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Hollows and their relationship with geochemical terrains

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1. Introduction

One of the most surprising discoveries revealed by the MESSENGER (Mercury Surface, Space, Environment, Geochemistry, and Ranging, [1]) spacecraft was the presence of shallow irregular and rimless flat-floored depressions with bright interiors, called hollows, at the Mercury surface. These features are widespread on the surface of the planet [2-4] and since they are fresh in appearance, they may be actively forming today via a mechanism that could involve depletion of subsurface volatiles [2-4], whose nature is not yet known. In this work, we want to characterize in deeper detail the behaviour of hollows located in three different craters, applying a spectral clustering technique [5] to understand if there are similarities among them from a compositional point of view.

2. Dataset and Methodology

We chose three different craters hosting hollows: (i) the **Dominici crater** (1.38N, 323.5°E, Kuiper quadrangle) with a diameter of 20 km [6]; (ii) an **un-named crater** (25.62°N, -3.4°W, Victoria quadrangle) with a diameter of 25 km; (iii) the **Velazquez crater** (37.74°N, 304.77°E, Victoria quadrangle) with a diameter of 128 km. For each crater, we chose a WAC dataset of different filters in order to apply a spectral clustering technique based on a K-mean algorithm [7-9]. This allows us to separate our studying area in clusters (as reported in [5]), each one characterized by an average multi-color spectrum and its associated variability, as shown in Fig. 1.

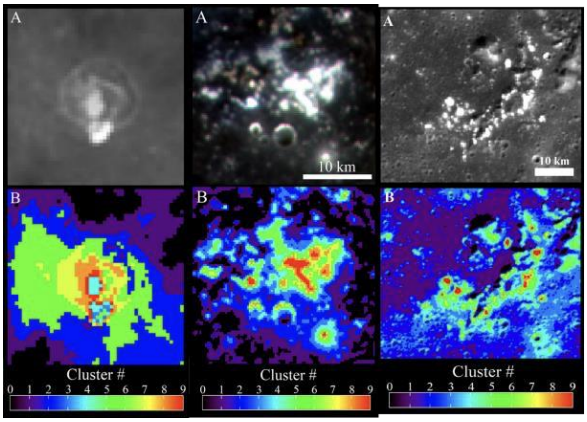


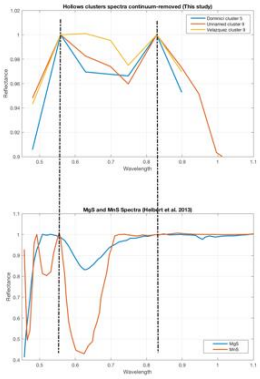
Fig. 1. *A:WAC reference images (EW0210848973D) (EW1017269227D) (EW1020781879D) for Dominici, un- named and Velazquez crater respectively. B: The relative 10 clusters identified in the MDIS datasets.*

3. Results

From the clusters' spectra we managed to separate areas associated to hollows from both the surroundings and intermediate terrains. Within all craters, we were then able to identify a unique hollows' representative spectrum that is characterised by a wide absorption band between 0.558 and 0.828, with a possible hint of absorption towards 1 μm (top of Fig. 3). Our analysis suggests that the spectral behavior of hollows cannot be explained by sulfides alone (CaS, MnS and MgS, [10]), as reported from the comparison between spectra in Fig. 3. Even if the mechanism forming hollows likely involves the loss of volatiles from the surface, we have to take into account other minerals that could be in part responsible of the absorption. In this context, we consider bedrock-forming material contributing to the spectral identified hollow behavior, in particular pyroxene presenting transitional elements (Cr and Ti) and clynopyroxenes in which Ni is substituting Mg (Ni-diopside) [11,12] seem to be particularly well suited.

Figure. 3 *On top the continuum removed hollows spectra found in our crater cases, while on bottom left the continuum removed MgS*

and MnS spectra reported in [10], which are already cited candidates for hollows composition in literature. The comparison shows that sulfides alone cannot be considered as the only responsible of the absorption found in hollows spectra.



4. Conclusion and future work

In this work we suggest that hollows terrains are the expression of both the remnant material coming from a process that involve degassing and the bedrock-forming material in which they formed. Indeed, all the considered hollows show a similar spectral behaviour, suggesting that their location is not strictly associated to the presence of a particular element. In order to understand if the 0.558 and 0.828 μm band is present on all hollows, independently from the location, the next step will be the analysis of other hollows features located in the high rich Mg-region [13]. Here, 80 hollows groups were previously found [4]. We are currently investigating them in order to understand if the presence of Mg in high concentration within the bedrock could affect the hollows' spectral behaviour in that region.

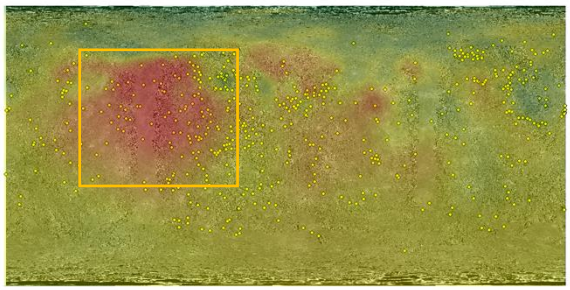


Figure 4*: High Mg-region [13] highlighted by the orange square on Mercury basemap. Yellow dots are the location of hollows group as reported by [4].*

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