Urvara's central peak - further evidence for past cryo-volcanism on Ceres?

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Introduction: Dwarf planet Ceres is the largest and most massive object in the main asteroid belt, located at a mean solar distance of ~2.8 AU. NASA's Dawn spacecraft, equipped with the Framing Camera (FC), the Visible and Infrared Spectrometer (VIR), and the Gamma Ray and Neutron Detector (GRaND), investigated the origin and evolution of Ceres by exploring its present geology and mineralogy. One of the most remarkable discoveries on Ceres are surface features, which likely formed due to cryovolcanic processes. The both well-known examples are Occator's faculae [1, 2, and references therein] and Ahuna Mons [3]. The question arises whether further cerean surface features could have been formed by cryovolcanic processes. Cryovolcanism was found before exclusively on icy planetary moons of the outer Solar System, where tidal forces of the giant planets induce such geologic activities. However, Ceres is not subject of severe tidal forces and thus internal processes in combination with impact triggering are required to explain the recent cryovolcanic activity [1, 4].

FC and Dawn's XMO7 orbit: The FC was equipped with one panchromatic and seven color filters, covering the wavelength range 0.4 to 1.0 µm [5]. In June to August 2018 the FC obtained the highest resolution images ever. Besides Occator crater a large part of the Urvara crater was imaged with pixel scales ≤ 25 m, while selected areas have been studied with pixel scales ≥ 3 m. These new images are about 10-times higher in resolution than previous images of Urvara crater.

Geology of Urvara crater: Urvara is a 170 km diameter impact basin (Fig 1), located on the southern hemisphere of Ceres, west of the larger Yalode basin. Urvara's morphology is consistent with a complex [6], medium age (242±16 Ma, LDM) impact crater [7], exhibiting a preserved ejecta blanket. A sharply defined continuous rim with vast terraces are found in the southern and eastern rim segment, while a steep single scarp defines the northern and northeastern rim. A central peak, located slightly off center, exhibits several bright exposures. The eastern floor, in the vicinity to the central peak, is traversed by a system of ridges, grooves, and channels.

Central Peak: Urvara's central peak extends ~26 km from southeast to northwest, while its cross-axis measures ~13 km with a height difference of up to ~3 km above to the southern floor. Interestingly, the central peak's ridge shows exposures of bright material with reflectances of up to ~0.08 (at 0.55 µm), which is similar to the brightest faculae outside of Occator crater. Significantly higher reflectances we measured at highest spatial resolutions (pixel scale ~3-5 m), caused by small-scale concentrations of bright material, a few meters in size. These are associated with a cliff on the northeastern summit of the central peak (Fig. 2). Maximum reflectance values here reach ~0.15 (in clear filter), which is comparable to reflectances determined at Vinalia Faculae in Occator crater. Further but less bright exposures are found along the ridge of the central peak. All bright material exposures on the central peak seem to be exposed by slumping on steep slopes, excavating small lenses of bright material, which mixes with dark background material by downslope movement. Interestingly, the presence of bright material (defined as surfaces showing reflectances ≥ 0.035 at 0.55 µm, [7]) is limited in Urvara, only one small-scale deposit is found on its floor, some exposures on the central peak, and a some on the upper rim scarp. The presence of bright material exposures on the central peak is remarkable and raises the question of how and when the material was deposited.

Analysis and Workplan: A detailed investigation of the latest FC XM2 data products of Urvara crater is in progress and will be presented at the meeting. Our preliminary results support both potential hypotheses of bright material origin: 1) By cryovolcanism, 2) By deep material uplift due to the impact and subsequent excavation by slumping.

