THE GLOBAL GEOLOGIC MAP OF CERES BASED ON DAWN HAMO OBSERVATIONS.
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Introduction: NASA's Dawn spacecraft arrived at Ceres on March 5, 2015, and has been studying the dwarf planet through a series of successively lower orbits, obtaining morphological, topographical, mineralogical, elemental, and gravity data [1]. The Dawn Science Team is conducting a geologic mapping campaign for Ceres similar to that done for Vesta [2,3], including production of an Approach- and Survey-based global geologic map [4] at 1:10M-scale, a High Altitude Mapping Orbit (HAMO)-based global geologic map [5] at 1:2.5M-scale, and a series of 15 Low Altitude Mapping Orbit (LAMO)-based 1:500K-scale quadrangle maps [e.g., 6]. In this abstract we discuss current results from the HAMO-based global geologic mapping effort for Ceres.

Mapping Methodology: The HAMO-based global geologic map of Ceres is being produced at a scale of 1:2.5M using image, spectral and topographic data from the Dawn mission. Primary mapping materials include the Dawn Framing Camera (FC) HAMO (~140 m/pixel) mosaic and individual images [7], the global HAMO DTM (137 m/pixel) derived from FC stereo images [8], and FC color mosaics (0.44-0.96 µm) [9]. These data are used to identify contacts and for map unit characterization. Some higher resolution LAMO images also were used in limited cases where the locations of contacts or features were difficult to discern.

Base materials were compiled and the geologic mapping conducted in ArcGIS. Geologic units were discriminated primarily by differences in albedo and surface texture. In some cases, FC color images are used to constrain the extents of units, as well as to characterize units relative to surrounding units. Contacts are mapped as polylines with accurate, approximate, and inferred symbologies. Point features are used to identify important features that characterize a unit or feature (e.g., bright spots on the floor of crater Occator, small tholi, central peaks). Linear features, mapped as polylines, include structures and features that are linear to arcuate in planform shape; linear features include both positive-relief (e.g., ridges, crater rims, scarps) and negative-relief (e.g., grooves, crater chains, pit chains, troughs) types. Because of the map scale, only units and features that meet minimum size criteria are represented on the map: geologic units greater than 100 km^2 in area, impact craters greater than 20 km in diameter, and linear features greater than 20 km long.

Physiography of Ceres: Ceres exhibits ~16 km of topographic relief [8], and prelimnary mapping from Approach and Survey images [4] showed that Ceres is dominated by broad expanses of low-lying terrains and small areas of elevated terrains. The "lows" within the low-lying terrains appear to have been shaped by large-diameter impacts, forming basins. The "highs" within the elevated areas appear to be composed of large knobs and the rims of degraded craters.

Mapping Results: Geologic mapping has defined several widespread units: *cratered terrain*, *smooth material*, and units of the Urvara/Yalode system. *Cratered terrain* forms most of Ceres' surface and contains rugged surfaces derived largely from the structures and deposits of impact features. The material of the cratered terrain includes the oldest terrains exposed on Ceres, but the geologic materials likely consist of crustal materials heavily mixed with impact materials. *Smooth material* forms nearly flat-lying to hummocky plains in the western equatorial hemisphere; this unit is found on the floor of, and surrounding, crater Kerwan, where it embays the cratered terrain. The geologic materials related to the Urvara and Yalode basins consist of impact materials (floor, rim, and ejecta deposits) that cover a broad part of Ceres' eastern and southern hemispheres. Urvara ejecta consists of a rugged and a smooth facies, whereas Yalode ejecta can be distinguished by its smooth and rolling to stucco-like texture. Superposition relations show that ejecta deposits and structures from Urvara superpose Yalode.

In addition to Urvara and Yalode, impact materials can be identified across Ceres, and include *crater materials* and smooth and hummocky *crater floor materials*. Crater material is identified around many of the more fresh-appearing craters. These deposits include primarily rim and ejecta materials, as well as crater floors where floor materials can not be discerned.

