INVESTIGATION OF FOUR CANDIDATE LANDING SITES INSIDE MARE MOSCOVIENSE. S. Mikolajewski[1], H. Hiesinger[1], C. H. van der Bogert[1] and N. Schmedemann, [1]Institut für Planetologie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany (sascha.mikolajewski@uni-muenster.de)

Introduction: The future of lunar exploration cannot be achieved by human exploration alone. Exploration with automatic landers and rovers such as past Soviet and the recent Chinese missions have shown that automatic sample return is an important way to obtain new samples from the lunar surface [1,2]. 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 in the northern hemisphere of the lunar farside at 27°N, 148°E [3]. The Moscoviense region was chosen as a destination because numerous studies [4,5] showed that the crust is the thinnest here and insights can be gained about the internal structure of the Moon [3]. Here, we present four scientifically valuable potential LSs on volcanic units located inside the Moscoviense basin, which represent volcanic materials with different ages and morphologies as shown in the geological map of [6]. The LSs were chosen to allow a rover to reach the science targets of interest within one lunar day according to [7].

Data/Methods: Numerous studies [2-14] 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 [8, 9] and Kaguya [3,10] 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 [10], multispectral Clementine FeO and TiO_2 data [8], and LROC datasets [12] to define morphological and compositional geological units in Mare Moscoviense. Utilizing digital terrain models [13], slope maps, and LRO Diviner rock abundances [11], 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: The first LS (red star: **Fig. 1**) is located at the eastern part of the Moscoviense basin near crater Titov. The NAC image shows no craters ≥ 700 m are present (**Fig. 1**). The surface morphology of this site is smooth and at the southern part of the LS ray material from a fresh crater is visible on top of the underlying volcanic material (**Fig. 1**). The NAC DEM and the derived slope map for the red LS show that the targeted landing site is fairly flat and smooth and also indicate that the slope angles are less than 10° and only exceed 10° at the walls craters ≥ 700 m in the southern part of the LS. In the south-eastern part of the Moscoviense basin is a second possible LS (yellow star: **Fig. 1**). The yellow LS is located north of crater Komarov on a smooth dark volcanic unit (**Fig. 1**). The NAC image shows that the surface is free of craters ≥ 1.3 km and darker compared to the material of the red LS (**Fig. 1**). At the northern and southwestern part of the designated site, slope angles exceed 10°. In the northern part slope angles ≥ 10°, are associated with the wrinkle ridge and thus are above the safety threshold of a lander. At the southwestern part, the slope

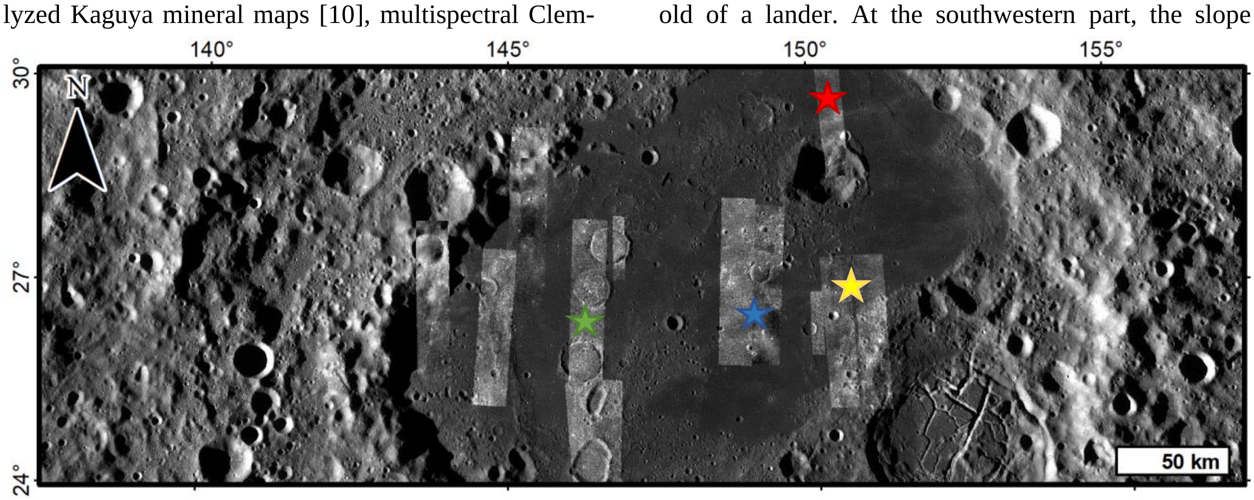

Figure 1: Candidate landing sites (stars) in the Moscoviense basin, as shown on the LRO WAC mosaic with LRO NAC image (modified after 13).

