GROOVES OF PHOBOS AS SEEN ON RECTIFIED IMAGES TAKEN BY THE MARS EXPRESS HIGH RESOLUTION STEREO CAMERA. A.T. Basilevsky[1,2] , J. Oberst[3,4], K. Willner[3], M. Waehlisch[4] and G. Neukum[2], [1]Vernadsky Institute, Moscow, Russia, [2]Free University Berlin, Germany, [3]TU Berlin, Germany, [4]DLR Berlin, Germany.

Introduction: At the beginning of January 2011, Mars Express has accomplished 158 flybys of the Martian satellite Phobos. In this work, we analyze images taken by the onboard HRSC camera to revisit the problem of the origin of grooves, numerous linear features, often turning to chains of small craters, which criss-cross its surface. They were originally assumed to be fractures resulting from the impact that created the largest crater of Phobos Stickney and/or from tidal stresses [e.g., 1,2]. Then, several more hypotheses have been suggested, the most discussed of which is a suggestion that the grooves were formed by rolling blocks of Phobos crater ejecta [3,4,5] or that they are chains of coalescing secondary craters formed by ejecta from large craters of Mars [6,7]. We plan to examine different hypotheses involving the HRSC images of Phobos and some other data.

The images under analysis: The used HRSC images have been photogrammetrically processed: They were all orthorectified using the DTM models of Phobos body [8], projected into a stereographic projection at 10 m/pxl resolution with central longitudes 31° and 103° W. This eliminated significant parts of perspective distortions which made previous photogeologic analysis of the more difficult. Figures 1, 2 and 3 show some of these images.

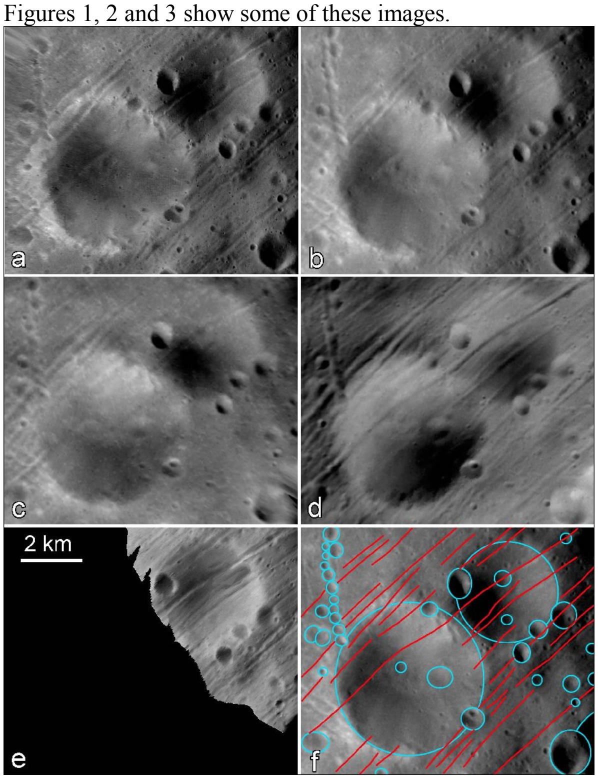

Figure 1. The HRSC images of craters Drunlo (lower left, D = 4.2 km, center at 36.5°N, 92°W) and Clustril (upper right, D = 3.4 km, 60°N, 91°W). The shown are fragments of images taken at orbits 0756 (image a), 2780 (b,f), 2813 (c), 3310 (d) and 5851 (e). All these images are reprojected for central longitude 31°W.

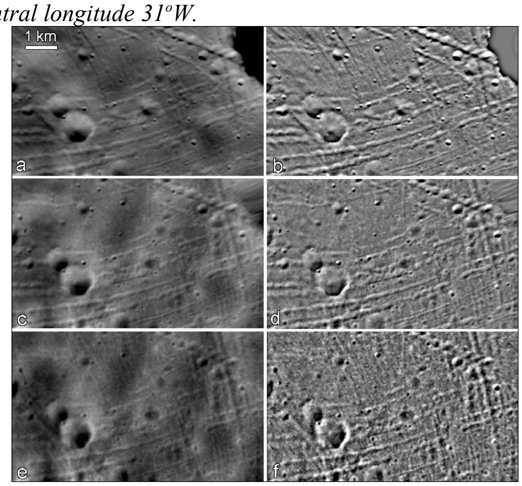

Figure 2. Groove intersections SW of crater Drunlo. Fragments of images taken at orbits 6906 (a,b), 4847 (c,d), and 2813 (e,f), reprojected for central longitude 102°W.

