DEFORMATIONAL FEATURES ON CERES' SURFACE COMPARED TO OTHER PLANETARY BODIES.

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Introduction: The dwarf planet Ceres has been studied by NASA's spacecraft Dawn since it arrived at Ceres on March 5 in 2015. Ceres' most distinctive deformational surface features are intersecting lineaments, grooves, fractures, troughs, ridges, and domes. These features have been identified on Ceres' surface using High Altitude Mapping Orbiter (HAMO) images (140m/px res.) and a Survey mosaic (400m/px res.) and in later stadium will be supplemented with Low Altitude Mapping Orbiter (LAMO) images (35m/px res.) of the Dawn mission [1]. Additional images of comparable planetary bodies like Enceladus, Ganymede or the Moon provided by the Cassini and Lunar Reconnaissance Orbiter mission were used with respect to the comparison of the different deformation features concerning the morphology and shape, the distribution, orientation and possible building mechanisms. In this study we will concentrate on small scale fractures located on crater floors on Ceres and compare them with floor fractures on icy satellites like Enceladus and Ganymede and also with floor-fractured craters on the Moon (Figure 1).

Fractures on Ceres: On Ceres' surface, fractures could be divided into two different groups. The first one includes fractures normally arranged in a subparallel pattern often located on the crater floors but also on the crater rims. Mostly they appear in combination with comparatively smooth material. Their sense of direction is relatively uniform. In some cases the edges seem to be sheared in one direction, for example in Yalode crater (Figure 2a). This could indicate that the main normal stress strikes vertical to the fractures. En echelon structures are also identified in these groups of parallel fractures (Figure 2b).

The second group consists of joint systems, which spread out of one single location, sometimes arranged concentric to the crater rim e.g. in Dantu (Figure 2c). Occator, for example, shows also fractures that look like desiccation cracks or cracks due to up doming of surface material. This indicates a possible building history caused by cooling-melting processes. In Occator it is also particular that some of the fractures cut through the bright spot with a presumable central dome. This leads to the assumption that they were built prior to the fault in the center. The fractures were also influenced by the bright spot as they seem to be deformed by the building as they are lightly twisted around it (Figure 2d).

Fractures on icy satellites and the Moon: On the icy satellite Enceladus for example, fractures normally cut through the crater rims in parallel sets and sometimes in lozenge forms (Figure 1a). Studies from e.g. Martin and Kattenhorn (2012) interpret these fractures as crater-fracture interactions [2]. Ganymede shows similar intersecting crater fractures, but also some that are arranged concentric to the crater rim (Figure 1b).

In comparison the floor-fractures on the Moon are subdivided into several different groups in dependency of e.g. modification type or size. Their origin is proposed as volcanic-related activity or viscous relaxation [4, 5]. Those with shallow and mare flooded floors show concentric and radial fractures. They were likely formed by magma which rose up under the crater floor. Because of the pressure of the rising magma, the crater gets lifted up and fractures form [3]. Karpinskiy crater (72.609°N, 166,801°E) is one of these examples (Figure 1c). The crater shows floor fractures, concentric to the crater wall, wall terraces, and superimposed linear fractures formed as the crust has been pulled apart [4]. The process of viscous relaxation occurs while the crust gains isostatic equilibrium during excavation and loss of large amounts of material. Fractures occur when the original curved floor flattens and is pushed up [2].

Discussion and results: There are two different groups of fractures distributed on Ceres' surface. Crater-fractures that show a uniform sense of direction could possibly be formed in case of low ambient pressure, while the main normal stress strikes vertical to the fractures. Those that show predominantly no uni-

form sense of direction and run concentric to the crater rim were likely formed by cooling-melting processes during the impact. Other reasonable explanations could be a source from below or sinkage of the crater floor.

Ganymede's crater fractures look similar to those on Ceres' surface, but because of the low resolution of the data set it is difficult to compare them exactly.

While on the one hand it is difficult to find similarities in fracturing between Enceladus and Ceres, structures on the Moon show parallels to the ones on Ceres and could indicate similar building mechanisms. Although it is unlikely that up doming magma on Ceres is the reason of inducing concentric fractures, up doming ice-rich material could be reasonable [6].

Further work will include the comparison of the fractures with additional planetary bodies and the trial to explain why fracturing e.g. on Enceladus differs from that on Ceres.

