HAZARD MAPPING OF THE SOUTHERN LUNAR SURFACE: CANDIDATE ARTEMIS LANDING SITE - MALAPERT MASSIF.

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Introduction: In 2017, NASA unveiled the Artemis Program, a program aimed at rekindling our journey to the Moon after a near half-century hiatus [1]. The Artemis missions will land the first woman as well as the first person of color on the Moon. This program also aims to enable the first long-term stay on the Moon [1].

This research examines one of the 13 potential Artemis 3 sites using data available from QuickMap to assess landing hazards and accessible geology. Our aim is to evaluate the pros and cons of sending the Artemis 3 mission to Malapert Massif. Assessments of terrain, lighting conditions, communication capabilities, and resource potential can inform site selection and mission planning.

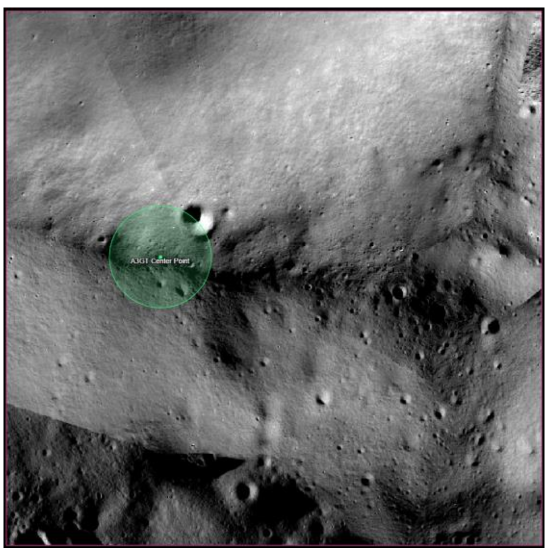

Figure 1. Image of Malapert Massif from QuickMap with A3 Geology Team point included (green circle) [2].

Methods: In this study, we used topographic maps from the QuickMap database to collect information about temperatures, rock abundance, Earth and Sun visibility, and permanently shadowed regions. We also examined data collected by Mini-RF radar instrument. We have also taken it upon ourselves to analyze the known payload [3] of the Artemis 3 mission to see what temperatures these instruments can sustain, to ensure they would work properly in the Malapert area. Some of the instruments that will be included in the payload of the Artemis III mission include ROLSES (Radio Observations of the Lunar Surface Photoelectron Sheath), LRA (Laser Retro-Reflector Array), NDL (Navigation Doppler Lidar for precise velocity and range sensing), SCALPSS (Stereo Cameras for Lunar Plume-Surface Studies), and LN-1 (Lunar Node 1 Navigation Demonstrator). Of these instruments, only two have temperature limitations: LRA and ROLSES. The LRA was thoroughly evaluated in a vacuum and performed as expected over a temperature range of 85 to 385K [4]. The ROLSES needs to stay below 65 Celsius (338.15 K) [5].

Results: Our analysis of the Malapert Massif site revealed several advantages and disadvantages of sending the Artemis 3 astronauts to this location. At the time this was written, we are researching slopes, rock abundance, and permanently shadowed regions. As mentioned earlier, we did not have a map of sub-kilometer permanent shadowed regions in the Malapert Massif area, and there are plans to create a map to explore this further. In addition to this, we will also need to research other limitations of instruments and machinery that be a part of the Artemis III mission such as what slopes could a lander land on, what rovers can climb, and what astronauts can safely climb, especially in their suits and with other equipment. We also will be looking into rock abundance across the area, to make sure that we do not land in an area that is too bumpy for landing and take-off.

Other topics researched include temperature, Sun visibility from the surface, and Earth visibility from the surface.

The temperature data and maps (which were derived from the data of the Diviner Lunar Radiometer Experiment on the Lunar Reconnaissance Orbiter) that we used can be found on QuickMaps. From here, we divided the map into four quadrants for ease of description. This also helps us to have a closer look at Malapert, rather than looking at the large area, as the whole region covers a nearly 21 by 21-kilometer area, although the desirable area would be about a 1 by 1 kilometer area.

In Figure 1, there is a clear ridge that extends across the landing area, and as can be seen in Figure 3, the Earth is not visible past this ridge. South of this ridge (quadrants 3 and 4, where quadrant 1 starts at 3 o'clock and goes to 12 o'clock, and the quadrants continue counterclockwise) temperatures drop dramatically, no matter the season. Often, the absolute highest or absolute lowest temperatures in a quadrant would be at a singular point and were not widespread. Table 1 demonstrates some examples of this.

