# GROOVES ON 21 LUTETIA INDICATE A LAYERED STRUCTURE

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**Introduction:** On the images of asteroid 21 Lutetia impact craters as well as grooves can be identified. The grooves are of similar character to those found on Phobos, Gaspra and Ida. On the basis of their existence, it can not be excluded, that Lutetia is also a remnant of a larger, differentiated protoplanet broken into pieces by a huge collision. The crater-count-rate-age of such small bodies might give observational time limits for the first differentiation period in the early Solar System.

**Discussion:** A flyby of asteroid 21 Lutetia has been carried out on the 10th of July 2010 by the European Rosetta space probe on its way to comet 67P/Churyumov-Gerasimenko. The image of best resolution was made from 3162 km by the OSIRIS camera.

Up-till-now 14 small asteroid-like objects have been investigated by space probes: small satellites, cometary nuclei and asteroids. The first two of them were Phobos and Deimos, the moons of Mars, in 1976-77 by Viking 1 and 2. On the surface of Phobos impact craters and a conspicuous, complicated groove system are visible [1] (*Fig. 1a*). We have demonstrated that this groove system can be divided into three categories – very probably each arising from different mechanisms.

The most numerous and coherent parallel groove system can be the manifestation of the layered structure of Phobos [2, 3, 4, 5]. Since, however, there is no known mechanism for layer formation on such a small celestial object, it has to be supposed that Phobos is a near-surface block of a larger, differentiated parent body, where layers of different hardness could have been formed by ancient successive volcanism.

On the photos of asteroids 951 Gaspra (*Fig.2a*) and 243 Ida (*Fig.3a*), imaged by the Galileo space probe, similar groove systems have been identified [6, 7], so the same conclusion can be true in the case of Gaspra and Ida as well. In their cases the existence of remnant magnetic fields is also an important argument in favour of this hypothesis.

The photos of these small bodies were processed by the "Emboss" filtering module of the Photo Finish software of the ZSoft Company. Features perpendicular to the filtering direction are enhanced. and can be mapped (*Fig. 1, 2, 3*).[8, 9]
Recently the same method has been applied by us to the best resolution photo of Lutetia as well (*Fig. 4*).

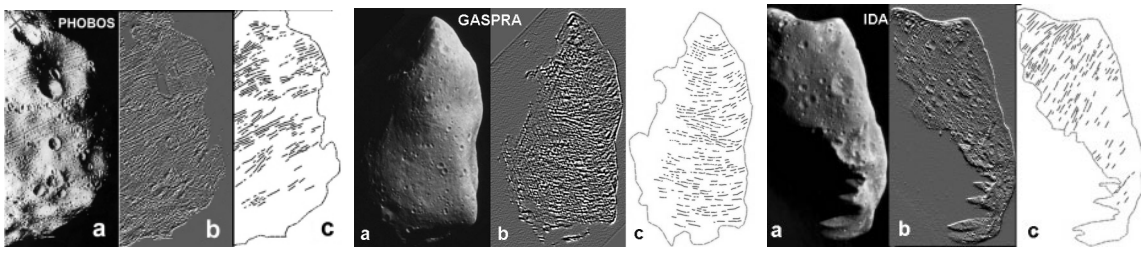


***Fig. 1, 2, and 3. The filtered photomosaic of Phobos (19x22x29 km), 951 Gaspra (9x11x18 km) and 243 Ida (17x25x59 km) composed of Viking and Galileo images respectively . The system of grooves indicated on the figure is approximately perpendicular to the long axis of the objects [6, 7]***

**Conclusion:** From the 14 asteroid-like small bodies investigated up-till-now by space probes already four display parallel groove-systems on their surfaces. These parallel groove systems may hint at parallel layered structures inside these small bodies – earlier they might have been near-surface parts of some larger, differentiated protoplanetary bodies that later were broken apart.

This result implies that already at the time of the disintegration a kind of different-tiation and successive volcanism has already been happened. On the basis of our Phobos investigation we have anticipated already in 1977 [2] that the surface of some members of the asteroid belt might also have similar character, hinting at their layered inner structure. The fact, that already three such objects have been found in the asteroid belt, strengthens our earlier anticipation.

