EPSC Abstracts
Vol. 11, EPSC2017-188-2, 2017
European Planetary Science Congress 2017

Spectral clustering reveals similar behavior between Mercury's hollows

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Introduction

The Mercury Dual Imaging System (MDIS, [1]) onboard NASA MESSENGER (MErcury Surface, Space ENvironment, GEochemistry, and Ranging) spacecraft, provided high-resolution images of Mercury surface showing that specific areas exhibiting high reflectance and relative bluer colors were composed of shallow, irregular and rimless, flat-floored depressions with bright interiors and halos, often found on crater walls, rims, floors and central peaks [2,3,4]. These features were named "hollows": they are fresh in appearance and may be actively forming today via a mechanism that involves depletion of subsurface volatiles [2,5]. Understanding the composition of these features provides additional information on Mercury's surface characterization. Therefore, we decide to perform a spectral clustering on different hollows located on the surface of Mercury. The approach was previously applied to the Dominici crater's hollows bringing successful results [6]. In this work we use the same technique to characterize other hollows cases and, specifically we study an unnamed crater located in the south-eastern corner of the Victoria quadrangle (Fig. 1).

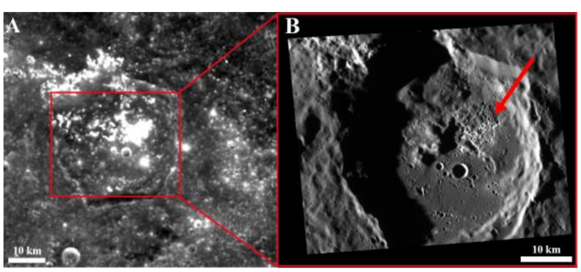

Figure 1: A: the WAC image (EW1017269227D) showing the crater under study (center latitude = 25.62°N, center longitude = -3.4°W). B: the NAC image (EN1022224039M) showing hollows in the center of the crater (red arrow).

1. Method

The MDIS imager was equipped with a monochromatic narrow angle camera (NAC), and a multiband wide angle camera (WAC), used to investigate the surface composition. Here we used the WAC dataset covering the unnamed crater with a scale of 260 m/pixel through eleven filters, ranging from 0.433 to 1.012 μm.

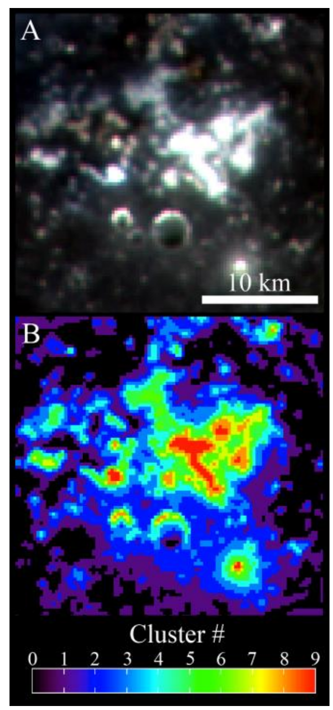

Figure 2: Above it is shown close up of the WAC reference image showing hollows (EW1017269227D), while below are reported the 10 clusters identified on the MDIS dataset.

The images have been photometrically corrected with Hapke methods [7], using the parameters derived in [8], i.e. incidence angle of 30°, emission angle of 0° and phase angle of 30°. On the photometrically corrected dataset we applied a statistical clustering over the entire dataset based on a K-means partitioning algorithm [9]. It was developed and evaluated by [9-11] and makes use of the Calinski and Harabasz criterion [12] to find the intrinsically natural number of clusters, making the process unsupervised. A natural number of ten clusters was identified within the crater and its closest surrounding, see Fig. 2. Each resulting cluster is characterized by an average multi-color spectrum, and its associated variability. This approach has been previously applied for compositional interpretation of different Solar System objects, e.g. asteroids, Mars, Phobos and Iapetus [11, 13, 14, 15]. The algorithm is agnostic of the physical meaning of the resulting clusters, and scientific interpretation is required for their subsequent evaluation**.**

2. Results and Future works

The application of the spectral clustering technique provides similar results to the previously analysis regarding the Dominici crater [1]. Indeed, we found that hollows clearly present a wide absorption band between 0.558 and 0.828 µm that could be a possible diagnostic absorption indicative of sulfides (as reported in [6, 16]), and a hint of absorption towards the IR (Fig. 3). The application of the clustering technique permits to study in deeper detail the spectral differences characterizing craters hosting hollows. In particular by means of this method, we can correlate different spectral units with well-defined geomorphological ones. Therefore, the next step is to perform detailed geomorphological maps of the features under study in order to make a comparison with the spectral clustering results. In addition, we are studying other craters hosting hollows in order to find if these features exhibit similar spectral behavior all over the planet surface.

Acknowledgements

This activity has been realized under the BepiColombo ASI-INAF contract no.I/022/10/0. M. Pajola was supported for this research by an appointment to the National Aeronautics and Space Administration (NASA) Post-doctoral Program at the Ames Research Center administered by Universities Space Research Association (USRA) through a contract with NASA.

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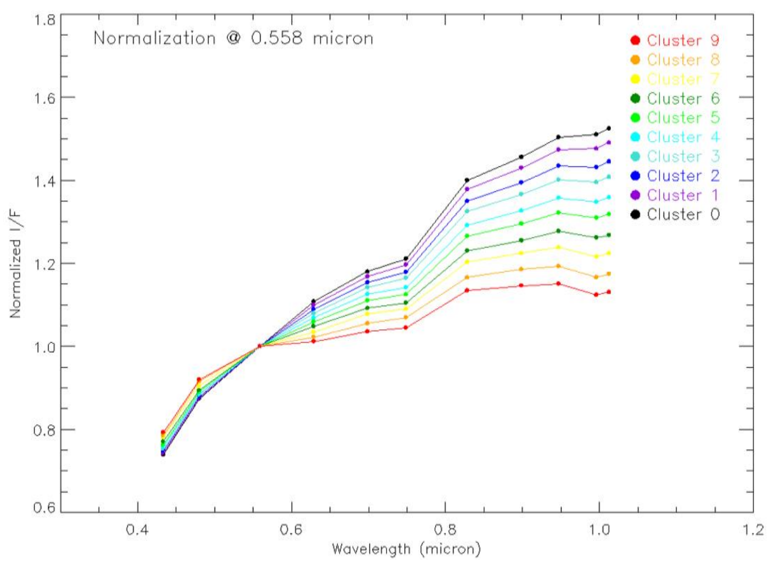

Figure 3: The average normalized spectra derived on all the identified clusters. Colors refers to Fig. 2. The legenda shows the cluster # and its not normalized I/F value at 0.558 µm