IDENTIFYING POTENTIAL LANDING SITES FOR ESA'S PROSPECT INSTRUMENT- NASA/CLPS.

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Introduction Remote sensing observations indicate the existence of water ice and volatile deposits in the south polar region of the Moon [e.g., 1-3]. These provide the opportunity to answer numerous important science questions. Lunar polar cold traps may provide a record of Solar System volatiles from numerous sources over an extended period of time and would thus be key to understanding the history and behavior of volatiles on Moon and other airless bodies (e.g., The National Research Council (NRC) 2007, [4], [5-7]). Therefore, the south polar region is the target landing site for many future upcoming missions [e.g., 8-11] including for ESA's PROSPECT instrument, which has been selected for flight on the 10th NASA Commercial Lunar Payload services (CLPS) mission [12,13]. NASA CLPS-10 will be a static lander and contain a range of instruments including PROSPECT (Package for Resource Observation and inSitu Prospecting for Exploration Commercial exploitation and Transportation) which, using the Drill, will sample the lunar surface up to 1 m depth with the aim to detect volatiles including water ice if present [12,13]. These samples are then analyzed for the gases that are given off when samples are heated, within the onboard laboratory, known as ProSPA [12,13]. This will develop the understanding of the composition of the lunar surface and the geological knowledge of the south polar region. It is essential that a landing site is chosen that is expected to be rich in volatiles and has thermal conditions that support water ice to be stable if present. In this study, we are down selecting the landing sites that have the best conditions for PROSPECT from a scientific and mission perspective.

Datasets: A range of datasets with GIS remote sensing methods was used to investigate the south polar region (84 -90° S), including Lunar Reconnaissance Orbiter (LRO) images; NAC (Narrow Angle Camera) and WAC (Wide angle camera) [14]. We have analyzed the elevation of the region using the LOLA 30 m/pixel dataset. Slope maps were derived from the LOLA 30 m/pixel digital elevation model (DEM) to identify areas with slopes of less than 10. Verified thermal models for the lunar surface and subsurface, developed by king et al. [15] and Paige et al. [2] were used to analyze the surface temperatures of the region and whether conditions were suitable to support water ice being stable over geological timescales down to the targeted drill depth [2,15]. Potential Ice exposures identified by Li et al 2018 [1] in the region have been identified and compared with surface temperatures and the slopes within the region. The Mazarico *et al.*, 2011 [16], illumination model was also used alongside ISIS tools and a toolkit from ispace to investigate the Earth visibility, horizon, and surface illumination (Figure 1).

Down selection method: Points of interest within the south polar region were identified as areas which met the following criteria which was selected based on reasonable constraints for a lunar south polar mission; slopes 10 ° or less, 30% or more illumination, 50% or more Earth visibility and that both the Oxford thermal model and the Paige model suggest conditions are suitable for water ice to exist if present between the surface and 20 cm beneath the surface. Where there were 4 pixels or more that met these criteria, a point of interest was placed. Down selection of these points of interest was done using a science matrix, which analyzed whether the science requirements for PROSPECT were met. Similar methods have been used for previous missions including ExoMars.

Sites of interest: 49 sites of interest were identified which met the landing site criteria based on constraints for landing and operating the spacecraft (Figure 2).

Down selecting sites of interest. The scientific requirements for PROSPECT were then used to down select these 49 sites. 18 of the sites had thermal conditions for water ice to be stable, if present, between 0-10 cm depth and likely at deeper depths too due to temperatures decreasing with depth. This is favorable, because then there is the greatest range of depths available to sample using the PROSPECT drill. 10 of the 49 sites had temperatures of 110 K or less, throughout all seasons, where 110 k is the temperature commonly used to predict conditions for water ice to be stable over geological timescales (with sublimation rates less than 1 kg/m^2 per billion years [2]). Only 5 of 49 sites had temperatures lower than 110 K and had conditions for water ice to be stable if present between 0 -10 cm depth.

