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**MAPPING SOLAR IRRADIANCE WITHIN SCHRÖDINGER BASIN FOR FUTURE ROBOTIC SAMPLE RETURN MISSIONS.** N. J. Potts<sup>1,2</sup>, A. Gullikson<sup>3</sup>, N. M. Curran<sup>4</sup>, G. Chang<sup>5</sup>, J. K. Dhaliwal<sup>6</sup>, M. K. Leader<sup>7</sup>, R. N. Rege<sup>8</sup>, D. A. Kring<sup>9</sup>. <sup>1</sup>The Open University, UK (nicola.potts@open.ac.uk) <sup>2</sup>VU University Amsterdam, NL, <sup>3</sup>Northern Arizona University, USA, <sup>4</sup>The University of Manchester, UK, <sup>5</sup>Jet Propulsion Laboratory, USA, <sup>6</sup>Scripps Institute of Oceanography, UC San Diego, USA, <sup>7</sup>The University of Texas, USA, <sup>8</sup>Columbia University, USA, <sup>9</sup>Lunar and Planetary Institute, USA.

**Introduction:** The US National Research Council (NRC) identified eight scientific concepts and thirty-five prioritized investigations to be addressed with continued lunar exploration [1]. These objectives are broadly consistent with those identified throughout the international community (e.g., [2]). The majority of these objectives require sample return from the Moon. Schrödinger basin has been highlighted as a particularly attractive location to find suitable samples [3].

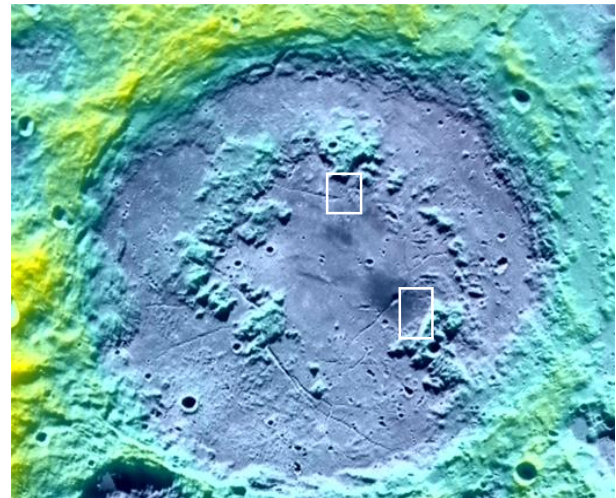
Schrödinger basin is the second youngest basin on the Moon and is located within the farside's South Pole-Aitken basin, the oldest and largest basin on the Moon. A sample return mission to Schrödinger has the potential to constrain the beginning and end of the basin-forming epoch (including the lunar cataclysm), which are the two highest science priorities [1]. The Schrödinger basin-forming impact uplifted a peak ring of lunar crustal material that M<sup>3</sup> data [4] suggest contains diverse lithologies. Sampling the peak ring lithologies and adjacent clast-bearing impact breccias would constrain the lunar magma ocean hypothesis and the crust's evolution. Furthermore, mare basalt flows and a pyroclastic vent within the basin provide unique opportunities to explore the magmatic evolution of the Moon.

Three potential landing sites have previously been identified within Schrödinger for missions with crew and the Lunar Electric Rover [5]. However, there is currently no infrastructure for landing crew on the Moon's surface. While it is being developed, a human-assisted robotic sample return mission has been proposed [6]. In this scenario, crew on NASA's Orion Multi-Purpose Crew Vehicle tele-operate a rover on the lunar surface from the Earth-Moon L2 point.

Two landing sites for the robotic missions are near those suggested for crew, but have been adjusted slightly to facilitate rover ConOps (Fig 1.) that optimize sampling opportunities with a short-duration mission [7, 8]. Schrödinger impact material that could be used to determine the age of the basin is present at both sites. Samples at the northern landing site would consist of peak-ring material, mare basalts thought to be younger than those on the nearside, and potentially volatile-bearing lithologies in a deep fracture. The southeastern landing site provides unique exposures of both the peak ring and a pyroclastic vent with in situ

