NEW CARTOGRAPHIC AND TOPOGRAPHIC INSIGHTS OF EUROPA FROM NEW JUNOCAM IMAGES. P. M. Schenk[1], G. C. Collins[2], C. J. Hansen[3], J. T. Keane[4], E. J. Leonard[4], M. Ravine[5], and M. Caplinger[5]. [1]Lunar and Planetary Institute/USRA, (pschenk@lpi.usra.edu), [2]Wheaton College, [3]Planetary Science Institute, [4]Jet Propulsion Laboratory, California Institute of Technology, [5]Malin Space Science Systems

Introduction: Europa, one of Jupiter's four main moons, consists of a water-ice shell underlain by a liquid water ocean and is a prime target of exploration [e.g., 1,2]. The geology and topography of the surface thus has implications for the nature of the ice shell, vertical transport within it and future exploration of Europa. Due to large gaps in cartographic and especially topographic coverage of Europa from Voyager and Galileo much remains unclear about the ice shell and its properties. Hence any additional data prior to the arrivals of Europa Clipper and JUICE will be important.

The Juno spacecraft performed a close flyby of Europa on September 29th, 2022 and returned 4 new mosaics of Europa's surface with pixel scales of ~1 to 3.6 km of much of the sub-Jovian hemisphere of Europa (Fig. 1). These provide improved resolution in an important Galileo coverage gap (~30-70°E) and an improvement in illumination that allows discrimination of topographic relief between 340 and 360°E, possibly associated with true polar wander [3] (Fig. 2). These data improve our understanding of feature locations on Europa and allow us to search for changes on the surface since Galileo and New Horizons in 1998 and 2007.

Cartography: The 4 Junocam (JC) mosaics cover the longitudes 340°E to 80°E and overlap parts of the Galileo E4 and E25 mosaics (at 1.4 to 1.0 m/pixels). The JC mosaics also partly fill the gap in Galileo coverage between E4 and E25. Two of these mosaics were obtained at phase angles and coverage limits comparable to lower resolution E2 and E10 4-6 km/pixel Galileo images at these longitudes (and are better suited to change detection due to less severe shading contrasts).

The preliminary 200-m pixel scale 3-color global map from Voyager and Galileo by the author [4] is being updated using the new JC mosaics where they exceed Galileo resolution or quality. Each of the 4 JC mosaics was integrated into the existing control networks using ISIS control net software. Positional updates were no more than a few km. Geologic mapping using these products is also underway [5].

The nature of the JC imaging system allowed us to use super-resolution techniques to extract full information content. Each of the 4 main mosaics was acquired in 3 colors and by map projecting each color framelet into its own mosaic at resolutions 3x better than nominal pixel resolution and summing the 3 filter sub-mosaics for each observation, we were able to mitigate fringing effects on narrow lineaments inherent in these images and improve feature recognition in the mosaics. This super-resolution version is then recombined with the 3-color-mosaics to produce full resolution color mosaics (Fig. 1).

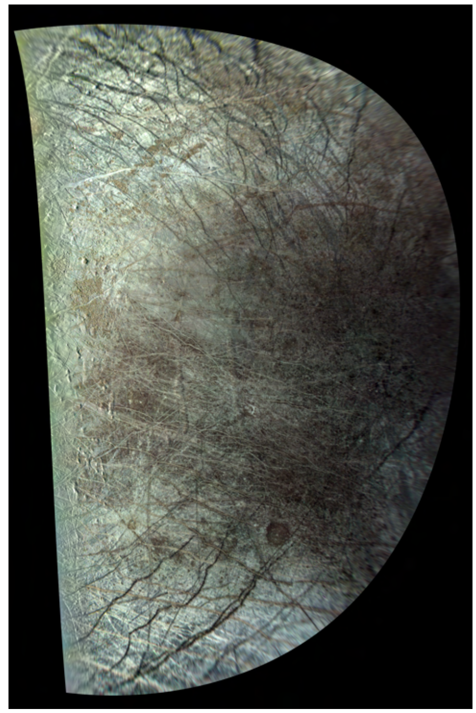

Figure 1. Calibrated and rectified Junocam 3-color mosaic of Europa. Mosaic has been projected at ~330 m/pixel and red-green-blue mosaics stacked to improve resolution and feature discriminability.