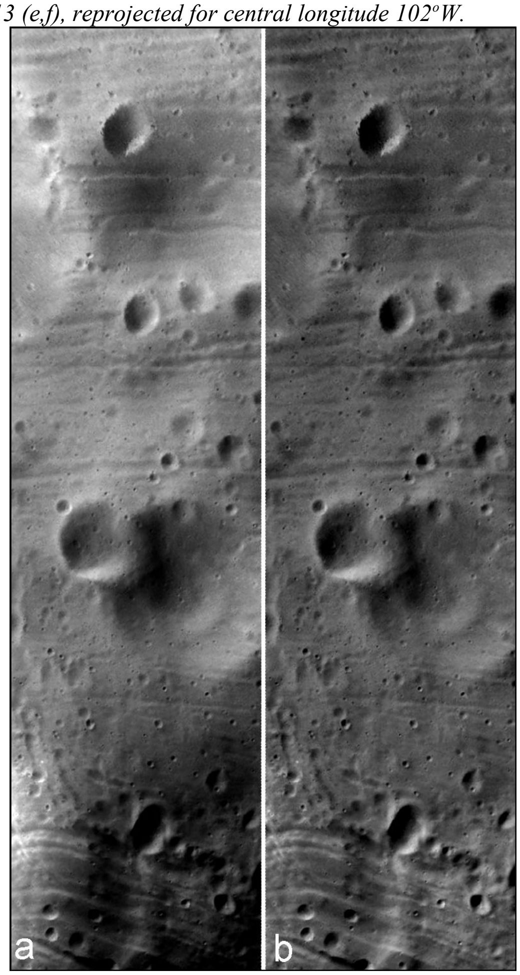

Figure 3. Grooves morphology along 90º angular distance. Fragment of image taken at orbit 0756 (central longitude 31ºW). Craters Drunlo and Clustril are in the image top.

Photogeologic consideration: As one can see in Figures 1-3, grooves of Phobos look very much like fractures and their turning to chains of craters was earlier explained by the drainage of regolith into the fractures or by blowing it out by the gas released from the Phobos interior [e.g., 1,2]. But the suggestion that Phobos grooves are fractures (faults) has a difficulty because fractures typically have to show lateral offsets of the younger fracture when they meet the older fractures while the Phobos grooves whose systems are believed to be of different age [e.g., 7] show no such offsets (Figures 1 and 2). The presence of offsets follows from theoretical considerations [9] and was described as observations in the literature on example of faults on Venus [e.g., 10]. Figure 4 shows intersections of faults in the plains close to Quilla Chasma, Thetis Regio, Venus. Here the younger NEE trending rift-associated faults cross the NW-trending older faults.

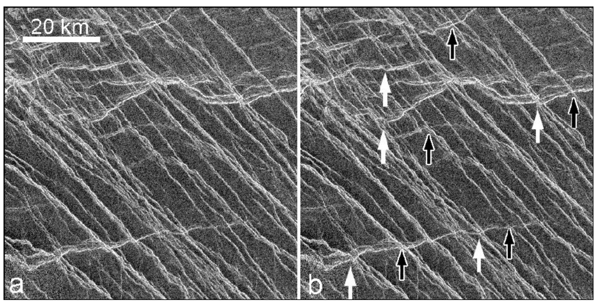

Figure 4. Magellan SAR image showing intersections of Venusian faults. White arrows show intersections where the younger fault is offset at the older fault; black arrows show intersections without visible offsets.

It is seen from Figure 4 that indeed at some intersections the younger fault shows offset along the older fault, but it is also seen that this is obvious at only some intersections and the visible offsets are typically relatively small. If grooves of Phobos are wider than the faults underlying them, then this widening may and probably should mask the offsets.

