GANYMEDE IMAGED BY JUNOCAM 42 YEARS AFTER VOYAGER. M. A. Ravine[1], C. J. Hansen[2], M. A. Caplinger[1], G. C. Collins[3] and P. M. Schenk[4], [1]Malin Space Science Systems, San Diego CA, ravine@msss.com, [2]Planetary Science Institute, Tucson AZ, [3]Wheaton College, Norton MA, [4]Lunar & Planetary Institute/USRA, Houston TX.

Introduction: The JunoCam instrument on the Juno Jupiter orbiter acquires wide field of view color images scanned by the rotation of the Juno spacecraft. JunoCam was designed to image Jupiter's polar regions as Juno passed over the poles in its highly elliptical orbit. During Juno's primary mission, JunoCam made observations of Jupiter's atmosphere during thirty-two perijove passes, discovering the circumpolar cyclones [1] among other things. While there were no close flybys of the Galilean Satellites during Juno's five year primary mission (2016-2021), the extended mission included a close encounter with Ganymede on 7 June 2021, just before Juno's 34th perijove pass. Here we present the JunoCam images acquired during the Ganymede encounter on perijove 34 with discussion of initial results. A mosaic of the first two JunoCam images in this sequence is shown in Figure 1, projected as viewed from Juno's location at the time of the second image acquisition.

Figure 1. Mosaic of the first two JunoCam images from the PJ34 Ganymede encounter. The image quality is a substantial improvement over the coverage Voyager 1 acquired of this part of Ganymede in 1979. NASA/JPL-Caltech/SwRI/MSSS/ Björn Jónsson**.**

Encounter: Juno flew by Ganymede moving west to east, with a closest approach altitude of approximately 1,000 km at a sub-spacecraft point west of the terminator (i.e., in the dark). Shortly after crossing the terminator, JunoCam acquired four images in color (red, green and blue), separated by 60 seconds (Figure 2). JunoCam used the spacecraft rotation to build up each image with a series of "framelets," separately acquired 1600 by 128 pixel images in each color. Each image consists of 69 such framelets. Over the four JunoCam images, the range to Ganymede increased from approximately 1,000 km for the first to over 4,000 km for the fourth. At those ranges, the spatial scale in the images ranged from ~0.8 km pixel per pixel in the first to > 4 km per pixel in the fourth. The incidence angle decreased from 90° in the first image, which included the terminator, to about 30° for the fourth image.

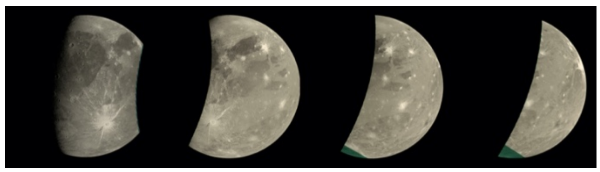

Figure 2. The four PJ34 JunoCam images of Ganymede.

JunoCam uses the rotation of the Juno spacecraft to scan out each image. Each image is built up of separate exposures of the instrument's CCD detector, through an RGB color filter array. These exposures are repeated about once every two seconds to capture the overlapping framelets in each band, providing complete coverage in all three colors. This mode of operation, which we call "pushframe," also includes the capability of clocking the CCD to perform time delay integration (TDI), providing the option of extending the integration time by small integer multiples of the rotation smear-limited exposure time of 3.2 milliseconds. A section of the raw first image of the Ganymede encounter is shown in Figure 3.

The solid angle covered by a JunoCam image is limited by the 58° field of view in the cross-scan direction and by the number of framelets commanded in the along-scan direction, which can be up to 360°. The format of an image in the cross-scan direction is 1600 pixels—the width of the detector—and 9000 pixels in the along-scan direction—a full 360° rotation. While the Juno spacecraft rotates every 30 seconds, certain timing constraints on the commanding and readout of JunoCam during the Ganymede encounter limited acquisition of Ganymede to every other rotation (i.e., 60 seconds apart). For the velocity of the PJ34 encounter, the spacecraft velocity relative to Ganymede was large enough that there are significant viewing geometry differences between the JunoCam images, enabling limited stereo topography from this dataset. In fact, given that it took about ten seconds to scan out the full disk of Ganymede, there were non-trivial changes in geometry over each image. A more detailed description of the JunoCam instrument, including its development, specifications and operation is provided by [2].

