PRELIMINARY INVESTIGATION OF THE CRUSTAL CHARACTERISTICS OF CERES THROUGH ANALYSIS OF IMPACT CRATERS. M. F. Zeilnhofer and N. G. Barlow, Dept. Physics and Astronomy, Northern Arizona University, Flagstaff, AZ 86011-6010 mfz3@nau.edu, Nadine.Barlow@nau.edu.

Introduction: Ceres' low density (2162 kg/m^3) led to the pre-Dawn proposal that the surface would show a minimal number of preserved impact craters due to viscous relaxation in an icy crust at Cerean temperatures [1]. The Dawn mission's Framing Camera (FC), with a resolution of 400 m/pixel, instead revealed a heavily cratered surface [2]. This cratered surface did show an interesting phenomenon, which was the lack of large preserved impact basins possibly erased by a past resurfacing event [3].

We have produced a database of all craters > 1-km-diameter visible in FC images for Ceres. We analyzed craters containing central peaks and central pits to further understand the crustal characteristics. Central peaks are common throughout the solar system and provide insights into target strength [4]. The formation of central pit craters is typically attributed to crustal volatile content. Previous studies suggest volatile content contributes to the frequency of central (floor) pit craters displayed on a body. Bodies which are volatile-rich tend to have a higher frequency of floor pits than bodies which are volatile-poor, whereas the frequency of summit pit craters is higher on bodies with lower crustal volatile contents [4].

This study investigates craters on Ceres to determine their depth-diameter ratio and the frequency of various interior morphologies with an emphasis on central peak and central pit craters. These preliminary results are for the entire surface of Ceres, excluding the permanently shadowed south polar region.

Methodology: Data were collected using the Java Mission-planning and Analysis for Remote Sensing (JMARS) crater measurement application with the HAMO global mosaic for Ceres [5]. We have catalogued all craters ≥ 1.0-km diameter across most of Ceres (84.66° S – 89.62° N 0° – 360° E). The longitude, latitude, and crater diameter were obtained using the 3-point crater counting routine and exported into an Excel spreadsheet.

Various physical parameters were analyzed for each crater, including minor crater diameter, crater degradation state, ejecta and interior morphologies (if present), crater depth and polygonality. Ejecta deposits were classified as radial or layered (single, double, or multiple) ejecta morphologies [6]. Up to two interior morphologies were classified for each crater. Eight different interior morphologies have been recorded: bright albedo (BA) and dark albedo (DA) features, central peak (Pk), central pit (SP for summit pit and SY for floor pit), ejecta blanket deposits (EB), floor deposits (FD) and wall terraces (WT). Measurements of the average central peak basial diameter and central pit diameter were recorded for craters which displayed these morphologies. The ratio of peak-to-crater diameter (D_{pk}/D_c) and pit-to-crater diameter (D_p/D_c) also were recorded for use in a comparison study of other solar system bodies which display these features [7].

We used topography information obtained from stereo FC analysis to calculate the crater depth using the mean spheroid and oblate spheroid models [8]. The digital elevation model (DEM) was used to generate the mean spheroid model by calculating the DEM radii for elevations above or below 469,430 m. To preserve local topographic variations across the surface, the oblate spheroid model was generated by subtracting the DEM radii from an oblate spheroid.

Preliminary Results: We have catalogued 44,594 craters across the surface of Ceres. Few craters smaller than ~5 km display obvious ejecta, which is likely due to low image resolution. Table 1 shows the number of craters which exhibit a specific interior morphology and the percentage of the morphology compared to all cataloged craters. The first four morphologies were seen in craters of all diameters whereas the latter four complex morphologies were present in craters with diameters >17.6 km.

Interior Morphology	Number of craters	Total Percentage
BA	135	0.30
DA	52	0.12
EB	85	0.19
FD	436	0.98
Pk	265	0.59
SP	4	0.01
SY	10	0.02
WT	22	0.05

Table 1: Interior morphologies present in craters on Ceres.

The distribution of central peak and central pit craters are vastly different from one another. Central peaks are located over the entire surface of Ceres whereas the central floor pits are located between 10.0-74.0°N. Summit pits were evenly distributed in both hemispheres, although only four such craters were identified. The peak frequency of central peak craters occurs at a mean diameter of 38.6 km (Figure1) whereas the frequency peak for central pit craters occurs at a mean diameter of 77.3 km (Figure 2).

