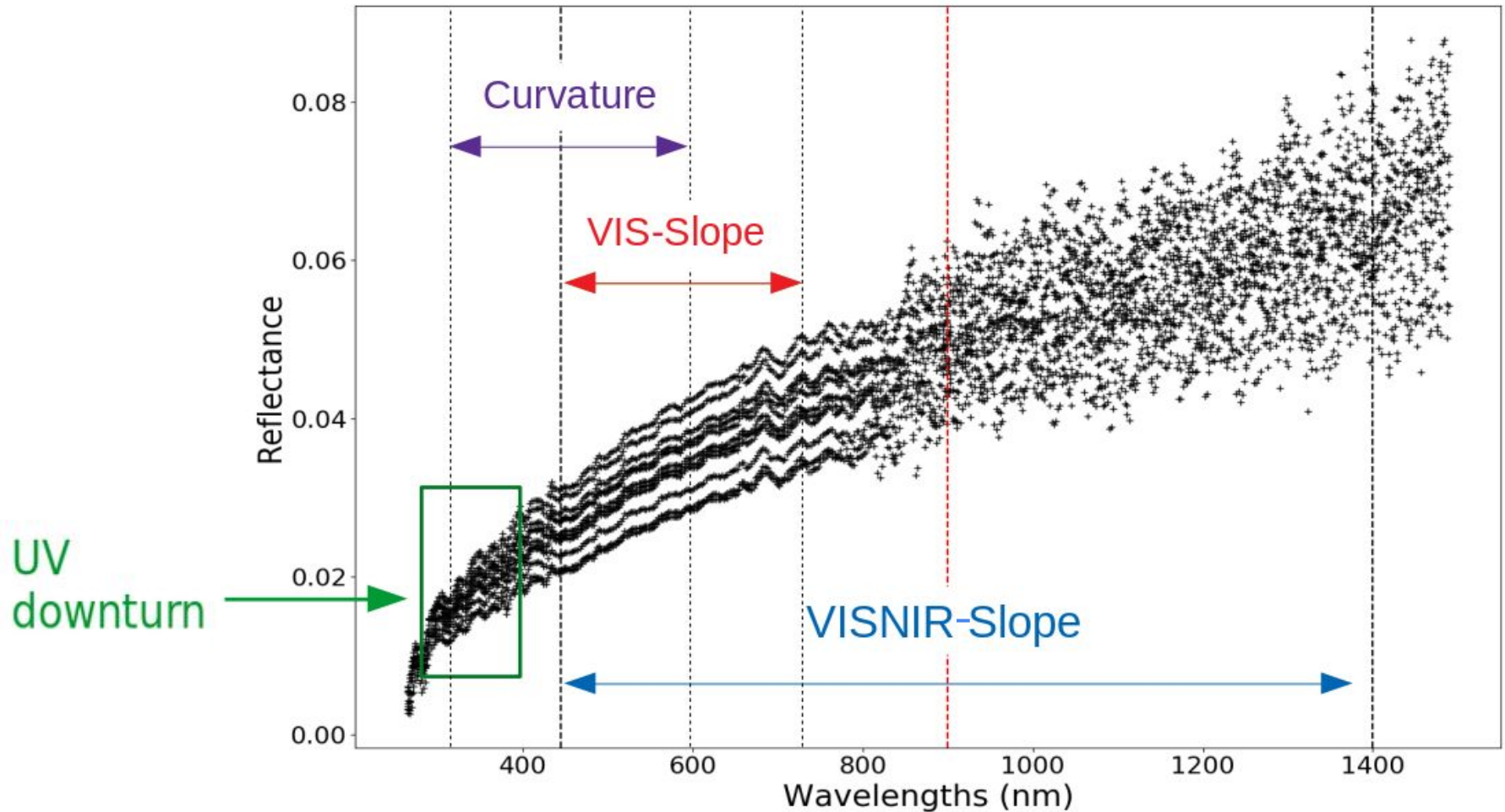
→ 75 % of pure sulfides needed (Izenberg et al., 2014)

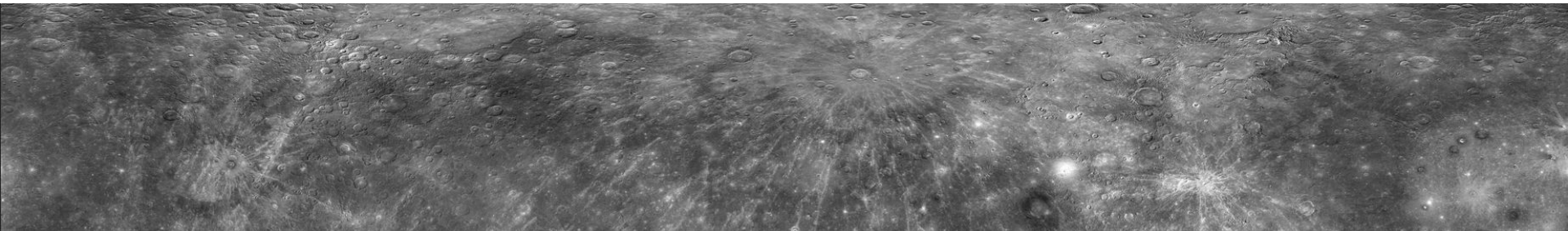
3. Diversity in hollows material

Vilas et al., (2016)



