

**LANDING SITE EVALUATION INSIDE MARE MOSCOVIENSE.** S. Mikolajewski<sup>1</sup>, H. Hiesinger<sup>1</sup>, C. H. van der Bogert<sup>1</sup> and N. Schmedemann, <sup>1</sup>Institut für Planetologie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany (sascha.mikolajewski@uni-muenster.de)

**Introduction:** The past Soviet and recent Chinese missions have shown that automatic landing maneuvers on the Moon work successfully and that it is possible to obtain new samples from the lunar surface that can provide insights, for example, into lunar volcanism. Beside the chosen landing sites (LS) of these missions, another interesting region is the Moscoviense basin, a 450 km wide multi-ring impact crater with three distinct rings, located on the farside of the Moon. The basin is located in the northern hemisphere of the lunar farside at 27°N, 148°E. In this study, we present four possible LS located inside the Moscoviense basin. All landing sites are on volcanic units of different ages

and morphology as shown in the map of [3].

**Data/Methods:** Numerous studies [2-13] have used multispectral data and imagery to explore the Moon and gain insight into the evolution of mare volcanism and to characterize hazards for lunar missions. Clementine [4, 5] and Kaguya [6, 7] spectral data have been used to study the differences in the composition of lunar rocks and regolith. In this work, we used recent Lunar Reconnaissance Orbiter Camera data sets for the Mare Moscoviense to investigate four possible landing sites for future missions. In ArcGIS, we analyzed Kaguya mineral maps [6], multispectral Clementine FeO and TiO<sub>2</sub> data [4], and LROC datasets [10] to