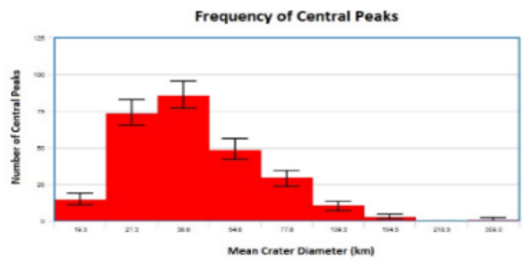

Figure 1: Frequency of central peaks as a function of crater diameter. Central peak frequency is greatest in the 30-40 km-D range and decreases with increasing crater diameter. Error bars were calculated using Poisson distribution for error propagation.

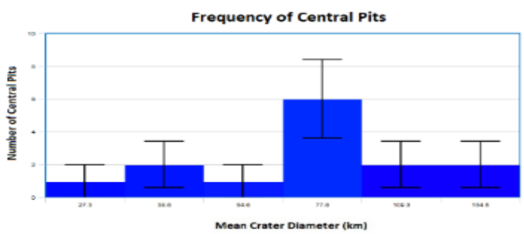

Figure 2: Frequency of central pits as a function of crater diameter. Central pits are more common in the 70-80 km-D range. There is no obvious trend with crater diameter. Error bars were calculated using Poisson distribution for error propagation.

We have compared the median D_{pk}/D_c and D_p/D_c for Ceres to those on Mercury, Mars, Ganymede, Rhea, Dione, and Tethys [4]. Ceres' median D_{pk}/D_c of 0.19 is most similar to the median D_{pk}/D_c of 0.16 for Mercury. The median D_p/D_c for Ceres is 0.13 for floor pits and 0.08 for summit pits. The median D_p/D_c for floor pits is comparable to the floor pit value found for Mars, and the summit pit value is similar to that found for Mercury [4]. This indicates Ceres has a crustal strength closer to a rocky body than an icy body. The northern and southern hemispheres appear to have different crustal strengths based on the comparison of the median D_{pk}/D_c: 0.25 in the north compared to 0.13 in the south. These results suggest a stronger crust in the southern hemisphere. This is consistent with findings of a thick crust at Samhain Catenae [9] and possible mantle uplift at Kerwan and Yalode supports topographic features in lieu of a thick crust [10]. The concentration of central pits in the northern hemisphere suggests a difference in subsurface structure between the two hemispheres [7].

Crater depth-diameter relationships for both the mean sphere and oblate sphere models are shown in Figure 3, with the average d/D ratio being 0.11 and 0.09, respectively. There is no definitive simple-to-complex transition diameter (D_{sc}) for Ceres, but previous studies report D_{sc} as a range of values from 6.0-21.0 km [11], 7.5-12.0 km [12], and ~10.0 km for an icy body or ~50.0 km for a rocky body [13]. This study narrows D_{sc} to a range between 15.0-20.0 km. This is consistent with central peak and central pit dimeter data: the smallest central peak crater diameter is 17.6 km while the smallest crater with a central pit is 30 km.

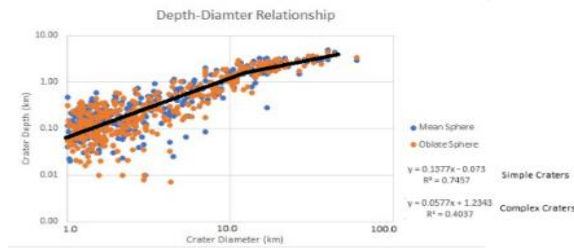

Figure 3: Depth-diameter for the mean sphere and oblate sphere models for the freshest craters. D_{SC} is determined from the trendline slope change, which is between 15.0-20.0 km-D.

Conclusions: Our preliminary results show the D_{sc} range is lower than expected for a rocky body and higher than what is expected for a purely icy body. A high frequency of central peaks is displayed across the surface with a few floor pit craters seen in the northern hemisphere and even fewer summit pit craters found in both hemispheres. The median D_{pk}/D_c for Ceres is similar to the value for Mercury, which indicates Ceres has a higher crustal strength. This result is consistent with the large number of preserved impact craters, but contrary to the D_{sc} which indicates a weaker crust. Further work includes investigating regional concentrations and ages of central peak and central pit craters, as well as a more detailed study of the numerous polygonal craters. These additional studies should provide more insight into Ceres' crustal characteristics.

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