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Geological Evolution and Composition of the Dantu Crater

J. Kallisch (1), A. Nathues (1), T. Platz (1), G. Thangjam (1), K. Mengel (2) and M. Hoffmann (1)
(1) Max Planck Institute for Solar System Research, Goettingen, Germany, (kallisch@mps.mpg.de), (2) Clausthal Technical University, Clausthal-Zellerfeld, Germany

Abstract

The Dantu crater, located in the Vendimia Planitia depression at the northern hemisphere (centered at 24.3° N / 138.2° E) of dwarf planet Ceres, was investigated regarding its geological surface features and spectral appearance. For this purpose data of the Framing Camera (FC) and the Visible and Infrared Spectrometer (VIR) onboard the Dawn spacecraft were utilized and processed. Geological mapping of Dantu crater and its vicinity was conducted and absolute surface model ages were derived by measurements of crater size-frequency distributions. Dantu shows several features that are unevenly distributed in its northern and southern part, like fractures, bright spots and spectral properties. In this research we focus on possible processes that finally led to the observed dichotomies of the Dantu crater.

1. Results

3.1 Geological context

With a diameter of ~120 km Dantu is well above the transition margin for a complex crater on Ceres and therefore shows remnants of a central peak and a wide, flat floor (Fig. 1). Our derived model age is 230 Ma +/- 30 by crater counting of the ejecta blankets. The north-eastern wall almost completely collapsed within an arc of ~40 km and only remnants are still visible. Terraces are only well preserved in the north-western segment of the crater rim. In other rim segments previously formed terraces are stronger eroded by ongoing mass wasting processes which led to an extensive formation of irregularly shaped hills, now referred to as hummocky terrain (Fig. 1). In most areas a sharp transition from the hummocky terrain to the much smoother crater floor exists. The crater density also lowers significantly when reaching the floor, indicating a younger surface age. No indications for melting events are found and thus we conclude that debris avalanches and granular flows filled up the central portion of the crater. The rectangular wall segments are further indications for crater wall collapse events that led to the formation of several avalanches. The most extensive and most recent one originated from a ~60 km wide wall segment of the south-west. In this area no hummocky terrain is found and the smooth floor material directly sets in at the bottom of the crater wall (Fig. 1). We see similarities at Occator, where the south-eastern part of the wall collapsed, resulting in a debris avalanche deposit that covers a large portion of the crater center [1]. Dantu shows a prominent system of fractures which are abundant in the southern portion but less frequent in the north (Fig. 1). Approximately 80 % of the southern fractures show a concentric orientation with respect to the crater center, spanning around half of the floor. Just a small number is radial orientated or shows no specific orientation. In some cases bright spots are associated with these fractures. We found more than 80 small bright spots with diameters between 100 and 500 m and a few with about 1 km diameter within the crater. Most of the bright spots are located in the southern crater wall and within a 10.5 x 9 km area in the southern hummocky terrain, showing a significantly higher albedo. The whole southern floor and hummocky

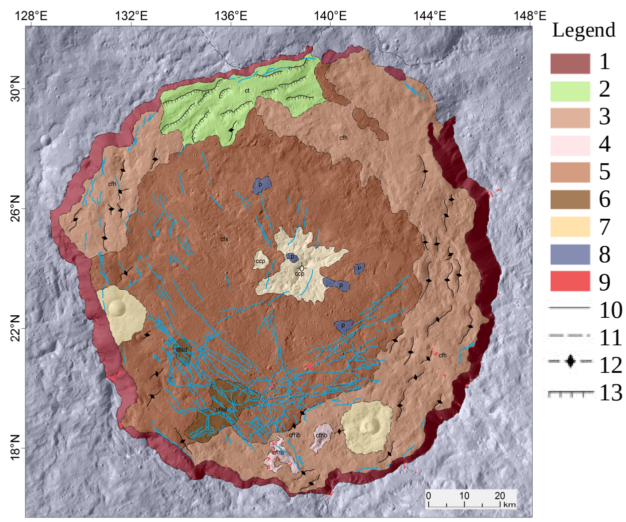

Figure 1: Geological mapping of the Dantu crater in stereographic projection. 1: crater wall, 2: crater terrace, 3: hummocky terrain, 4: bright hummocky terrain, 5: crater floor, 6: dark floor material, 7: central peak material, 8: pitted terrain, 9: bright spots, 10: accurate contact, 11: approximated contact, 12: ridge crest, 13 scarp.

terrain area is on average about 1 km higher in elevation compared to the majority of the northern floor.

