LANDING SITES FOR THE RUSSIAN LUNA-RESURS MISSION TO THE MOON.
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Introduction: As it is stated in Russian Federal Space Program, the priority task for the first Luna-Resource mission with lunar rover is the study of frozen volatiles in the Moon polar areas. The idea that water ice might exist in permanently shaded craters near the lunar poles was first suggested by Watson with co-authors [1]. Arnold [2] was the first who investigated mechanisms of water ice capture in these areas, and Hodges [3] estimated an equilibrium temperature in permanently shaded craters. The most probable accumulation and preservation of water ice is expected in “crater in crater” double cold traps, where the equilibrium temperature can reach 36 K [4]. At such low temperatures not only H_2O and CO_2 but also CO, N_2 and argon can be frozen. Organic compounds of cometary and asteroidal origin may also be cold-trapped at the poles of the Moon [5]. Surface erosion due to sublimation, sputtering, the interstellar UV radiation and micrometeorite bombardment makes it very unlikely that ice could stay on the surface [6-11]. Earth-based radar observations [12] and Kaguya data [13] confirmed absence of ice on lunar surface. The minimum thickness of the upper ice-free layer of regolith is estimated to be 40 cm [14]. Frozen volatiles below it may be down to the depth of 2 m. The age of frozen volatiles may reach 2 billion years. Concentration of water ice in cold traps is estimated within 0.3-1% [14]. According to the data [11], water concentrations in the polar cold traps cannot be greater than 350 ppm and optimal concentration may be even lower by ~2 orders of magnitude. Thus, regolith samples for the planned *in-situ* study should be taken at depth not less than 1 m.

There is also a possibility that at least part of the hydrogen detected by the neutron spectrometry [14] could be the solar wind protons captured by the surface layer of lunar regolith [15-18].

Landing sites: Landing sites should meet the following requirements: 1) they should be in direct radio visibility from Earth; 2) the landing ellipse size is 15x30 km; and should be oriented by long axis along a local meridian; 3) the topography within a landing ellipse should be smooth, slopes on the base of a few meters and larger should typically not exceed 10-15°; 4) the site at the landing moment should be illuminated; 5) the permanently shadowed areas should be close to the landing ellipse boundaries. Considering that mission will be in October 2012, two landing sites have been selected, both in the South Pole region: #1 (basic), and #2 (back-up).

Landing site #1: Coordinates of the landing ellipse centre are 87.2°S, 68°E. The landing site is in between craters Shoemaker (D = 63 km) and Faustini (D = 45 km) (Fig. 1). The landing site is at a relatively flat plain with the hundred meters altitude range. The illumination rate of the landing site is high enough and reaches 40-50 % (Fig. 2), including both summer and winter periods. Following the topography the illumination rate at the northern and southern parts of the ellipse decreases to 30 % and less [19]. The closest permanently shaded areas are in craters Shoemaker and Faustini (Fig. 2) as well as in small craters near the northern border of the ellipse. Permanently shaded areas in craters Shoemaker and Faustini are the largest cold traps at the South Pole. Their total area is estimated to be more than 2000 км^2 that is half of the area of all cold traps at the South Pole [19]. Both craters due to their old ages perhaps have a number of double cold traps with the lowest temperature. The landing site#1 is in the zone of maximum concentration of hydrogen at the South Pole [20]. The basic expected objects of the research are cold traps in crater Faustini. Topographical profile along an approach trajectory to the landing site is shown in Fig. 3.

Landing site #2: Coordinates of the landing ellipse centre are 88.5°S, 297°E. The site is located at the western rim of crater de Gerlach (D = 31 km) (Fig. 1). Deep crater of 15 km in diameter, which is a double cold trap, is located in a southeast part of crater de Gerlach. The crater rim within the landing ellipse is a flat-top height dominating over surrounding area by ~2 km. The illumination rate of the landing site is high, and even during the winter period does not fall below 70-75 % [19, 21-23]. It is a unique area with the maximum illumination rate on the South Pole. Only illumination rate in the most distant southern part of the landing ellipse decreases to 30% (Fig. 2). The illumination profile of the landing site is favorable enough and consists of three periods of illumination and blackout. The longest periods of illumination and blackout are 358 and 140 hours accordingly. The general duration of the illumination period is 510 hours from 708 hours of full lunation [21]. Permanently shaded areas are in small craters near the eastern border of the landing ellipse and in crater de Gerlach. The mentioned 15- km crater is a double cold trap. And small craters inside it will be the three-fold cold traps. The equilibrium temperature in the latters can reach 30-40 K [4]. The landing site №2 is in a zone of the maximum hydrogen concentration of 145 ppm in the South Pole [20]. The basic objects of research are permanently shaded areas in small craters near the east border of the landing ellipse and in a double trap in crater de Gerlach. Topographical profile along an approach trajectory to the landing site is shown in Fig. 4.

