DAILY TEMPERATURE REGIME OF THE SURFICIAL REGOLITH OF PHOBOS IN THE LANDING SITE REGION FOR THE PHOBOS-GRUNT MISSION LANDER IN DIFFERENT SEASONS: THE MODEL PREDICTIONS. R.O. Kuzmin[1,2], E.V. Zabalueva[1], 1-*Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, 19 Kosygin str., Moscow 119991, Russia (rok@geokhi.ru); 2- Space Research Institute, Russian Academy of Sciences, Profsoyuznaya str. 84/32, Moscow, 117810, Russia.*

Introduction: This study has been conducted specially for the region on Phobos, selected as the potential landing site for the Russian *Phobos-Grunt* Mission. While the mission was not realized because of the failure due to the onboard computer's error during coming out of the spacecraft on the trajectory to Mars, the results of our study might to be useful for future missions to the Phobos. Because of the absence of the atmosphere, the short duration of the Phobos day (7.7 hours) and the presence of a highly porous and fine-grained soil on its surface, all components of a future Landers (including the science instruments) will operate on the body surface under frequent and sharp temperature changes: from positive to extremely low negative temperatures. The first analysis of the daily temperature regime of the Phobos surface in the proposed before landing site (15°S, 310°W) has been conducted based on the numerical model [1] in the initial stage of the *Phobos–Grunt* Mission development. During the completing stage of the *Phobos–Grunt* Mission preparation the new landing site was selected on the hemisphere of Phobos opposite to Mars (15°N, 230°W [2, 3]) on the Lagado Planitia (see Figure 1). Here we present the results of the numerical modeling of the thermal regime of the surface regolith layer within the new selected landing site (on daily and seasonal time scales).

Thermal model of the Phobos's surface: So far as Phobos represents an atmosphere less body and the density of its surface regolith is close to the lunar one, we can suggest that the physical properties of the surficial material on the body and the Moon are quite similar. In the thermal model of Phobos, we also take into account the dependence of the thermal parameters (thermal conductivity and the specific heat) on temperature and depth that was confirmed early for Moon [5]. In developing the computer code for the estimation of the daily and seasonal temperature variations in the surface regolith layer, we used as a basis the thermal model of Phobos surface [6], which takes into account: the ellipsoidal shape of the Phobos figure, the eclipses of Phobos by Mars, the reflected and thermal radiation of Mars, the variable thermal conductivity and the specific heat of the material, and the absence of the internal heat sources. The thermal regime in the surface layer within the Lagado Planitia has been described by the one-dimensional nonlinear thermal conductivity equation with the boundary conditions and the initial condition likewise it was described in our first paper [1]. The next main

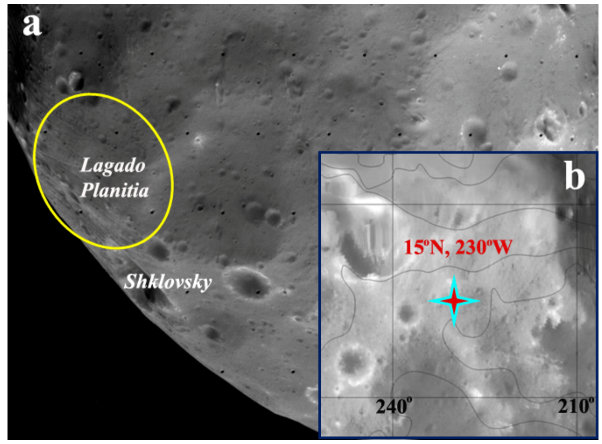

Figure 1. a - Location of the new landing site region selected for the FOBOS-GRUNT MISSION (yellow circle). b - Fragment of the HRSC Controlled Mosaic (b) of the Phobos (from [4]) with the indicated region used for modeling of the surface thermal regime. A - Viking-1 image VO1_246a68.

characteristics were included in the computational procedure: (1) the consecutive orbital positions of Mars are taken with a step equal to 1/100 of its annual period (6.9 days), (2) for each Mars position, the computation is made for one spin of Phobos around Mars (the satellite begins its motion at local noon for the given point on Phobos), (3) the step in the Phobos orbit is taken to be 7.5° outside from the eclipse by Mars and 0.5° within the eclipse zone, (4) the results of the temperature calculation as a function of time and depth were considered only after 5.5 Martian years. The model deals with a 40-cm-thick regolith layer, which is divided into sublayers with the first one being 0.08 mm thick. The thickness of the subsequent sublayers increases as the progression with a geometric ratio of 1.26. The regolith layer is assumed isothermal at the initial time and its temperature is taken to be 200 K. The computations start at the perihelion of the Martian orbit.

