POTENTIAL WATER AND DRY ICE DISTRIBUTION IN THE LUNAR SOUTH POLAR REGION.

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Model Calculations of Ice Distribution in the South Polar Region: Using previously developed methods (e.g., [1]), the possible stabilities of water ice (H_2O) and dry ice (CO_2) in the upper 50 cm and 1 m of the regolith were calculated. Water ice is stable within those near-surface zones over a greater geographic area than is dry ice. To illustrate the model results, we highlight several locations in the south polar region.

Shackleton Crater: Artemis III, the first Artemis lunar surface mission, is designed to land near the south pole, which is located on the rim of Shackleton crater. The crater hosts a large PSR that calculations suggest may have a near-surface environment with water ice, but little dry ice (**Fig. 1**).

Amundsen Crater: A previous analysis [2] of landing sites suitable for addressing lunar science objectives [3] suggested the floor of Amundsen crater is a high-priority target. An analysis [4] of the International Space Exploration Coordination Group (ISECG) design reference mission also pointed out that Amundsen is a good place for a tele-robotic subsurface survey for water ice. Calculations presented here (**Fig. 1**) illuminate the advantages of that type of location: it contains a diversity of ice types, on an easily traversable crater floor, in close proximity to sunlight and the power it provides.

Model Calculations of Resource Potential: Near-surface deposits that do not require energy for the removal of overburden may be attractive ISRU targets. Using the calculated ice distributions described herein, the potential resource tonnage was calculated in the upper 1 m (**Fig. 2**). Resource tonnage is derived assuming 5.6 ± 2.9 wt% H_2O in the regolith, as determined from the LCROSS experiment [4]. Because that experiment target Cabeus crater, the resource tonnage calculated for Cabeus (**Fig. 2**) should be viewed with a higher confidence than that for other sites (e.g., Haworth, Shoemaker, Faustini, and Shackleton craters). We note that the 5.6 wt% value is strictly applicable only to the coldest portion of Cabeus, where dry ice is stable at the surface. Thus, we also provide the potential resource tonnage for lower proportions (0.1, 0.5, and 1.0 wt%) of H_2O in the regolith.

Model calculations suggest 2×10^{10} kg to no more than 5×10^{10} kg water ice could be recovered from the uppermost 1 m of regolith in Cabeus crater. Similar values for Haworth, Shoemaker, Faustini, and Shackleton are 9×10^9 to 3×10^{10} kg, 9×10^9 to 3×10^{10} kg, 6×10^9 to 2×10^{10} kg, and 1×10^9 to 4×10^9 kg, respectively. Additional tonnage can be recovered at deeper (>1 m) horizons. Depending on the resource recovery methodology, it may be more efficient to access deeper ice at a single location than surface ice at geographically distant sites.

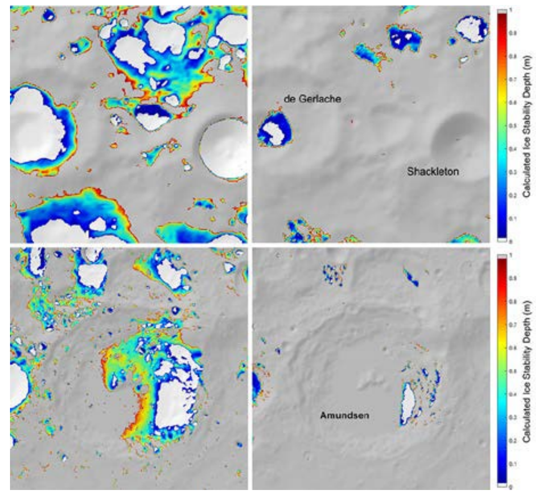

Fig. 1. *Maps of calculated stability of water ice (left) and dry ice (right) in the upper 1 m of regolith in Shackleton (top) and Amundsen (bottom) craters.*

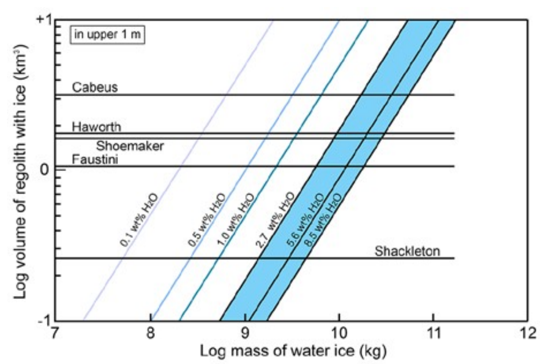

Fig. 2. *Calculated masses of water ice in several south polar craters with a regolith water abundance (5.6 ± 2.9 wt%, blue zone) measured by the LCROSS experiment. A log mass value of 9 on the horizontal axis is equivalent to a million metric tons.*

References: [1] Siegler M. A. et al. (2016) *Nature, 531*, 480–484. [2] Lemelin M. et al. (2014) *Planet. Space Sci., 101*, 140–161. [3] NRC (2007) *The Scientific Context for Exploration of the Moon*. [4] Allender E. J. et al. (2019) *Adv. Space Res., 63*, 692–727.

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