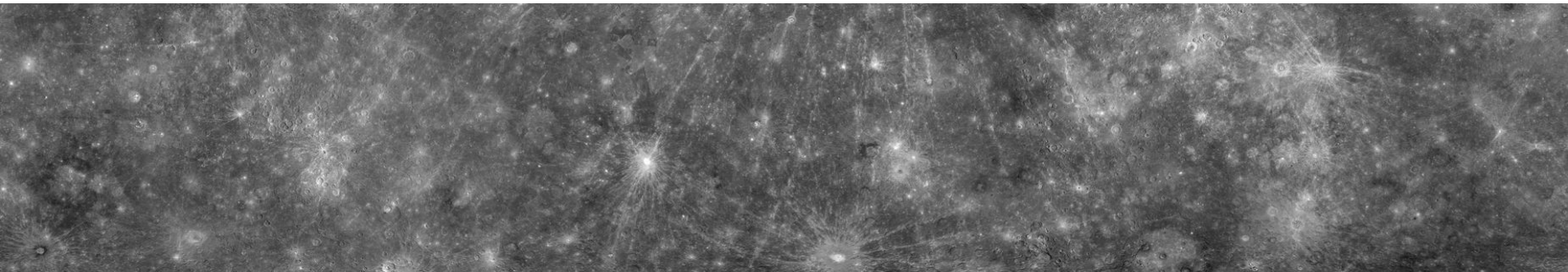
Spectral parameters



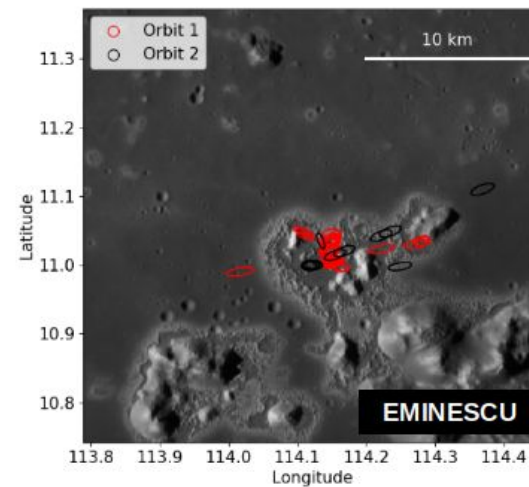
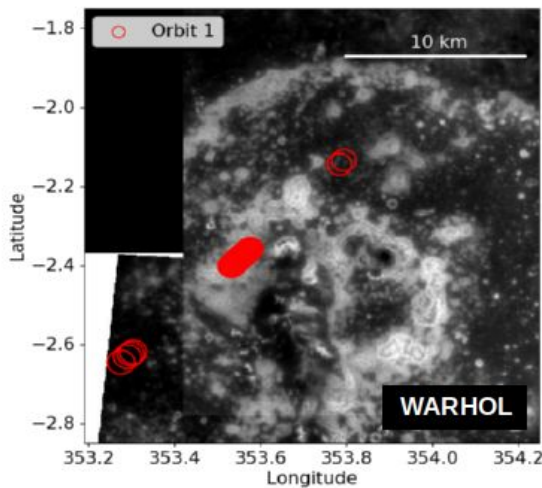
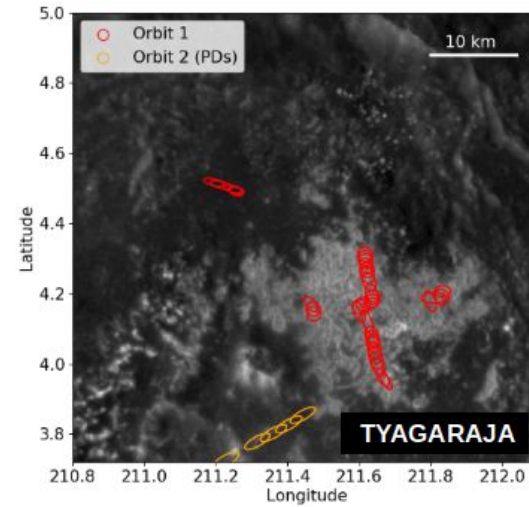
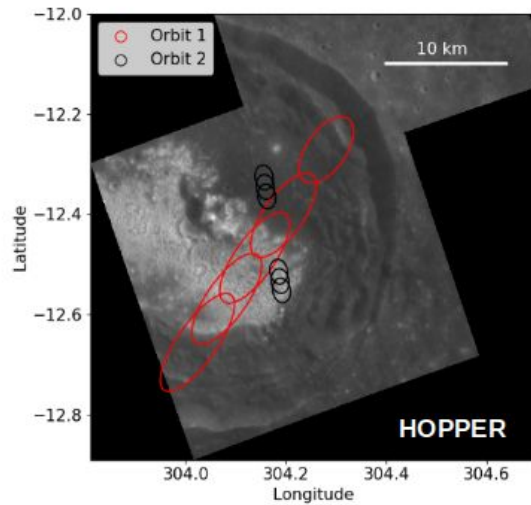


