CRATER-RELATED SURFACE MORPHOLOGIES OF THE IKAPATI CRATER, CERES.

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Introduction: Ceres is the largest planetary body in the asteroid belt and the only dwarf planet in the inner solar system. Ceres is suggested to have an ice-rich mantle [1–3]. A growing body of morphological evidence suggestive of subsurface ice has been discovered on Ceres, including large-scale viscous relaxation of craters [4], smooth hills, known as tholi, of possible cryovolcanic origin [5], crater-related lobate material indicative of ice-cemented flows [6], and crater-related pitted terrain [7,8]. Crater-related pitted terrain, interpreted as volatile-rich impact melt, has recently been documented at 4 Cerean craters [7], and was previously documented on Mars [8] and Vesta [9]. The pits are suggested to be the result of rapid degassing of volatiles [10] within and/or in contact with impact melt-rich deposits [8]. Dissected material is interpreted to be flowing impact melt devoid of pits and has been documented on Mars [8]. However, it is unknown whether dissected terrain on Mars is the result of flowing impact melt or liquid water. The occurrence of dissected and pitted terrain on Ceres may provide insight into dissected materials on Mars.

The spatial relationships of pitted and dissected materials within and around impact craters on Ceres has yet to be studied in detail. The purpose of this project is to map the distribution of the pitted and dissected materials and ejecta of the Ikapati crater (45.5°E, 22.8°N) and identify various facies among ejecta deposits. The overarching goal is to determine if the spatial distributions of pitted and dissected materials and associations with other units/facies are consistent with them being impact melt bearing deposits. In turn, these mapping results will provide insight into (1) the relationships between ejecta facies and cratering processes, (2) ejecta emplacement mechanisms, and (3) the effect and role of volatiles during the impact process.

Methods: The Dawn spacecraft entered Ceres orbit in March 2015. The Framing Camera (FC) on board images the surface of Ceres from a high-altitude mapping orbit (HAMO; 140m/pixel) and low-altitude mapping orbit (LAMO; 35m/pixel) [11]. Clearly defined units and facies were able to be defined at the Ikapati crater with the use of LAMO images of the Cerean surface coupled with topographic and slope data derived from HAMO.

Results and Map Explanation: We mapped 4 morphologic units and 3 facies, including, pitted, dissected, and smooth facies (Fig. 1). Here the units are presented in stratigraphic order.

Unit 1 can be differentiated from the surrounding cratered terrain by its relative lack of superposed craters and its relatively muted and in some cases scoured appearance in LAMO images. The extent of these units is outlined. *Interpretation: Unit 1 is composed of the continuous, ballistically-emplaced ejecta blanket.*

Unit 2 is characterized by its rough and hummocky surface texture. It is predominantly found where slope is between 5° and 15° which occurs at the central uplift, the northeastern portion of the crater floor and around crater rim and other basin rings. It is in direct contact with and grades into unit 3 and consists of dissected facies (Fig. 2). The dissected facies occurs where there is an indication of overland flow by unit 3 materials (Fig. 2). *Interpretation: Unit 2 likely represents a mixture of hummocky ejecta and pre-existing target material with impact melt flowing over it.*

Unit 3 consists of smooth, slightly hummocky and sporadically pitted material that covers approximately 3,830 km^2 of the surface. It is often confined to partially to fully enclosed local topographically low regions and roughly approximates an equipotential surface (i.e., ponds) (Fig. 1). Unit 3 is predominantly found within the crater interior and extensively external to the crater rim to the west and southwest where it flows into and fills pre-existing craters (Figs 1 & 2). It overlies units 1 and 2. We divide Unit 3 into smooth and pitted facies (Fig. 1). Smooth facies are the most common and represent a flat near equipotential surface drastically lacking in superimposed craters when compared to the surrounding terrain. Pits are found in clusters and are characterized as nearly rimless depressions with round-to-irregular margins that overlap [7-9]. Pits are larger and more obvious inside the crater, but are also readily identified in the surrounding terrain beyond the crater rim. *Interpretation: The spatial distribution and behavior with its surrounding units are consistent with Unit 3 being ponded and flowing pitted impact melt-bearing deposits [7-9]*.

Unit 4 is characterized by mass wasting and terraced material which occurs where a part of the crater rim is breached in the northeast and southeast resulting in a mixture of terraced, slumped, and hummocky material (Fig. 1). *Interpretation: Unit 4 represents the slump and terrace materials in the crater interior.*

Discussion: The regional slope decreases northwards; however, several degraded large craters, outlined for reference, create topographic depressions to the west of Ikapati. It is suggested that impact melt was preferentially emplaced outside of rim breaches to the west and southwest and continued to flow based on regional slopes where they accumulated in low-lying pre-existing features, such as older craters.

