ORIGIN AND DISTRIBUTION OF POLYGONAL CRATERS ON (1) CERES. K. A. Otto[1], R. Jaumann[1,2], K. Krohn[1], D. L. Buczkowski[3], I. von der Gathen[1], E. Kersten[1], S. C. Mest[4], A. Naß[1], A. Neesemann[2], F. Preusker[1], T. Roatsch[1], S. E. Schröder[1], F. Schulzeck[1], J. E. C. Scully[5], K. Stephan[1], R. Wagner[1], D. A. Williams[6], C. A. Raymond[5] and C. T. Russell[7], [1]German Aerospace Center, Institute of Planetary Research, Berlin, Germany (katharina.otto@dlr.de / Fax:+49-30-67055-402), [2]Freie Universität Berlin, Planetary Science and Remote Sensing, Germany, [3]Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, USA, [4]Planetary Science Institute, Tucson, AZ, USA, [5]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA, [6]Arizona State University, Tempe, AZ, USA, [7]University of California LA, Institute of Geophysics, Los Angeles, CA, USA

Introduction: With approximately 950 km diameter and a mass of 1/3 of the total mass of the asteroid belt, (1) Ceres is the largest and most massive object in the Main Asteroid Belt. As an intact protoplanet, Ceres is key to understanding the origin and evolution of the terrestrial planets [1]. In particular, the role of water during planet formation is of interest, because as a differentiated dwarf planet, Ceres is thought to possess a water rich mantle overlying a rocky core [2].

The Dawn spacecraft arrived at Ceres in March 2015. At Ceres, the on-board Framing Camera (FC) collects image data which reveal a large variety of impact crater morphologies including polygonal craters (Figure 1). Polygonal craters show straight rim sections aligned to form an angular shape. They are commonly associated with fractures in the target material, which may be preserved as linear structures on Ceres [3, 4]. Simple polygonal craters develop during the excavation stage when the excavation flow propagates faster along preexisting fractures [5, 6]. Complex polygonal craters adopt their shape during the modification stage when slumping along fractures is favored [5]. Polygonal craters are known from a variety of planetary bodies including the Earth [e.g. 7], the Moon [e.g. 6], Mars [e.g. 8], Mercury [e.g. 9], Venus [e.g. 10], and outer Solar System icy satellites [e.g. 11].

Aim: By analyzing the morphology and distribution of polygonal craters we aim to infer the structural and tectonic properties of Ceres' surface. The presence or former presence of subsurface ice may introduce preferred orientations in the material as a prerequisite for the formation of polygonal craters. The analysis of Ceres' polygonal craters will thus help to understand the tectonics and structure of its crust.

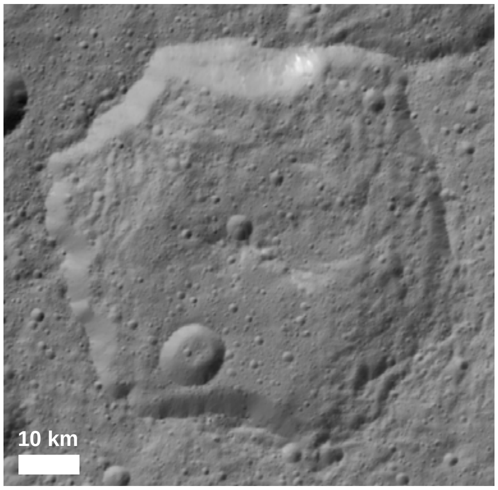

Figure 1: Fejokoo is a ~70 km diameter hexagonal crater located at 29°N and 312°E.

Data: We use FC images and mosaics to interpret the distribution and geology of polygonal craters at the highest available resolution. The Low Altitude Mapping Orbit (LAMO) is providing image resolutions of up to 35 m/pixel. Additionally, we support the identification of polygonal craters with a Digital Terrain Model (DTM) of ~140 m/pixel spatial resolution [12].

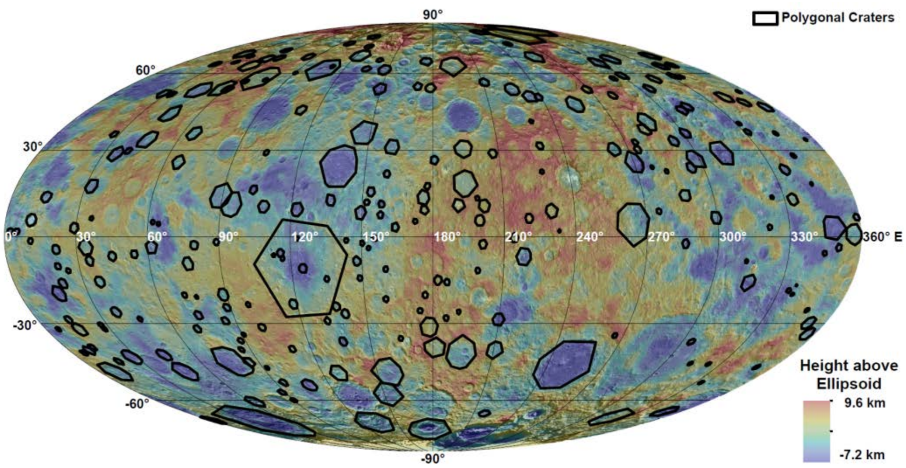

Figure 2: The distribution of polygonal craters on Ceres. The map is in Mollweide projection. The height is referenced to a 482 km x 446 km bi-axial ellipsoid.