Our Analysis

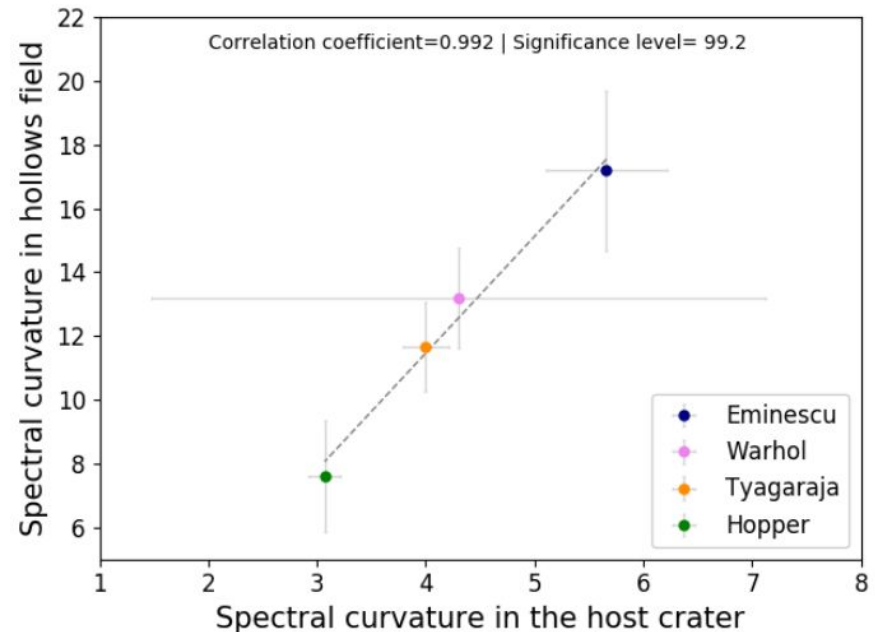
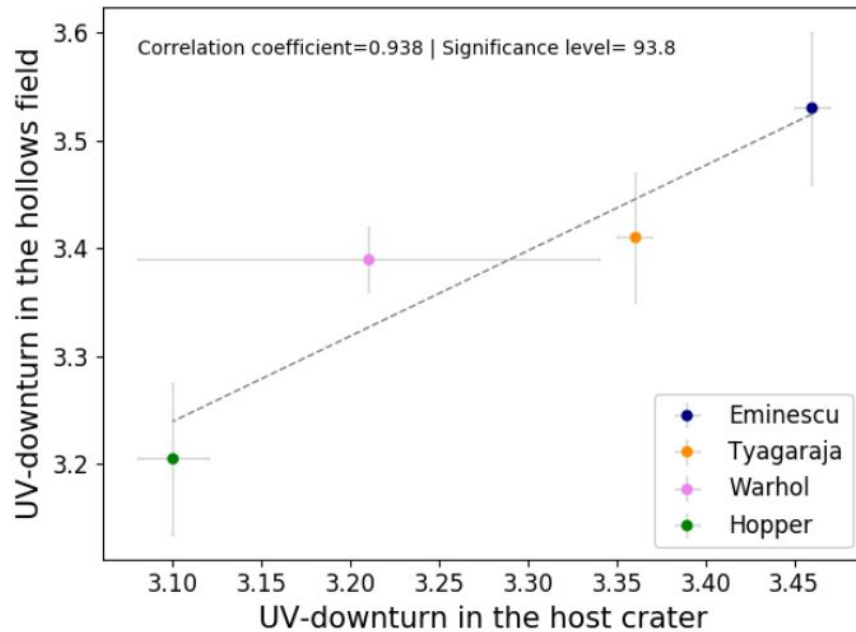
1. Search for absorption band and spectral analysis
2. Investigation of the geological context



