GLOBAL GEOLOGIC MAPPING OF CERES. S.C. Mest[1], D.A. Crown[1], D.A. Williams[2], D.L. Buczkowski[3], J.E.C. Scully[4], R.A. Yingst[1], D.C Berman[1], A. Frigieri[5], A. Nass[6], A. Neesemann[7], T.H. Prettyman[1], and H. Sizemore[1], [1]Planetary Science Institute, 1700 E. Ft. Lowell Rd., Suite 106, Tucson, AZ 85719 (mest@psi.edu), [2]School of Earth & Space Exploration, Arizona State University, Tempe, AZ 85287, [3]Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, [4]NASA Jet Propulsion Laboratory, Pasadena, CA 91109, [5]Istituto Nazionale Di Astrofisica Inaf, Rome, Italy, [6]DLR, Deutsches Zentrum Fuer Luft- Und Raumfahrt, DLR, Bonn, Germany, [7]Freie, Universität, Berlin, Germany.

Introduction: The Dawn mission to Ceres began in 2014 after its successful mission to Vesta. Dawn acquired image, spectral, and topographic data on its approach to Ceres and through two extended missions, until its conclusion in November 2018.

We are creating a Low Altitude Mapping Orbit (LAMO)-based global geologic map of the dwarf planet Ceres, which builds upon the global lower resolution High Altitude Mapping Orbit (HAMO)-based mapping effort [1] and the LAMO quadrangle-based maps [2-4]. This project has three main objectives: (1) Constrain the lateral extent of the major geologic units observed on Ceres. (2) Characterize the nature and composition of geologic units to understand the nature of internal layering, stratigraphy, and post-emplacement processes. (3) Evaluate the temporal relationships of geologic units and events and determine their position within the current Cerean chronostratigraphy [1]. Objectives 1 and 2 will be addressed by creating the LAMO-based geologic map, which involves analyses of the full suite of Dawn mission datasets. Objective 3 will be addressed by (a) determining relative and absolute ages, (b) evaluating stratigraphic relationships of mapped geologic units and features, and (c) updating Ceres' geologic history and chronostratigraphy.

Background: We are utilizing the Dawn Framing Camera (FC) LAMO mosaic (35 m/pixel) as our mapping base (Figure 1). We are also using the HAMO-based Digital Terrain Model (DTM) (136.7 m/pixel) to provide topographic information, and Visible and Infrared (VIR) Mapping Spectrometer and Gamma Ray and Neutron Detector (GRaND) data to provide compositional information. Linework and units are being identified and mapped primarily from the FC mosaic, and the topographic and spectral datasets are being used to inform the mapping by characterizing features and geologic units.

This geologic map of Ceres will be published as a U.S. Geological Survey (USGS) Special Investigation Map (SIM) at 1:3,000,000 scale for the equatorial region (+/- 60° latitude) and 1:1,500,000 scale for the polar regions (>60° N and S latitude). This mapping effort follows the mapping standards set by the United States Geological Survey and will produce a USGS SIM, enabling dissemination throughout the scientific community and use in future scientific analysis [5].

Global Physiography: Ceres exhibits ~17 km of relief (with respect to the two axial best-fit ellipsoid of 482x446 km) with the highest elevation (~9.5 km) located at the peak of Yamor Mons near the north pole (85.5°N, 11.9°E), and the lowest elevation (~-7.3 km) located on the floor of crater Rongo (68 km in diameter; 3.2°N, 348.7°E). Topographically, Ceres exhibits broad expanses of low-lying terrains and areas of elevated terrains [6]. The low-lying terrains are shaped by large-diameter impact structures (e.g., Urvara, Yalode, Kerwan, and Vendimia Planitia [7]) that form large basins and broad low-lying plains (e.g., Vendimia Planitia), whereas the elevated terrains are formed by Hanami Planum and the rims of impact craters, such as within the north polar region.

Impact craters are the most prevalent geologic features on the surface of Ceres, and appear to have caused most of the visible modification of the surface [1,2,6,8]. Impact craters on Ceres exhibit sizes ranging from the limits of resolution to larger structures such as Urvara (170 km), Yalode (260 km), and Kerwan (284 km). Ceres also contains a number of large quasi-circular depressions that are only apparent in topographic data [7]. Ceres' impact craters exhibit morphologies ranging from "fresh" to moderately degraded with rims that are raised above the surrounding terrain and continuous ejecta blankets. Most craters exhibit circular to nearly circular shapes, but a number of craters have rims that display polygonal planform shapes, reflecting either preexisting fractures in the subsurface and (or) modification of the rims by mass wasting [9].

