CRATERING ON GASPRA; Clark R. Chapman (Planetary Science Inst./SAIC, Tucson, AZ), Gerhard Neukum (DLR, Berlin/Oberpfaffenhofen, Germany), Joseph Veverka (Cornell Univ., Ithaca, NY), and Michael Belton (NOAO, Tucson, AZ)

The October 1991 *Galileo* flyby of Gaspra shows that its crater population is dominated by fresh craters several hundred meters in diameter and smaller. They appear to represent a production population because the spatial density is relatively low (few overlaps) and because fresh craters are very abundant; equilibrium could be attained at diameters near to or below the resolution limit of the best image. These craters are the first direct record of the population of main-belt asteroids some tens of meters in diameter.

We have counted, measured, and classified craters primarily from the highest resolution, "high phase" image, on which over 600 craters are visible in 90 sq. km (Fig. 1); earlier counts [1] were made on the lower resolution four-color images, which show an order of magnitude fewer craters because of the resolution limit. The population index (exponent of the differential power law approximately describing the crater sizes) has a very high negative value (-4.3 ± 0.3, meaning that the log-log slope is "steep"), appreciably steeper than the value of -3.5 thought to reflect collisional equilibrium according to theory.

The Gaspra crater population is very different from that observed on Phobos (Fig. 2); Phobos's craters may reflect either (a) equilibrium from much greater production of the same population or (b) a different population due to circum-Martian debris. However, Gaspra's population is similar to crater populations observed on the Moon and Mars at these sizes. It is also similar to the near-Earth asteroid population recently identified by Spacewatch [2]. This lends strength to the idea that a common production function has been cratering all objects throughout at least the inner solar system, and that it is *not* a simple power law [3].

Gaspra's fresh craters are superposed on a landscape that appears "smoothed" at a vertical scale of hundreds of meters. A significant population of "soft", subdued crater-like features is visible with diameters commonly around 500 meters and larger. Some of these are associated with the linear grooves on Gaspra and may reflect sinkholes or other kinds of endogenic collapse features. Others may be pre-existing impact craters deeply blanketed or otherwise much degraded.

At its grossest scales, Gaspra is a highly irregular object. One or more "facets" were recognized in the four-color sequence, and one of these (over 8 km across) is well seen on the limb in the high-phase image. Another 5 km scale feature is visible emerging from the southern terminator in the image. We initially speculated from these images (both from approximately the same perspective) that Gaspra's shape might reflect its origin by large cratering, spallation, and chipping away from an initially larger precursor body. However, the largest of these facets would exceed the largest crater relative to body radius ever observed on a planet or satellite or expected from collisional fragmentation models. Not only would Gaspra have been disrupted and dispersed by such cratering events, but later facet-forming events would be expected to have destroyed earlier facets.

Playback in November 1992 of a full sequence of lower-resolution images of Gaspra covering a full rotation period has clarified the question of large or very large craters on Gaspra. Much of Gaspra's surface has now been seen. Two intermediate size craters about 3 km in diameter have been identified, but there is no crater approaching even half the radius of Gaspra. Furthermore, the new perspectives of Gaspra reveal a peanut-like shape, suggestive (although less obvious) of the contact binary shapes of the two other imaged asteroids, Castalia [4] and Toutatis [5]. It is intriguing that the most prominent grooves observed on the high-phase image are near the "neck" between the two "lumps".

We expect that Gaspra, as we now know it, was created from a larger parent body by a sequence of collisions beginning 4.5 b.y. ago. Perhaps Gaspra's gross configuration of two connected lumps reflects a part of a rubble pile or compound precursor body that was disrupted. Subsequent large, sub-catastrophic collisions would have seismically shaken proto-Gaspra and, provided that ejecta velocities are low, created a "rubble pile" or at least deep, coarsely worked surface layers analogous to the lunar megaregolith. Perhaps Gaspra's subdued craters enable us to peer back through this last collision.

Since the creation of Gaspra's present surface, there has been cratering by the steep production function. The density of such craters is very low at visible size ranges, implying that Gaspra is relatively youthful. Scaled to a calculated 0.5 Gyr age for bodies of its size, based on asteroid collision models and assuming that Gaspra does not have metallic strength, we estimate its cratering lifetime could be as young as 0.2 Gyr, with large (factor 3) modelling uncertainties.