Relation with host crater



Relation with host crater

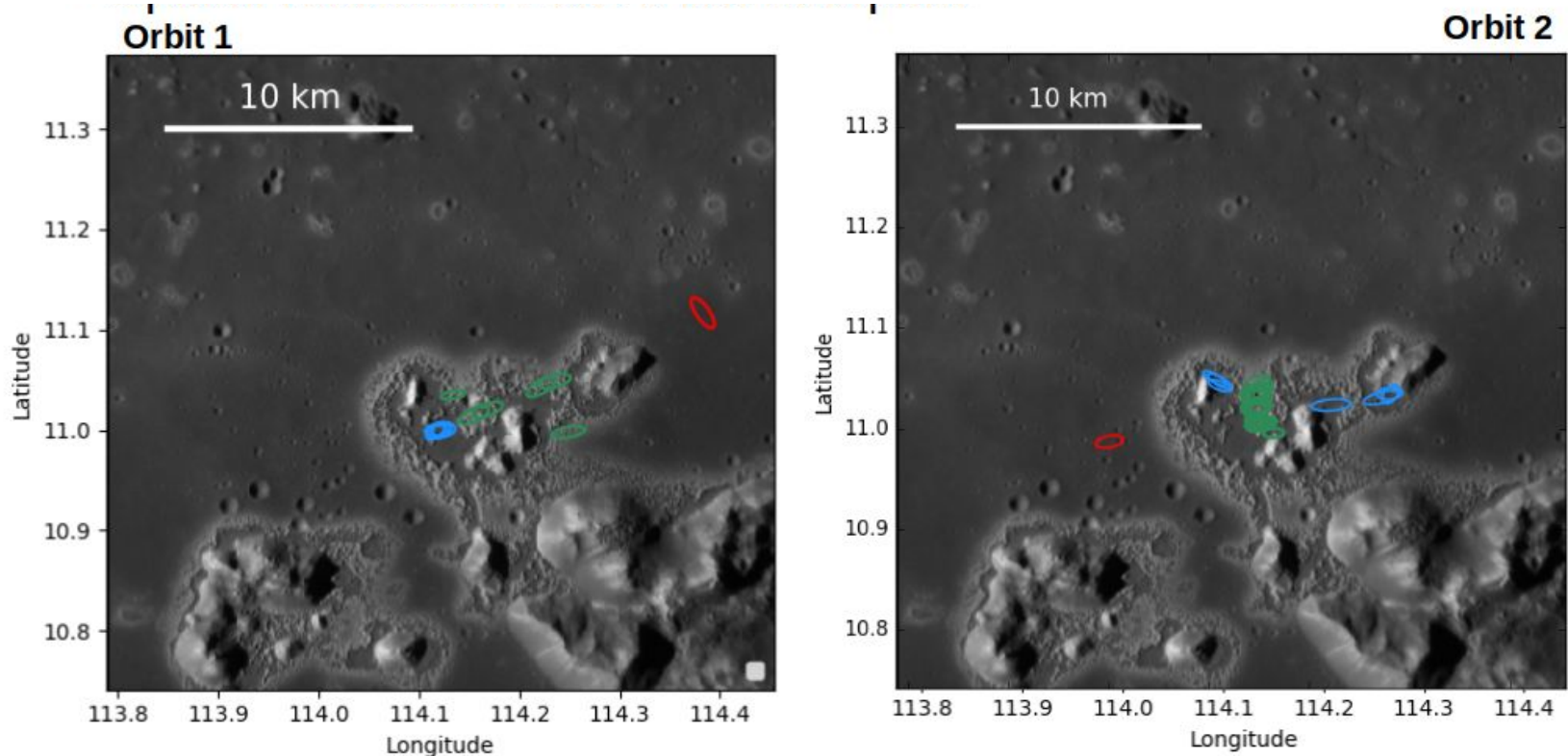


- Strong correlation with host crater in the UV domain
 - Mixing in the footprint
 - Physical/chemical relation

Detailed analysis



Eminescu impact crater floor

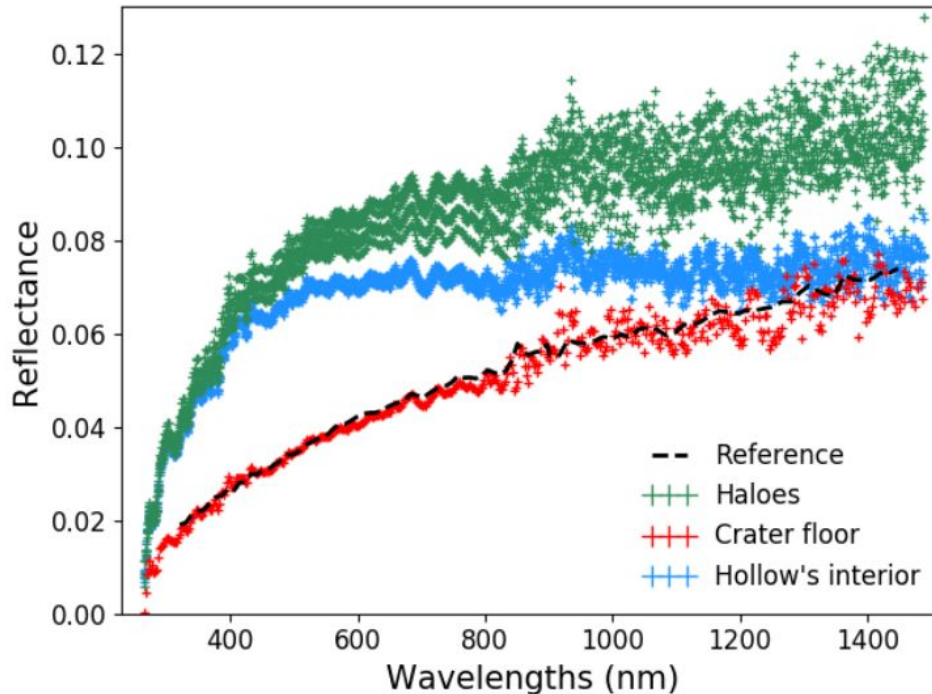


- 2 orbits (2014) with a suitable resolution to resolve hollows
- Spatial resolution : 0.2-1 km²/footprint

