LAYERED AND LOW-ASPECT-RATIO EJECTA ON CERES: PROBING THE EFFECT OF GROUND ICE ON FLUIDIZED EJECTA DEPOSITS

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Introduction and previous work: NASA's Dawn spacecraft arrived at the dwarf planet Ceres, the largest object in the asteroid belt (mean diameter of ~950 km), on March 6th 2015. Dawn is the first spacecraft to visit Ceres, which was previously studied by telescopic observations since its discovery on January 1st 1801 [e.g. 1, 2, 3]. Dawn has, and continues to acquire Ceres science data through three main orbital phases of decreasing altitude: Survey, High Altitude Mapping Orbit (HAMO) and Low Altitude Mapping Orbit (LAMO). Data is collected by Dawn's radio science experiment, Framing Camera (FC), Visible and Infrared spectrometer (VIR), and Gamma Ray and Neutron Detector (GRaND).

During the Survey, HAMO, and LAMO phases of the primary mission Dawn's FC observed a multitude of globally distributed lobate deposits. These flows were broadly interpreted as either similar to ice-cored/ice-cemented flows (Type 1 flows) on Earth and Mars, long run-out terrestrial or martian landslides (Type 2 flows), or highly mobile fluidized ejecta-like deposits (Type 3 flows) [4, 5, 6]. The Type 3 flows are morphologically similar to fluidized/layered ejecta found on Mars and Ganymede [7, 8]. The main structural difference between these putative cerean fluidized ejecta flows and their martian/ganymedean counterparts is that the latter tend to form full aprons around the entire circumference of their parent crater, while the former generally only occur around a fraction of the circumference (usually < 180º) of their parent crater (Fig. 1).

Though there exists no consensus on the mode of fluidization for these ejecta deposits on Mars or Ganymede a large number of authors have interpreted the martian variety to be related to the presence of volatiles (particularly water ice) within the regolith target materials [such as 7, 9, 10, 11]. We address the hypothesis that the occurrence, morphology, and mobility of Type 3 cerean flows are a result of impact into, and emplacement on, a ground ice rich near-surface layer and that variations in the upper structure of Ceres and/or quantity of ground ice alters the mobility of fluidized ejecta in otherwise similar craters. We do this by cataloguing the global distribution of these flows and making comparisons to GRaND elemental abundance and VIR mineralogical data. We also quantify the ejecta mobility as a function of crater diameter and latitude. We define ejecta mobility (EM) as the atio of the radius of the ejecta blanket versus the radius of the parent crater, and compare measured EM to a simple kinematic sliding model similar to the one developed in [11]. We also measure drop-height-to-runout-length ratios (H/L) and compare them to planetary and experimental analogs of known composition,

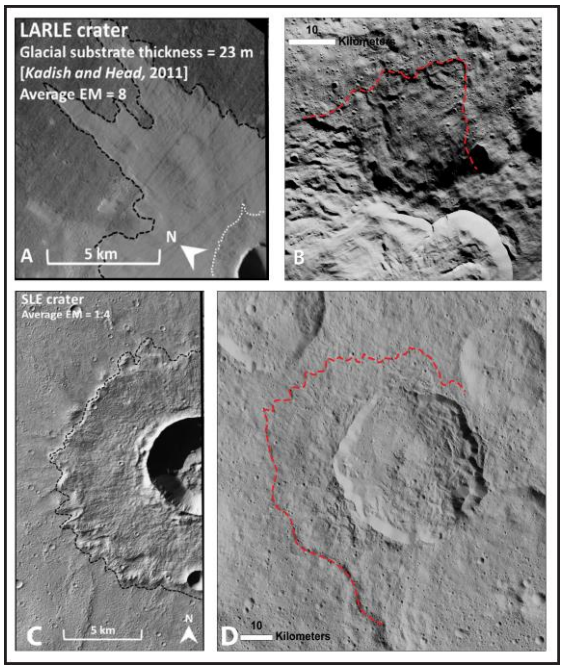

Figure 1: Examples of martian and putative cerean fluidized ejecta: (A) martian low-aspect-ratio layered ejecta (LARLE) crater, adapted from [10, 11]; (B) Type 3 cerean flow (118º W, 64º N) exhibiting LARLE-like morphological elements and possibly multiple ejecta layers; (C) martian single layer ejecta (SLE) crater, adapted from [11]; (D) Type 3 cerean flow (13º E, 22º S) exhibiting a SLE-like appearance.

