CHARACTERIZATION OF LUNAR ICE STABILITY REGION (ISR) HOST CRATERS: SIZE DISTRIBUTION AND AGE CONSTRAINTS. B. J. Thomson[1], C. I. Fassett[2], S. S. Bhiravarasu[3], C. D. Neish[4], C. A. Nypaver[1], E. A. Fisher, and G. W. Patterson[2], [1]Dept. of Earth and Planetary Sciences, Univ. Tennessee, Knoxville, TN, USA (bthom@utk.edu), [2]JHU Applied Physics Lab, Laurel, MD, USA, [3]Space Applications Centre (ISRO), Ahmedabad, Gujarat, India, [4] Univ. Western Ontario, London, ON, Canada, [5]Univ. Hawaii, Honolulu, HI, USA.

Introduction: High-priority exploration targets for the planetary science community are deposits of lunar polar volatiles (largely H_2O but also H_2S, NH_3, SO_2, C_2H_4, and OH, among others [1]). These volatile deposits have been detected in near-polar ice stability regions (ISRs), which are regions where the maximum temperature does not exceed a threshold temperature for volatile stability (e.g., ~100–110 K on Mercury or the Moon [2-4]). The age and potential source(s) of volatiles in these ISRs remain the subject of active investigation.

Here we examine the crater size-frequency distribution (CSFD) of crater-hosted ISRs greater than 1 km in diameter. Our objective is to better understand the populations of ISRs in the north and south polar regions to place general constraints on the ages of these features (a factor that in turn can inform our understanding of the origin of the volatiles that they potentially host).

Methods: To delineate ISRs, we used temperature data from the Lunar Reconnaissance Orbiter Diviner instrument [5]. Fisher et al. [6] observed an abrupt brightening in near-infrared measurements of surfaces with temperatures <110 K at the south pole, and we adopt this temperature threshold for this study to delineate ISRs. As described below, the majority of ISRs are hosted within impact craters. To characterize these craters, we used the lunar impact crater catalog compiled by [7], which is nearly complete down to craters >1 km in diameter. We identified all craters that host ISRs poleward of 80° N and S latitude, calculated the percentage of each crater interior that meets the <110 K threshold, and also manually identified craters that were nested (i.e., a small ISR crater superposed inside a larger, crater-hosted ISR region).

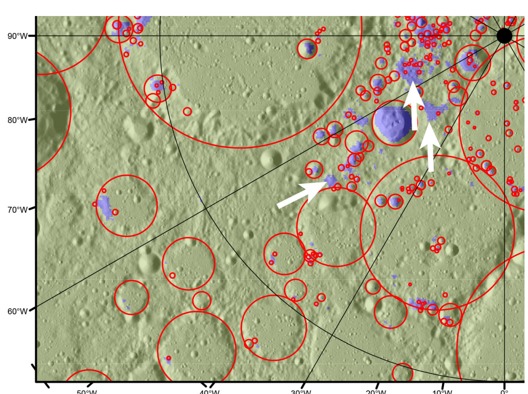

Figure 1. Shaded relief map of a portion of the lunar north polar region. ISRs are given in purple; craters hosting ISRs are outlined in red. White arrows indicate ISRs *not* hosted in craters.

Results: A somewhat unexpected result is that not all ISRs are hosted within well-defined impact structures. As indicated in **Fig. 1**, some ISRs are located on the rugged terrain at the periphery of larger craters. The north polar region has a larger percentage of non-crater hosted ISRs, about 5% of the total ISR area.

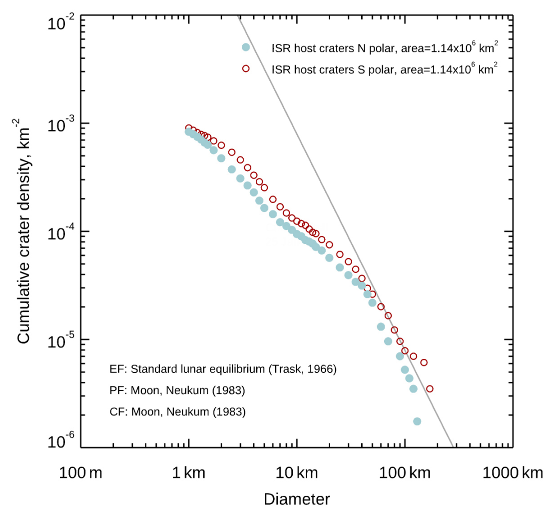

Figure 2. Cumulative crater size-frequency distribution of the number of ISR-hosting craters in the north (>80°N; solid blue circles) and south (<80°S; open red circles) polar regions.

For crater-hosted ISRs, we determined crater size-frequency distributions. The results are given in **Fig. 2** and **Fig. 3** in cumulative and incremental size-frequency distribution formats, respectively. In **Fig. 2,** it is apparent that the cumulative number of craters that host ISRs is greater in the south than in the north, an observation that is consistent with prior measurements of a ~40% difference in the total terrain that lies in permanent shadow in the south versus the north [8, 9].