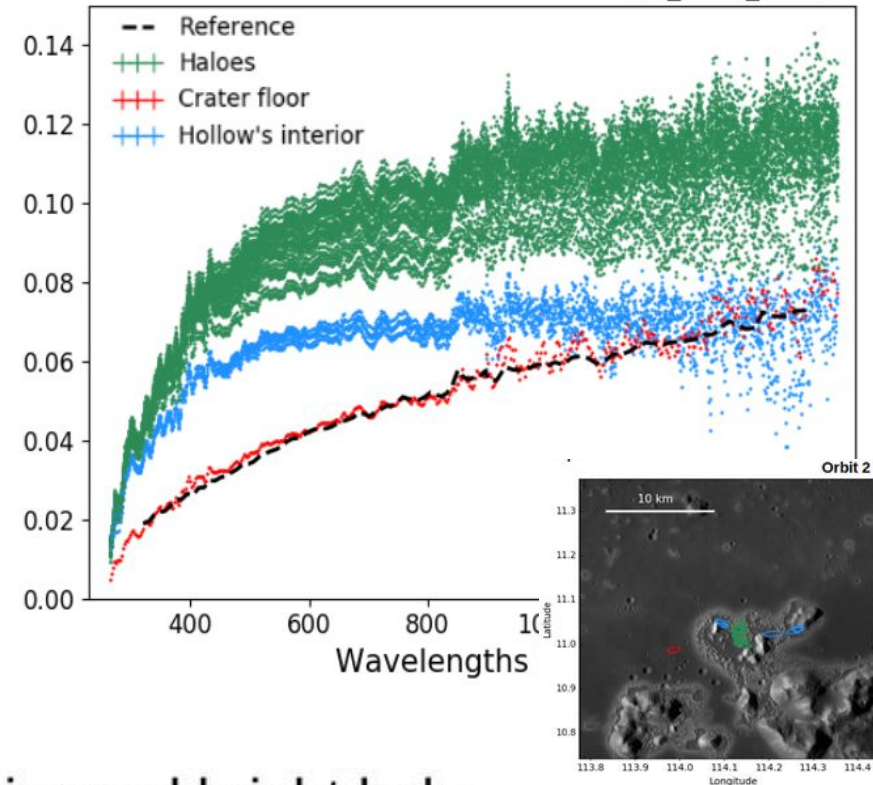
Detailed analysis



Orbit 1



Orbit 2



- Different spectra between interior and bright halo
- Crater floor close to the reference spectra (Izenberg et al., 2014)

Summary of findings



1. No spectral features observed with MASCS

Calibration errors, insufficient abundance, compositional variations in hollows

2. Strong relation between hollows and host crater

Mixing, grain size, composition

3. Differences between hollows interior and bright halo

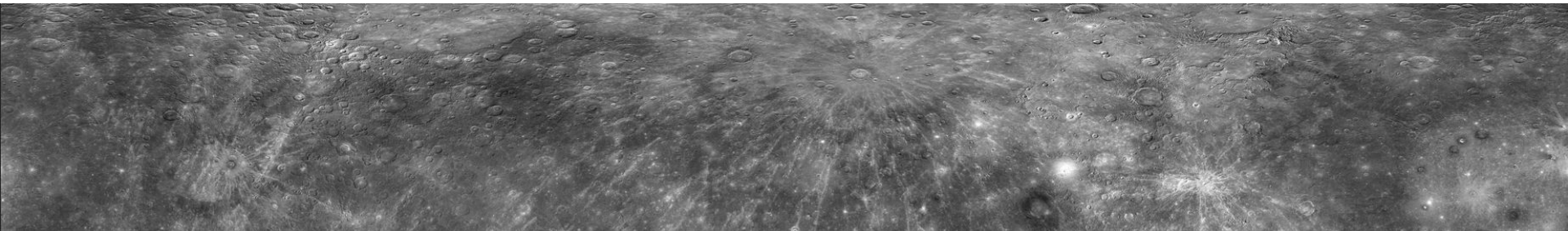
Consistent with a loss of a reddening component

Barraud, Doressoundiram and Besse (almost ready to submit)

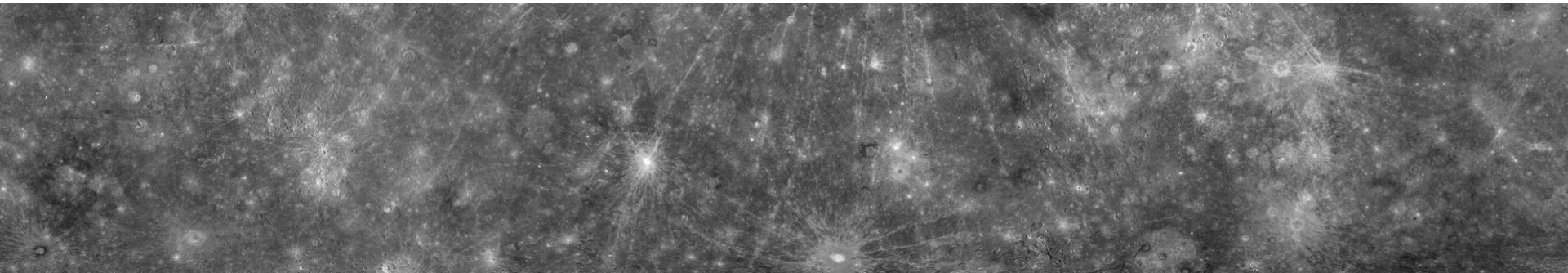


bepicolombo

BepiColombo is the only way to discriminate the effect of composition, grain size, mixing and maybe identify the volatile component !