Impact melt facies, and the presence or lack of pitting, provide evidence of differences in velocity and turbulence during melt emplacement [see Figs. 12 & 13 in 8]: (1) Pitted facies indicate little to no movement allowing for volatile degassing to take place and pits to form, (2) Dissected and some smooth facies indicate high flow velocities where pits could not form, and (3) The pitted and smooth facies that exist on the same deposit may indicate a complex thermal history of the unit as a whole or an uneven subsurface topography creating preferential pathways for volatiles to degas.

Future Work: Mapping is ongoing. Units will be further divided to provide a clearer more detailed map. For example, unit 4 will be separated out into different units to distinguish between slump and terraces, and unit 2 will be separated to distinguish between central uplift (interior) and hummocky or pre-existing terrain (exterior). However, we are finding it difficult to distinguish between hummocky ejecta and target materials. All units and facies will be reviewed and adjusted accordingly.

Implications: Crater-related dissected material on Mars has only been observed where pitted material is also present [8]. Dissected terrain on Mars may be the result of flowing impact melt or liquid water. However, crater-related dissected material has been observed on Ceres where liquid water has never been suggested to influence the surface. A better understanding between the relationships of pitted and dissected terrain an airless planetary body like Ceres and Vesta can help us better understand impact processes on volatile-rich bodies, such as Ceres, Mars and Earth.

References: [1] Thomas, P. C. et al. (2005) *Nature, 437*, 224-226. [2] Russell, C.T. et al. (2016) *Science, 353*, 1008-1010. [3] Ermakov, A. I. et al. (2016) *LPSC XLVII*, Abs. #1708. [4] Bland, M. T. et al. (2016) *Nat. Geosci., 9*, 538-542. [5] Ruesch, O. et al. (2016) *Science, 353*. [6] Hughson, K.H.G. et al. (2017) Icarus. [7] Sizemore, H. G. (2017) *GRL* [8] Tornabene, L. L. et al. (2012) *Icarus, 220*, 348-368 [9] Morris, A. et al. (2010) *Icarus*. [10] Boyce, J. M. et al (2012) *Icarus, 221*, 262-275. [11] Sierks, H. U. et al. (2011) *Space Science, 163*, 263-327.

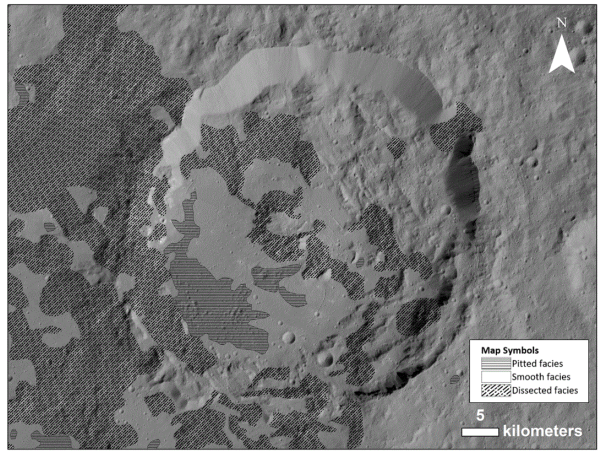

Figure 1: *Ikapati impact ejecta facies, including pitted, smooth, and dissected, described above. Mapped units are not displayed in this figure; however, all 4 units can be identified by their descriptions outlined above. Displayed on top of the Framing Camera clear filter LAMO glabl mosaic in orthographic projection centered at Ikapati crater (45°N, 33°E).*

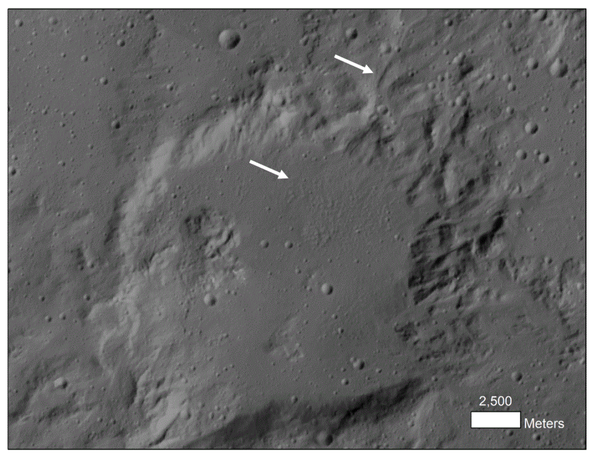

Figure 2: *Pre-existing crater southwest of Ikapati. Impact melt flowing into and ponding in pre-existing crater southwest of Ikapati. Flowing melt creates dissected terrain (top arrow). Ponded melt creates smooth and pitted (bottom arrow) facies.*