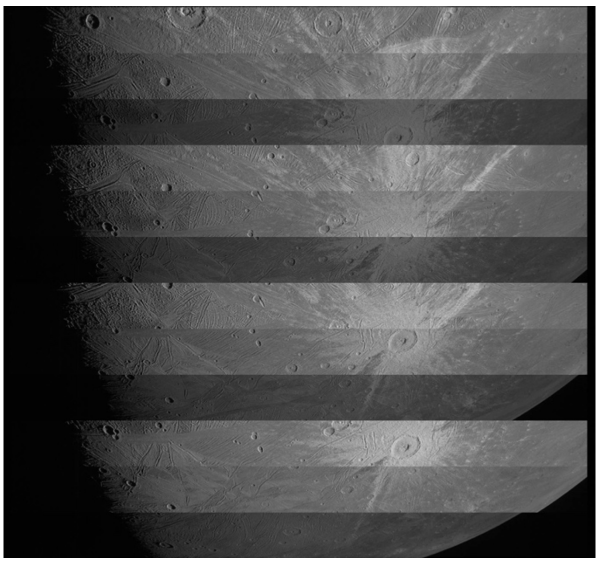

Figure 3. Twelve raw JunoCam framelets from the first PJ34 Ganymede encounter image. Each set of three was acquired at the same time through red, green and blue filters. It took 69 framelets to cover Ganymede from north to south.

Changes: To compare the JunoCam PJ34 images with the previous coverage of the same area of Ganymede, we reprojected the JunoCam images using a simple cylindrical projection at a scale of 1 km per pixel. This sampling is a reasonable representation of the intrinsic scale of the JunoCam images (just under 1 km per pixel to over 4 km per pixel) and it matches the scale of the mosaic of Voyager 1 Imaging Subsystem (ISS) and Galileo Solid State Imager (SSI) images [3]. While the Galileo SSI coverage is higher resolution that 1 km per pixel, that is only the case over the limited areas over which Galileo acquired coverage.

Flickering back and forth between the JunoCam and Voyager images revealed no changes at the 1 km per pixel scale. Given the high albedo of fresh craters and ejecta on Ganymede, we argue that craters down to 250 m diameter would be detectable in images of 1 km per pixel scale. Taking the Ganymede cratering rates from [4] and extrapolating below 1 km, we get a probability of JunoCam observing a new crater over 12.2 million km^2 in 42 years of 1 in 1500, certainly consistent with not having observed any.

Other investigations: We have used these JunoCam images to pursue two separate lines of investigation: topographic and geologic. DEMs generated from stereo from the adjacent image overlap has confirmed and better characterized the large topographic dome at the sub-jovian point [5]. We have identified eight previously unobserved paterae (caldera-like features) shown in Figure 4, and increased the fidelity of the geologic map over this section of Ganymede [6].

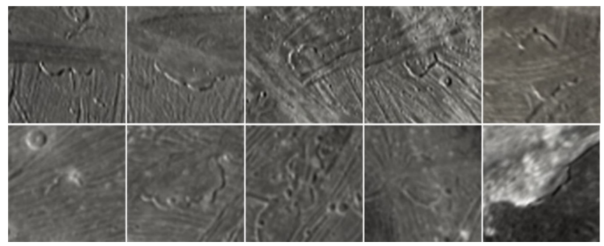

Figure 4. The ten paterae found in the JunoCam images, eight of which were previously unidentified.

Conclusions: JunoCam imaged 12.2 million km^2 of Ganymede's northern subjovian hemisphere (around 0° longitude), significantly improving the quality of available imaging coverage there. No changes were detected over the area in the 42 years since it was first imaged by Voyager 1. Topography has been extracted of several features, including Tros Crater and the large topographic dome at the subjovian point [5]. The higher quality coverage over this area has been used to significantly improve the geologic map over this area, and previously unidentified paterae and craters were identified [6]. The JunoCam images are now available from the PDS for use by the planetary science community [7].

Acknowledgments: The image data used in this research is now available from the NASA Planetary Data System: Caplinger, Michael, Juno JunoCam, RDR V1.0, NASA Planetary Data System, JUNO-J-JUNOCAM-3-RDR-L1A-V1.0, 2014. https://doi.org/10.17189/1520279.

References: [1] Orton, G. S., et al. (2017) *GRL, 44*; [2] Hansen, C. J., et al. (2014) *SSR, 213*; [3] Schenk, P. M. (2010) *Atlas of the Galilean Satellites, CUP*; [4] Zahnle, K., et al. (2003) *Icarus, 163*; [5] Schenk, P. M., et al. (2022) this meeting; [6] Collins, G. C., et al. (2022) this meeting; [7] Reference in acknowledgements above.