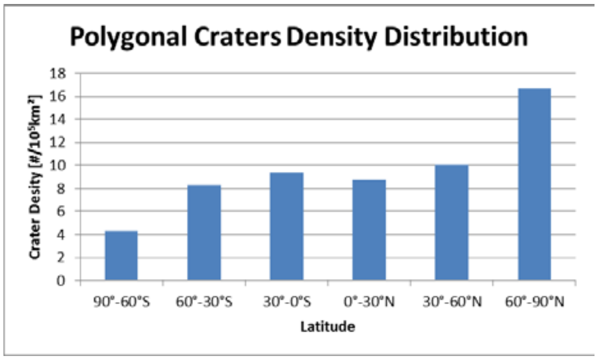

Figure 3: The polygonal crater density distribution with latitude. The northern latitudes show a density above and the southern latitude a density below average. A total of 258 polygonal craters were found.

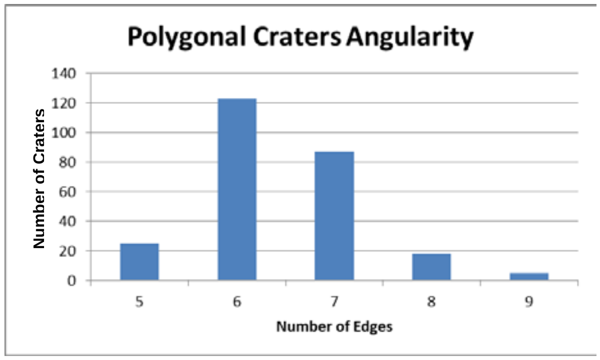

Figure 4: Number of edges of polygonal craters. A total of 258 polygonal craters were found.

Results: On Ceres, we find polygonal craters with a size ranging between 5 km and 280 km in diameter. However, the majority of polygonal craters have diameters ranging between 10 km and 50 km diameter. A preferential hexagonal shape is observed and some polygonal craters exhibit central peaks or relaxed crater floors (Figure 2).

On average there are eight to ten polygonal craters per 100,000 km², however the northern latitudes have a slightly higher and the southern latitudes a slightly lower polygonal crater density (Figure 3). This may hint at an older and younger age of the northern (> 60° N) and southern regions (> 60° S) compared to the mid latitudes, respectively. Alternatively, the relaxation of craters may be advanced in the mid latitudes which are generally warmer than the poles and thus support the relaxation of depressions. Also, the southern region harbors relatively large craters which may have altered or destroyed preexisting structures in the crust which are necessary for the formation of polygonal craters.

Most polygonal craters have six or seven straight rim sections (Figure 4); however, there is a tendency for fewer edges with decreasing crater size. Although this observation may be biased due to the map resolution, it is also possible that the impactor creating a relatively small polygonal crater embeds less energy and thus forms the straight rim sections during the excavation stage. This may result in fewer straight rim sections compared to more energetic impactors which form their polygonal shape during the modification stage.

Straight rim sections and edges of polygonal craters often align with linear features associated with Ceres' tectonics. Small and medium-sized polygonal crater rims tend to align with the general direction of linear features, whereas very large polygonal crater edges tend to be intersected by the linear features. This may hint at the different formation processes of polygonal craters depending on the embedded energy. In contrast, polygonal craters are also present in areas with no obvious tectonic features. These polygonal craters may be produced by sub-resolution or subsurface fissures and fractures.

References: [1] Russell, C. T. et al.: Dawn: A journey in space and time, PSS, Vol. 52, pp. 465-489, 2004. [2] Thomas, P. C. et al.: Differentiation of the asteroid Ceres as revealed by its shape, Nature, Vol. 437, pp. 224-226, 2005. [3] Buczkowski, D. et al.: Preliminary investigation of linear structures on Ceres, GSA 2015, 1-4 November 2015, Baltimore, MD, USA, #282-8, 2015 [4] von der Gathen, I. et al.: Ceres: Tectonic features juxtaposed with analogies on other planetary bodies, GSA 2015, 1-4 November 2015, Baltimore, MD, USA, #282-9, 2015 [5] Öhman, T. et al.: Polygonal impact craters in the solar system: Observations and implications, in Large Meteorite and Planetary Evolution IV, GSA Special Paper 465, pp. 51-65, 2010. [6] Eppler, D. T. et al.: Sources of shape variation in lunar impact craters: Fourier shape analysis, GSA Bull., Vol. 94(2), pp. 274-291, 1983. [7] Poelchau, M. H. et al.: Rim uplift and crater shape in Meteor Crater: Effects of target heterogeneities and trajectory obliquity, JGR, Vol. 114(E01006), pp. 1-14, 2009. [8] Öhman, T. et al.: Polygonal impact craters in the Argyre region, Mars: Evidence for influence of target structure on the final crater morphology, Meteorit. Planet. Sci, Vol. 41(8), pp. 1163-1173, 2010. [9] Weihs, G. T. et al.: Polygonal impact craters on Mercury, Icarus, in press, 2015. [10] Aittola, M. et al.: The characteristics of polygonal impact craters on Venus, Earth Moon Planets, Vol. 101(1-2), pp. 41-63, 2007. [11] Beddingfield, C. B. et al.: Testing for non-visible fractures on Dione by identifying polygonal impact craters, 46th LPSC, 16–20 March 2015, The Woodlands, TX, USA, #1159, 2015. [12] Preusker et al.: Dawn at Ceres: Shape model and rotational state, this meeting.