FLOOR-FRACTURED CRATERS ON CERES: IMPLICATIONS FOR INTERNAL COMPOSITION AND PROCESSES D.L. Buczkowski[1], H. G. Sizemore[2], L. M. Jozwiak[1], P.M. Schenk[3], J.E.C. Scully[4], I. von der Gathen[5], R. Park[4], F. Preusker[5], R. Jaumann[5], C.A. Raymond[4], C.T. Russell[6]. [1]JHU-APL, Laurel, Maryland, USA; [2]PSI, Tucson, AZ, USA; [3]LPI, Houston, Texas, USA; [4]NASA JPL, California Institute of Technology, Pasadena, California, USA; [6]DLR, Berlin, Germany; [6]UCLA, Los Angeles, California, USA.

Introduction: Several of the impact craters on Ceres have patterns of fractures on their floors. These fractures are morphologically similar to those found within a class of lunar craters referred to as Floor-Fractured Craters (FFCs). We present a geomorphic and topographic analysis of the Ceres FFCs and propose hypotheses for their formation.

Data: Geologic analysis was performed using Dawn spacecraft [1] Framing Camera (FC) [2] mosaics from late Approach (1.3 km/px), Survey (415 m/px), the High Altitude Mapping Orbit (HAMO - 140 m/px) and the Low Altitude Mapping Orbit (LAMO – 35 m/px) orbits, including clear filter and color images and digital terrain models derived from stereo images.

Lunar floor-fractured craters: Lunar FFCs are characterized by anomalously shallow floors cut by radial, concentric, and/or polygonal fractures [3]. These FCCs have been classified into crater classes 1 through 6, based on their morphometric properties [eg. 3, 4, 5]. The depth vs. diameter (d/D) relationship of the FFCs is distinctly shallower than the same association for other lunar craters [eg. 4, 5]. Models for FFC formation have explained their shallow floors by either floor uplift due to magmatic intrusion below the crater [eg. 3, 4, 5] or floor shallowing due to viscous relaxation [e.g. 6]. However, only magmatic uplift models can explain the degree of floor uplift and the asymmetric nature of the uplift present in several of the FFC morphometric classes [5, 7].

Ceres floor-fractured craters: We have cataloged the Ceres FFCs according to the classification scheme designed for the Moon. Dantu (Fig. 1) and Occator craters are the type examples for a Class 1 Ceres FFC, having both radial and concentric fractures at the crater center, and concentric fractures near the crater wall. In the magmatic model presented by [5] these craters represent fully mature magmatic intrusions, with initial doming of the crater center due to laccolith formation resulting in the crater center fractures, while continuing outward uplift of the remaining crater floor results in concentric fracturing adjacent to the crater wall. Other large (>50 km) Ceres FFCs which have only linear or radial fractures at the center of the crater (e.g. Azacca, Ezinu and Gaue) are also classified as Class 1 FFCs, but likely represent a less mature magmatic intrusion, with doming of the crater floor but no tabular uplift.

Smaller craters on Ceres are more consistent with Type 4 lunar FFCs, having less-pronounced floor fractures and v-shaped moats separating the wall scarp from the crater interior. Lunar Class 4 FFCs all have the v-shaped moat, but have three sub-classes defined by the interior morphology [5]. Lociyo crater is an example of a Class 4b FFC, having a distinct ridge on the interior side of its v-shaped moat and subtle fracturing (Fig. 2). Meanwhile, Ikapati crater is a potential Class 4a FFC, with both radial and concentric fractures, and a possible moat. Other small Ceres craters more closely resemble Class 4c FFCs, with a moat and a hummocky interior, but no obvious fracturing.

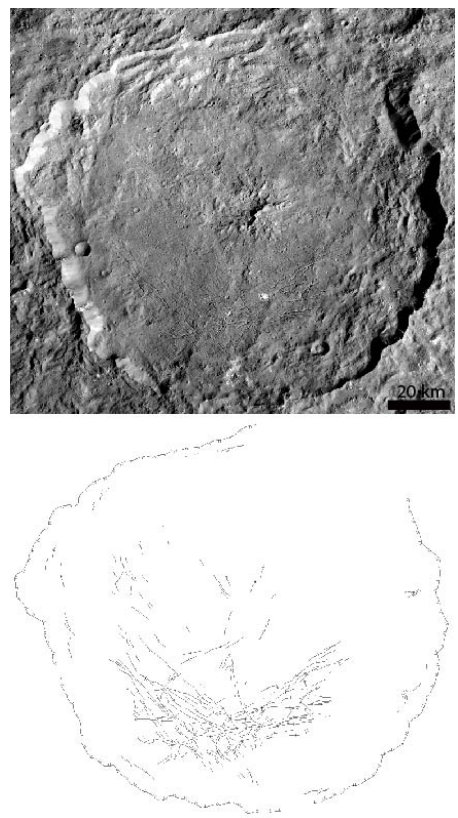

Figure 1. FC LAMO (35 m/p) mosaic of Dantu crater (126 km diameter), and corresponding fracture map.

