# The Surface of Asteroid 5535 Annefrank


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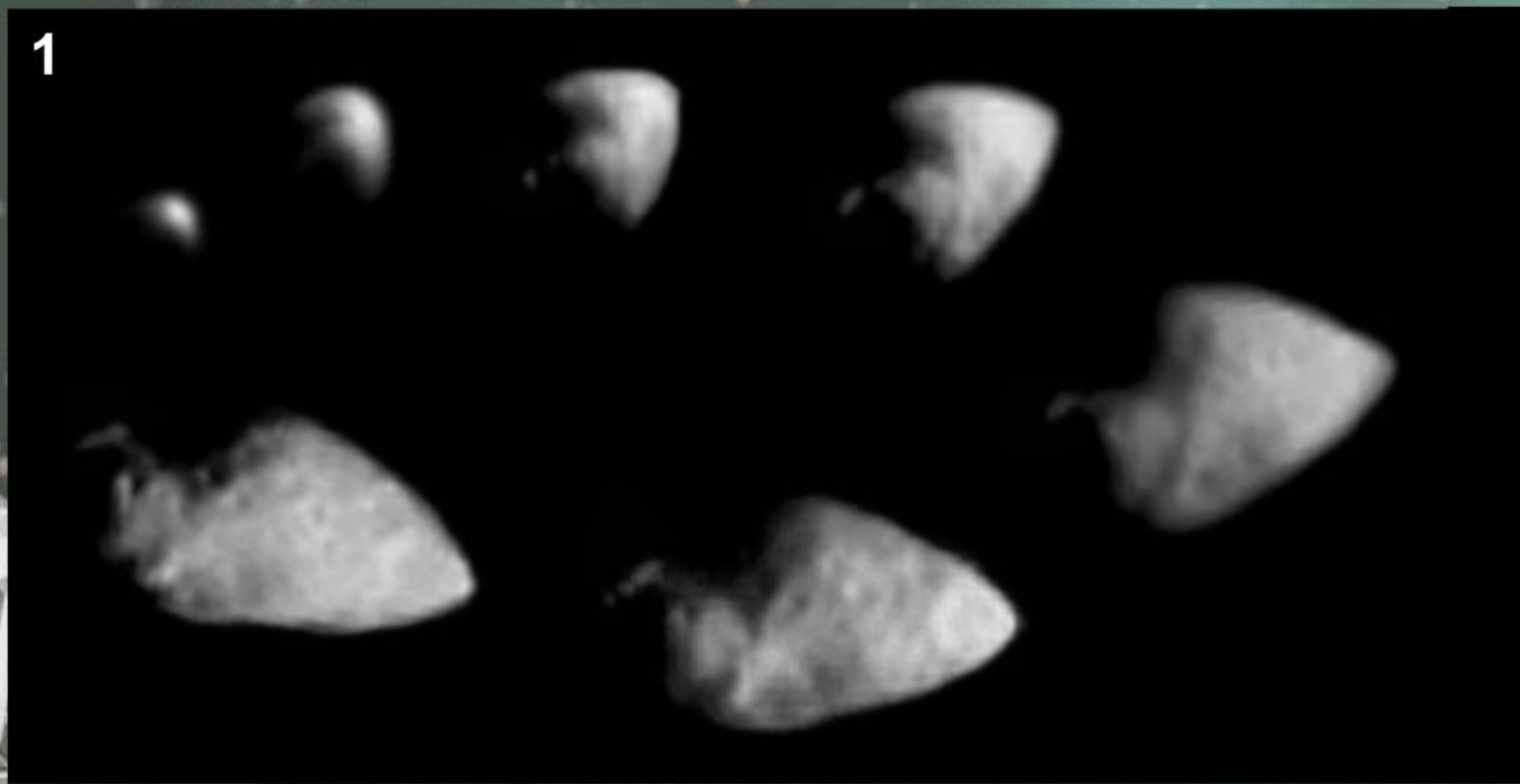
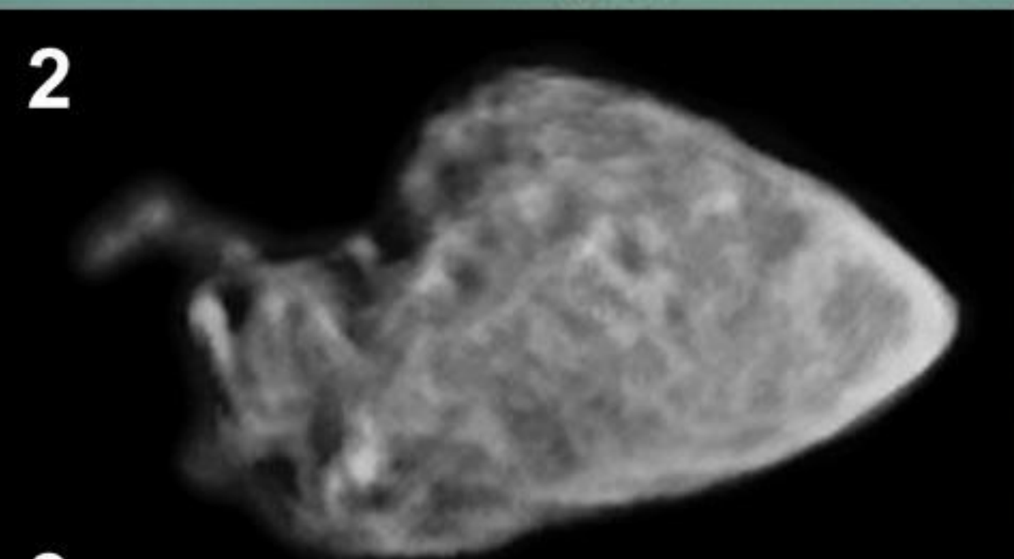
**Introduction:** On 2 November 2002 NASA's Stardust spacecraft passed asteroid 5535 Annefrank at a range of 3079 km. Images were taken during the flyby and are presented here as processed by Ted Stryk. They were used to prepare a map of the asteroid by Phil Stooke. Some geological observations include the detection of linear markings, perhaps of structural origin.

