Revisiting the Geology of Occator Crater on Ceres: Recently Active Cryovolcanism? A. Nathues[1], G. Thangjam[1], N. Schmedemann[1], J.H. Pasckert[2], E. Cloutis[3], K. Mengel[1], O. Ruesch[4], L. Le Corre[5], V. Reddy[6]; [1]MPI for Solar System Research, Justus-von-Liebig-Weg 3, 37077, Göttingen, Germany (nathues@mps.mpg.de), [2] Institut für Planetologie, WWU Münster, Germany, [3]Department of Geography, University of Winnipeg, Canada, [4]ESA-ESTEC, Noordwijk, The Netherlands, [5] Planetary Science Institute, Tucson, USA, [6] Lunar and Planetary Lab/UA, Tucson, USA

Introduction: Asteroid (1) Ceres is the largest and most massive body in the main asteroid belt. It is the only dwarf planet in the inner solar system 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 astonishing discoveries on Ceres is the evidence of cryovolcanism, which is possibly triggered by endogenic forces [1, 2], being the first of its kind identified on an asteroidal body. Cryovolcanism has been found before exclusively on icy planetary moons of the outer Solar System, where tidal forces of the giant planets induce such geologic activities. During its final orbit (XMO7), embedded in the extended mission phase 2 (XM2), Dawn FC obtained several thousands high resolution images of Occator crater. This imagery is suited to shed further light on the origin and evolution of Occator and Ceres itself.

FC and Dawn XMO7 orbit: The FC is equipped with one panchromatic and seven color filters, covering the wavelength range 0.4 to 1.0 µm. In June to August 2018 the FC obtained the highest resolution images ever. The whole Occator crater was imaged with pixel scales of ≥ 25 m/pix (Fig. 1), while selected areas have been studied with resolutions of ≥ 3 m/pix. These new images are about 10-times higher in resolution than previous images of Occator. Figure 1A displays an global view of this crater that hosts the brightest surface material on Ceres with reflectance up to ~0.5 in ~3 m/pix panchromatic filter data.

Cryovolcanism: Cryovolcanism on Ceres was associated with the young giant dome-like mountain Ahuna Mons [2]. Similar dome-like surface features have been identified and studied by [3], suggesting a more widespread presence of these features across Ceres. Ahuna Mons, the youngest of these domes, is dated to be less than ~200 Ma old [2, 4]. An even younger cryovolcanic activity, as young as ~4 Ma, has been reported by [1, 5] and is associated with bright material on the floor of Occator crater. This crater (Ø 92 km, ~4 km deep) is one of the most intriguing surface features on Ceres because the brightest material on Ceres was detected on its floor. Previous studies revealed that the bright material deposited in the central pit of Occator and on its eastern floor (cp. Fig. 1 A) is compositionally enriched with sodium carbonate [7, 8]. Floor and pit areas, which are covered with bright material, exhibit a unique brightness variation that could be attributed to the presence of haze [9, 10], a potential indication of present (low) activity. The bright material deposits are significantly younger than the impact crater itself [1, 5]. However, due to the limited spatial resolution of the FC imagery up to the Low Altitude Mapping Orbit (LAMO), a reliable age determination of the bright deposits was not feasible. As will be shown, the most recent XM2 imagery is suited to determine the ages of many different geologic units (pit, lobate deposit, terraces etc., see [11]) of the crater floor. [1] suggested that the bright material deposits on the central pit are the result of a long lasting, periodic or episodic ascent of brines from a deep subsurface reservoir. This view is supported by [5, 12] and our most recent results on XM2 data that we intent to present during the conference. Alternatively, the bright deposits could be fomed by extrusion originating from shallow subsurface reservoirs generated by the impact that also inflated the impact melt sheet [6]. However, this formation scenario is less supported by our most recent results.

Analysis and Workplan: A detailed investigation of the latest FC XM2 data products of Occator crater is in progess and will be presented at the meeting. Our preliminary results support and strengthen the idea of recent cryovolcanic activity on the floor of Occator. Cryovolcanism seems to be associated with the bright material deposits on the crater floor but also with the lobate flows. A chronostratigraphy of these events will be constructed using the Crater Size Frequency Distribution (CSFD) technique, which is typically applied for dating planetary surfaces. By combining information about age, geomorphology, and spectral properties of Occator's surface units, we will refine our understanding of the formation and evolution of the Occator crater.