3.2 Mineralogical context

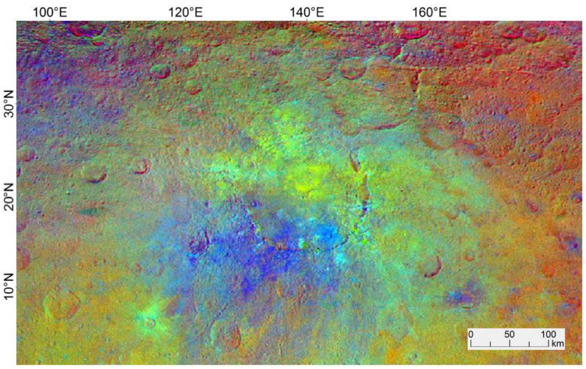

Figure 2: FC HAMO false color ratio mosaic in stereographic projection (R = 0.97/0.75 µm, G = 0.75 µm, B = 0.44/0.75 µm).

Comparison of the false color image with the geological map reveals a correlation between the bluish colors and floor and hummocky terrain in Dantu's south, which is also associated with a higher elevation and more abundant fractures and bright spots (Fig. 1, 2). Central and northern parts, however, show a more green-yellowish FC spectral slope. VIR IR spectra of the same areas do not show significant spectral variations. The typical Dantu spectrum exhibits, as the global average, strong absorptions around 2.7 µm, 3.1 µm and 3.9 µm, as well as some ambiguous absorptions around 3.2 – 3.5 µm and 4.2 µm. The 2.7 µm absorptions are associated with structural OH-groups in phyllosilicates [2]. The 3.1 µm absorptions are likely due to ammoniated phyllosilicates [3]. The 3.9 µm absorptions are consistent with carbonate phases [3, 4]. The spectra of the blue southern and the yellow-green central and northern areas don't show significant variations of the phyllosilicates and carbonates absorptions, which is an indication for similar mineralogy. This infers variations of physical parameters, such as grain size, to explain the differences in the FC color spectra.

2. Discussion

The measured elevation of 1 km of the southern portion of the crater and its higher abundance of fractures and bright spots is possibly caused by an ice/brine reservoir beneath the surface of Dantu's southern portion. The lower density of such a reservoir leads to uprising of the material and thus to extensional geological processes at the surface and eventually to the formation of fractures and bright spots. Alternatively the elevation could be explained by more extensive mass wasting of Dantu's southern terraces, indicated by a larger hummocky terrain area and the large debris avalanche which originated from the southwest. The concentric fracture system could then be explained by slowly inward slumping of the higher elevated area towards the north and the crater centre. A third possible scenario is an oblique impact from a northern direction. An impact angle of ~20° with respect to the surface normal could lead to the observed asymmetric crater floor profile without necessarily forming an elongated crater [5]. Furthermore, this scenario could provide a material sorting mechanism, leading to the observed spectral dichotomy and also explain the irregular distribution of the ejecta blanket.

3. Summary and Conclusions

Our study of Dantu revealed a diverse complex crater, showing non-uniformly distributed features like fracture systems, a high number of small bright spots, an asymmetric floor profile, uneven distributed spectral properties and an irregular ejecta distribution. The likeliest process that led to the observed dichotomies is a brine upwelling, causing extensional geological processes. However, large crater wall mass wasting and the possibility of an oblique impact, striking from the north, cannot be ruled out yet to be responsible for the heterogeneities.

References

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