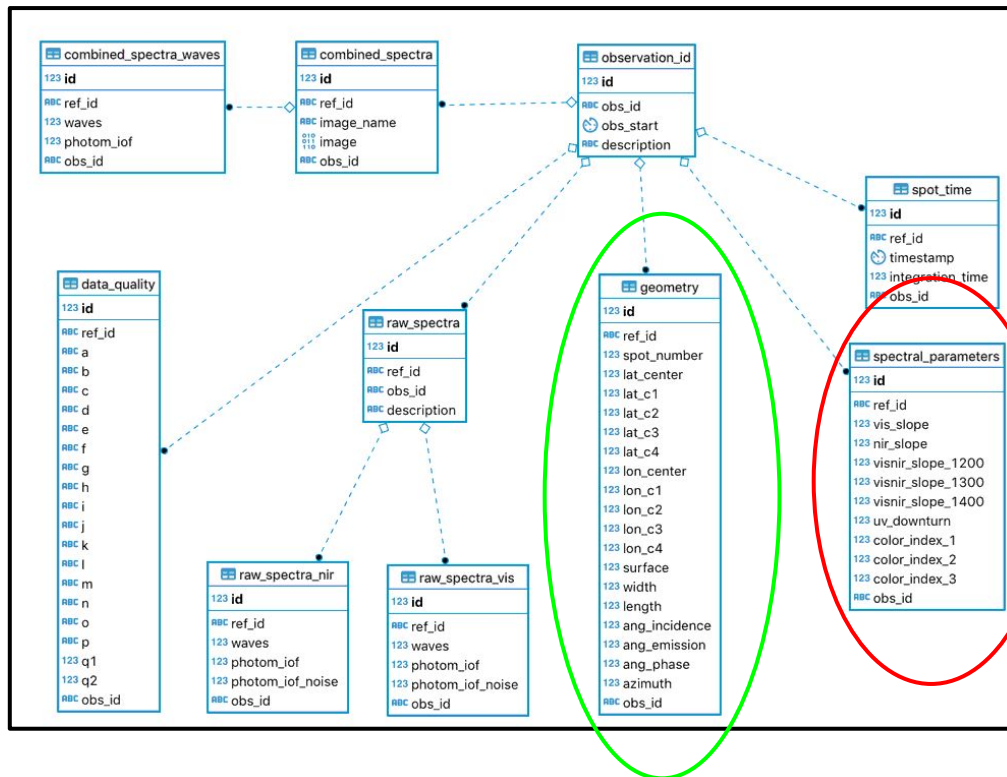
The spectral database



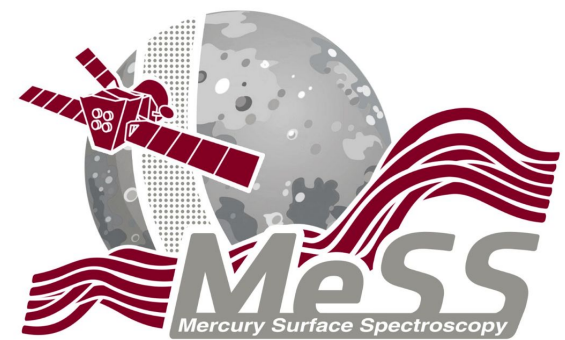
The MeSS project



All the observations done by the MASCS spectrometer onboard MESSENGER



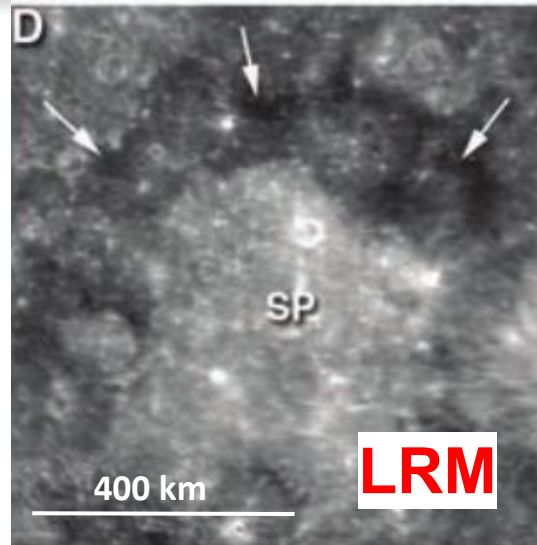
- + Metadata
- + Spectral Parameters
- + Quality Parameters



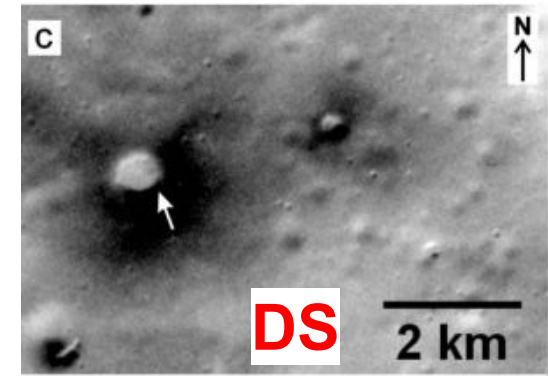
Geological unit on Mercury surface



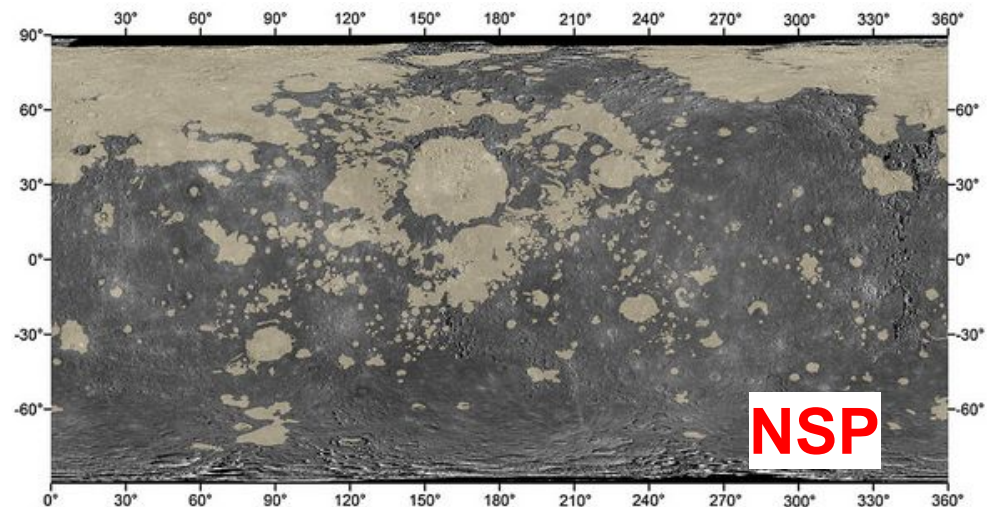
- Low reflectance material (LRM)
- Dark spots (DS)
- Hollows
- Faculae
- Northern smooth plains (NSP)



