THE SURFACE OF ASTEROID 5535 ANNEFRANK. 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 and Centre for Planetary and Space Exploration, University of Western Ontario, London, Ontario, Canada N6A 5C2 (pjstooke@uwo.ca).

Introduction: On 2 November 2002 NASA's Stardust spacecraft passed the small main belt S-class asteroid 5535 Annefrank at a range of 3079 km. Images were taken to help plan the flyby observations of comet 81P/Wild 2 in January 2004. Here the images are presented as processed by T. Stryk, with mapping of the asteroid surface by P. Stooke and some geological observations including the detection of linear markings, perhaps of structural origin.

Images and Processing: 72 images were taken of Annefrank over 26 minutes during the flyby, which was not long enough to detect rotation between the images [1,2]. The rotation period determined from lightcurves is >15 hours and perhaps as large as 22 hours [3]. The best resolution is 185 m/pixel, placing about 36 by 18 pixels across the roughly 6.6 by 3.4 km ellipsoidal body. The viewing direction ranged from along the major axis to within 10° of the intermediate axis of the ellipsoid, and from roughly 10° N to the equator, revealing most of one elongated ‘hemisphere’ of the body (about 40% of the surface) [2].

The Stardust images are small and are compromised by scattered light caused by residual contamination in the optics. The fogging in the optics was reconstructed and subtracted from the images. Subsets were then stacked in sets of 5-6 images (10 for the closest two stacks). The individual frames were deconvolved prior to stacking. The camera contained a mirror which was rotated to track the target, and all raw images are mirror-reversed [2]. Every previous publication of these images shows them in the reversed orientation. Figure 1 presents the images in their true orientation (as a human observer would have seen the asteroid).

Mapping: Duxbury *et al*. [2] compared images with an ellipsoidal model of the asteroid, providing a geometric basis for the mapping done here. The images and the corresponding model in its true orientation were used to establish tentative control for mapping, but it must be emphasized that no high precision shape model is available and accuracy is necessarily limited at this stage. An example of an approximate latitude-longitude grid on the best image is shown in Figure 2. The best image was reprojected using that grid to create a partial photomosaic map of Annefrank (Figure 4), with small improvements from other images. A shaded relief interpretation was prepared based on the appearance in all images, and will be included in the accompanying poster.

Geology: The new images offer a clearer look at Annefrank than was possible with the initial processing by the Stardust science team. One hypothesis to account for the appearance of the asteroid is that it is composed of several objects in contact [2], and the simulations in that paper reflect that interpretation. We suggest that there is little evidence to support this, and the appearance of the asteroid can be more simply explained as a result of cratering, with the irregular terminator region composed of several large crater rims. In this respect Annefrank is suggested to resemble a miniature Gaspra rather than a large Itokawa. In particular, a bright region protruding from the darkness at the western extremity of the mapped area is interpreted here as part of a crater rim rather than an isolated hill. A dark shading in medium resolution images, suggestive of a valley, resolves into several craters in the best image, casting doubt on the earler interpretation [2] that it represented the contact area between components of the asteroid.

Several linear features (mapped by T. Stryk) are apparent in the images (Figure 3). The larger valley-like structure, described above as resolving into craters in the best image, would be orthogonal to the structures mapped in Figure 3, if it is in fact a linear structure, and there are hints of other lineaments parallel to it, so it is possible that the surface of Annefrank is marked by a grid-like system of lineaments. The low resolution makes this uncertain, and even more uncertain would be any attempt to interpret the linear features geologically. Phobos has a well-known system of grooves of uncertain origin, and less well defined grooves have been imaged on both Gaspra [4] and Lutetia [5]. All three cases include at least some areas with roughly orthogonal sets of grooves. These might reflect deep joint-like fractures produced during impacts [4]. Thus Annefrank may be another example of a grooved body.

References:

[1] Brownlee, D. E. et al., (2004) *Science, 304,* 1764–1768. [2] Duxbury, T. C. et al. (2004) *JGR-Planets, 109,* E02002, doi:10.1029/2003JE002108. [3] Chang, C.-K., et al. (2015). *Astrophysical Journal Supp. Series,* 219(2): 27. [4] Stooke, P. J. (1996), *Earth, Moon, Planets 75 (1),* 53-75. [5] Sierks, H. et al. (2011). *Science, 334*, 487-490.