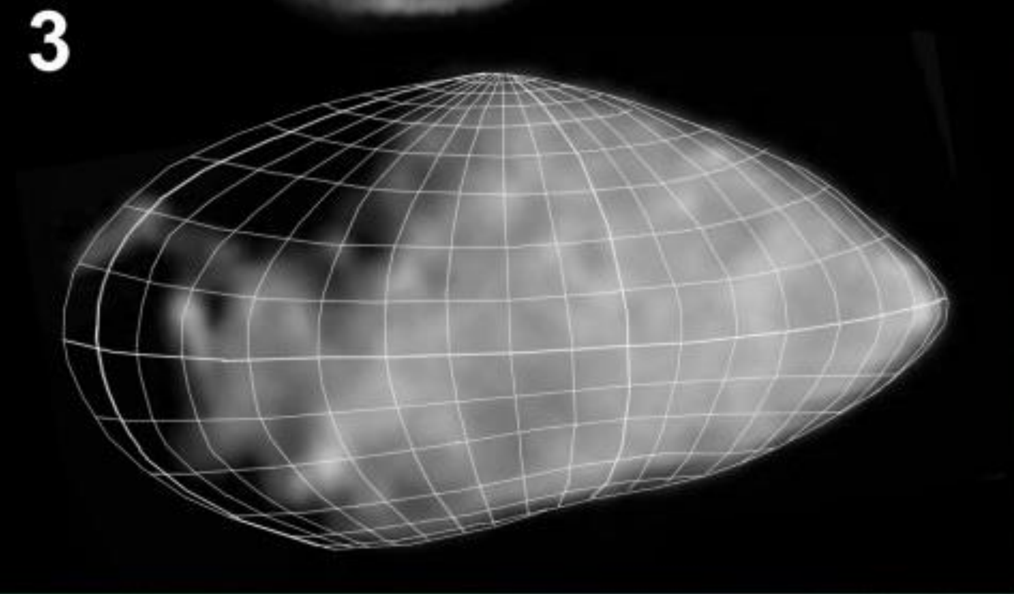
**Images and Processing:** 72 images were taken over 26 minutes during the flyby, not long enough to detect rotation between images [1,2]. The rotation period from lightcurves is between15 and 22 hours [3]. The best resolution was 185 m/pixel (c. 36 by 18 pixels across the 6.6 by 3.4 km body). The images reveal most of one elongated 'hemisphere' of the body (about 40% of the surface) [2].

