

**GEOLOGIC MAPPING OF THE URVARA AND YALODE QUADRANGLES OF CERES.** D. A. Crown<sup>1</sup>, H. G. Sizemore<sup>1</sup>, R. A. Yingst<sup>1</sup>, S. C. Mest<sup>1</sup>, T. Platz<sup>1,2</sup>, D. C. Berman<sup>1</sup>, N. Schmedemann<sup>3</sup>, D. L. Buczkowski<sup>4</sup>, D. A. Williams<sup>5</sup>, T. Roatsch<sup>6</sup>, F. Preusker<sup>6</sup>, C. A. Raymond<sup>7</sup>, and C. T. Russell<sup>8</sup>, <sup>1</sup>Planetary Science Institute, Tucson, AZ ([crown@psi.edu](mailto:crown@psi.edu)), <sup>2</sup>MPS, Göttingen, Germany, <sup>3</sup>Freie Universität, Berlin, Germany, <sup>4</sup>JHU-APL, Laurel, MD, <sup>5</sup>Arizona State University, Tempe, AZ, <sup>6</sup>DLR, Berlin, Germany, <sup>7</sup>JPL, Pasadena, CA, <sup>8</sup>UCLA, Los Angeles, CA.

**Introduction:** We used Dawn spacecraft data to produce geologic maps of the Ac-13 Urvara (21-66°S, 180-270°E) and Ac-14 Yalode (21-66°S, 270-360°E) Quadrangles of dwarf planet Ceres (Fig. 1) [1]. Dawn Framing Camera (FC) datasets [2-4], including image mosaics, DTMs, and color/color ratio images, were used with ArcGIS software to analyze Ceres' surface geology and geologic evolution in these and surrounding areas affected by the Urvara and Yalode impact basins. The Urvara and Yalode maps are 2 of 15 Low Altitude Mapping Orbit (LAMO; 35 m/pixel)-based quadrangle maps being generated for Ceres [5].

**Geologic Setting:** Urvara (45.9°S, 249.2°E; 170 km) and Yalode (42.3°S, 293.6°E; 260 km) are adjacent impact basins located in Ceres' southern hemisphere. They are the 2nd- and 3rd-largest distinct impact structures on Ceres after Kerwan (284 km) [6]. East of Yalode is the subdued expression of a similar-sized circular depression, presumably the site of a degraded impact basin that predates Yalode. Urvara has a more well-preserved morphologic expression than Yalode, and structures radial to Urvara extend across Yalode. Distal impact deposits and structures extend into neighboring regions, including the Zadeni, Occator, and Rongo Quadrangles [7-10].

**Geologic Mapping:** We mapped 14 geologic units and 14 geologic feature types (line and point features) in the Urvara and Yalode Quadrangles. Main unit types include cratered terrain, Urvara and Yalode basin deposits, and various types of impact crater materials. *Cratered terrain* represents ancient crustal materials that are widespread across Ceres, is the oldest unit in the map region, and is interpreted as ancient impact ejecta and crater materials, but may also include younger crater materials not clearly delineated or linked to specific source craters. Mapped craters interpreted to be geologically young typically have sharply defined inner walls covered with talus and sometimes include terraces. They also show lobate ejecta patterns that cover or mute underlying terrains. The wide range in morphologic signatures for impact craters is attributed primarily to relative age but may also be influenced by substrate characteristics.

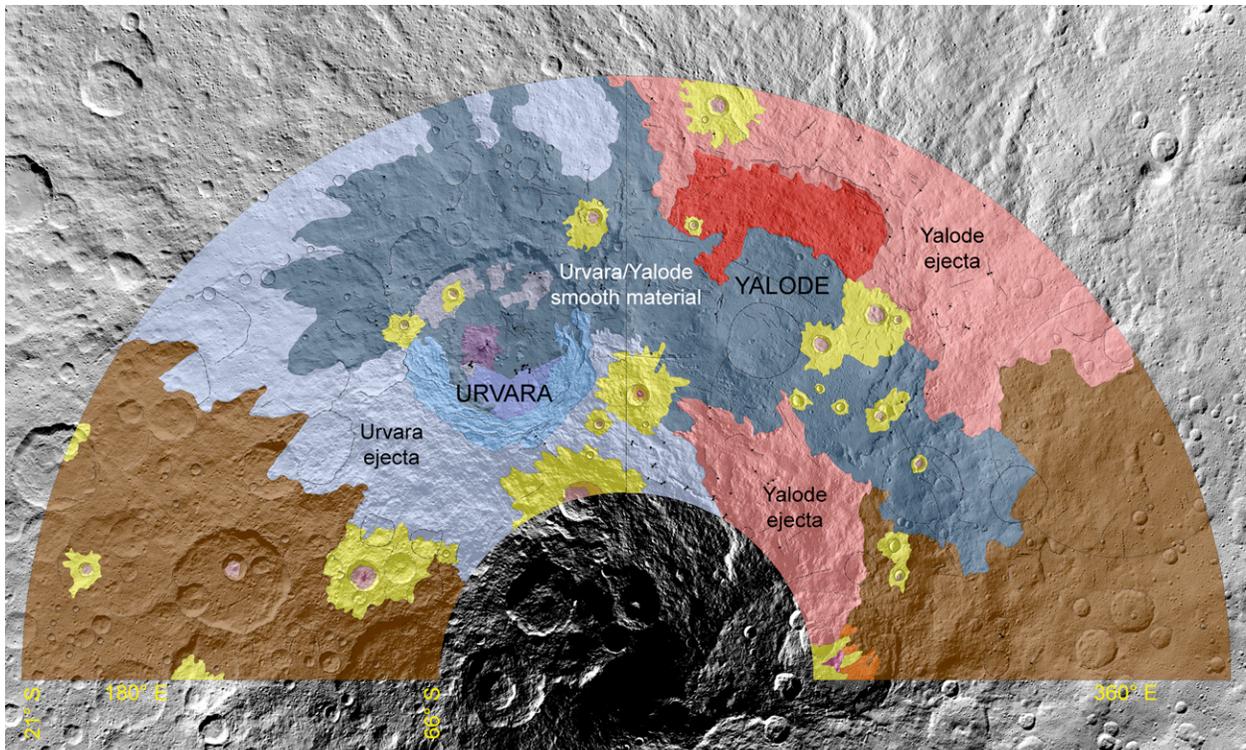
Due to the prominence and large areal extents of Urvara and Yalode basins as well as their importance as global stratigraphic markers for Ceres, we mapped basin materials separately from other crater materials,