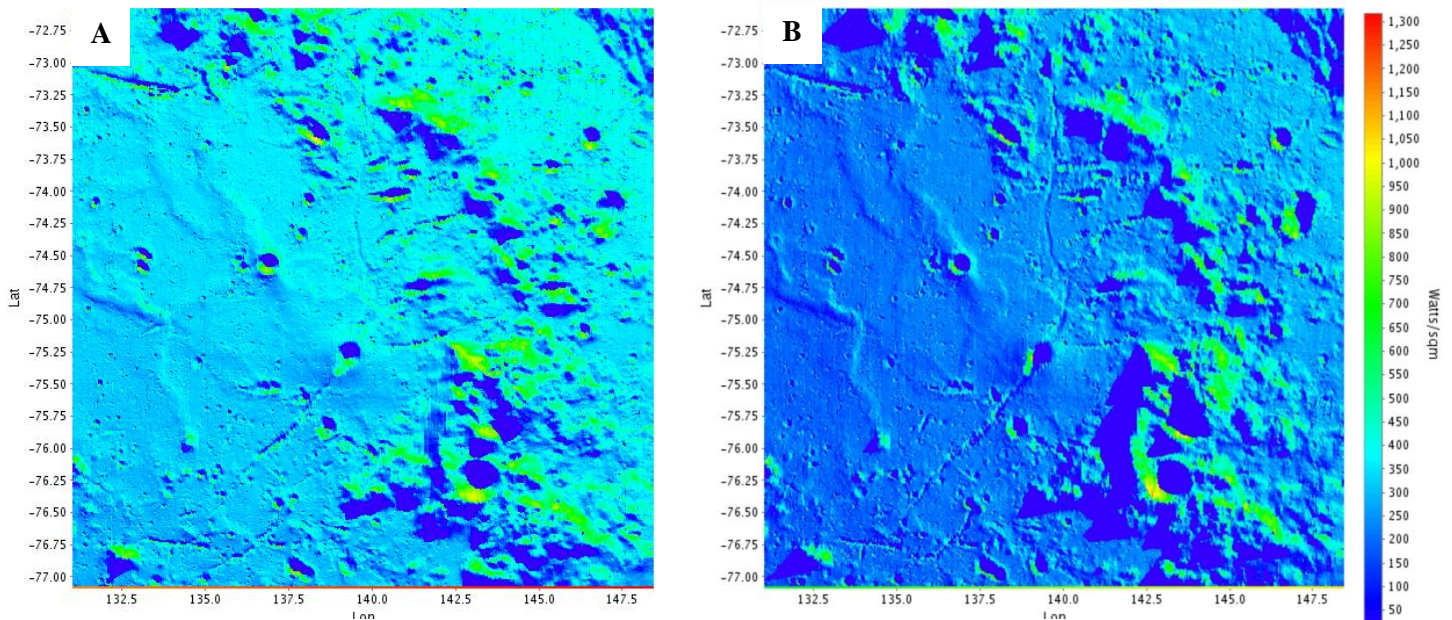
resource utilization (ISRU) potential.

Traverses within each site were designed using a combination of Lunar Orbiter Laser Altimeter (LOLA) data and Wide-Angle Camera (WAC) imagery [7-8]. Narrow-Angle Camera (NAC) imagery was used to ensure the suitability of each station for sampling. Traverse time between stations of interest was constrained for a rover with a base speed of 1 km/hr (already demonstrated by Lunokhod 1 & 2) and the ability to traverse up to slopes of 16°.



**Figure 1:** Topographic image of Schrödinger basin (320 km in diameter). White boxes correspond to sites of interest. Image taken from Iliads.

**Solar Irradiance:** A short-duration solar-powered rover mission must coincide with a period of lunar illumination (~14 Earth days). Solar irradiance (sunlight power on surface) data from Lunar Mapping and Modeling Portal (LMMP) for the period January 2018 through December 2021 were analyzed to coincide with potential Orion launch dates. An area covering both localities (-72.5545N, 131.041E to -72.108N, 148.4384E) was selected. A mesh size of 1 m with 39% Earth shine and terrain reflection were used. Results (Fig. 2) are given in watts/sqm. LMMP utilizes LOLA topography data combined with lunar ephemeris to provide the highest resolution grids of lunar polar topography thus far [9]. When combined with local topography, variations in the amount of sunlight available across the lunar surface can be extracted.



**Figure 2:** Solar irradiance map covering both proposed mission localities with Schrödinger for comparative period of illumination for August 2018 (A) and January 2019 (B). The maps highlight the difference in solar power (watts/sqm) between the two periods, with the Eastern Inner-Basin floor averaging 450 watts/sqm in August 2018 compared to an average of 150 watts/sqm in January 2019.

The optimal periods of solar irradiance are the months July through September, which have a ~15% longer than average period of lunar illumination (Fig.2). The period of August 2021 was identified as an optimum date for this mission in terms of solar irradiance, illumination, and potential Orion mission dates.

Tracking variations in sun angle over a one year period indicate some areas within Schrödinger may be in complete shadow one year and have adequate solar power the next. This is particularly evident behind local topographic highs such as the peak ring at the northern landing site, which was not always illuminated during the period of interest. The base of the peak ring at the southeastern landing site did not have any areas that were shadowed during periods of lunar illumination. Traverse routes in that region are, therefore, less restricted in date than those at the northern landing site.

**Conclusions:** Solar irradiance within Schrödinger varies by a factor of 3, depending on the time of year. Thus not every 14-day-long illumination period provides the same solar power on the surface. This does not preclude missions in the first half of the year, but they may require larger solar panels or a more power-efficient rover.

This illumination study can facilitate several mission trade studies involving the sizes of the rover, solar panels, and power storage; the number of instruments requiring power (whether they are limited to those

needed for sample return or also include those for in situ analyses); and whether the capacity to survive a lunar night or not is necessary. The illumination results can also be used to select traverse routes and station locations [7, 8] that maximize access to solar recharging.

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**References:** [1] National Research Council (2007), *The Scientific Context for Exploration of the Moon, Final Report* [2] Crawford I. et al. (2012) *PSS*, 74, 3-14 [3] Kring D. A. and Durda D. (2012) *LPI Contrib. No. 1694* [4] Kramer G. Y. et al. (2013) *Icarus*, 223, 131-148 [5] O' Sullivan K. M. et al. (2011) *GCA Spec. Pap.* 477, 117-127 [6] Burns J. O. et al. (2013) *J. Adv. Space Res.* 52, 306-320 [7] Curran N. M. et al. (2014) *LPSC XLIV (This Conference)* [8] Gullikson A. et al. (2014) *LPSC XLIV (This Conference)* [9] Mazarico E. et al. (2011) *Icarus*, 211, 1066-1081