Geology of the Lunar Glob landing sites in Boguslawsky crater, Moon.

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Introduction:

On Nov. 17, 2011, the Space Council of the Russian Academy of Sciences, formally announced that the Luna-Glob and Luna-Resurs missions will be split into separate landing and orbiting missions. Although the main objective of the Luna-Glob lander is to test landing techniques, it will also carry a small scientific payload. The floor of crater Boguslawsky (~95 km in diameter, centered at 72.9S, 43.26E) was selected as primary landing site for the Luna-Glob mission. Two landing ellipses, 30x15 km each, were chosen on the floor of the crater: Ellipse West is at 72.9S, 41.3E, Ellipse East is at 73.3S, 43.9E.

Data and Methods:

For our analyses, we used data from several lunar missions, including the Lunar Reconnaissance Orbiter [Wide and Narrow Angle Camera images (WAC, NAC), Diviner temperature data, MiniRF radar data, laser altimeter data (LOLA)] and Chandraayan (M^3). We geologically mapped the crater, investigated its morphology and morphometry, performed crater size-frequency distribution (CSFD) measurements to derive absolute model ages, calculated temperatures and thermal inertia, derived rock abundances, and counted rocks in selected areas of interest.

We used CraterTools [1] to perform our crater counts and CraterStats [2] to plot the CSFDs. We used the production function (PF) and the lunar chronology of [3]. A detailed description of the technique of CSFD measurements is given by e.g., [4-6]. On the basis of LRO Diviner data, we calculate the relative rock abundance of Boguslawsky crater by analyzing temperature differences between fine material and exposed rocks during lunar night [7,8]. These temperatures are merged to a single observed temperature within the field of view. Due to the nonlinearity of the Planck function, brightness temperatures are higher at lower wavelengths and approach the average at higher wavelengths. Using multispectral measurements the concentration of the two components within a field of view can be derived. Temperatures of the surface are modeled by using a 1-D thermal model [9].

Results: In the geologic map of [10] the pre-Nectarian Boguslawsky crater (pNc) is superposed on pre-Nectarian rugged basin (pNbr) material. It is older than the close-by Upper Imbrian (Ic2) Schomberger crater and is partly covered by its secondary crater material [10]. The floor of Boguslawsky was mapped as Nectarian terra-mantling and plains material (Ntp), while Boguslawsky D, which is superposed on the eastern rim of Boguslawsky crater, is of Eratosthenian age (Ec). Somewhat younger than Boguslawsky crater, but still of pre-Nectarian age is Boussingault crater, which superposes Boguslawsly crater in the NE [10].

Fig. 1: Geologic map of [10] with Boguslawsky crater close to the center

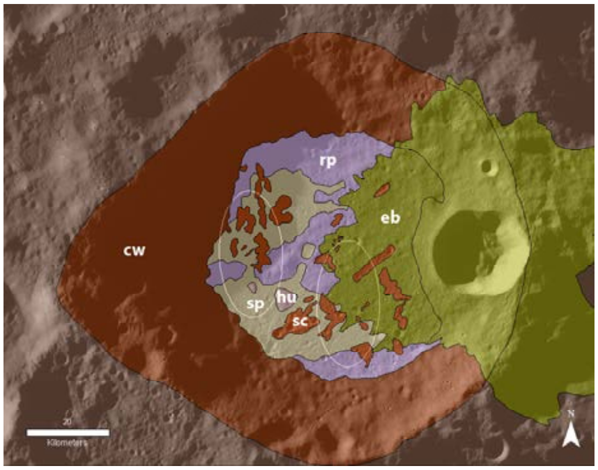

Fig. 2: New geologic map of Boguslawsky crater. Landing ellipses shown in white.

Using high-resolution LROC images, we identified six geologic units within Boguslawsky crater, including smooth plains *sp*, rolling plains *rp*, secondary craters *sc*, a hilly unit *hu*, the crater wall *cw*, and the ejecta blanket *eb* of the 24-km sized crater Boguslawsky D (Fig. 1,2). Within the western landing ellipse, units *sp*, *rp*, *sc*, *hu*, and possibly *cw* are accessible. The eastern landing ellipse covers unit *sp*, *rp*, *eb*, and *sc*. The SW of Boguslawsky crater shows numerous SW-NE oriented secondary craters, some of which might be related to the younger crater Schomberger and Schomberger A, consistent with the interpretation of [10]. Despite the large number of secondary craters, we were able to derive plausible absolute model ages for some of our geologic units. Based on our CSFD measurements, we favor a formation of Boguslawsky at about 4 Ga ago. This age is derived from a count area at the western crater wall, which might have been modified by mass wasting. Thus, our age represents a minimum age, i.e., the crater might be older.