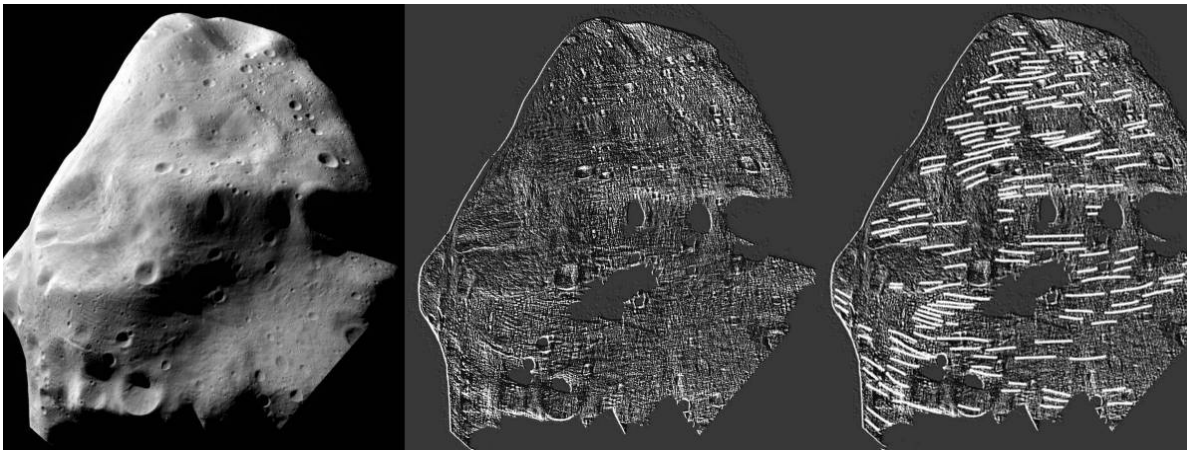

***Fig.4. The filtered photo of Lutetia (10.07.2010, 26x101x132 km). Image taken by the European Rosetta spacecraft. The system of grooves (white) indicated on the figure is approximately perpendicular to the long axis of the asteroid***

Phobos, as an independent object (after broken apart from its parent body), indicates a crater-count-rate-age of 4.5 billion years. That is, this observational fact gives an independent observational time limit to the first differentiation period for protoplanets in the early Solar system.

**References**: **[1]** P. Thomas, et al. (1978) Origin of the Grooves on Phobos, *Nature*, 273, 282. **[2]** E. Illés, A. Horváth (1977) Are Striations on Phobos Evidence of layered Structure?, Paper on meeting on planetology, Tihany 1977, in: *Papers from I. Planetology Seminar*, ed. P. Szemerédy, Hungarian Astronautical Society, Budapest 1980, pp. 161-198, in Hungarian.
**[3]** A. Horváth, E. Illés (1981) On the Possibility of the Layered Structure of Phobos, Paper A1-2.15, EGS meeting, Budapest 1980, *EOS Transactions* 62, No. 17, p. 203. **[4]** E. Illés, A. Horváth (1981) On the Origin of the Grooves on Phobos, *Adv. Space Res*. 1, 49-52. **[5]** J. Head (1986) The geology of Phobos and Deimos and the origin of grooves on Phobos: scientific questions for Phobos mission, in: *Scientific and Methodological Aspects of the Phobos Study*, ed. R. Sagdeev, Space Research Institute, Moscow, pp. 61-69.
**[6]** A. Horváth, I. Almár, E. Illés-Almár, A. Szabó (1994) Comparison of the Surface Grooves on Gaspra, Ida and Phobos, XXX. COSPAR Meeting in Hamburg, July 1994, Paper B.4 – 015. **[7]** A. Horváth, I. Almár, E. Illés-Almár, (2001), Comparison of the Surface Grooves the on Graspa, Ida and Phobos, Adv. Space Res. 26, 1489-1992. **[8]** E. Illés, A. Horváth, F. Horváth and A. Gesztesi (1985) In Situ Measurements to Determine if Phobos is Layered, *Acta Astronautica* 12 (6), 455-464. **[9]** Sz. Bérczi, A. Horváth and E. Illés (2003) Comparision of the Cracking and Fracturing Systems of Phobos and Europa, Sixth Int. Conf. On Mars, 20-25 July, No. 3198, Pasadena.