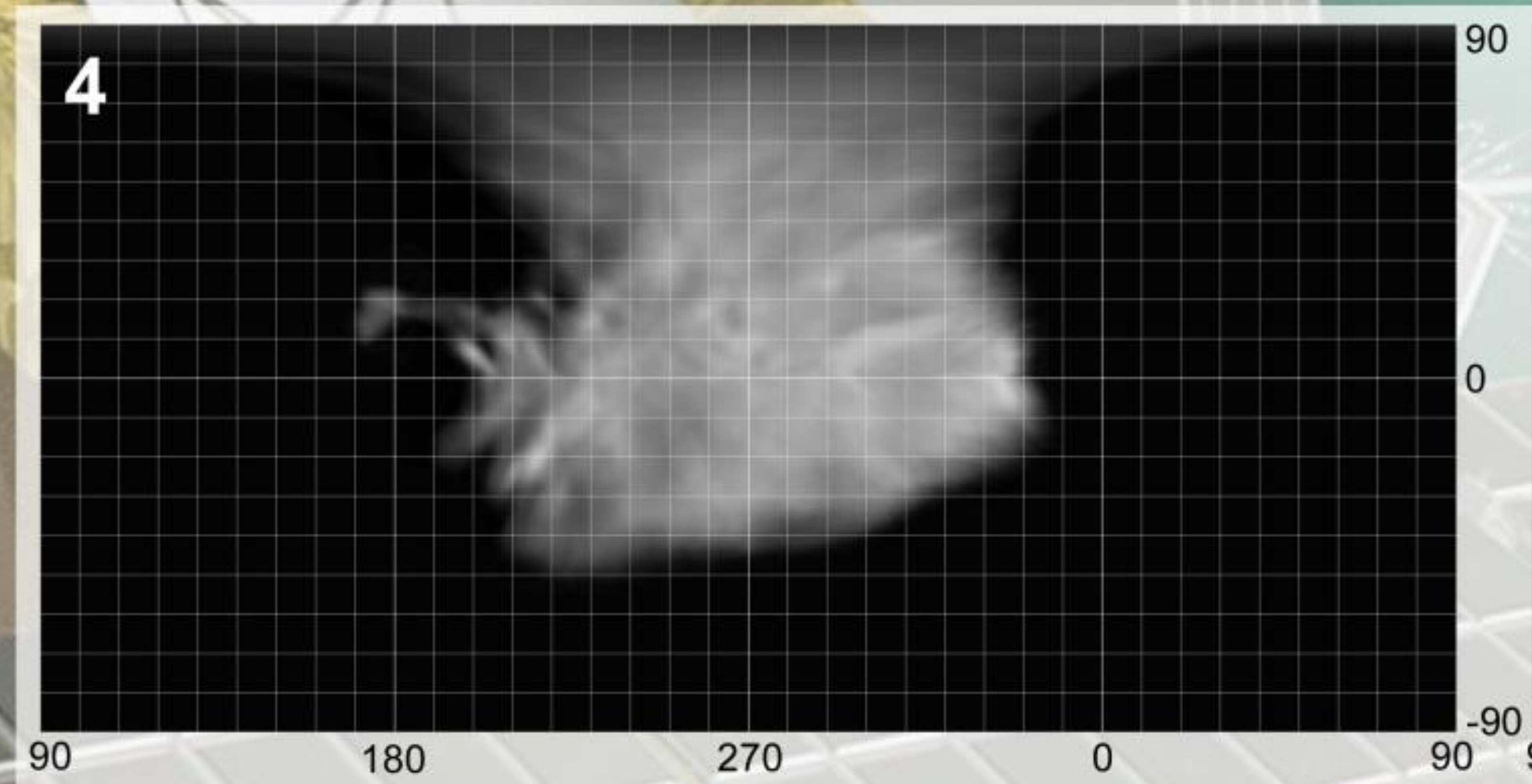
The asteroid images are compromised by scattered light. The fogging in the optics was reconstructed and subtracted from the images. Subsets were then stacked in sets of 5-6 images (10 for the closest two stacks). Each frame was deconvolved prior to stacking. The camera used a mirror to track the target, so raw images are mirror-reversed [2]. Previous publications show these images reversed. In Figure 1 the images are in their true orientation (as a human observer would have seen the asteroid). Figure 2 shows the best image with optimum processing.

