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

Océane Barraud\textsuperscript{1}, Alain Doressoundiram\textsuperscript{1}, Sébastien Besse\textsuperscript{2}, Claudio Munoz\textsuperscript{2} and Thomas Cornet\textsuperscript{2}.

\textsuperscript{1} LESIA, Observatoire de Paris, Meudon, France
\textsuperscript{2} ESA-ESAC, Madrid, Spain
Why Mercury?

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

Water Ice

Volcanism

Geochemical terranes

Introduction Hollows spectral analysis The MeSS project
What are hollows?
Mercury Surface

Mariner 10 highlighted bright patches on the surface of Mercury.

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

Fig. 2. Mercurian bright patches.

Introduction

D. Dzurisin (1977)

Hollows spectral analysis

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

Robinson et al., (2008)

Blewett et al., (2011)
Hollows

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

Introduction

Hollows spectral analysis

The MeSS project
Hollows

Geological settings:

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

Blewett et al., (2011)

Introduction

Hollows spectral analysis

The MeSS project
Hollows spectral features

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

Blewett et al., (2013)

Introduction
Hollows spectral analysis
The MeSS project
Hollows spectral features

- None expected absorption band between 558 and 828 nm.
Hollows spectral features

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

Lucchetti et al., (2018)
Our Analysis

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

<table>
<thead>
<tr>
<th></th>
<th>Spatial resolution</th>
<th>Spectral resolution</th>
<th>Spectral range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MDIS</strong>*</td>
<td>8 m to 7 km per pixel</td>
<td>around 60 nm</td>
<td>433 - 1012 nm</td>
</tr>
<tr>
<td><strong>MASCS</strong>**</td>
<td>0.1<em>3 km to over 6</em>7 km</td>
<td>5 nm</td>
<td>300 - 1400 nm</td>
</tr>
</tbody>
</table>

*MDIS: Mercury Dual Imaging System

**MASCS: Mercury Atmospheric and Surface Composition Spectrometer.

---

**Introduction**

**Hollows spectral analysis**

**The MeSS project**
Hollows observations with MASCS

Introduction

Hollows spectral analysis

Tyagaraja

Eminescu

Hopper

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

Absorption Band?

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

UV downturn

Curvature

VIS-Slope

VISNIR-Slope

Wavelengths (nm)

Reflectance

Introduction

Hollows spectral analysis

The MeSS project
Our Analysis

1. Search for absorption band and spectral analysis
2. Investigation of the geological context
Relation with host crater

Hollows spectral analysis

The MeSS project
- Strong correlation with host crater in the UV domain
  Mixing in the footprint
  Physical/chemical relation
Detailed analysis

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

Eminescu impact crater floor
Detailed analysis

Orbit 1

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

Orbit 2

Introduction
Hollows spectral analysis
The MeSS project
Summary of findings

1. No spectral features observed with MASCS
   Calibration errors, insufficient abondance, 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 lost of a reddening component

Barraud, Doressoundiram and Besse (almost ready to submit)

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

The MeSS project
Comparison with hollows

- Hollows are different in the UV domain
- Not different in MDIS range of wavelengths

Introduction  Hollows spectral analysis  The MeSS project
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
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 !!

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