effectively defining geologic formations for Urvara and Yalode. Yalode units include *Yalode ejecta*, evident N and S of the basin, and *Yalode floor material hummocky*, deposits interpreted to be degraded terrace materials mixed with local mass-wasting and perhaps Urvara ejecta. Yalode ejecta has a hummocky surface with scarps, ridges, and grooves trending in both circumferential and radial patterns. Urvara, which is better preserved and clearly overlies Yalode, includes central peak, terrace, and floor (hummocky and smooth) units in addition to *Urvara ejecta*.

*Urvara-Yalode smooth material* comprises a major portion of Urvara basin's floor deposits, extends N and NE from Urvara's rim, and far to the E, covering much of Yalode's floor and eastern rim. Smooth material is interpreted to drape and bury pre-existing terrain, such that it may show morphologic variability due to the underlying local surface. Given its large areal extent and distribution across variable topography and elevation, *Urvara-Yalode smooth material* is interpreted to be a combination of deposits from both impact events merged together and perhaps mixed with localized ice-rich resurfacing.

**Synthesis:** Geologic mapping using Dawn FC datasets shows that the Urvara-Yalode region included early formation of cratered terrain, a middle phase of basin formation, and late-stage emplacement of smooth deposits coupled with continued cratering. Crater size-frequency distributions for selected areas support relative age interpretations based on mapping and provide absolute age estimates (using the lunar-derived model [11]) for the formation of the Urvara basin (~120-140 Ma) and Yalode basin (minimum age of 1.1 Ga; +0.5 Ga, -0.4 Ga).

**References:** [1] Crown D.A. et al. (2107) *Icarus* in review (*Urvara-Yalode Quadrangles*). [2] Nathues A. et al. (2104) *Icarus* 239, 222-237. [3] Preusker F. et al. (2016) *LPS XLVII*, Abstract #1954. [4] Roatsch T. et al. (2016) *PSS 129*, 103-107. [5] Williams D.A. (2017) this issue. [6] Williams D.A. et al. (2017) *Icarus* in review (*Kerwan Quadrangle*). [7] Williams D.A. et al. (2017) *Icarus* in review (*Ceres Mapping*). [8] Buczkowski D.L. et al. (2017) *Icarus* in review (*Occator Quadrangle*). [9] Platz T. et al. (2016) *PGM*, Abstract #7030. [10] Mest S.C. et al. (2017) this issue. [11] Hiesinger H. et al. (2016) *Science* 353, doi:10.1126/science.aaf4759.



GEOLOGIC UNITS	
Ue	Urvara ejecta material
Ut	Urvara terrace material
Ucp	Urvara central peak material
Ufs	Urvara floor material smooth
Ufh	Urvara floor material hummocky
UYs	Urvara/Yalode smooth material
Ye	Yalode ejecta material
Yfh	Yalode floor material hummocky
crt	cratered terrain
c	crater material
ct	crater terrace material
ccp	crater central peak material
cfs	crater floor material smooth
cfh	crater floor material hummocky

MAP SYMBOLS	
—	contact, accurate
- - -	contact, approximate
—	pit chain
·	pit of impact crater floor
▬	raised rim of large impact crater
—	raised rim of small impact crater
⋯	buried impact crater rim
---	channel
⋯	degraded impact crater rim
—◆—	graben trace
—	groove
—	impact crater chain
▬	lobate scarp
—◆—	ridge crest
▬	scarp
—▽—	trough or narrow depression

Figure 1. Combined geologic map of the Urvara (left) and Yalode (right) Quadrangles of Ceres in polar stereographic projection centered on 270° E. Background is HAMO mosaic. Urvara is 170 km in diameter.