From this data, we can see that the instruments mentioned earlier that have temperature limits should work as expected and have no issues in the northern quadrants. Though there is one outlier in the winter average temperatures in the lowest temperature recorded in quadrant 2, this is very likely to be from the bottom of a crater, in a permanently shadowed region. It is also important to note that this temperature would only be a concern for the LRA, which will be attached to the lander [4], so unless the mission was set to land in a permanently shadowed region, which would not happen, this will not be a concern.

Summer Avg Temp	Highest	Lowest
Q1	170.824	97.412
Q2	184.941	124.235
Q3	187.765	76.235
Q4	176.471	70.588
Winter Avg Temp	Highest	Lowest
Q1	187.82339	84.39355
Q2	193.2993	67.3935
Q3	112.96837	49.99928
Q4	158.84326	46.40419

Table 1: Some of the data collected from the QuickMap data sets for summer and winter average temperatures. All values are in Kelvin.

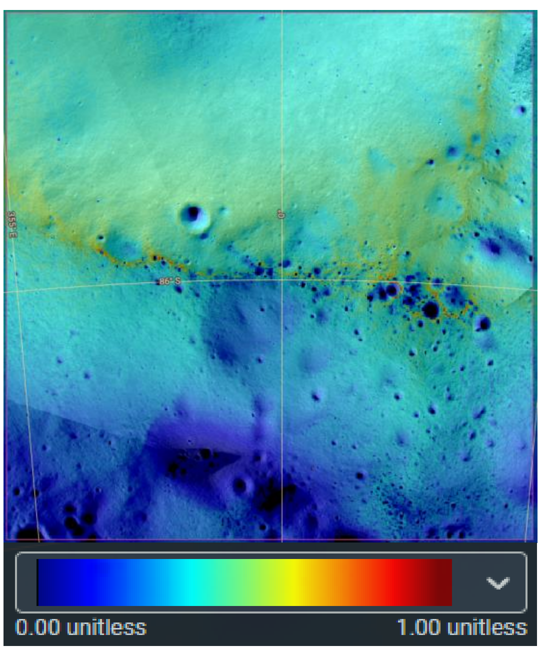

Figure 2. Image of Malapert Massif from QuickMap, using Sun Visibility for 60 meters/px data from LOLA. [2]

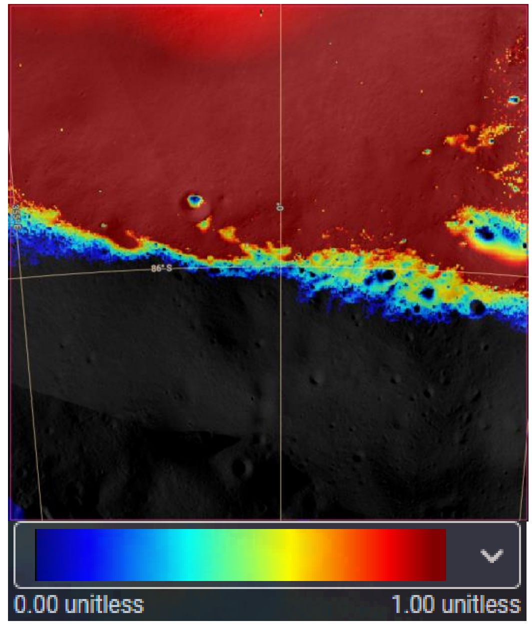

Figure 3. Image of Malapert Massif from QuickMap, using Earth Visibility for 60 meters/px data from LOLA. [2]

References: [1] Dunbar B. (2017) Artemis, https://www.nasa.gov/specials/artemis/. [2] Malaret E. et al. (2022) *Lunar Polar Volatiles Conf.*, Abs #5028 [3] Intuitive Machines (2022) https://www.intuitivemachines.com/_files/ugd/7c27f7_a92b5ec52851418582ff43d5afc6843b.pdf [4] Sun X. et al. (2019) *Optica*, 58(33), 9259–9259, doi:10.1364/ao.58.009259. [5] Burns J. O. et al. (2021), *Planetary Science Journal*, 2(44), doi:10.3847/psj/abdfc3.