

## SPECTRAL UNITS IDENTIFICATION IN THE H05-HOKUSAI QUADRANGLE ON MERCURY.

F. Zambon<sup>1</sup>, C. Carli<sup>1</sup>, J. Wright<sup>2</sup>, D. A. Rothery<sup>2</sup>, F. Altieri<sup>1</sup>, M. Massironi<sup>3,4</sup>, F. Capaccioni<sup>1</sup> and G. Cremonese<sup>4</sup>

<sup>1</sup>INAF-Istituto di Astrofisica e Planetologia Spaziali, Via del Fosso del Cavaliere, 100, I-00133 Rome, <sup>2</sup>The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK, <sup>3</sup>University of Padua, Department of Geoscience, Via Gradenigo 6, I-35131 Padua, Italy, <sup>4</sup>INAF - Osservatorio Astronomico di Padova

**Introduction:** The study of Mercury's surface received a considerable boost after the MESSENGER mission [1]. The Dual Imaging System (MDIS) covered the whole of Mercury [2], in particular MDIS-Wide Angle Camera (WAC) revealed plenty of color variations, in some cases linked with compositional diversity [3].

The surface of Mercury has been divided into 15 quadrangles. The Hokusai (H05) quadrangle is in Mercury's northern mid-latitudes (0–90°E, 22.5–65°N) and covers almost 5 million km<sup>2</sup>, or 6.5%, of the planet's surface. A previous detailed geological study by [4] identifies several morpho-stratigraphic units in H05, e.g., the northern smooth plains of Borealis Planitia (the most extensive unit in H05), other smooth plains, intercrater plains, intermediate plains, and localized features such as crater materials (classified on the basis of their degradation state), crater rays and faculae, often associated with putative explosive volcanic vents.

Here we show a follow up of [5, 6], investigating the global spectral properties of H05 through the identification of spectral units (SUs). This approach allows not only for a more comprehensive view of the spectral properties of the materials in H05, but at the same time makes possible a comparison with the morpho-stratigraphic units, laying the groundwork to create new integrated products, we call “geostratigraphic” maps.

**Data and Methods:** We considered the data acquired by the MDIS-WAC [2], and publicly available at the Mercury Orbital Data Explorer (ODE: <https://ode.rsl.wustl.edu/mercury/>). MDIS-WAC was equipped with 11 filters, covering a range of wavelengths between 430 and 1000 nm. Global coverage of Mercury surface was acquired with 8 of the 11 filters available. Here, we used the same 8-color mosaic already considered by [5]. Based on Mercury spectral characteristics, we derived a suitable set of parameters: the reflectance at 750 nm (R750) and the spectral slopes between 430 and 560 nm (Slope I - SI), and between 750 and 1000 nm (Slope II - SII) plus a global slope (GS) covering the 430 and 1000 nm spectral range. We calculated the spectral parameters using the method illustrated by [7, 8]. R750 is particularly useful to identify morphological units and bright and dark material. GS is useful to study the

terrain maturity, often linked to space weathering effects [9], and it is a powerful parameter to identify bright fresh ejecta and crater ray materials. SI is useful for distinguishing opaque mineral phases [10, 11, 12] associated with low-reflectance material (LRM), and to identify regions with volcanic origin, e.g., Borealis Planitia, faculae, and vents, characterized by high SI values. Lastly, since many mafic minerals have a 1 μm absorption band, negative or low SII values could indicate the potential presence of this absorption feature. This set of parameters reveals the main spectral properties of H05 obtained with MDIS-WAC data, therefore they are suitable to retrieve H05 SUs.

**Spectral Unit definition:** We define SUs by thresholding the value of each spectral parameter into six intervals: Very Low (VL), Low (L), Intermediate Low (IL), Intermediate (I), Intermediate High (IH), High (H) and Very High (VH) values. Then, we did all the possible combinations for the four selected parameters, merging together the units with similar characteristics. We obtain spectral units conveying at the same time the spectral information carried out by all the parameters, facilitating the understanding of Mercury's surface spectral properties.

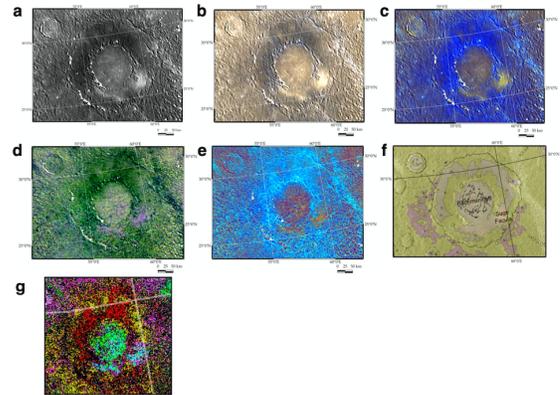
**Results:** We identified 11 SUs in H05. Some of these units are widespread across the quadrangle and in some cases partially associated with the morpho-stratigraphic units. Among the 11 spectral units, 4 are within the northern smooth plains, demonstrating spectral variations within Borealis Planitia. Another unit characterizes the rays material, and includes the two major ray systems of the quadrangle: Hokusai crater ejecta, which covers large part of the western side of H05, and the rays of Fonteyn crater. The different spectral characteristics of Borealis Planitia and the large area covered by the Hokusai rays, generate a clear western-eastern dichotomy across H05. We also identified localized SUs, mainly associated with Nathair and other faculae, and LRM within Rachmaninoff Basin (RB) (fig. 1a), which show peculiar compositional characteristics. Furthermore, we found small localized SUs linked with bright fresh crater material and distributed across the quadrangle.

In fig. 1, we show one of the most significant examples of SUs in H05, located in RB. RB floor annulus between the inner and outer peak-rings is characterized by LRM, and pyroclastic deposits called

“Suge Facula”, visible in the south-eastern side of the annulus. The spectral units identified in this region are evident in fig. 1g. The red unit dominates the annulus and corresponds with the most prominent LRM area of the quadrangle. This region is characterized by low reflectance and SI and GS values, and has spectral opposite behavior with respect to the cyan unit, associated with Suge Facula. The differences between these units are also evident in the RGB color composite mosaics of fig. 1b, c, d, e. While the morpho-stratigraphic map in fig. 1f indicates Suge Facula as a surficial feature and shows two different main units one associated to the floor and another one to the surrounding regions. The internal floor (green unit) displays intermediate spectral properties, while the external terrains have the spectral characteristics of the intercrater plains and intermediate plains.

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**Fig. 1:** **a)** Reflectance map at 750 nm of RB. **b)** RGB false color mosaic: R: 996 nm, G: 750nm, B: 430 nm. **c)** RGB “Enhanced Color” mosaic, R: PC2, G: PC1, B: 430/1000 nm. **d)** RB RGB “Spectral Slope” color composite mosaic”: R: GS, G: SII, B: SI. **e)** RB RGB “Clementine-like” color composite mosaic: R: R(750 nm)/R(430 nm), G: R(750 nm)/R(830 nm), and B: R(430 nm)/R(750 nm). **f)** Morpho-stratigraphic map of RB. **g)** Spectral unit map of RB.