Results of the thermal regime computation: Based on the conducted numerical modeling we estimated both the daily variations of the temperatures on the surface itself and within the upper surficial layer (up to several centimeters depth) of Phobos during the different seasons at the point with coordinates 15° N, 230° W, with the albedo value 0.07 (typical for the area) and the regolith density 1100 kg/m3. The model daily surface temperature course in the indicated point of Phobos (separately for different seasons) is shown on the Figure 2. Each temperature curve was obtained for a definite orbital position of Mars (winter, Ls= 316°; spring, Ls=45.7°; summer, *L*s=136°; autumn, Ls=224°). The values of the highest surface temperature varies from one season to other being in the range 291-305K and the lowest temperatures varies from 109K to 117 K. The daily subsurface temperature

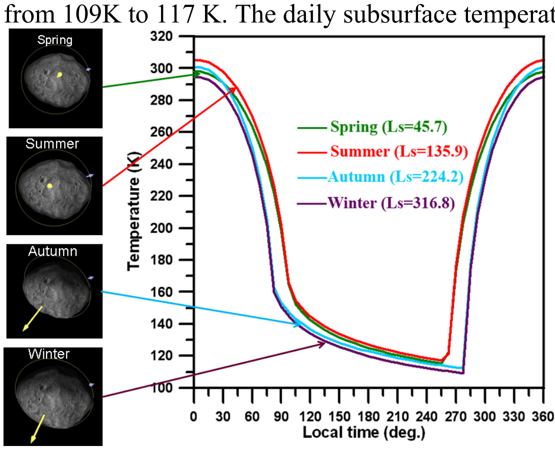

Figure 2. The model daily temperature fluctuations on Phobos surface in the Lagado Planitia during the different season (in the northern hemisphere of Mars). Yellow arrows on the images show direction on the Sun in the noon.

fluctuations within the regolith layer, estimated for the different seasons, are shown on the Figure 3. As it clearly seen from the figure 2 and 3, the daily

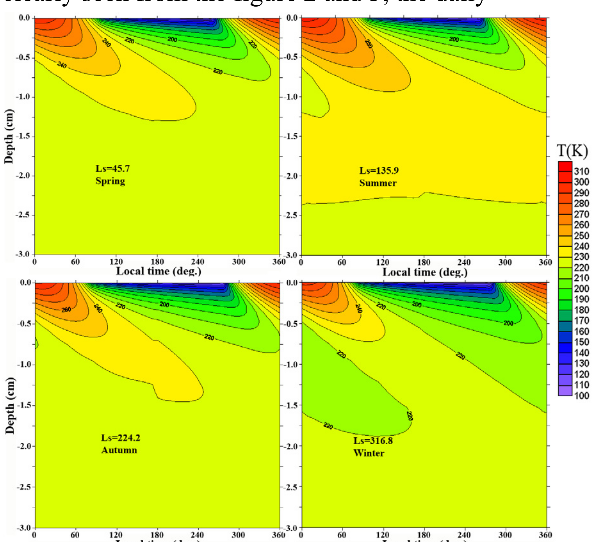

Figure 3. The model daily temperature fluctuations within the surface layer of the Phobos regolith during the different seasons.

temperature fluctuations on the Phobos surface in the proposed landing site have large amplitude (182°-188°) which are getting shorter very swiftly with depth, beginning from a small depth (in several millimeters). At that, the amplitude of daily variations of the surface temperature decreases by a factor of *e* at a depth of ~0.3 cm, and the decrease of temperature variations down to 1° occurs at a depth of 1.5–1.8 cm, depending on a season. To understand how the daily surface temperature fluctuations are different on the opposite and the sub-Martian hemispheres of Phobos for the same season we conducted the numeric modeling for the point with coordinates 15º N, 310º W (see Figure 4). As it well seen from the Figure 4, the diurnal temperatures on the opposite and the sub-Martian hemispheres of Phobos have the same values, whereas the value of the surface temperatures during the midnight in the sub-Martian hemisphere are on 40º higher than one in the opposite hemisphere due to the

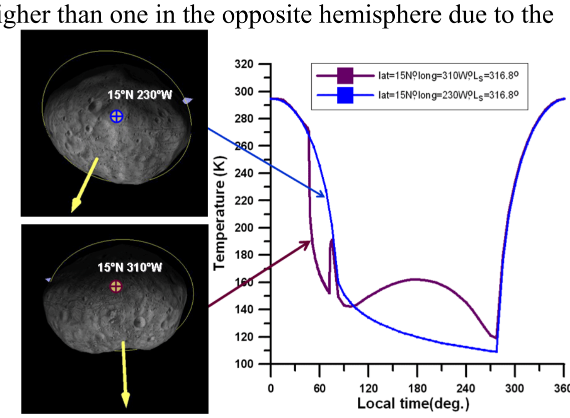

Figure 4. The model daily surface temperature fluctuations on the opposite (blue cross) and the sub-Martian (red cross) hemispheres of Phobos during the winter season (Ls=316.8º). Yellow arrows on the images show direction on the Sun in the noon.

influence of the reflected radiation of Mars. However, the duration of the dark time of the day in the sub-Martian hemisphere is notably longer than in the opposite one. Based on our results we can suppose that the thermal regime of Phobos surface depending of the landing sites location on Phobos (at the same season and latitude) may to show noticeable distinctions.

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