Robinson et al., (2008)

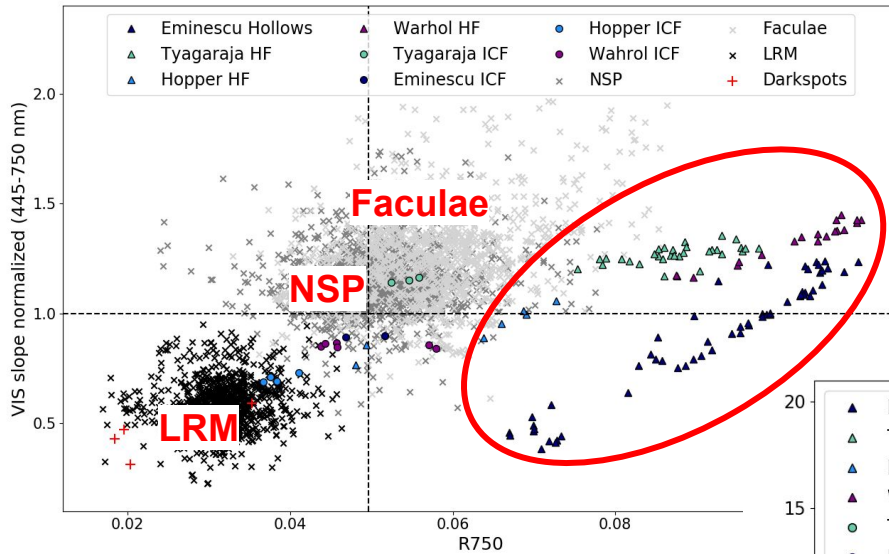


Xiao et al., (2013)



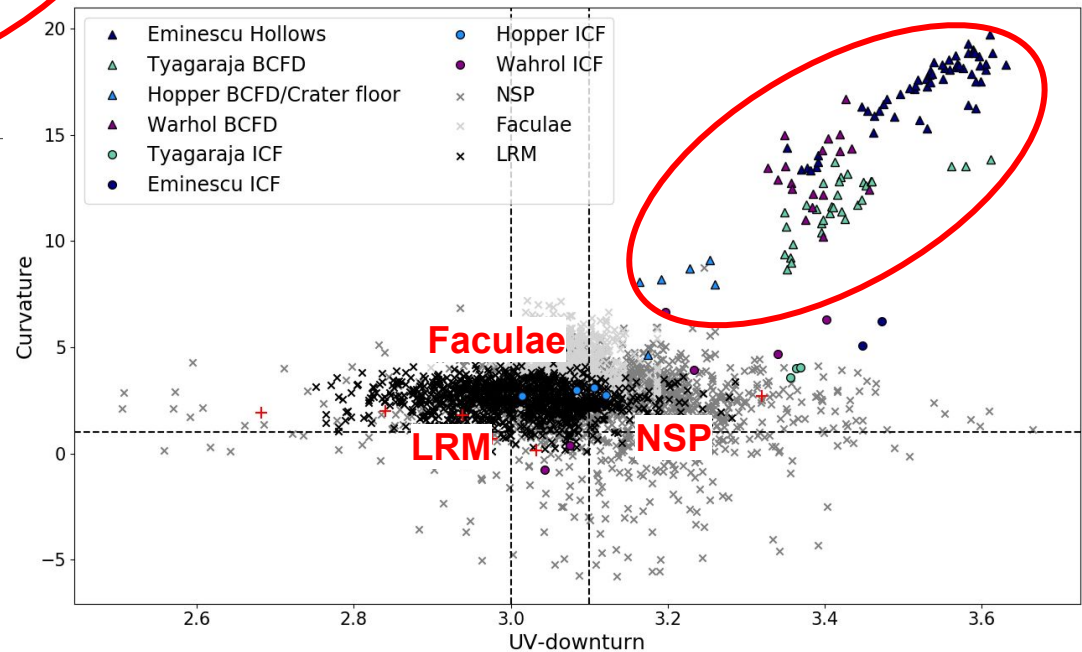
Denevi et al., (2013)