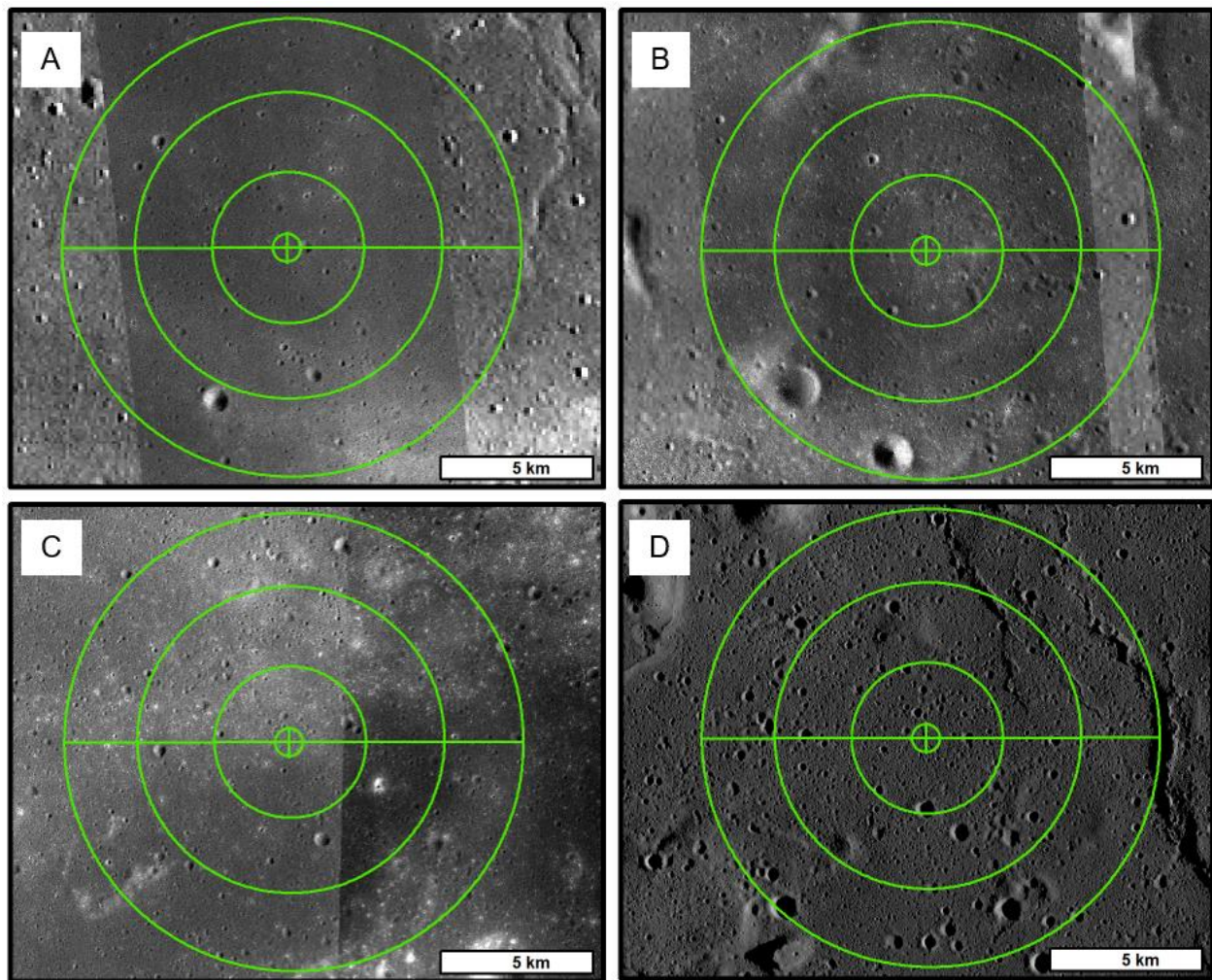


Figure 1: NAC and Kaguya images for the candidate sites North is on top: (A) east of Titov, (B) north of Komarov, (C) northwest of Komarov, and (D) north of Titov. The circles represent possible operation radii and landing ellipses of 1, 5, 10, and 15 km radius.

define morphological and compositional geological units in Mare Moscoviense. Utilizing digital terrain models [11], slope maps, and LRO Diviner rock abundances [9], we examined the topography and rock distributions of Mare Moscoviense in light of lander safety. Using these data, as well as numerical modeling of ejected material from craters in the vicinity, we investigated the characteristics of the four proposed landing sites.

**Results:** Landing site A is located at the eastern part of the Moscoviense basin near crater Titov. The NAC image shows that no large craters are present at site A and the surface morphology of this site is smooth (**Fig. 1 A**). At the eastern part of the LS, a wrinkle ridge is located. At the southern part of the LS, ray material from a fresh crater is visible on top of the underlying volcanic material (**Fig. 1 A**). The NAC DEM and the derived slope map for site A show that the targeted landing site is fairly flat and smooth and also indicate that the slope angles are less than  $10^\circ$  and only exceed  $10^\circ$  at the walls of larger craters in the southern part of the LS. LS B is located north of crater Komarov on a smooth dark volcanic unit (**Fig. 1 B**). The NAC image shows that the surface is free of large craters and darker compared to the material of LS A (**Fig. 1 B**). At the northern and southwestern part of the designated site, slope angles exceed  $10^\circ$ . In the northern part slope angles  $\geq 10^\circ$ , are associated with the wrinkle ridge and thus are above the safety threshold of a lander. At the southwestern part, the slope angles also exceed  $10^\circ$  along the steep crater walls of two larger bowl-shaped craters. Nevertheless, the area around the central part of the LS has low slope angles which  $\leq 10^\circ$ . Site C is located northwest of crater Komarov (**Fig. 1 C**). The surface is also free of large craters and relatively smooth. The surface is also brighter compared to the material present at the previous LS. At LS C, the DEM, slope map, and the NAC images show a smooth and flat surface (**Fig. 1 C**). Only in the northern part of the LS are several bowl-shaped craters located with slope angles larger than  $10^\circ$ . Most of the LS is characterized by slope angles of less than  $10^\circ$ . LS D is located north of crater Titov (**Fig. 1 D**). The LS contains a small dome-like structure between the 5 and 10 km circles, which could be a volcanic vent. The surface morphology of this site shows that there are no large craters, which is important for the safety of the lander. At LS D, a wrinkle ridge is located (**Fig. 1 D**). The WAC DEM of LS D shows that the area around the preferred landing site is flat. Only in the northern part of the investigated LS D does the topography increase by 300 m. In most parts of the LS, slope angles are less than  $10^\circ$ . Only in the northern and eastern part

of the investigated LS, the slope angle is above the safety threshold. In the northern part of the LS, the rim of Moscoviense basin is located and in the eastern part of the LS, slope angles also exceed  $10^\circ$  at the wrinkle ridge, which is approaching the safety limits of a possible rover.

**Discussion:** At all sites, slope angles  $\geq 10^\circ$  are limited to crater walls and wrinkle ridges. The surface of all sites is flat and the rock abundance at the examined sites is below 0.05 %. According to [7], at LS A and C volcanic domes are present. All LS are located on mare material and therefore give access to volcanic material. LS D gives access to a small wrinkle ridge, which could be investigated by a rover and analyzed with a ground penetrating radar (GPR) as shown by [13] at the Chang'E-4 LS. The three landing sites on the eastern mare unit of Moscoviense [3] provide access to at least two different mare units, ray material of a younger crater, several wrinkle ridges which could be analyzed with a GPR, and give insights into the small-scale mare volcanism of the lunar farside as shown by [14, 15, and this work].

**Conclusion/Future work:** We have presented four possible landing sites in the Moscoviense basin. All are located on volcanic mare units. These volcanic units have different ages and differ in morphology as shown by [3, 4, 7, and 8]. For future work, we will investigate other possible landing sites within the Moscoviense basin and will define rover traverses for upcoming potential missions proposed to Mare Moscoviense. The eastern part of Mare Moscoviense, particularly the darker volcanic units, would be most promising to gain a better understanding of the timing of young mare volcanism and the study of lunar cooling processes as well as wrinkle ridge formation.

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