VOYAGER 2 IMAGES OF URANIAN SATELLITES: REPROCESSING AND NEW INTERPRETATIONS. T. Stryk[1] and P. J. Stooke[2], [1]Humanities Division, Roane State Community College, Harriman, Tennessee, United States 37849 (strykt@roanestate.edu). [2]Department of Geography, University of Western Ontario, London, Ontario, Canada N6A 5C2 (pjstooke@uwo.ca).

Introduction: Voyager 2 imaged the southern hemispheres of the satellites of Uranus during its flyby in January 1986. The northern hemispheres were not illuminated by the sun, but Stooke [1] first observed that parts of them were illuminated by reflected light (sunlight reflected off the planet). For every Uranian satellite, half of the northern hemisphere centered on the prime meridian should have received some reflected light. If that region was visible to Voyager 2 in the highest resolution observation sequences, new surface features might be visible. Stooke described bright crater ejecta deposits and a large tectonic feature [1]. Here, more sophisticated processing by the first author enhances these images further to allow new interpretations, and extends the study to other satellites.

Data and Processing: Voyager 2 approached the Uranian system nearly perpendicular to the satellite orbit plane, obtaining images with gradually increasing resolution. Closest approach to each large satellite occurred when the spacecraft was near the orbit plane, so the highest resolution images for most satellites have phase angles of about 60º. Miranda is the chief exception, with a 16º phase angle in the highest resolution mosaic. The phase angle corresponds to the part of the surface potentially visible in reflected light, depending on the central longitude. For Miranda, only a thin crescent might be seen in reflected light, while for Ariel and Titania a wide crescent is available. Umbriel and Oberon, seen in less detail, were intermediate in viewing geometry.

Processing: The individual frames were first converted to 16 bit images. After moiré removal and ordinary calibration using frames taken for that purpose, the individual colums were binned for 100-200 rows for the columns adjacent to the frames, skipping rows containing originally contained moiré. Pixel to pixel deviations of more than six levels (based on the original 8-bit format) were removed. This construction was then stretched vertically and subtracted from the image. This eliminated the vertical striping often seen even in calibrated Voyager images. At this point, desmearing was applied to smeared frames.

For dayside images, when more than one frame was available from the same angle, they were then stacked and underwent processing based on Tim Parker's super resolution methods. However, instead of using unsharp masking, a PSF-based deconvolution algorithm was applied to the images. The images were weighted based on their sharpness. In other words, if five frames were stacked, and two of them were of high quality but the other two were grossly underexposed, the good images might be weighted in the stack as 23 percent each while the poorer three frames would be weighted at 17 percent each. After merging the stack, an overlay was produced with low contrast, high frequency features removed. Very high contrast features were maintained to prevent the limb from being damaged. This allowed the enhancement of surface details across the entire disk.

For nightside images, when available, the frames were summed to increase the effective exposure time. High-pass filtering was mixed with enhancements which allowed low-frequency features to be preserved. Versions were produced with and without 2x2 binning, but the images without binning showed no meaningful additional data and the effects of noise were distracting. The images were also merged with a smoothed version to reduce the "stair-step" effects produced by only having a few layers of gray available.

Results - Ariel: Ariel has a complex surface with many tectonic structures, craters and large albedo variations associated with fresh ejecta. The newly reprocessed images extend into the northern hemisphere and enable the mapping of tectonic structures, fresh crater ejecta blankets, and possibly a large impact basin or fault-bounded polygonal region (Figure 1). These features are best seen in the image pair 26845.37 and 26845.39. An earlier mosaic at a smaller phase angle does not increase coverage, but shows features consistent with the higher-phase imaging, bolstering the case that these features are not artifacts. A low resolution image sequence made after encounter with a very high phase angle shows a thin crescent of reflected light but no resolvable surface details.

The main tectonic feature seen in these newly processed images is an extension of the long rift zone Kachina Chasmata. The two best Ariel mosaics show Kachina Chasmata extending roughly 1200 km from limb to terminator. The new images extend it to or nearly to the northern limb, adding between 500 and 800 km to its length. Careful processing of images 26797.28-46 shows another extension of the Chasma to roughly 180º long., giving a total length of approximately 1800-2200 km. Thus Kachina rivals Ithaca Chasma on Tethys for scale.