The suggestion that Phobos grooves were formed by rolling blocks (large boulders) of Phobos crater ejecta is strongly supported by similarity in general morphologies between them and tracks of rolling and bouncing boulders on slopes of lunar landforms [4,5]. However if Phobos grooves were formed by this mechanism, one may expect that at least some grooves should have blocks at their ends. The suggestion that the blocks are destroyed with time by the meteoritic/micrometeorite bombardment seems to be not convincing enough because the grooves underwent the same bombardment and if the grooves are still visible, some remnants of the blocks are expected to be visible too, but have not been been described or identified recently [4,5].

This suggestion also implies that the blocks should have enough kinetic energy, otherwise they would not produce long grooves. But if so, the blocks should be sent flying beyond the positive bends of the topography such as edges (rims) of large prominent craters and there the groove should be interrupted. Figure 1 shows several grooves entering in and leaving craters Drunlo and Clustril with no evidence of such interruptions.

The suggestion that Phobos grooves are chains of coalescing secondary craters formed by ejecta from large craters of Mars is strongly supported by general similarity of the grooves and the secondaries' chains. As it follows from consideration by [6,7] this mechanism could also explain formation of several families of parallel grooves. But this seems to meet difficulties as images show (see Figure 3, left is original image, right is highpass-filtered one) a family of parallel grooves along 90º of angular difference (from image top to the bottom). If these groves were formed by ejecta from the same impact event on Mars the impact angles for the craters forming the upper (on the image) grooves should differ by 90º from the impact angles forming the lower groove. In that case the morphology of secondary craters and thus morphology of grooves should be rather different, which seems to be not the case.

Another problem for the secondary craters hypothesis is a discovery of grooves (at least two systems) very similar to the Phobos ones on asteroid Lutetia [11,12] (Figure 5).

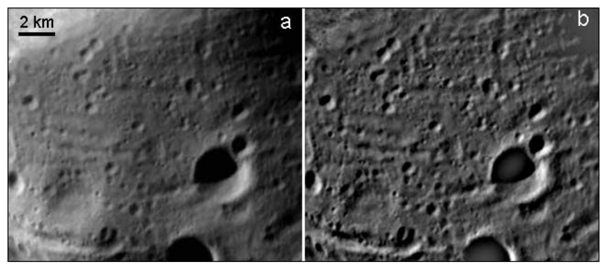

Figure 5. Grooves on asteroid Lutetia, area 15 x 25 km: a – original image taken by the Rosetta camera Osiris (http://www.esa.int/images/4_closest_approach,0.jpg), b – the same image highpass-filtered and contrast-enhanced.

Lutetia is the main belt asteroid of ~100 km in diameter and it is difficult to find any object(s) in the vicinity, impact cratering of which could provide secondaries necessary to form these grooves.

Conclusions: All suggested hypotheses of formation of grooves on Phobos have their strong and weak sides. Further analysis of images of Phobos with higher that we have now resolution may help to resolve the problem of the groove formation.

References: [1] Thomas P, et al. (1978) *Nature*, 273, 282-284. [2] Morrison S.J. (2009) *Icarus*, 2004, 262-270. [3] Wilson L. & Head J.W. (1989) *LPSC-20*, 1212. [4] Wilson L. & Head J.W. (2010) *1MSSS-2-3*, http://ms2010.cosmos. ru/pres.htm. [5] Duxbury T. et al. (2010) *1MSSS-2-4*. [6] Murray J, et al., (2006) *LPSC-37*, 2195. [7] Murray J. (2010) *1MSSS-2-5*. [8] Wählisch M. et al. (2010) *EPSL, 294*, 547-553. [9] van der Pluijm B.A. & Marshak S. (2004) *Earth Structure: An Indroduction to Structural Geology and Tectonics*. Norton and Company, NY. 656 p. [10] McGill G.E. (1993) *Geophys. Res. Lett*., 20, 2407-2410. [11] Keller H. et al. (2010) American Geophysical Union, Fall Meeting 2010, abstract #P14B-02. [12] Thomas N. et al. (2010) Bull. American Astron. Soc., 42, 1043.