References: [1] Nathues A. et al. 2017. AJ, 153, 3, 12. [2] Scully J.E.C. et al. 2019. Icarus, Vol. 320, p. 213-225. [3] Ruesch O. et al. 2016. Science, 353, 6303. [4] Nathues A. et al. 2019. Icarus, Vol. 320, p. 24-38. [5] Sierks H. et al. 2011, Space Sci Rev 2011, 163:263–327. [6] Crown D.A. et al. 2018. Icarus, Vol. 316, p. 167 – 190. [7] Thangjam G. et al. 2018. M&PS Vol. 53, Nr. 9, p.1961 - 1982

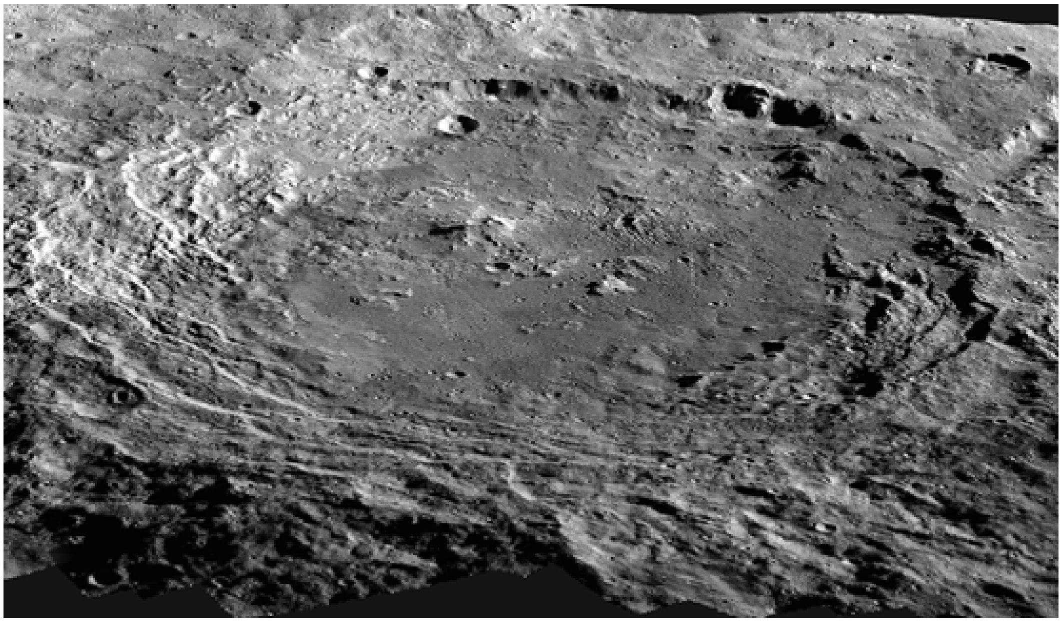

Fig. 1: *Perspective view of the complex Urvara crater from southeast in clear filter. Low altitude mapping orbit (LAMO) imagery (pixel scale ~35 m) and a high altitude mapping orbit (HAMO) DTM were used to derive this figure. The central peak is slightly off center.*

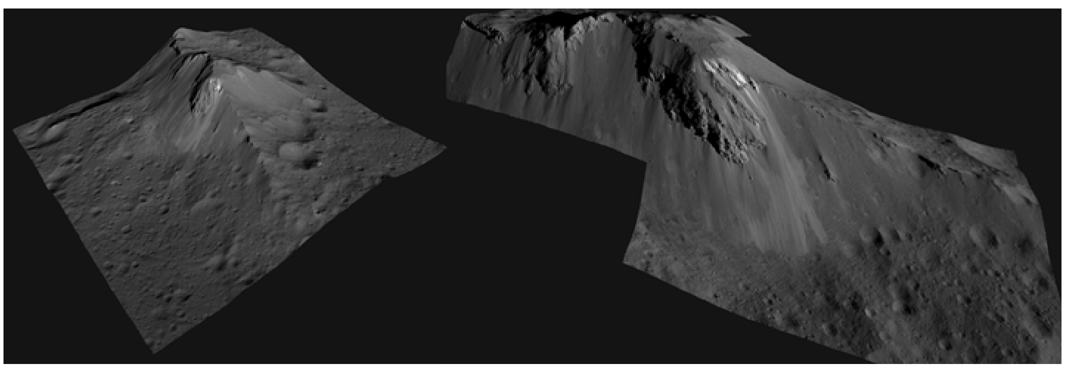

Fig. 2: *Clear filter mosaics of Urvara's central peak in perspective view. The left figure is produced from images at a pixel scale of ~15 m, while the right figure contains images at pixel scale of ~5 m. The central peak's brightest material is located near its summit at one of the main cliffs. Bright material moves downslope and mixes with dark material. View is towards the west (left image) and northwest (right image).*