References: [1] Nathues A. et al. 2017. AJ, 153, 3, 12. [2] Ruesch O. et al. 2016. Science, 353, 6303. [3] Sori M.M. et al. 2018. Nature Ast. 2, 946-950. [4] Platz T. et al. 2018. Icarus, 316, 140-153. [5] Nathues A. et al. 2018. Icarus, in press. [6] Scully J.E.C. et al. 2018. Icarus in press. [7] De Sanctis M.C. et al. 2016. Nature, 536, 7614, 54-57. [8] Raponi A. et al. 2018. Icarus, in press. [9] Nathues A. et al. 2015. Nature, 528, 7581, 237-240. [10] Thangjam G. et al. 2016. ApJL, 833, 2. [11] Scully J.E.C. et al. 2018b. Icarus in press. [12] Quick L.C. et al. 2018, Icarus in press.

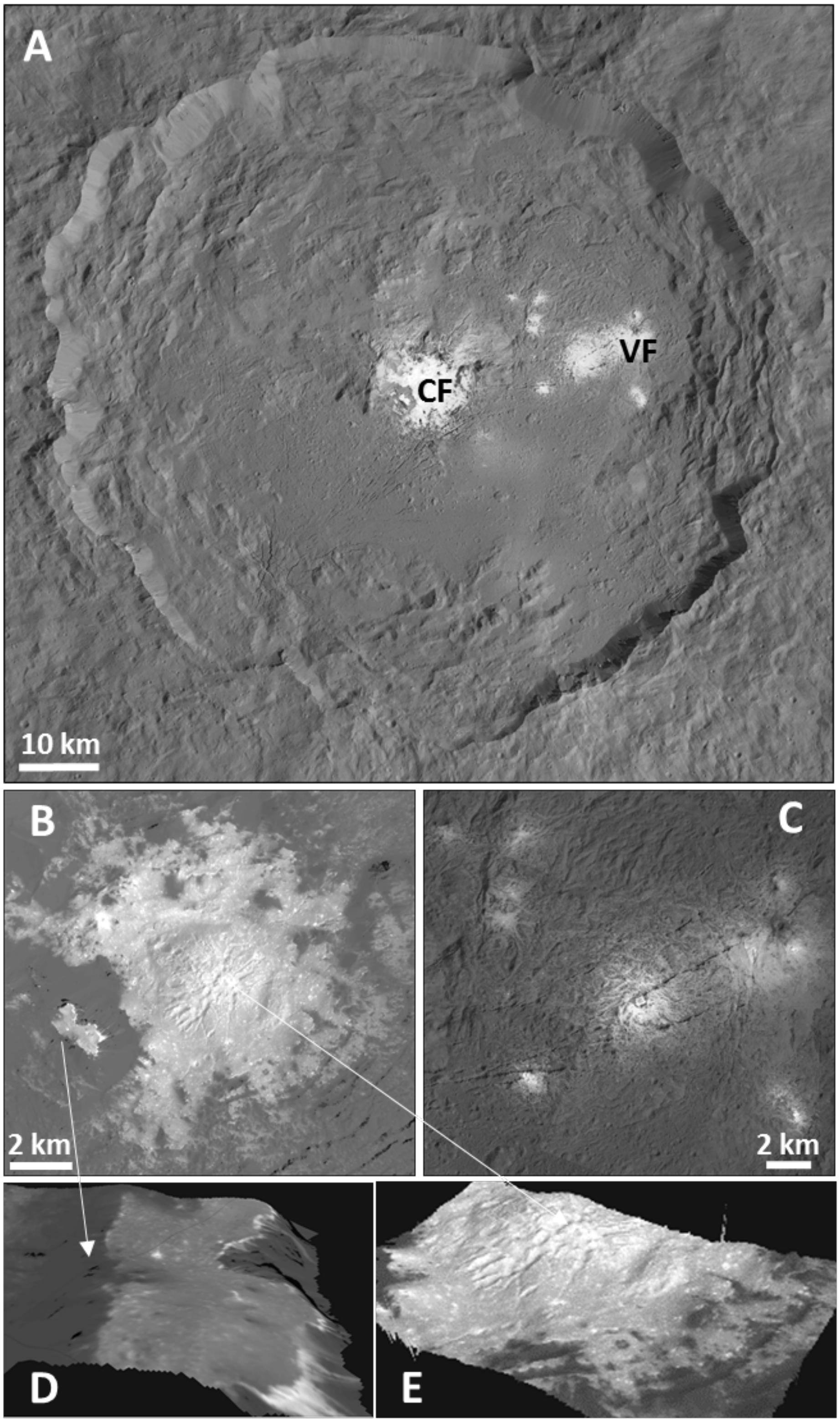

Fig. 1: *Views of Occator crater in clear filter from XM2 orbit. (A) Full reprojected mosaic at ≤15 m pixel scale with Cerealia Facula (CF), Vinalia Faculae (VF), (B) CF at ≥3 m pixel scale, and (C) VF at ≥3 m pixel scale. (D, E) Perspective views of selected areas at ≥3 m pixel scale using topographic information derived from those images by stereophotogrammetry: (D) Mesa, (E) central pit and dome.*