Comparison with hollows



- Hollows are different in the UV domain

- Not different in MDIS range of wavelengths

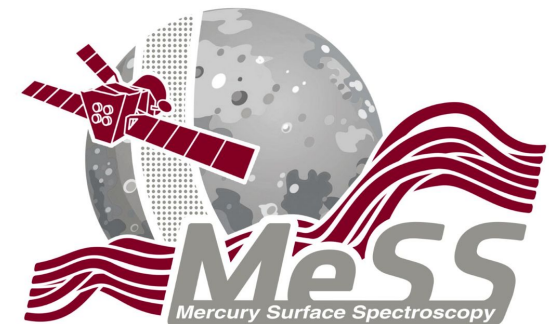
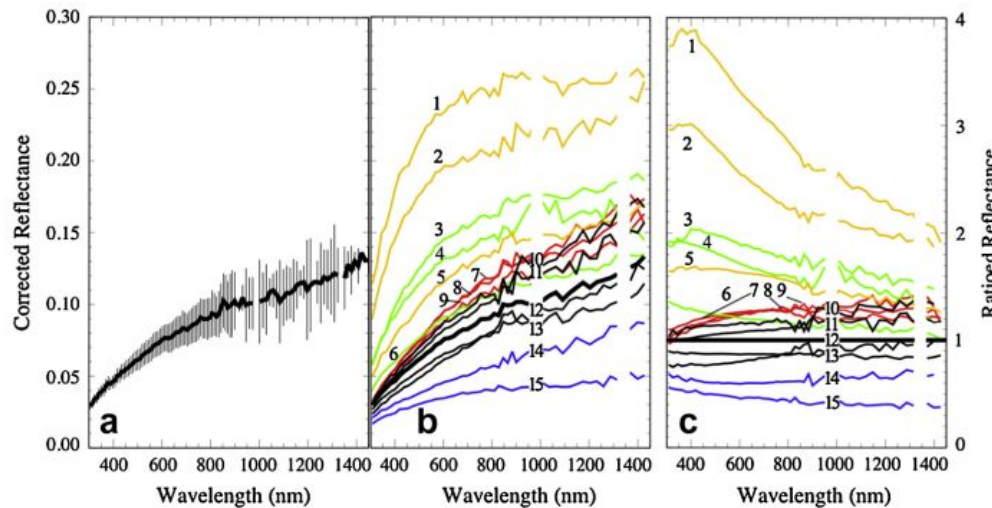


Our project (1)



Using the spectral Database to:

- **New mean spectrum of Mercury**
 - Quality parameters, data quality index (temperature), geometry...
- **Mean spectrum of each geological units**
 - LRM, NSP, PDs, DS, Hollows...



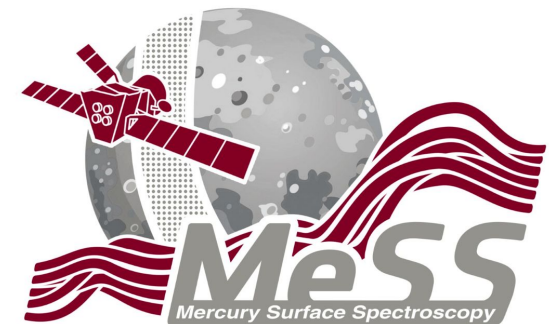
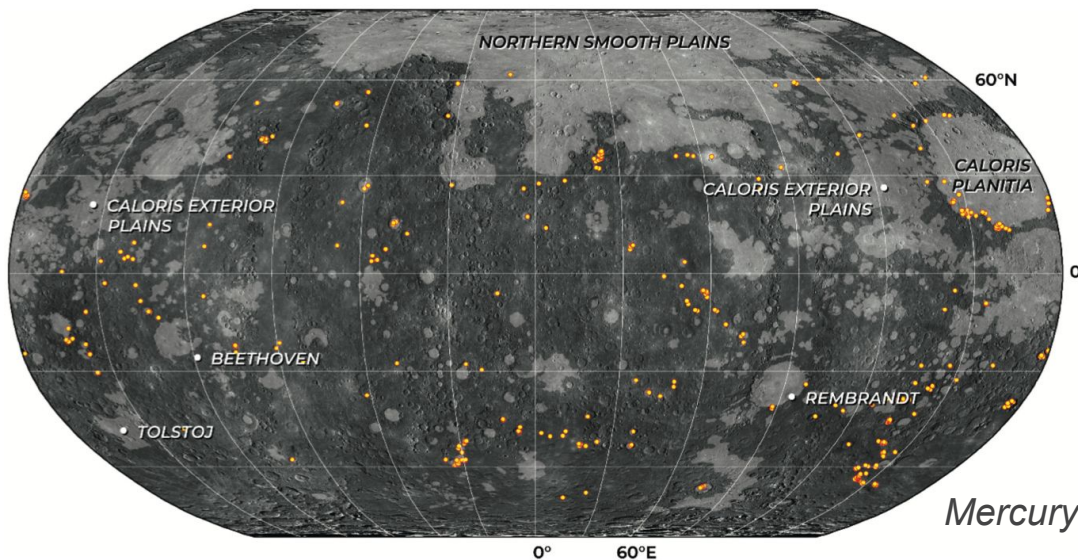
Izenberg et al., (2014)

Our project (2)



Using the spectral Database to:

- **Investigate volcanism on Mercury**
 - Radius of the more than 200 candidates previously define
 - Spectral properties of faculae
 - Search for new candidates (global)
 - Determine the surface of the volcanic deposits



Mercury: The view after MESSENGER

Output of the database



The MeSS project is a success and we have more than 4 million spectra to study!

Next steps:

- redefine the mean spectrum of Mercury
- Investigate the spectral properties of the geological units at a global scale
- Study volcanism and in particular explosive volcanism

MESSENGER to BepiColombo !!



bepicolombo

Acknowledgment:

- To the faculty council for the support: One paper almost submitted !
- Various persons at ESAC: **Sébastien Besse, Thomas Cornet and Claudio Munoz !**

