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Landing site selection for Luna-Glob mission in crater Boguslawsky

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ABSTRACT

Boguslawsky crater (72.9°S, 43.3°E, ~100 km in diameter) is a primary target for the Luna-Glob mission. The crater has a morphologically smooth (at the resolution of WAC images), flat, and horizontal floor, which is about 55–60 km in diameter. Two ellipses were selected as specific candidate landing areas on the floor: the western ellipse is centered at 72.9°S, 41.3°E and the eastern ellipse is centered at 73.9°S, 43.9°E. Both ellipses represent areas from which Earth is visible during the entire year of 2016 and lack permanently shadowed areas. Boguslawsky crater is located on or near the rim of the South Pole–Aitken basin, which provides the unique possibility to sample some of the most ancient rocks on the Moon that probably pre-date the SPA impact event. The low depth/diameter ratio of Boguslawsky suggests that the crater has been partly filled after its formation. Although volcanic flooding of the crater cannot be ruled out, the more likely process of filling of Boguslawsky is the emplacement of ejecta from nearby and remote large craters/basins. Three morphologically distinctive units are the most abundant within the selected landing ellipses: rolling plains (rpc), flat plains (fp), and ejecta from crater Boguslawsky-D (ejf), which occurs on the eastern wall of Boguslawsky. The possible contribution of materials from unknown sources makes the flat and rolling plains less desirable targets for landing. In contrast, ejecta from Boguslawsky-D represents local materials re-distributed by the Boguslawsky-D impact from the wall onto the floor of Boguslawsky. Thus, this unit, which constitutes about 50% of the eastern landing ellipse, represents a target of clearer provenance and a higher scientific priority.

1. Introduction

The upcoming lander mission Luna-Glob (http://www.lg.cosmos.ru) will study the physical conditions and composition of regolith in a region near the South Pole of the Moon, and will test a new generation of technologies for soft landing. The Luna-Glob lander will carry a suite of instruments, including a neutron and gamma-ray spectrometer, mass-spectrometer, and an IR spectrometer, aided by several TV cameras to study the surface chemistry, mineralogy, and the signatures of volatiles (http://www.lr.cosmos.ru/devices).

Due to engineering constraints formulated by the prime contractor, Lavochkin Association, which is responsible for the design of the Luna-Glob mission, the potential landing sites are defined as $15 \times 30\ km^2$ ellipses that must lie within a region between 70–85°S and 0–60°E. The surface within the landing ellipses should be relatively smooth (the upper safety limit of slopes at a 30-m baseline is defined as 7°) and essentially boulder-free (boulders on the surface that are larger than about 30–50 cm are considered as serious threats to the lander).

During preliminary analyses of the landing areas for the Luna-Glob and Luna-Resource missions, several potential landing areas in the northern and southern polar regions were selected (Ivanov et al., 2014). These areas are characterized by both relatively smooth surfaces and a low flux of epithermal neutrons, which suggest higher contents of hydrogen in the regolith (Basilevsky et al., 2011; Mitrofanov et al., 2012). At a later stage of the landing site selection process, Boguslawsky crater (72.9°S, 43.3°E, ~100 km in diameter) was proposed as a primary target for the Luna-Glob mission because this area is more favorable from an engineering point of view. The crater has a morphologically smooth (at the resolution of WAC images), flat, and horizontal floor, which is about 55–60 km in diameter. Two ellipses were

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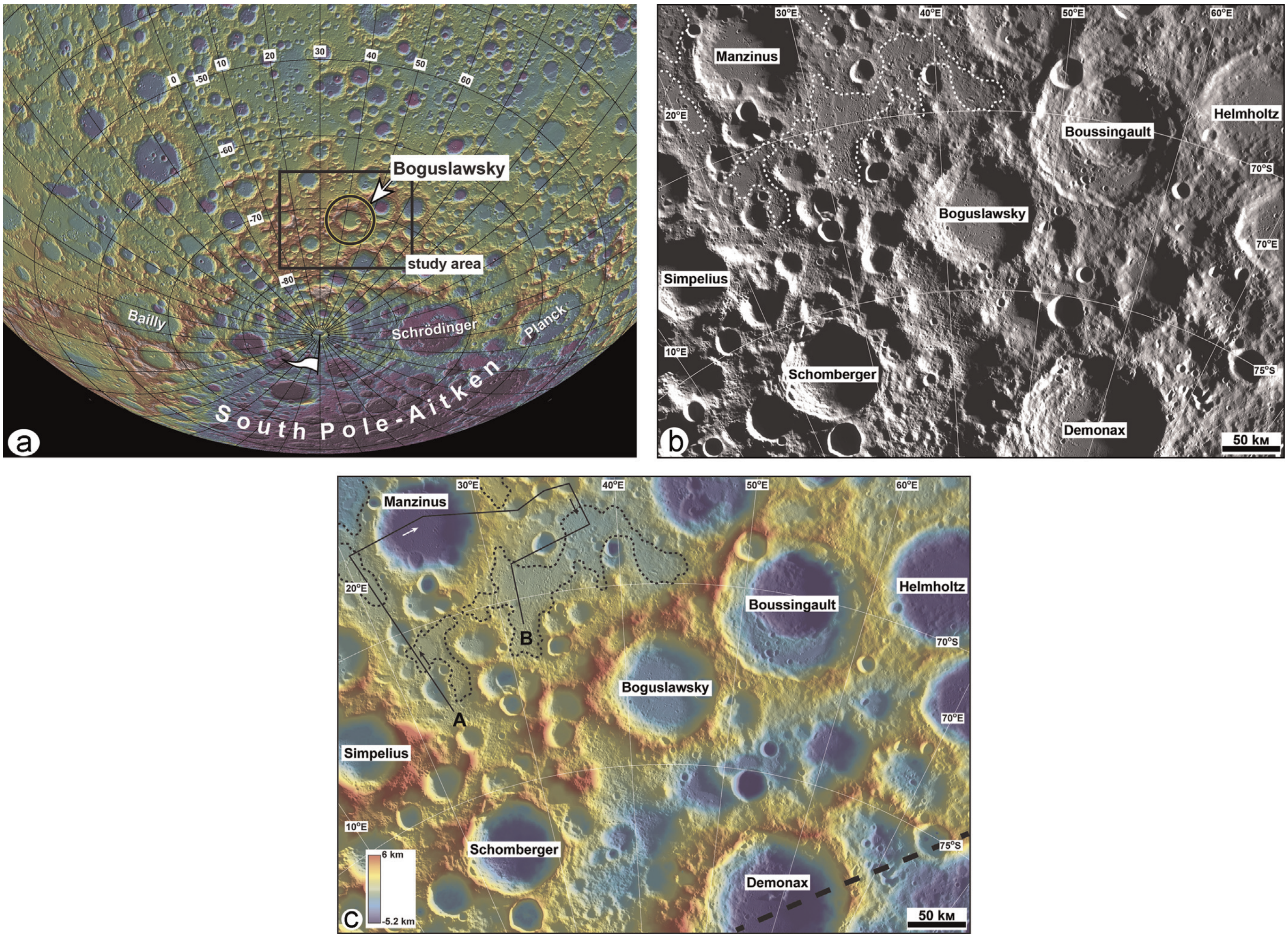

