STRATIGRAPHY OF (1) CERES FROM GEOLOGIC AND TOPOGRAPHIC MAPPING AND CRATER COUNTS USING IMAGES OF THE DAWN FC2 CAMERA. R. J. Wagner[1], N. Schmedemann[2], K. Stephan[1], R. Jaumann[1], T. Kneissl[2], A. Neesemann[2], K. Krohn[1], K. Otto[1], F. Preusker[1], E. Kersten[1], T. Roatsch[1], H. Hiesinger[3], D. A. Williams[4], R. A. Yingst[5], D. A. Crown[5], S. C. Mest[5], C. A. Raymond[6], and C. T. Russell[7]; [1]Institute of Planetary Research, German Aerospace Center (DLR), Berlin, Germany (Email: roland.wagner@dlr.de); [2]Institute for Geological Sciences, Free University Berlin, Germany; [3]Institute of Planetology, Westphalian Wilhelm University, Münster, Germany; [4]School of Earth & Space Exploration, Arizona State University, Tempe/Az., USA; [5]Planetary Science Institute, Tucson/Az., USA; [6]Jet Propulsion Laboratory, Pasadena/Ca., USA; [7]Institute of Geophysics & Planetary Physics, UCLA, Los Angeles/Ca., USA.

Introduction: The Dawn spacecraft has been in orbit around dwarf planet (1) Ceres since its capture on March 6, 2015. Since then, the FC2 Framing Camera [1][2] has been acquiring imaging data at increasing spatial resolution from continuously lower altitudes. In this paper we use image and topographic data to map geologic units and to carry out crater counts in order to derive the global, regional and local stratigraphy of Ceres in four campaigns, using imagery from: (1) the Rotational Characteristics sequence 2 (RC #2), (2) Survey orbit, (3) HAMO (high-altitude mapping orbit), and (4) LAMO (low-altitude mapping orbit). Investigations using HAMO and LAMO data for local stratigraphy in specific areas of interest are in progress or in preparation. In this abstract we focus on data from the Survey orbit.

Data base and procedure: We use global mosaics of imaging data from each of the various orbital phases [3][4] for geologic mapping and crater counts. Geologic units are mapped according to the criteria (a) morphology, (b) topography, and (c) superimposed crater frequency. The topographic information is taken from digital elevation models (DEMs) [5]. Major impact features are used as stratigraphic markers. In general, differences in crater frequencies used to identify mapping units can be defined only crudely by subdividing units into one group which is "densely" and another one which is "sparsely" cratered. More exactly, the relative stratigraphic position of a unit is obtained from its cumulative crater frequency. Abolute ages derived for the mapped units are based on a cratering chronology model derived by Schmedemann and colleagues for Ceres, updating a previous model [6][7][8].

Geologic units, ages and stratigraphy: Broadly, Ceres' globally abundant cratered plains can be subdivided by their topographic position – high, middle, and low level – and by a generally higher or lower crater frequency (densely versus sparsely cratered). In addition, major impact features are mapped as separate units (crater rim outlines). Many of them are mappable in more detail and be further subdivided into geologic units in high-resolution images from the HAMO and LAMO phase.

Previous results from RC2 images. Investigating data from the RC2 sequence in the first mapping campaign has been finished [9][10]. Densely cratered plains are the spatially most abundant units and occur at all three topographic levels. Their cratering model ages range from ~ 3.7 to ~ 3.3 Ga. Sparsely cratered plains show frequencies a factor ~ 3 to 5 lower than the densely cratered plains. The resulting model ages are younger than ~ 3 Ga. No correlation between model age and topographic level was found. The three large impact features *Kerwan*, *Yalode* and *Urvara* form an age sequence from older to younger, despite poor statistics for the latter two features in RC2 data.

Results from Survey and HAMO data. The first measurements in Survey data confirm the age sequence of the major impact features *Kerwan – Yalode – Urvara* extended towards the smaller craters superimposed on their floors. The crater distributions and model ages of *Kerwan* (unit *kef*) and *Urvara* (unit *urhs*) are included in the cumulative diagram shown in *Fig. 1*. According to the model by [7][8], *Kerwan* has a model age of ~ 2.8 Ga, *Yalode* of ~1.8 Ga (data points and curve not included in *Fig. 1*), and *Urvara* of ~ 480 Ma. Based on the two stratigraphic horizons given by *Kerwan* and *Urvara*, a time-stratigraphic system for Ceres can be established by subdividing the stratigraphic column into a *Urvaran* (youngest), *Kerwanan* and *Pre-Kerwanan* (oldest) system or chronologic period.

First crater counts on high-standing densely cratered plains (unit *cpdh*) in the *Ac-08 Nawish Quadrangle* yield a model age of ~3.6 Ga, well within the range of model ages found in RC2 data. The two largest craters in the Ac-08 quadrangle, *Kumitoga* (unit, *ktf*, red points in *Fig. 1*) and *Nawish* (not included in *Fig. 1*) have comparable model ages of ~ 3.4 Ga, measured in crater distributions on their floors. Thus, the cratered plains in Ac-08 and these two large craters can be stratigraphically put into the *pre-Kerwanan* system.