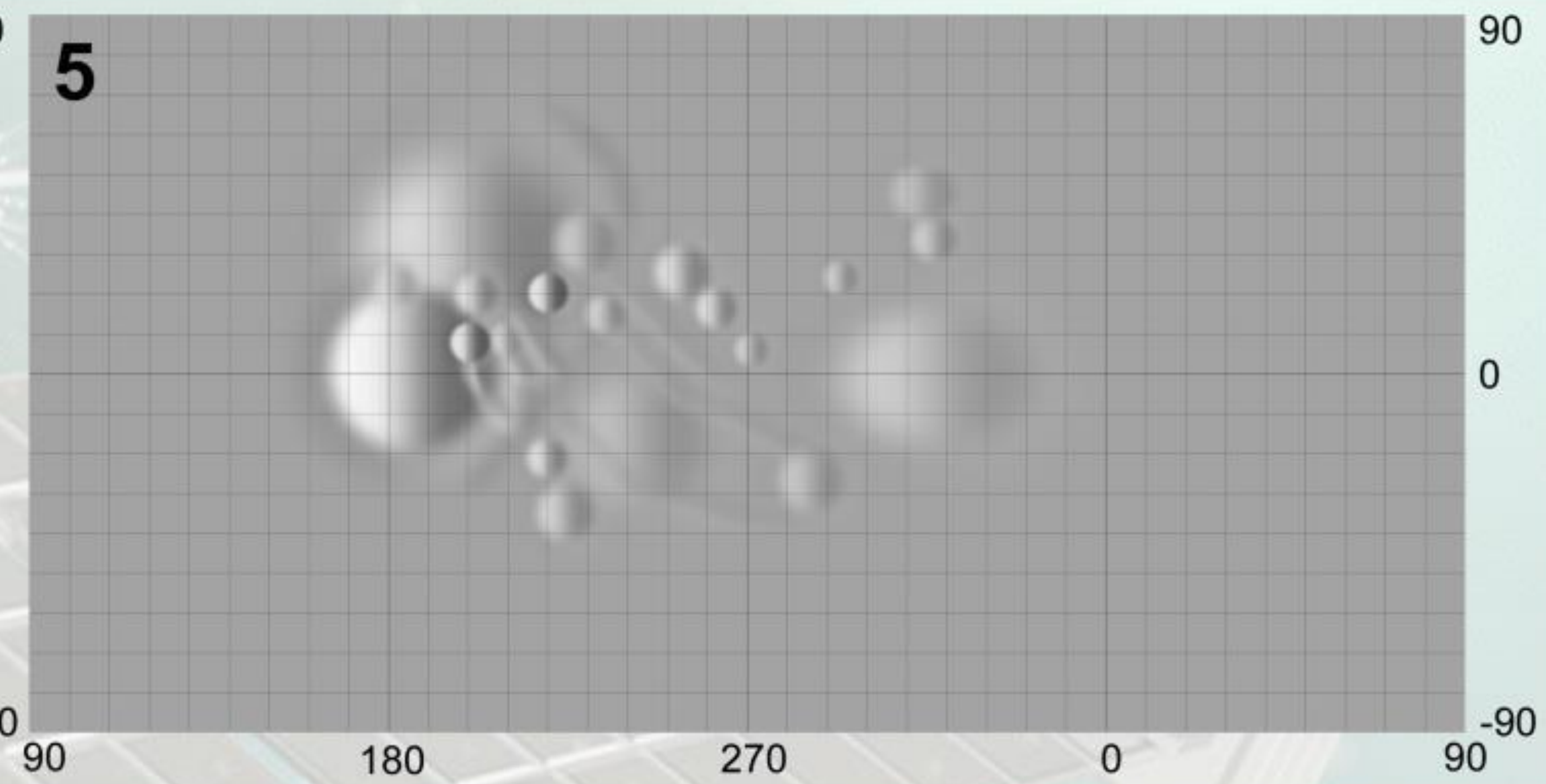
**Mapping:** Duxbury *et al.* [2] compared images with a model of the asteroid, providing a geometric basis for mapping. That model was used to establish tentative control, but no detailed shape model is available and accuracy is limited at this stage. An estimated latitude-longitude grid on the best image (Figure 3) was used to create a partial photo-mosaic map of Annefrank (Figure 4), with some small improvements from other images. A shaded relief map was interpreted from the images (Figure 5).

