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Geologic and spectral surface properties of outflowed impact melt on Mercury

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Abstract

On the basis of the interpretation of the latest Mercury Dual Imaging System (MDIS) Narrow Angle Camera (NAC) images from the MErcury Surface, Space ENvironment, GEochemistry and Ranging (MESSENGER) Mission, we have studied the characteristics of outflowed impact melt on Mercury. After chosing two cases of study, Kuiper crater (30 W; 11 S) [1,2] and the so-called "Blue Tongue" crater (106 W; 9 S), we have compiled a geologic map of the two samples trying to clarify first of all their morphologic and stratigraphic context. Since both the craters show a certain amount of outflowed melt, it was possible to perform a calculation of the maximum distance reached by the impact melt (from the rim crest) and compare these values with similar studies made on Lunar and Mercurian analogs. [3,4,19] These two craters also represent a great opportunity for studying the influence of space weathering on the surface of Mercury [5-15]. In order to understand if any kind of compositional differences between impact melt and surrounding surface deposits exist, we have analyzed the Mercury Atmospheric and Surface Composition Spectrometer (MASCS) data from MESSENGER. We normalized all the spectra at 700 nm, managing to strongly reduce phase angle effects. This procedure allowed us to create a cluster map of the global surface of Mercury, which showed the occurrence of two Mega-Regions with different spectral properties. On a local scale, we have also observed spectral variations over of both the examined craters. Spectral differences on the surface of Mercury may represent real compositional heterogeneity or may be caused by other factors that obscure the underlying mineralogy, such as space weathering, thermal processing, or other physical effects. However, the comparison between visual and spectral data seems to suggest that the variations represent compositional differences.

1. Introduction

The MESSENGER Mission is continuously providing new insights about geologic and compositional features of Mercury, unveiling some of its peculiar surface properties and differences from the Moon. We have analyzed the main properties of outflowed melts on two cases of study on Mercury. Our study is divided in two parts: the first part, focused on the interpretation of MDIS NAC images, is intended to clarify the morphologic and stratigraphic frame of Kuiper crater and "Blue Tongue" crater on Mercury. By using ArcGIS, we compiled a geologic map of the two areas of interest. On the basis of the comparison with lunar analogs [3,4], we have also calculated the ratio between the maximum distance reached by the outflowed impact melt from the rim crest (D) and the radius (R) of the crater itself (D/R ratio). The second part of our work is instead devoted to highlighting the spectral background of Mercury both under a global and local (over the two locations of interest) scale.

2. MDIS mapping

The morphologic and stratigraphic mapping of Kuiper crater and Blue Tongue crater showed a strong influence of the pre-existing topography over the present geologic context. Both the craters are located on the rim of an older impact crater that may have affected the slope direction of the outflowing melt. The Blue Tongue crater's outflowed impact melt is relatively dark and seems to be very well distinguished from the brighter surrounding surface deposits, while Kuiper crater's impact melt does not show the same contrast in albedo. Kuiper crater and Blue Tongue crater are characterized by a D/R value of respectively 2,4 and 3,1, which is much higher than the D/R value previously calculated for same sized craters on the Moon [3,4].

These results indicate that impact melt on Blue Tongue and Kuiper crater tends to flow much farther than any other outflowed melt so far observed on the Moon [3,19].

3. MASCS data analysis

3.1 Global scale cluster map

In order to facilitate a comparison between MDIS visual observations and MASCS spectral data, we created from the MASCS observations a global data set corrected for phase angle effects using normalization. We could thus create a global cluster map of Mercury, which groups all the spectra in primarily two Mega-Regions containing two very distinctive spectral classes.

3.2 Local scale MASCS coverage

The local analysis of the MASCS coverage over Kuiper crater [16] and Blue Tongue crater seems to confirm the consistency between observational interpretation and surface spectral properties. Blue Tongue's impact melt, comparatively dark, is also spectrally differentiated from its surrounding deposits. Kuiper crater's MASCS coverage is lower, but still enough for distinguishing its central peak as a distinctive reddish spectral unit (FIG. 1).

4. Outlook

The geologic study of Blue Tongue crater and Kuiper crater demonstrated that their impact melt was able to flow for longer distances than observed on the Moon for same sized craters [3,19]. While we tend to exclude that the observed spectral heterogeneities of Blue Tongue's impact melt can be due to space weathering effects (the stratigraphic interpretation is not consistent with this hypothesis), at least two other possibilities could be considered to explain the observed situation: the dark appearance of Blue Tongue's impact melt may be due to compositional differences with the surrounding deposits or due to textural chenges during the cooling process (thus keeping the same composition). At the present state we are still not able to clearly favour one possibility over the other.

Kuiper crater's central peak is in contrast characterized by a very distinctive reddish spectrum: we consider this as an evidence of compositional differences of the central peak with respect to the surrounding deposits. This idea is also well supported by the mechanics of formation of impact craters, where in fact central peaks usually ascend from greater depths. Our ongoing laboratory measurements [17,18] will tell us something more about Mercury's surface composition, helping us to understand if and how compositional heterogeneities can affect the surface reflectance: we are constantly improving our datasets to answer the many still standing questions.

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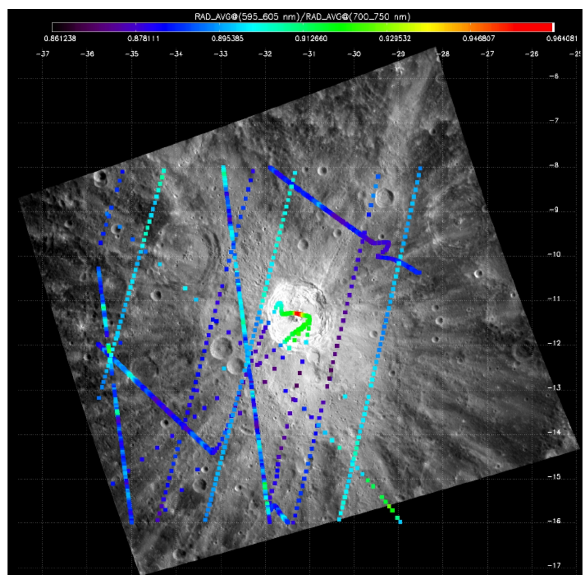

FIG. 1 – Kuiper Crater (30 W; 11 S). Colored MASCS footprints show the ratio of reflectance at 585-605 nm to that at 700-750 nm wavelengths; background is Mercury Dual Imaging System Wide-Angle Camera image EW0223443634I