First results from LAMO data. The summit region of the enigmatic mountain *Ahuna Mons*, located in the *Ac-10 Rongo Quadrangle*, was mapped in LAMO data and its crater distribution measured. Despite the comparably high spatial resolution of 35 m/pxl, the rough terrain in the summit region complicates the identification of small craters. Assuming that the features identified and measured as craters are of impact origin (see geologic map, *Fig. 2*), the cratering model age derived for the summit region of *Ahuna Mons* is on the order of ~10 Ma according to the chronology model by [7][8]. Given the poor statistics, this model age is comparably uncertain. It is also uncertain if this model age reflects the formation of the mountain or a subsequent process of geological resurfacing. Another feature counted in LAMO data from the first two cycles is the 8 km large crater *Oxo* (located on the boundary between quadrangles *Ac-02 Coniraya* and *Ac-05 Fejokoo*). According to the cratering chronology by [7][8], the crater was found to be quite young with a model age on the order of 0.5 – 1 Ma.

Ongoing work. Mapping and crater counts are being continued using DEMs derived from Survey, HAMO and LAMO data [5]. The current stratigraphic system established by the two major impact features *Kerwan* and *Urvara* is further used as a base but will be refined by detailed investigations of regional and local geology in HAMO and LAMO data. Of specific interest is the global distribution of young, spectrally distinct craters (e.g., *Oxo*), the range in their cratering model ages and the shape of their size distribution with respect to impactor origin.

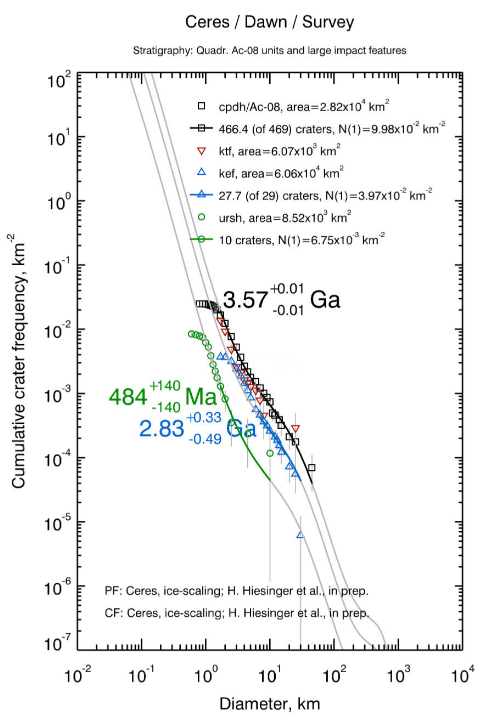

Figure 1: Cumulative crater frequency distributions measured in geologic units mapped in the *Ac-08 Nawish Quadrangle* and on the floors of two of Ceres' major impact features, *Kerwan* (blue) and *Urvara* (green). Images used are from the Survey orbit. Curves shown represent the crater production function (PF) derived for Ceres [7][8]. Cratering model ages from chronology model function (CF) derived and discussed in [7][8]. See text for further explanation.

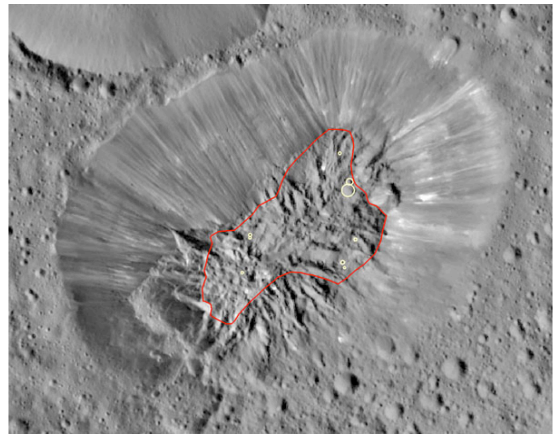

Figure 2: LAMO image mosaic CYCLE1 of *Ahuna Mons* with map of the summit region and small craters identified (yellow circles).

Conclusions: From RC2 data which very well reflect the global distribution of large and medium-sized craters (> 10 km), no correlation between topography and crater frequency is apparent. Both densely cratered as well as sparsely cratered plains show some range in cratering model ages (~ 3.7 – 3.3 Ga and ~ 3.0 – 1.0 Ga respectively). The two major impact features *Kerwan* and *Urvara* can be used as stratigraphic horizons to subdivide Ceres' global stratigraphy into the systems *Urvaran*, *Kerwanan* and *Pre-Kerwanan*, from youngest to oldest.

References: [1] Russell C. T. and Raymond C. A. (2011) *Space Sci. Rev, 163,* 3–23. [2] Sierks H. et al. (2011) *Space Sci. Rev., 163,* 263–327. [3] Roatsch T. et al. (2016) *Planet. Space Sci., in press.* [4] Roatsch T. et al., *this volume*. [5] Preusker F. et al. (2016)*, this volume*. [6] Schmedemann N. et al. (2015), *LPSC XLVI*, abstr. #1418. [7] Hiesinger H. et al. (2016), *in prep*. [8] Schmedemann et al. (2016), *this volume*. [9] Wagner R. J. et al. (2015a), *EPSC Abstracts, Vol. 10*, abstr. EPSC2015-248. [10] Wagner R. J. et al. (2015b), *GSA Annual Meeting*, abstr. No. 282-11.