References: [1] Roatsch T. et al. (2016) *PSS, in press*. [2] Martin E.S. and Kattenhorn S.A. (2012) 43rd LPSC. [3] Schultz P.H. (Received 1979) Space Science division. [4] NASA/GSFC/Arizona State University. [5] Hall J.L. and Soelomon S.C. (1981) Journal of Geoph. Research; Vol. 86; No. B10, Pages 9537-9552. [6] Buczkowski D.L. (2016) LPSC this session

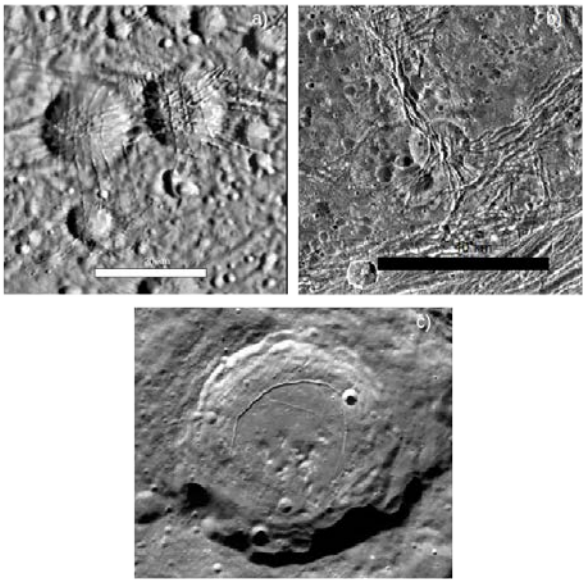

Figure 1: a) Tectonic fractures on Enceladus cutting through the crater. b) Sets of fractures on Ganymede's surface. c) Karpinskiy crater on the moon with a 6km diameter, showing concentric fractures.

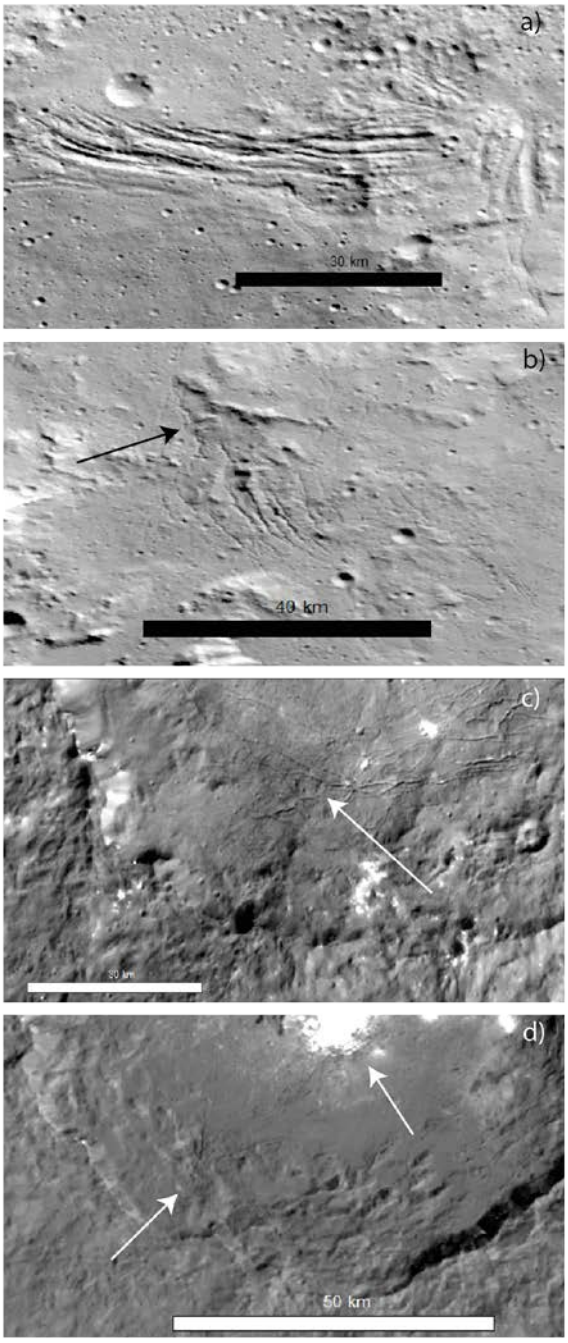

Figure 2: a) Parallel fractures on Yalodes crater floor. The possible mechanism is strain breakage in case of low ambient pressure, while the main normal stress strikes vertical to the fractures. b) Urvara crater shows en echelon structures in the parallel sets of joints. c) Dantu crater with joints spreading out of one single point nearly concentric to the rim. d) Fractures on Occators crater floor. Cutting through the "bright spot" indicating a prior origin and were deformed by the dome building. They also spread out of one single point.