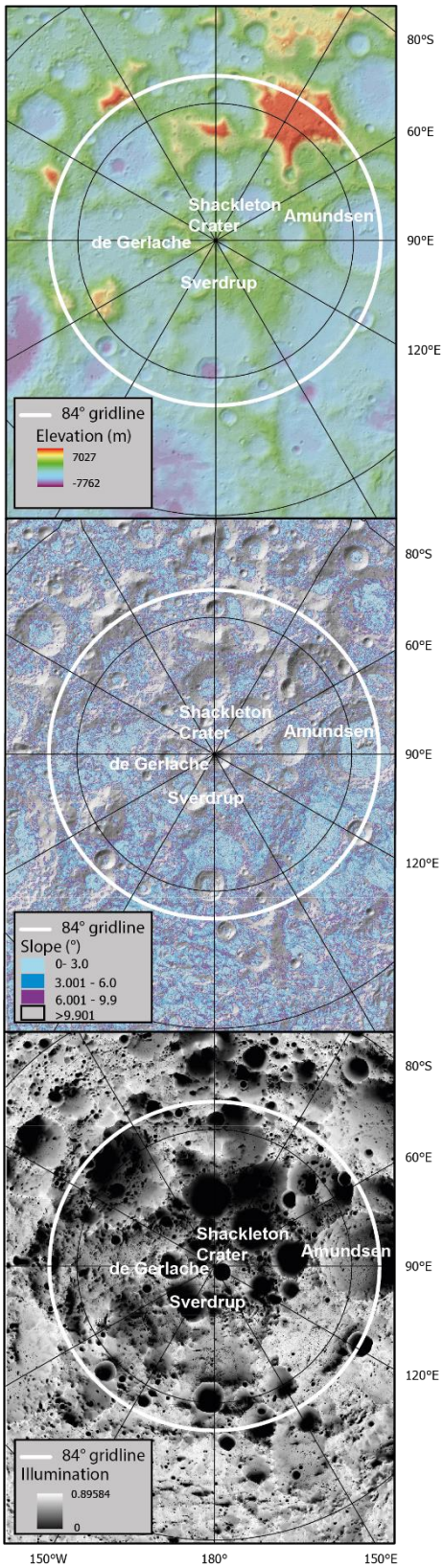

Figure 1: Elevation map (LOLA 30 m/pixel), Slope map derived from the LOLA 30 m DEM and illumination map (Mazarico et al 2011).

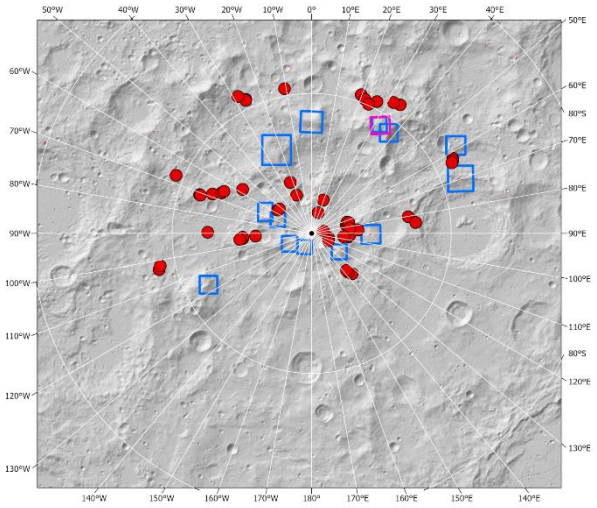

Figure 2: Points of interest marked on hillshade of south polar region. Red points show the 49 points of interest. The blue squares are the Artemis III candidate sites and the pink square is the viper landing site shown for reference.

Future work: Using the scientific matrix, we will down select the 49 sites to just 4 sites that have the best conditions for PROSPECT, including most likely to contain volatiles and conditions for water ice. These 4 sites will continue to be analyzed and detailed hazard mapping will be carried out and in addition identifying within the sites the best areas to sample. These 4 sites will be presented at LPSC. Ultimately a best candidate site and a reserve proposed landing site will be presented, which not only has the best conditions for PROSPECT, but also develops our understanding of the south polar region of the Moon and can contribute or assist scientifically with other future missions.

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