Topography of Depressions & TPW: The 4 JC mosaics have a maximum parallax angle difference of ~22°. This is sufficient to resolve vertical features on the scale of ~500 m. However, because most of the surface of Europa has relief of <500 m [6] no geologic features are resolvable in the stereogrammetric DEMs processed to date (even Midir reveals no substantive relief indicating that if a crater, it is more similar to shallow Pwyll or Manannan than to deeper Cilix [e.g., 7]). Additional processing may reveal broad scale surface undulations if of sufficient magnitude, but no large domical features have as yet been identified.

Numerous oval or elongate depressions were observed along the JC terminator. These are not resolved in stereo, but shape-from-shading (and attendant shadow lengths) indicate depths for most of up to 500 m (Fig. 2), consistent with prior depression measurements [e.g., 7]. The largest has a depth of ~900 m, similar to that of deep pits associated with true polar wander (TPW) [3]. Mapping of these features, which includes a previously unrecognized arcuate trough, reveals that most occur along the extension of one of the outer rings of the TPW pattern (Fig. 3), suggesting that many of the depressions observed elsewhere on Europa may be part of this pattern.

Figure 2. Portion of Junocam mosaic (left) and shape-from-shading DEM (right). Vertical scale is -0.5 to 0.5 km. Note ~900 m deep depression at top.

Change Detection: Simple ratioing of photo-metrically corrected JC and Galileo mosaics was used to perform a preliminary test of whether changes have occurred on Europa at km scales since 2001-2007. The ratio images (Fig. 4) show the abundant dark red lineations that cross the surface, mostly because of the different spectral and photometric sensitivities of the three imaging systems involved [e.g., 8]. To date no definitive unique surface changes have been detected in the JC imaging area (Fig. 4), but analysis is ongoing.

Conclusions: JunoCam imaging of Europa in Sept. 2022 provided important new mapping coverage of the subJovian hemisphere, a region not previously well observed. New topographic features were observed along the terminator with relief of ≤500 m (and one depression of ~900 m). These features correlate with cryptic albedo features observed by Galileo and suggest that the global crop circle patterns associated with TPW may be more complex than surmised from Galileo and Voyager. Cartographic updates were incorporated into a revised and improved global 200-m pixel scale global 3-color map. No surface changes or discrete plume deposits were detected but photometric camera differences limit this effort and imaging resolutions limit plume deposit scales that could be detected.

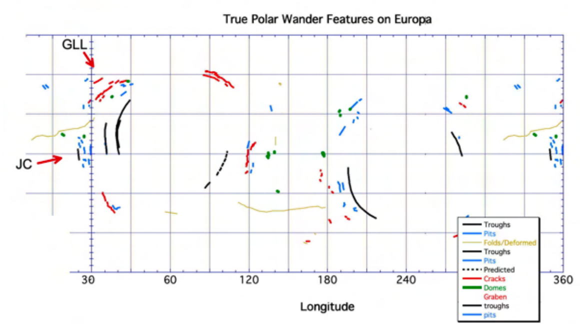

Figure 3. Map of arcuate features associated with TPW (modified from [3]) showing locations of new topographic features (JC arrow) observed by Junocam.

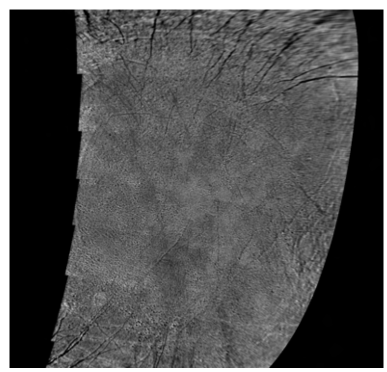

Figure 4. Ratio image of Galileo and Junocam imagery showing differences between 1998 and 2022. Most if not all differences are associated with differing sensitivities of the imaging systems involved.

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References: [1] Kivelson et al. 1999, *JGR: Space Physics* 104, no. A3 (1999): 4609-4625. [2] Hand et al. 2009, *Europa*, pp.589-629. [3] Schenk, P., et al., (2020), *Geoph. Res. Lett.* 47, e2020GL088364. [4] Schenk, P., [https://repository.hou.usra.edu/handle/20.500.11753/1412.](https://repository.hou.usra.edu/handle/20.500.11753/1412) [5] Leonard, E., 2023, *Lunar Planet Sci. Conf*, this conference. [6] Schenk, P., and F. Nimmo, 2023, in prep. [7] Schenk, P., and E. Turtle, 2009, in *Europa*, Univ. Ariz. Press. [8] Schenk, P., (2020). *Astrophys. J. Lett.*, 892, L12.