Results - Other satellites: Reflected light detection is favoured by proximity to Uranus and a suitable phase, and feature detection by large albedo contrasts. The highest resolution images of the terminator of Miranda are of the side facing Uranus, suggesting the shaded area may be illuminated by reflected light. Figure 2 shows this area. The limb is clearly visible, and surface features are faintly visible in a few places. While nothing dramatic is revealed, an extension of Elsinore Corona and a few small craters can be seen. Limb topography might provide useful topographic information.

Umbriel imaging geometry resembles Ariel, but at lower resolution. Two craters mostly lost in shadow beyond the terminator are visible in the processed images. Umbriel has a bland appearance and lower albedo than the other large Uranian moons, which does not lend itself to reflected light imaging, except for featurtes like the very bright-floored crater Wunda. It seems likely that there are no more Wunda-like craters in the region just north of the equator near longitude 0º where they would be most visible.

Titania shows a clear but bland surface and limb in the reflected light area. The underexposure is far more severe in the Titania images, so the fact that little detail can be seen is not surprising. Titania's sunlit surface shows bright ejecta deposits around fresh craters, but none are unambiguously detected in reflected light, although there is a bright albedo feature located in the lower central area of the reflected light region that is certainly a candidate. Very prominent ejecta deposits may be lacking in this area, but the reflected light is only just above the threshold of detectability.

Discussion: It is unfortunate that reflected light imaging was not planned for during the Voyager 2 flyby of Uranus. Properly planned exposures could have significantly increased surface coverage of the satellites at geologically useful resolutions. However, given the limited capacity (by modern standards) of Voyager's tape recorder coupled with the dartboard-like geometry of the Uranian system in 1986 and the severe smearing present in images requiring long exposures (such as those using the UV filter), using the precious data storage resources for such risky images might not have been desirable. Existing data reveal several new features on Ariel, dark limb profiles on Miranda, and 'negative detections' on Umbriel and Titania which might place weak limits on the unobserved features. Cassini data, especially for Iapetus, show that reflected light imaging can be very effective. New Horizons may also make significant use of the method. The technique should be considered whenever circumstances allow for its use.

References: [1] Stooke P.J. (2001) *LPS XXXII*, abstract no. 1074.

Figure 1. Ariel, highest resolution mosaic.

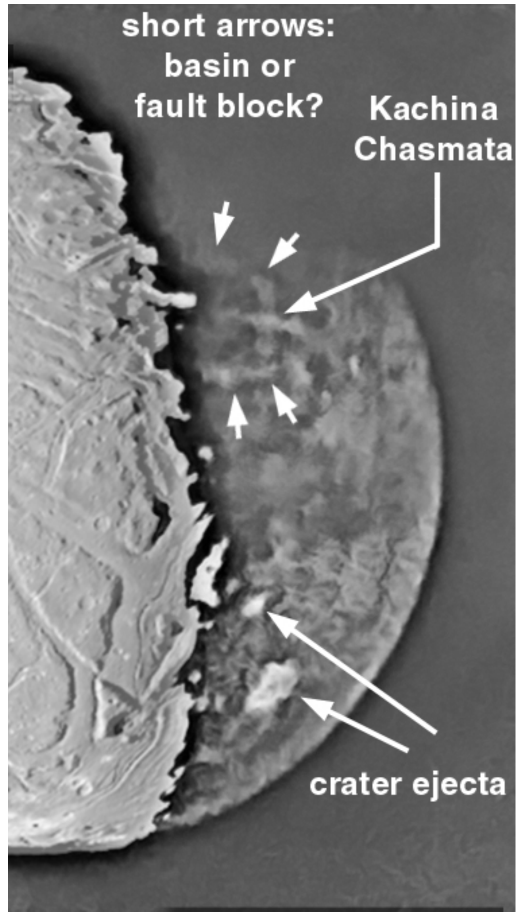

Figure 2: Miranda limb in reflected light.