THE GEOMETRY AND POSSIBLE ORIGIN OF FRACTURES IN FLOOR-FRACTURED CRATERS ON CERES.

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Introduction: NASA's spacecraft Dawn reached its target the dwarf planet Ceres in 2015 [1].

For our measurements we use a Low Altitude Mapping Orbit (LAMO) mosaic with a resolution of 35 m/px supplemented with a Digital Terrain Model (DTM) based on the High Altitude Mapping Orbit (HAMO) [2, 3] to investigate Ceres' surface features. Images reveal a number of Floor-Fractured Craters (FFC) on Ceres' surface. Fractures in these craters are linear and/or concentric. Occator e.g. exhibits both kinds of fractures that were likely formed by upwelling material [4, 5], while Kupalo on the other hand only shows concentric fractures, an indication for tear-off edges from slumps or cooling melting processes.

In this work we present the parameters length and width of the linear features located on Ceres' crater floors in dependency of their frequency and distribution. The geometry of faults is an important topic as it can provide insights into the fault system's evolution [6]. Possible formation mechanisms will be inferred by comparison with other planetary bodies like the Moon or Mars that also exhibit FFC's [7].

Methods: The presented geometrical data is based on detailed studies of the Framing Camera images. We measured about 1670 fractures in thirteen craters.

The fissures show curved but also straight pattern. In some cases they also consist of pits. Most fissures contain more than one main fault and fractures split into smaller segments that sometimes arrange to en echelon structures.

For all fracture types the length, width and azimuths were detected.

The accuracy of the measurements is limited by the resolution, especially the distinction between continuous and discontinuous fractures. For the same reason it is impossible to determine the throw of the fractures.

Fracture Geometry:

Length: In this work the length of a fracture is defined as the distance it can be traced as a continuous fissure or fault using the start and end point of each segment. It is obvious that most of the fractures are relatively short with an average length of about 2689 m (Fig 1).

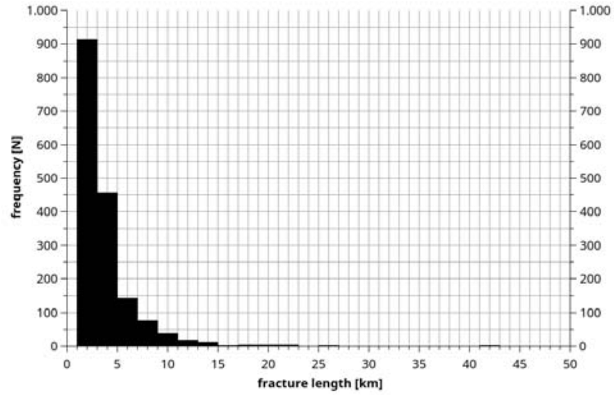

Figure 1 Frequency vs. length of 1670 fractures within the Floor-Fractured Craters on Ceres. Average length lies between 1 and 3 km.

Width: The fracture width is measured at the surface, irrespective of how it was generated. The width of the fractures often varies inside the particular fissure. That's why for every single fracture topographic cross-sections across the faults were drawn and a number of width measurements have been done to determine the mean value for each fracture. Figure 2 shows the width plotted against the length. The maximum width of individual fractures varies from several meters up to a few km. The average width is about 260 m within outlier under tens of meters and in the two thousand meter region.

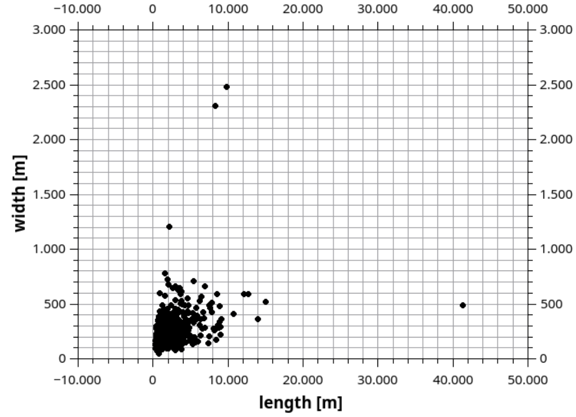

Figure 2 Width plotted against the length. On Ceres' surface small fractures arewider relative to long fractures.

In some cases fractures are of graben like structure e.g. in Yalode, whose fractures are different than for example in Dantu, Haulani or Kupalo. They are arranged in horst and graben or bookshelf structures. But this appearance is less common in FFCs on Ceres.

Strike: We calculated the orientation of each fracture by its geometry. Based on these azimuths we generated rose diagrams of every single crater for the comparison among each other. Figure 3 shows an example of a rose diagram of Dantu. In case of Dantu two different preferred striking directions in SE-NW and NE-SW are clearly visible. Collectively there is no explicit uniform sense of direction and, therefore, no obvious correlation between the azimuths of each crater.

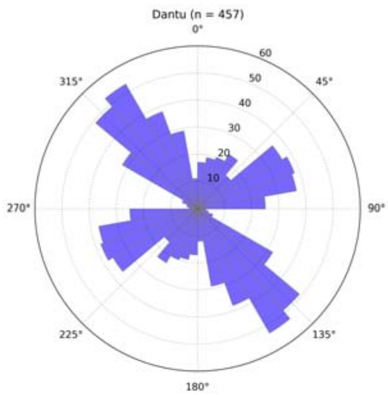

Figure 3 Example of a rose diagram of the azimuths of fractures in Dantu crater showing two preferred directions of striking in NE-SE and NE-SW. 457 fractures have been measured and divided into 10 degree classes.

Conclusion:

On Ceres there are three different kinds of fractures. The first one on top of hillside slides, the second one is radial and the third one is concentric to the crater floor.

In case of Ceres' FFCs the length, width and striking of the fractures varies for each crater. Therefore, we suggest that each one is globally independent and stands alone. In essence, we suggest that the variety in width, length and the high number of small fractures could denote a variance in the surface and underground material and indicates a local brittle material.

Formation mechanisms: Schultz et al. [8] described: volcanic-related activity and viscous relaxation as forming mechanism for Floor-Fractured Craters on the Moon.

Korteniemi [7] and Bamberg [9] described mechanisms like intrusive volcanism, subsurface ice, groundwater migration, near surface tensile stresses, and tectonics for FFCs on Mars.

We suggest three different hypotheses for the formation mechanisms of the FFCs on Ceres: (1) tear-off edges in case of slumping of the crater walls, (2) cooling melting processes and (3) possibly tectonically affected fractures. The third mechanism also comprises up doming of material e.g. in Occator. These mechanisms are comparable to those on the Moon although an uprising of magma is unlikely in case of Ceres [4].

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