CHANNELS AND CRYOGENIC FLOW FEATURES ON CERES

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Introduction: After studying the asteroid Vesta between 2011 and 2012 [1], NASA's *Dawn* spacecraft entered its orbit around the dwarf planet (1) Ceres in April 2015 [2]. The mission goal is to characterize the geology, elemental and mineralogical composition, topography, shape, and internal structure of Ceres [3].

Ceres´ surface is affected by numerous impact craters and some of them show features such as channels or multiple flow events forming a smooth, less cratered surface, indicating possible post-impact resurfacing [4,5].

Data: For the analysis of channels and flow features Dawn Framing Camera (FC) data (monochrome and color ratio images) [6] from the High Altitude Mapping Orbit (HAMO) with a spatial resolution of 140 m/px as well as a Digital Terrain Model (DTM) [7] derived from HAMO orbit data have enabled an initial characterization of the surface. At the time of this writing LAMO images (35 m/pixel) are just becoming available.

Flow features: Flow features occur on several craters on Ceres, such as Haulani, Ikapati, Occator, Jarimba and Kondos in combination with smooth crater floors [4,5,8,9]. They appear as extended plains, ponded material, lobate flow fronts and in the case of Haulani lobate flows originating from burst crest of the central ridge [8] partly overwhelming the mass wasting deposits from the rim. Haulani`s crater flanks are also affected by multiple flow events radiating from the crater and partly forming breakages. Flows occur as fine-grained lobes with well-defined margins (Fig.1) and as smooth undifferentiated streaky flows covering the adjacent surface. Thus, adjacent craters are covered by flow material. The fine-grained flows partly building islands around solid blocks [8].

Occator also exhibits multiple flows but in contrast to Haulani, the flows originating from the center overwhelming the mass wasting deposits from the rim (for more details see [9]).

The flows have a "bluish" signature in the ratio of the FC color filters 5 (965nm), 2 (555nm) and 8 (440nm).

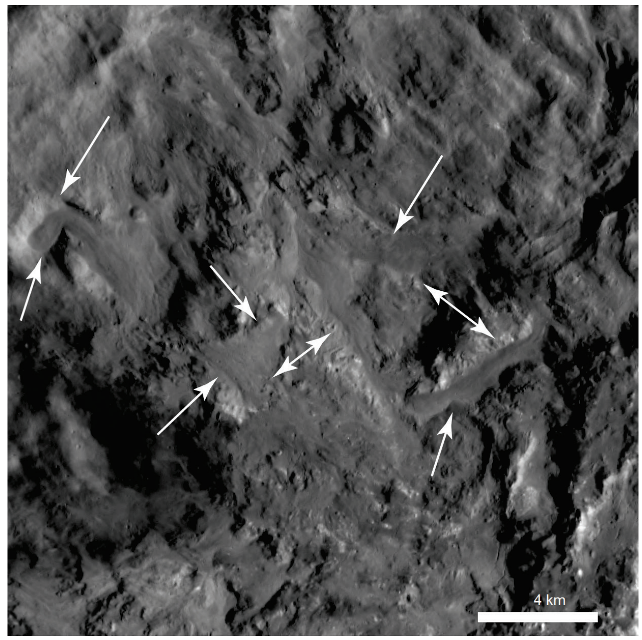

Figure1: Fine-grained lobate flows with well-defined margins northwest of Haulani.

Channels: Channels occur at relatively fresh craters. They also show the "bluish" signature like the flows and plains. Only few channels occur at older "reddish" craters. The channels are relatively fresh incised into flow features or crater ejecta. Most channels are small, narrow and have lobated lobes with predominant distinctive flow margins. The widths vary between a few tens of meters to about 3 km. The channels are found on crater flanks as well as on crater floors.

Discussion: The occurrence of flow features indicates viscous material on the surface. Those features could be formed by impact melt. However, impact melt is produced during the impact and assuming similar material properties as the ejecta, it is expected to have nearly the same age as the impact itself, but the flows and plains are almost free of craters, thus, they seem to be much younger than the impact itself. In addition, the source of impact melt flows is diffusely distributed, but many of the observed flows originate from district sources in the crater interior and the flows, however, are well defined.

The compositional differences derived from the color ratio and possible time variable effects are related to cryo-processes, either volcanic or glacial [4,5]. Furthermore, the suggestion of an occurrence of ice within the Cerean crust [10] as well as possible salts incorporated into a regolith layer [9,10,11] indicates similar geological processes as seen on other icy bodies. Some lobate flow-like deposits on Ganymede such as at Sippar Sulcus are suggested to be formed by volcanic eruptions creating a channel and flow, and cutting down into the surface forming a depression [12]. We see similarities in a smaller scale at Haulani. Thus, an endogenic formation process cannot be excluded. Such as the impact triggered mobilization of subsurface cryovolcanic deposits generating cro-volcanic surface deposits.

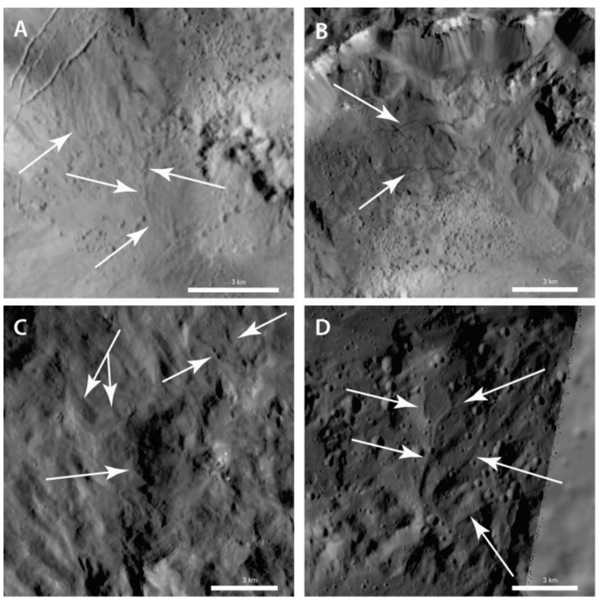

Figure 2: Examples of channels on Ceres. A: Small narrow channels on the floor of Haulani. B: well-defined dark lobate channels on Haulanis floor. C: Channel radial incising the crater flank of Haulani. D: Narrow well-defined channels on the smooth plains of Ikapati.

Future Work: Upcoming higher-resolution images and DTMs will allow us to identify and to analyze the flow features and channels more precisely. Additional spectral information will allow us to estimate the composition of surface. This information will enable us to understand the formation process of those features on Ceres.

References: [1] Russell C.T. et al. (2013) *Meteoritics & Planet. Sci.* 1-4. [2] Russell C.T. et al. (2015) *EPSC X*, Abstract #2015-14. [3] Russell C.T. and Raymond C. (2011) *Space Sci. Rev., 163*, 3-23. [4] Jaumann R. et al. (2015) *EPSC X*, Abstract #2015-83. [5] Jaumann R. et al. (2015) *AGU*, Abstract #P42A-05. [6] Sierks H. et al. (2011) *Space Sci. Rev., 163*, 263–327. [7] Preusker F. et al. (2015) *EPSC X*, Abstract #2015-186. [8] Krohn K. et al. (2016) *LPSC XLVII*, this issue. [9] Jaumann R. et al. (2016) *LPSC XLVII*, this issue. [10] McCord T.B. and Sotin C. (2005) *J. Geophys. Res., 110,* E05009. [11] Castillo-Rogez J.C. and McCord T.B. (2010) *Icarus 203,* 443–459. [12] Schenk P.M. and Moore J.M. (1995) *JGR 100,* E9, 19,009-19,022.

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