The cumulative volume of all visible craters could create a regolith only <10 meters deep, even if most ejecta were retained by Gaspra's weak gravity. Given Gaspra's very low escape velocity, most such ejecta are probably lost, so Gaspra's modern soil-like regolith, which is produced by the steep production function just as it is for the upper several meters on the Moon, is probably very thin: centimeters to a few meters at most. Gaspra could even be essentially bare. In any case, this is an inadequate environment for any mature weathering and reworking of Gaspra's visible surface during the last 0.2 Gyr. Indeed, depending on how far the steep production function extends to craters as small as ten meters, Gaspra could be subject to substantial erosion or "sand-blasting" by the saturation of small impacts. Any pre-existing megaregolith could have been eroded away to depths of tens of meters or more during the past 0.2 Gyr.

References: [1] Belton, M.J.S. (1992), *Science*, **57**, 1647-1652; [2] D. Rabinowitz (1993) *Astrophys. J.*, in press; [3] G. Neukum et al. (1975) *The Moon*, **12**, 201-229; [4] R. S. Hudson (1992) *EOS*, **73**, Oct. 27, 335; [5] S. Ostro (1993), presentation at "Hazards Due to Comets and Asteroids" meeting, Tucson, AZ, Jan. 1993 (see *NY Times*, 4 Jan. 1993, pg. 1).

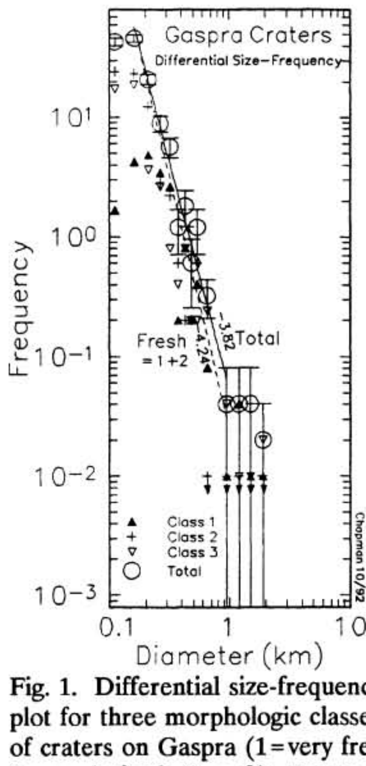

Fig. 1. Differential size-frequency plot for three morphologic classes of craters on Gaspra (1=very fresh, 2=nearly fresh, 3=soft). Least squares fits for classes 1+2 and for the total are shown, excluding incomplete data.

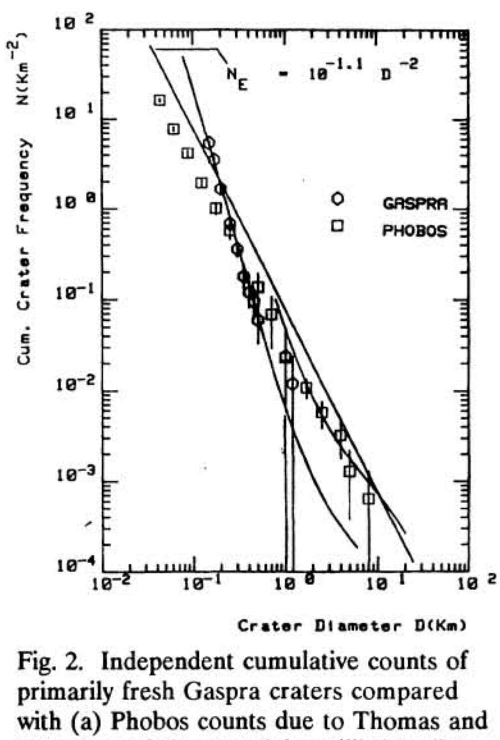

Fig. 2. Independent cumulative counts of primarily fresh Gaspra craters compared with (a) Phobos counts due to Thomas and Veverka and (b) a model equilibrium line.