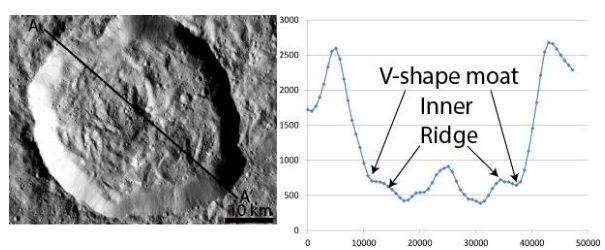

Figure 2. FC LAMO (35 m/p) mosaic of Lociyo crater (37.8 km diam.), and topographic profile from A to A'.

An analysis of the d/D ratio shows that, like lunar FFCs, the Ceres FFCs are anomalously shallow (Fig. 3). We also observe the d/D trend for the Class 1 FFCs is shallower than that for the Class 4 FFCs (Fig. 3). This is consistent with the magmatic intrusion models, which suggest that the increased fracturing of Class 1 FFCs is due to increased uplift.

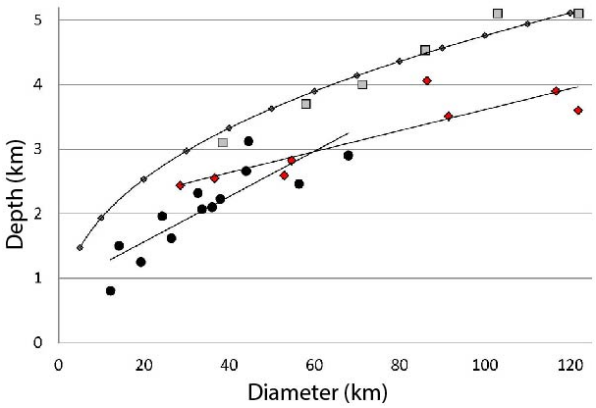

Figure 3. Depth vs diameter plot for all Ceres FFCs. Black diamonds represent the average Ceres crater [8]. Red diamonds represent Class 1 FFCs; black circles represent Class 4 FFCs; grey squares represent a sampling of non-FFC craters.

Discussion: It has been suggested that the Ceres FFCs may be a product of the intrusion of a cryomagmatic material below the craters uplifting their floors [9]. A cryovolcanic extrusive edifice has been identified on Ceres [10], and so the hypothesis of cryomagmatic intrusions is credible. Other features, mapped as large domes [9], have been proposed to be possible degraded cryovolcanic edifices [9, 10]. However, none of the impact craters that host large domes have fractured floors, although there are in some locations large domes near FFCs (Fig. 4). This anti-correlation suggests that there may be a difference in crustal properties between where the FFCs and the volcanic features form. Given the proximity of some FFCs and some large domes, this crustal change might be an alteration over time, rather than lateral variations in the crust.

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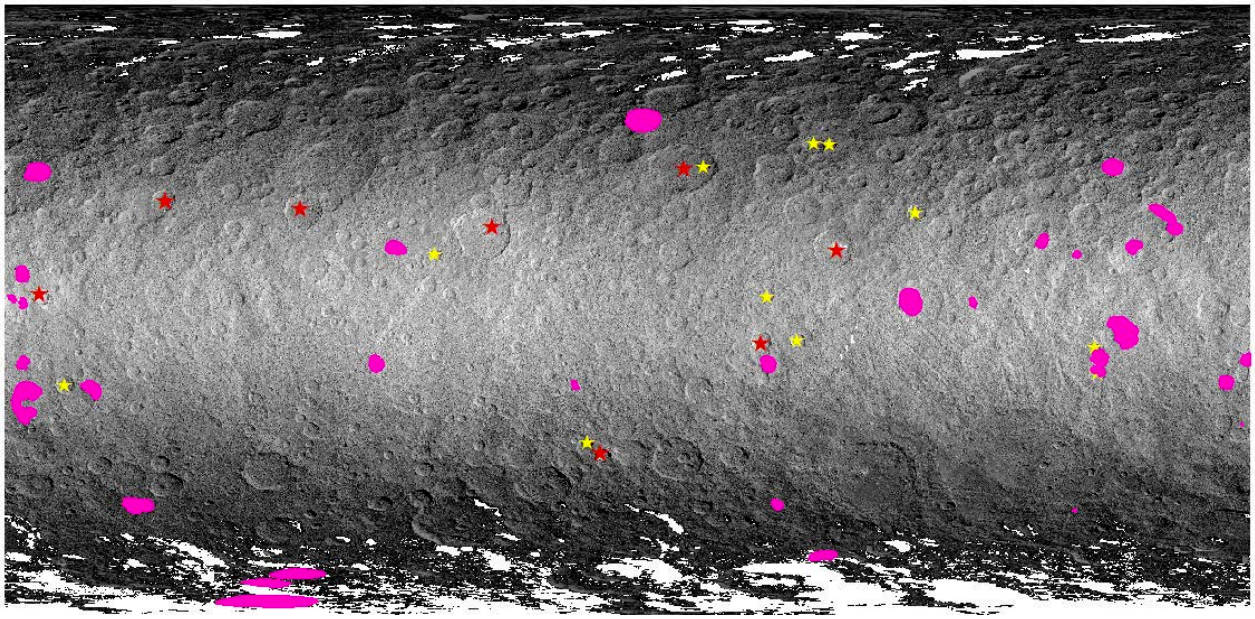

Figure 4. Global extent of both FFCs (red stars = class 1; yellow stars = class 4) and putative degraded cryovolcanic edifices (pink shapes) on Ceres.