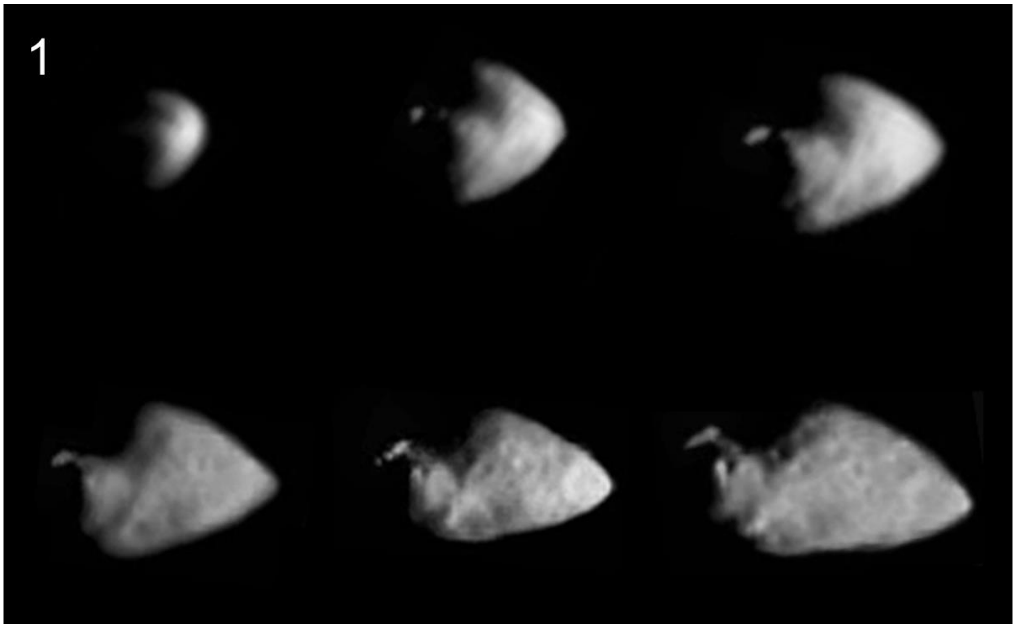
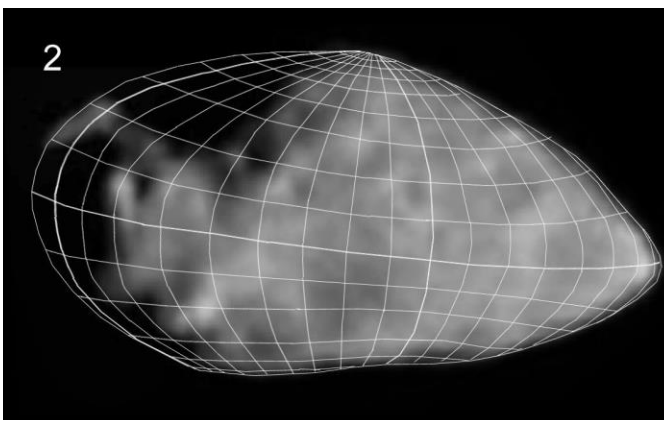


Figure 1. Representative images of Annefrank.



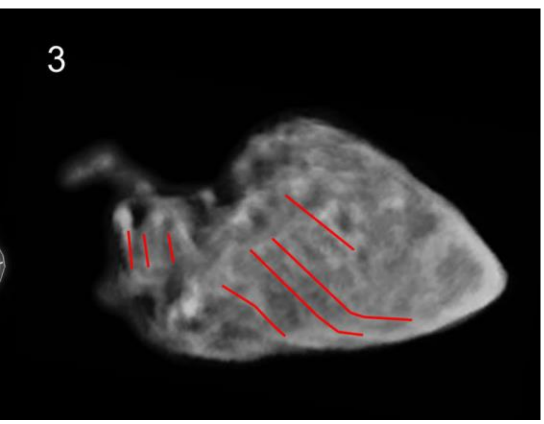


Figure 2. Best image with latitude-longitude grid.
Figure 3. Lineaments on Annefrank (T. Stryk).

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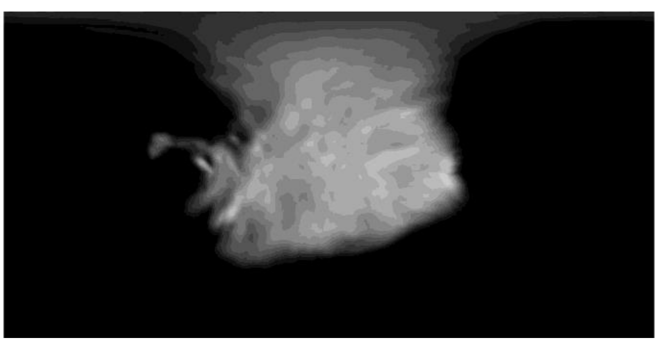

Figure 4. Simple Cylindrical map of Annefrank (P. Stooke).