Fig. 1. (a) Topographic map of the southern sub-polar region of the Moon (LOLA gridded topography, resolution is 1/64 of a degree). The higher, heavily cratered terrains at about 70°S on the near side correspond to the rim of the South Pole–Aitken basin (Wilhelms et al., 1979; Garrick-Bethell and Zuber, 2009). (b) Lunar Reconnaissance Orbiter (LRO) LROC Wide-Angle Camera mosaic (WAC, resolution 100 m/px) showing the study area. The mosaic is centered at 73°S, 43°E (the center of crater Boguslawsky). Dotted lines in the upper left corner of the image show the boundaries of intercrater plains. (c) Topographic map of the study area (LOLA gridded topography, resolution is 1/128 of a degree). Black line in the upper left corner of the image shows location of the topographic profile shown in Fig. 19d. Dotted lines in the upper left corner of the image show the boundaries of intercrater plains. Dashed line in the lower right corner of the image indicates locations of the SPA rim.

selected as specific candidate landing areas on the floor: the western ellipse is centered at 72.9°S, 41.3°E and the eastern ellipse is centered at 73.9°S, 43.9°E.

The neutron flux from the region of Boguslawsky does not show a noticeable suppression and, in fact, is characterized by slightly higher values of the count rates of ~1.7 to 1.8 (Mitrofanov et al., 2012). These values imply that the floor of the crater is not a region where enhanced concentrations of hydrogen are expected (hydrogen can represent protons of the Solar wind or enter water, OH, or any other type of compounds). If the observed neutron count rates are related exclusively to water, then the neutron flux from the Boguslawsky region may suggest that possible water content in the regolith of this area is relatively low and may be close to the background value of ~0.1–0.2 wt% typical of the south polar region (e.g., Feldman et al., 2000, 2001; Mitrofanov et al., 2012). The Boguslawsky floor, however, is convenient for testing of new soft-landing technologies.

Although non-distinctive in the water content in its regolith, Boguslawsky crater is located on or near the rim of the South Pole–Aitken basin (Wilhelms et al., 1979) (Fig. 1a). The basin is the largest known (Stuart-Alexander, 1978; Wilhelms et al., 1979; Spudis et al., 1994; Hiesinger and Head, 2004; Shevchenko et al., 2007; Garrick-Bethell and Zuber, 2009) and likely the oldest (Wilhelms, 1987; Hiesinger et al., 2012) impact structure on the Moon. Such a location provides the unique possibility to sample some of the most ancient rocks on the Moon, which form the SPA rim and probably pre-date the SPA impact event – considered to have occurred near the beginning of the geologic history of the Moon (Wilhelms, 1987), possibly ~4.2–4.3 Ga ago (Hiesinger et al., 2012).

In this paper we present the results of our photogeological and morphometric studies of Boguslawsky crater and its surroundings. The main goal of this study was to both qualitatively and quantitatively characterize the local geology of the floor and the selected landing ellipses. These studies provide a basis for the interpretation of the nature of materials that make up the Boguslawsky floor and can be analyzed by the lander instruments, and help to prioritize geological units within the landing sites by their scientific importance. We also analyzed the spatial and size–frequency distributions of slopes (at a 30-m baseline), abundance of boulders on the surface for the most scientifically important units, conditions of illumination and visibility of Earth in order to assess whether the proposed landing sites are safe/suitable for landing.

We studied the Boguslawsky floor using traditional, well established, and tested methods of photogeology (e.g. Wilhelms, 1990). The results of our investigation are based on the analysis of new medium- and high resolution imagery and topographic data.

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