The selected sites have been used for accessibility tests in the work on the Luna Resource project. Future analysis of the data acquired by the Kaguya and Chandrayan-1 missions, as well as analysis of results of ongoing studies by Lunar Reconnaissance Orbiter, may lead to change of the landing site locations.

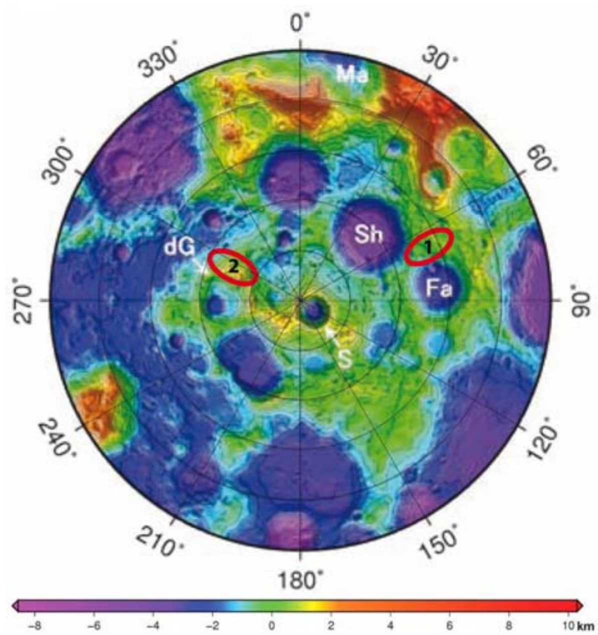

Figure 1. Topographic map of the South Pole of the Moon according to the Kaguya mision data [24]. The landing site #1 and #2 are shown by an ellipse of 15×30 km in size. dG – de Gerlache Crater, Sh - Shoemaker Crater , Fa - Faustini Crater S – Shackleton Crater.

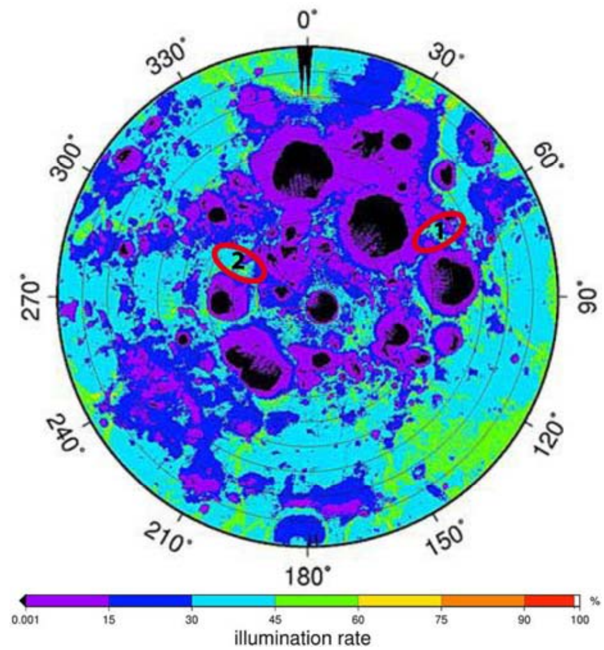

Figure 2. The illumination rate of the South Pole calculated for 2000 days [19]. The landing site #1 and #2 are shown by an ellipse of 15×30 km in size.

Figure 3. Topographic profile (250 km) along meridian 68°E to the #1 landing ellipse center.

Figure 4. Topographic profile (250 km) along meridian 63.3°W to the #2 landing ellipse center.

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