Methods:

1. Global classification: At the time of this writing 17 craters on Ceres have been identified with fluidized/layered ejecta deposits unambiguously (Fig. 2), although many more may exist around craters less than 2.5 km in diameter. By comparing the compiled distribution of Type 3 flows to the global hydrogen

abundance map derived from Dawn's GRaND instrument [12] we identify the water equivalent hydrogen concentration in the uppermost meter of Ceres at each of the identified flows. Combining this data with knowledge of the local mineralogy provided by the VIR spectrometer will allow for a first order determination of the ground ice content in regions surrounding Type 3 flows.

2. Mobility and Drop-Height-to-Runout-Length Ratios: Following the mapping of Type 3 flows on Ceres we measured the EM ratio and H/L of each identified flow, as well as their parent craters' diameters. This information was used in a k-means style analysis to determine whether there are any distinct populations of Type 3 flow generating crater in the parameter space of EM, H/L, crater diameter, water equivalent hydrogen, or latitude. We also used this analysis to determine whether the EM of Type 3 flows vary systematically or sporadically with latitude and parent crater diameter. Further, this analysis allowed us to assess whether the comparison between Type 3 flows and martian LARLE and SLE craters is appropriate, and if, by extension, morphological similarities between Mars and Ceres can be used to infer volatile content of cerean features.

3. Physical Modeling: Using the EM values for all Type 3 flows on Ceres we further test the hypothesis that these features are controlled by a near-surface layer of interstitial ground ice by comparing them to a kinematic sliding model similar to the one developed in [11] to model the ejecta mobility for impacts in a variety of ground ice rich substrates of differing volatile content on Mars. This simplistic model should provide constraints on the relative importance of the effective coefficient of friction of the substrate beneath these flows, as well an independent estimate of the water ice content in the near surface.

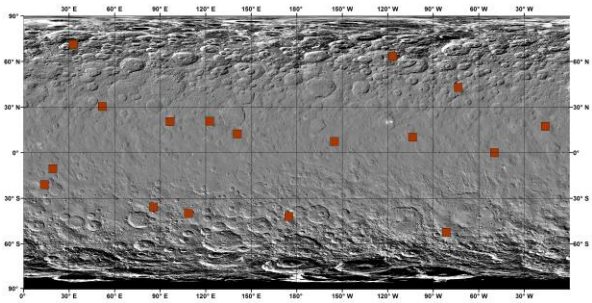

Figure 2 (bottom left): A preliminary global catalog of all Type 3 cerean flow generating craters down to diameters of ~2.5 km (red squares).

Discussion: Initial results from the global classification campaign suggests that Type 3 cerean flows preferentially occur at low- to mid-latitudes, which could be indicative of preferential creation or preservation at these locations. Measured H/L for these flows plot systematically lower than comparable length landslides on other terrestrial bodies. This reinforces their interpretation as propelled phenomena rather than gravitationally induced mass wasting. Since Ceres lacks any meaningful atmosphere, the morphological differences between Type 3 cerean flows and layered ejecta on Mars should be able to help quantify the role of interstitial gases and fluid drag in the creation of these features.

Before LPSC XLVIII we will:

1. Establish whether EM of Type 3 flows is correlated to crater size, latitude, or water equivalent hydrogen concentration.
2. Assess whether Type 3 cerean flows are behaviorally related to martian layered ejecta craters through the use of unique morphological indicators such as terminal ramparts and through physical modelling.
3. Estimate the volatile content of the substrate where Type 3 flows occur through the use of GRaND data and physical modelling.
4. Examine the influence of other phenomena on the morphology of these features, such as acoustic fluidization and Coriolis effects due to Ceres' rapid rotation.

References:

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