
Introduction: Understanding the first billion years (~3.5–4.5 Ga) of the impact history of the inner Solar System would have profound implications for deciphering the early evolution of planets and the influence that basin formation has on surface development. To this end, it was proposed to morphometrically and compositionally map the impact melt deposits of nine lunar impact basins, including Orientale [1] and Moscoviene, at 1:200,000. These geologic mapping efforts will allow us to describe and infer the geology, stratigraphy, and relative ages of the proposed melt deposits, and thus determine if they would be suitable places for future missions to corroborate the basin ages. Here we present in-progress results of our mapping of Moscoviene basin and the search for its associated impact melt.

Background: Moscoviene (Fig. 1) is a ~445 km diameter impact basin on the lunar farside centered at 27°N, 146°E. It is one of the very few farside basins to host a mare deposit. Investigations utilizing SELENE data suggest that mare volcanism in Moscoviene was active for at least ~1.5 Ga following the formation of the basin [2]. They further suggested that Moscoviene magma production was 3–10 times less than that within nearside basins.

Moscoviene has a peak ring that forms a ~200° arc in the center of the basin. There is a mascon (first identified in Lunar Prospector data [3]) associated with the region inside this ring (Fig. 1c). It has been suggested that Moscoviene has a thinner crust compared to other farside basins [2].

Methods: Mapping was performed using ArcGIS Pro. The basemap was a Lunar Reconnaissance Orbiter Wide Angle Camera (WAC) mosaic of the crater and the highlands immediately exterior to it (Fig. 1). Other data sets used in mapping were Moon Mineralogy Mapper (M3) hyperspectral data, Diviner thermal data, and Lunar Orbiter Laser Altimeter (LOLA) topographic data (Fig. 1b).

Geologic Units: Several morphometric units have been identified during mapping.

Moscoviene mare material, smooth: Mare material in Moscoviene covers a little more than half of the basin, including the floor of the inner basin and spilling past the peak ring into the northern part of the outer basin (Fig. 1). They are low albedo and smooth, with significantly less cratering than adjacent units.

These mare basalts have been estimated to be ~600 m thick, with a total volume of 9,500–16,000 km³ [2]. Four subunits within the mare have been identified by [4]. While all were originally dated to the Imbrian,
more recent work suggests that both the eastern [5, 6] and western subunits are actually Eratosthenian in age. Basin floor material, inner: The floor of the basin within the peak ring that is not mare is heavily cratered with impact craters <5 km in diameter and sparsely cratered with impact craters between 7-20 km diameter. The material is of moderate to low albedo, noticeably lighter than the mare but somewhat darker than material outside the peak ring. Basin floor material, outer: The floor of the basin outside the peak ring is heavily cratered with both primary and secondary impact craters. The material is of a moderate to high albedo. There is a higher number of impact craters in the 5-10 km diameter range than the inner basin floor material. Titov materials: Titov crater (Fig. 1a) is a ~30 km diameter heavily degraded polygonal crater located within the mare. Immediately adjacent to the crater is a digitate field of material that is more heavily cratered than the surrounding mare. This material is embayed by the smooth mare, suggesting that it is older. And yet, the material is approximately the same albedo, suggesting that it is an older deposit overlain by the smooth mare. [4] mapped this region as the oldest mare subunit; it has been dated to the Imbrian [5, 6]. The floor of Titov crater is indistinguishable from the surrounding materials, and is currently mapped as the same unit. Komarov crater materials: Komarov crater (Fig. 1a) is a ~80 km diameter floor fractured crater that impacts the NE portion of the basin, outside of the peak ring but inside the basin rim. Although it impacts into outer basin floor material, the presence of the floor fractures indicates that magmatic processes have uplifted the floor of the crater [7, 8], suggesting that more recent volcanic materials may comprise some part of the unit. Komarov mare materials: The western floor of the Komarov crater is a lower albedo than the eastern. The floor fractures in this region also appear muted and/or filled, suggesting that mare basalts were deposited on the crater floor after it was deformed. This mare material is constrained to Komarov and the crater is superposed, and has been dated to the Imbrian [4, 6]. Crater floor material: Hummocky material is identified within five of the craters on the floor of Moscovien. Highlands material: Heavily cratered, high albedo material outside of the basin. The southwestern rim of the basin and the adjacent basin floor are indistinguishable from highlands material. Some entrained blocks are found within these materials, and muted floor fractures are also observed. Interpretation: As of the date of writing, not much impact melt has been unequivocally identified with in Moscovien, likely due to it being sequestered beneath the mare. Five of the larger craters that impacted the basin (circled craters in Fig. 1a) have floors that are distinct from the surrounding mare or basin floor materials. These craters have hummocky floors with entrained blocks and possible muted fractures. These craters may be floored with their own impact melt material, or perhaps Moscovien impact melt brought up from depth beneath the mare. However, some of the craters also resemble Type 4 floor fractured craters [7]. Although the inner basin floor material does not present the usual morphologic markers of impact melt, its location within the basin suggests that it might represent impact melt that has been heavily gardened. We are exploring the hypothesis that the Titov mare materials might be Moscovien impact melt that was only lightly mantled with mare materials, enough to darken its albedo but without obscuring its rougher morphology. This would be consistent with previous work by [2] that has shown the mare materials in Moscovien to be thin. Future Work: We have yet to incorporate ongoing mineralogic analyses of the basin into our geologic map. We are using M3 hyperspectral data and Diviner thermal data to make compositional interpretations, but we will also compare our map with [6], which used other spectral data besides M3. This may reveal differences in the definition of units using different spectral datasets. [6] did not identify any impact melt units and suggested that their crater materials units do not contain identifiable melt, possibly since the basin is so old. However, they weren’t looking specifically for impact melt or locations to sample Moscovien melt materials. Once our compositional interpretations have been incorporated into our map, we will construct a geologic cross section of the near-surface stratigraphy, to better understand the processes involved in the formation of the basin. Acknowledgements: This research was supported by the NASA Lunar Data Analysis Program project 80NSSC22K1338; PI Dr. Kirby Runyon, PSI. References: [1] Runyon K.D. et al. (2024) LPSC, abs. this mtg, Abs. #1112 [2] Morota T. et al. (2009) GRL, doi: 10.1029/2009GL040472 [3] Konopliv A.S. et al. (1998) Science, doi: 10.1126/science.281.5382. 1476 [4] Kramer G.Y. et al. (2008) JGR 113, D16S39, doi: 10.1029/2007JD009168 [5] Haruyama, J. et al. (2009) Science, 323, 905 – 908. doi: 10.1126/science.1163382 [6] Mikolajewski S. et al. (2020) LPSC LI abs. 1894. [7] Joziwia L.M. et al. (2012) JGR 117, E11005. doi: 10.1029/2012JE004134 [8] Joziwia L.M. et al. (2015) Icarus 248, 424-447. doi: 10.1016/j.icarus.2014.10.052. 