Previous HAMO-based results: HAMO-based mapping of geologic structures showed that Ceres contains sets of linear to arcuate features – such as troughs, pit chains and impact crater chains – that dissect the surface [1-3,5]. Troughs display steep walls, are wide, and are relatively deep, and they are found in parallel sets oriented radial to several large craters, such as Dantu, Occator, Urvara and Yalode [1]. Pit chains display steep walls, are narrower and shallower than troughs, and some are oriented radial to impact craters. Pit chains are formed by connected circular to ovate depressions that do not display raised rims [10]. Impact crater chains are distributed across the surface of Ceres and are found within most geologic units [1]. Impact crater chains consist of closely-spaced to overlapping chains of small (<1-2 km diameter) craters with raised rims that are oriented radial to larger impact structures. *By mapping these structures in detail using LAMO data, we are building a database of linear features that includes their type, location, length, and cross-cutting relationships in order to better understand their distribution, formation mechanisms, and their place in the geologic history of Ceres.*

Previous HAMO-scale global geologic mapping of Ceres identified 21 geologic units that constitute three major unit types – plains, upland, and impact materials. Image resolution at the HAMO scale allowed for identification and characterization of most geologic units by their albedo and surface texture [1]. Smooth material represents the primary plains unit and covers the terrain within and surrounding Kerwan crater. Cratered terrain represents the primary upland unit and covers most of the surface of Ceres with the exception of impact crater materials. Lower resolution HAMO-scale images prohibited these extensive units from being subdivided in the previous global mapping effort.

Geologic mapping at the LAMO scale is allowing for further investigations of these units. In particular we are investigating the nature of the smooth material's relationships with other features (such as Kerwan), and the possible origin(s) of this deposit. Incorporating spectral and mineralogical data into our mapping effort is enabling compositional signatures to be identified and related to the physical properties of a unit. Furthermore, geologic mapping of the cratered terrain at LAMO scale is enabling us to investigate the unit for any previously unrecognized sub-units, and evaluate the precise areal extent of this unit. Lastly, mapping at LAMO scale is enabling more subtle differences in surface properties (e.g., texture, brightness) to be discerned and previously unmapped impact-related deposits to be identified. In addition, mapping distinct deposits for individual craters, and dating these individual deposits, will constrain their formation age and the ages of all mapped geologic units, within the Cerean chronostratigraphy.

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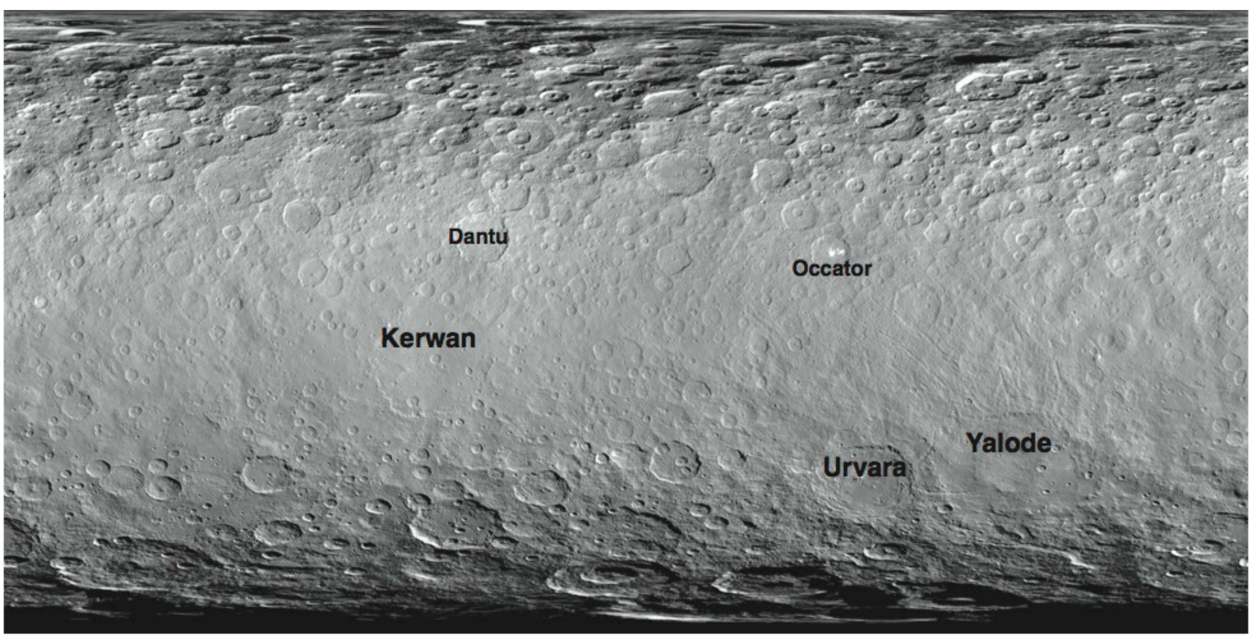

Figure 1. The Dawn global FC mosaic of Ceres at LAMO scale (35 m/pixel) is our primary basemap for geologic mapping. The equatorial region (60°N to 60°S latitude) is being mapped in Mercator projection, and the poles (±60° latitude) are being mapped in polar stereographic projection. Major impact craters are noted; Kerwan crater is 284 km in diameter. Global map shown here is in equatorial projection; quadrangle is centered at 0°N, 180°E.