angles also exceed 10° along the steep crater walls of two larger bowl-shaped craters. Nevertheless, the area around the central part of the yellow LS has low slope angles which ≤ 10°. A different LS (blue star) is located at the southern part of the Moscoviense basin northwest of crater Komarov (**Fig. 1**). The surface morphology for this site is smoother, compared to the surface at the yellow LS. The surface is also free of craters ≥ 650 m . Additionally, the surface is also brighter compared to the material present at the yellow LS. (**Fig. 1**). Only in the northern part of the LS are several bowl-shaped craters located with slope angles ≥ 10°. Most of the LS is characterized by slope angles of less than 10°. The final LS we examined is in the western part of the basin between to floor fractured craters (green star, **Fig. 1**). The surface morphology of this site is rougher compared to the red and blue sites. At the northern part of the LS the NAC image shows several craters with a diameter ≥ 500 m. The NAC DEM for the green LS shows that the area around the preferred landing site is flat. At the northern and southern part of the investigated LS the topography increase at the rims of the two floor fractured crates (FFCs) by approx. 100 m. In most parts of the LS, slope angles are less than 10°. Only in the northern and southern part of the investigated LS, at the rims of the FFCs, the slope angle is above the safety threshold.

Discussion: At all sites, slope angles ≥ 10° 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 [10], at the red and yellow LS volcanic domes are present. All LS are located on mare material and therefore give access to volcanic material (**Fig. 2**). Two of the four LSs (red and blue) provide access to at least two different mare units (*Imm1, Emm2;* **Fig. 2**), which differ in age and iron content as shown by [4,9,10 and 14]. Red gives also access to ray material from an Eratosthenian crater and several wrinkle ridges which could be analyzed with a ground penetrating radar (GPR) as shown by [15] at the Chang'E-4 LS and give insights into the small-scale mare volcanism of the lunar farside as shown by [16, 17, and this work]. The green LS is located on a younger volcanic unit compared to the yellow and blue LS (*Imm2*; **Fig. 2**). By studying the volcanic material at the green LS, insights can be gained into how the volcanic melt interacts with the crater rim of the FFCs.

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 [4, 9, 10, and 14]. 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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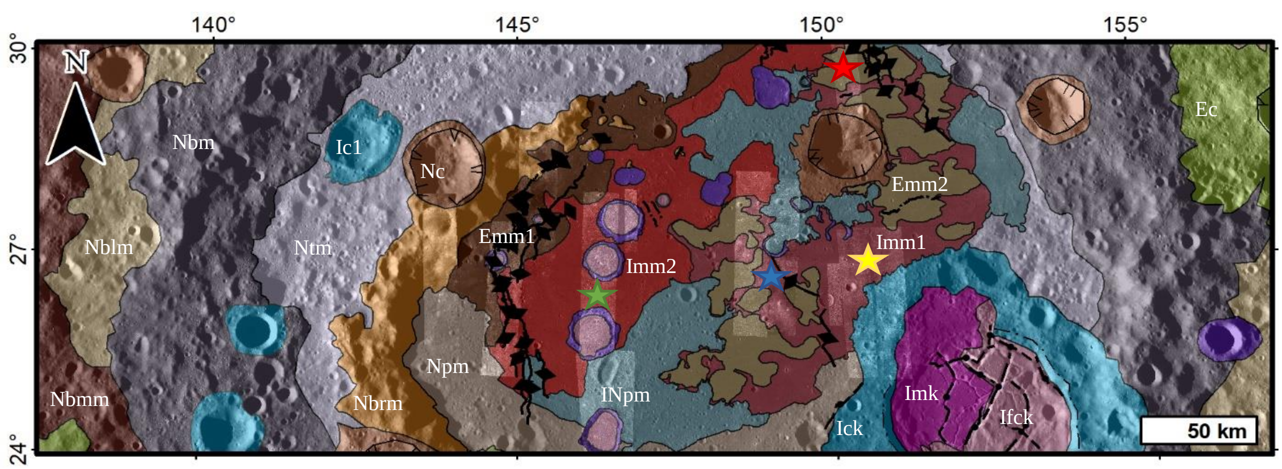

Figure 2: Excerpt of the geological map of the candidate landing sites (stars) showing the volcanic and basin units of the Moscoviense region (modified after 6)