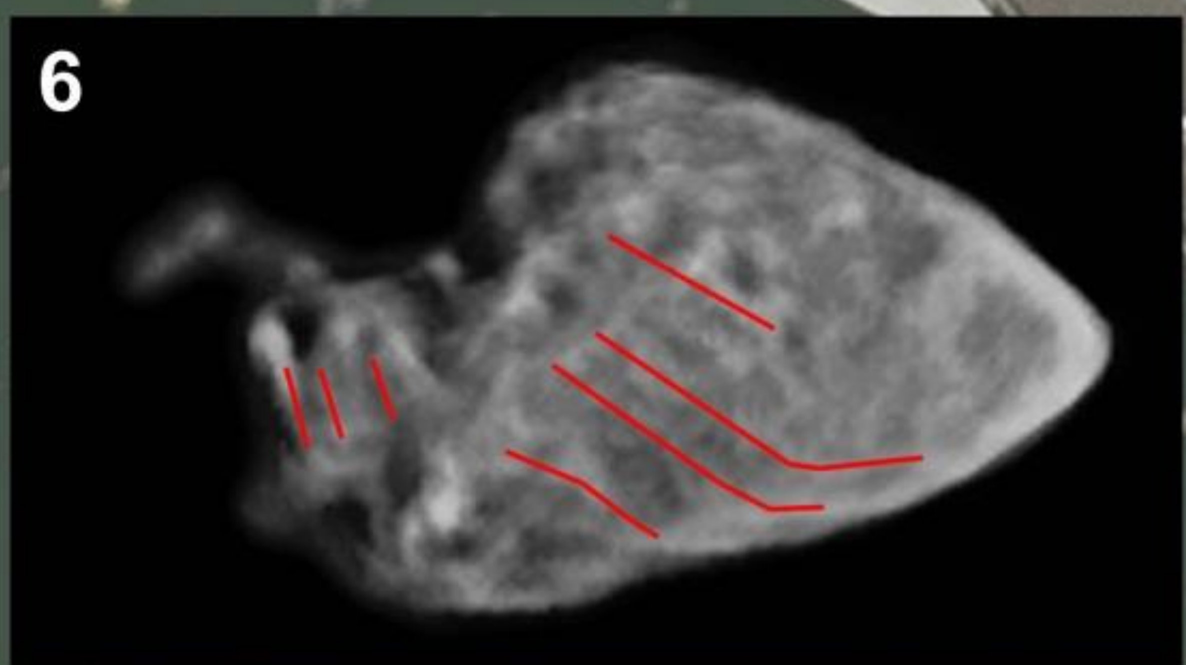



**Geology:** Duxbury *et al.* [2] explained the appearance of the asteroid as a compound object formed by several bodies in contact. We suggest that there is little evidence to support this. The appearance of the asteroid can be more simply explained as a result of cratering, with the irregular terminator region shaped by 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 earlier interpretation [2] that it represented the contact area between components of the asteroid.

Several linear features (mapped by T. Stryk) are discernable in the images (Figure 6). The larger valley-like structure, described above as resolving into craters in the best image, would be orthogonal to these linear features. There are hints of other parallel features. It is possible that the surface of Annefrank is marked by a grid-like system of lineaments. The low resolution makes this uncertain. Phobos has a well-known system of grooves of uncertain origin, and less well defined grooves are seen 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). *Ap. J. Supp.*, 219(2): 27.
[4] Stooke, P. J. (1996), *Earth, Moon, Plan.* 75 (1), 53-75. [5] Sierks, H. *et al.* (2011). *Science*, 334, 487-490.


background image: Stardust spacecraft,
NASA/JPL image from the Stardust website,
http://stardust.jpl.nasa.gov/images/gallery/sc0297a.jpg