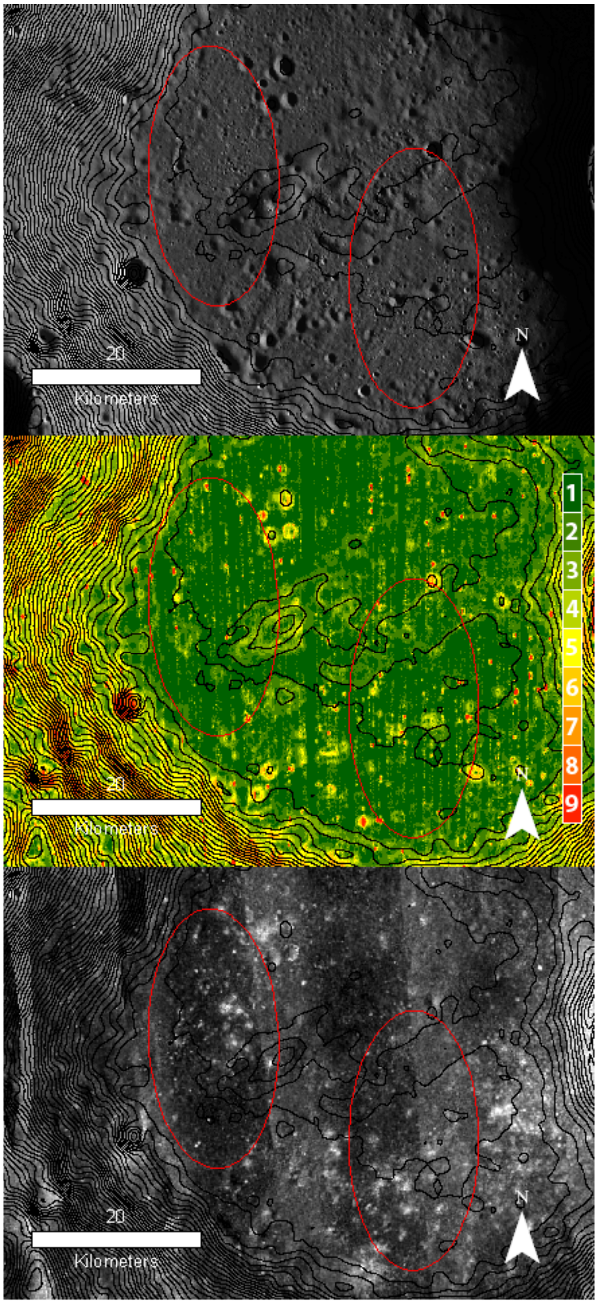

Fig. 3: WAC mosaic of the floor of Boguslawsky with superposed 100 m WAC contour lines [11] and proposed landing ellipses (top), slope map (center, 1: 0-5°, 2: 5-10°, 3: 10-15°, 4: 15-20°, 5: 20-25°, 6: 25-30°, 7: 30-35°, 8: 35-40°, 9: 40-45°), and MiniRF radar data (bottom [12])

Applying the stratigraphy of [13], Bouguslawsky is pre-Nectarian in age, consistent with the age assignement of the geologic map [10]. CSFD results indicate that the rolling plains are about 3.96 Ga old, thus being indistinguishable within the error bars from the CSFD of the Boguslawsky wall. The smooth plains were dated at 3.77 Ga, which is very similar to the age of the ejecta blanket of Bogouslawsky D (3.74 Ga). Those ages for the crater floor are somewhat younger than the ages in the geologic map [10] and Boguslawsky D appears to be older, i.e., it is Imbrian in age.

Although one of the scientific objectives of Luna Glob is to search for water, LEND epithermal neutron counts at the landing sites in Boguslawsky crater are significantly higher (>9.8 counts per second, cps) than for hydrogen-rich regions such as, Cabaeus and Shoemaker craters (<9.8 cps), thus indicating lower abundances of hydrogen [14].

Slopes at ~30m base length within the two proposed landing sites are generally less than 5-10 degrees. However, local slopes associated with small impact craters (mostly <500 m diameter) can be up to 45 degrees (Fig. 3).

Our thermal model identified several areas with higher thermal inertia and, thus, rock abundances. However, numerous of the areas are likely affected by temperature differences due to insufficient topographic correction. Several areas with high rock abundances, however, can not be explained by topographic effects and manual boulder counts on LRO NAC images confirm a large number of boulders on the surface (Fig.4). For example, in an area of about 4 km^2, we counted more than 16,000 boulders between ~0.5 m and up to 13 m in size around the small crater shown in Figure 4.

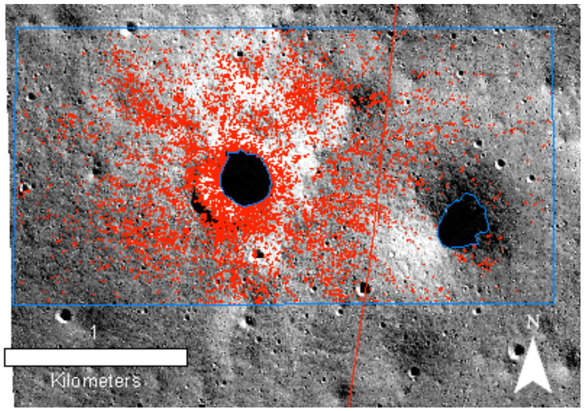

Fig. 4: Distribution of boulders around a small fresh bright crater at the eastern edge of the western landing ellipse (red line). The count area is shown in blue.

Summary: Boguslawsky crater represents a scientifically interesting landing site that will allow us to study the complex geology of an old crater in detail. More work needs to be done to ensure a safe landing of the spacecraft within the proposed landing ellipses.

References: [1] Kneissl et al. (2011), PSS 59; [2] Michael and Neukum (2010) EPSL 294; [3] Neukum et al. (2001), Space Sci. Rev. 96; [4] Crater Analysis Working Group (1979), Icarus 37; [5] Hartmann (1966), Icarus 5; [6] Hiesinger et al. (2000), JGR 105; [7] Christensen, P.R. (1986), Icarus 68; [8] Bandfield, J.L. et al. (2011), JGR 116; [9] Bauch et al. Submitted to PSS, [10] Wilhelms et al. (1979) USGS I-1162; [11] Scholten et al. (2012) JGR 117; [12] Nozette et al. 2010, Space Sci. Rev. 150; [13]Wilhelms (1987) USGS Prof. Paper 1348; [14] Litvak et al. (2012) JGR 117.