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A Geomorphic Analysis of Floor-fractured Craters on Ceres and a Study of Potential Formation Mechanisms

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Several of the impact craters on Ceres are morphologically similar to a class of lunar craters referred to as Floor-Fractured Craters (FFCs). We have cataloged the cerean FFCs according to the scheme designed for the Moon. Lunar FFCs are characterized by anomalously shallow floors cut by radial, concentric, and/or polygonal fractures, are classified into crater classes 1 through 6, based on their morphometric properties, and are modeled to form due to intrusions of magmatic material uplifting their floors [1,2,3].

Class 1 cerean FFCs have both radial and concentric fractures at the crater center, and concentric fractures near the crater wall. In the magmatic model for lunar FFCs [3] these craters would represent fully mature magmatic intrusions, with initial doming of the crater center 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) cerean FFCs which have only linear or radial fractures at the center of the crater 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 (<50 km) 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. An analysis of the d/D ratio shows that, like lunar FFCs, the cerean FFCs are anomalously shallow. In addition, the d/D trend for the Class 1 FFCs is shallower than that for the Class 4 FFCs. This is consistent with the magmatic intrusion models, which suggest that the increased fracturing of Class 1 FFCs is due to increased uplift.

Because of these observations, it has been proposed that the cerean FFCs may have formed due to cryomagmatic intrusions uplifting their floors [4]. However, preliminary models show that impact into a layer of low viscosity/low density (LV-LD) material within the crust can result in surface deformation due to solid-state flow [5]. In the models, this surface deformation is expressed as doming into the crater wall [5], but is also consistent with the location of some fracturing that we observe in certain FFCs. None of the impact craters that host large domes have fractured floors, suggesting that there may be a difference in crustal properties between the locations where FFCs and domes form. Domes might form where solid state flow has occurred, while the FFCs form where there was cryovolcanism, or perhaps differences in the LV-LD layer could account for changes in the observed surface deformation. Further modeling will need to be performed to determine which process is more consistent with the observed features and what we know of the Ceres surface and interior.

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