However, the incremental CSFD given in **Fig. 3** indicates that the north polar region has a higher density of ISR-hosting impact craters under ~3 km in diameter. The prevalence of ISRs in north polar craters under a few km is more evident from a plot of the cumulative area % of ISRs as function of host crater size (**Fig. 5**).

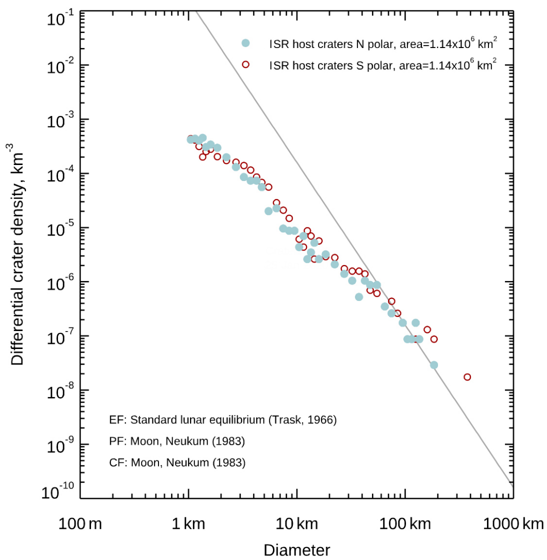

Figure 3. Incremental or differential crater size frequency distribution using same data given in Fig. 1.

Another way to characterize the north-south difference in ISR distribution is to calculate the total area of ISRs contained within craters as a function of crater size (**Fig. 4**). Again, it is clear that south polar region contains a much greater abundance of large ISRs hosted within impact craters that are 20–50 km in diameter.

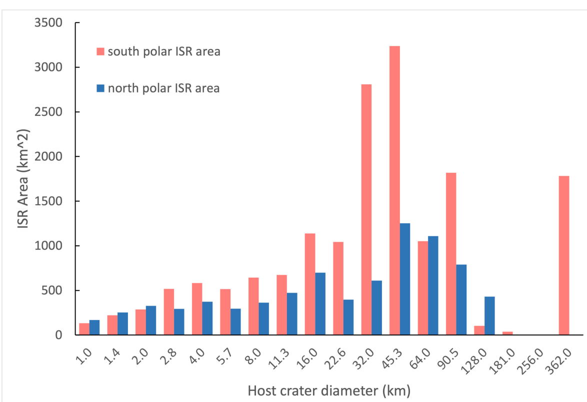

Figure 4. Bar plot of the area of ISRs (ice stability regions) binned by the diameter of the host crater. North polar ISRs are given in blue; south polar ISRs in red.

Discussion: These results confirm the visual impression that there is a larger abundance of small craters that host ISRs in the north polar region of the Moon compared to the south polar region, even though the total ISR area in the south is larger by a factor of ~1.4. This difference in crater size-frequency distributions has implications for the age of the volatile deposits. Recent research confirms that smaller lunar craters degrade faster than larger ones [e.g., 10, 11, 12].

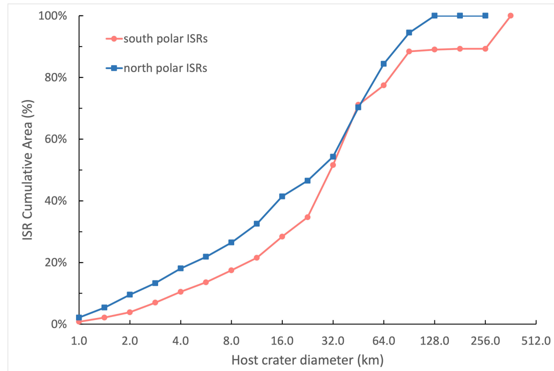

Figure 5. Cumulative percent area of ISRs in the north and south polar regions as a function of host crater diameter.

This finding means there is there is a positive correlation between ISR host crater size and age: volatile deposits in larger craters will tend to be older (i.e, their max potential age is greater). There is a stronger age constraint for smaller craters: volatile deposits in smaller crater *must* be younger or more recently emplaced than their larger counterparts. This study was limited by the resolution of the Diviner data that were binned at a resolution of 0.5 km. Smaller craters and depressions below this resolution limit likely exist [13]; these micro-cold traps must be even younger.

Volatile formation constraints: Numerous sources for the volatiles have been proposed, including from solar wind implantation, cometary and hydrous meteorite impacts, and endogenous lunar water from volcanic outgassing [e.g., 14]. Although the age constraints documented here are imprecise, the results suggest that small craters hosting ISRs in the north are unlikely to host remnants of a transient lunar atmosphere during peak volatile release ~3.5 Ga [15] due to their young ages. The results also suggest that different sized ISR-host craters may archive volatiles from distinct sources.

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