Impact craters are the most prevalent features on the surface of Ceres, and appear to have caused most of the visible geologic modification of the surface [10]. Impact craters on Ceres exhibit a range of sizes – from the limits of resolution to larger impact basins such as Urvara (170 km), Yalode (260 km), and Kerwan (284 km). Ceres' impact craters also exhibit a range of preservation styles. Many craters of all sizes appear morphologically "fresh" to moderately degraded with rims that are nearly circular and raised above the surrounding terrain. Small fresh craters (<15 km) display simple bowl shapes, whereas larger fresh craters display steep walls and flat (sometimes fractured) floors [4], though most contain hummocky or irregular-shaped deposits on their floors. Many craters exhibit irregularly shaped, sometimes scalloped, rim structures, and many craters contain debris lobes on their floors, suggesting instability in surface materials. Ceres also contains a number of large depressions that are only apparent in the topographic data. These depressions are quasi-circular in shape, suggesting ancient infilled basins, but clear rim structures are not apparent [e.g., 10,11].

In addition to the rims of impact craters and basins, the surface of Ceres contains a variety of structures. Of particular interest are sets of negative relief linear to arcuate features (such as furrows, grooves, troughs, pit chains and impact crater chains) that dissect Ceres' surface and form catenae and fossae that mostly extend radially from large impact structures. For example, linear to arcuate troughs and grooves radial to Yalode form Samhain and Uhola Catenae north of the basin. The lineations north of Yalode are a few (<20) kilometers wide and hundreds of kilometers long, whereas a portion of Samhain Catenae northwest of Yalode consists of a chain of closely-spaced circular to elongated depressions, interpreted to be a secondary impact chain from Yalode. Gerber Catena extends to the northwest of Urvara and is similar in morphology to Samhain and Uhola Catenae, but narrower. Ejecta from Yalode and Urvara are not observed on the floors of these catenae, which are interpreted to post-date these impacts. Evaluation of superposition and cross-cutting relations with these features and the units in which they occur is providing important age relationships for Ceres [e.g., 12].

Ongoing work: Based on the units presented here, we are currently engaged in crater-based age dating, determining superposition relations, and using this to interpret Ceres chronostratigraphy; this will be presented at LPSC, and will be discussed in detail in an upcoming manuscript.

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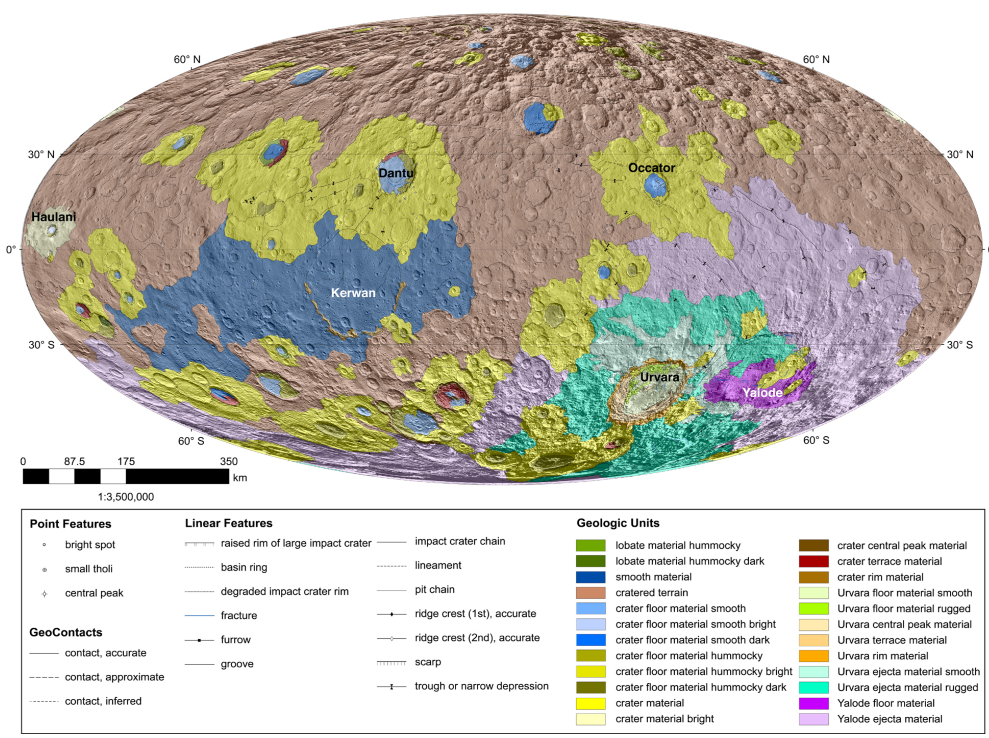

Figure 1: Global geologic map of dwarf planet Ceres. Map base is Dawn FC HAMO mosaic (courtesy DLR). Projection is Molleweide; center longitude is 180°E.