REFINING ICE ABUNDANCE ESTIMATES FOR SELECTIVE MINING UNITS ON THE MOON. K. M. Cannon[1] and D. T. Britt[1], [1]University of Central Florida, Department of Physics, 4111 Libra Drive, Orlando FL 32816 (cannon@ucf.edu).

Introduction: There are several constraints for ice abundances in polar regions on the Moon based on remote sensing data (Table 1). However, LEND, LPNS, and M^3 measurements have spatial resolutions far coarser than the likely scale that ice varies laterally and with depth [1], and LCROSS may be within that scale and therefore only provides a single data point.

Table 1. Water-equivalent hydrogen (WEH) and ice measurement ranges and associated spatial scales.

Meas.	Ref.	Area averaged over (m^2)	WEH/Ice (wt.%)
LEND	[2]	1×10^8	0.34-0.54[a]
LPNS	[3]	5×10^7-1.15×10^9	0.2-3.7
M^3	[4]	7.84×10^4	nd-20[b]
LCROSS	[5]	6×10^2(?)[c]	5.6

[a]Higher values possible with thick dry upper layer.
[b]Highest reported value 30% but see discussion below; nd = not detected.
[c]Corresponds to 25-30 m crater.

The highest reported abundance is 30 wt.% ice in a 280 m binned pixel [4], however the density of lunar soil used to convert volume to weight fractions in [4] was 1.8 g/cm^3, which is the bulk density when grain density should have been used. Applying ρ=3.1 g/cm^3 results in 20 wt.% ice instead of 30 wt.%. Ground truthing of Hapke-based modeling using XRD on Mars showed average errors of ~9 wt.% on crystalline components [6], and the M^3-based modeling would translate to 11-29 wt.% ice with a similar error applied (although individual errors in [6] were as high as 20 wt.%). We will use a maximum a posteriori probability model [6] in the future to further constrain estimates of ice fractions.

Higher ice contents are likely to be found at smaller scales than the M^3 binned pixel [4] because ice content probably varies on a scale of meters to decameters due to impact gardening, and standard deviation increases when the observation resolution increases.

Selective Mining Units: In terrestrial mining, a selective mining unit (SMU) is the smallest volume of material that can be classified as ore or waste. The size of an SMU depends both on the exploration techniques used to characterize an ore body, and the mining techniques to be used for extraction. For the Moon, proposed ISRU hardware includes excavation rovers such as NASA's ~1 m sized RASSOR [7], and active heating with capture tents sized at 5 m [8] or 10-32 m in diameter [9]. Extraction depths are usually discussed at decimeter to meter scales. We propose a reasonable SMU for prospecting and extracting ice in the Lunar polar regions might be 1×1×0.1 m (width×length×height) for excavation-based methods, and 10×10×0.1 m for thermal/radiant methods. Exploration efforts should focus on measuring ice content at these scales using orbital and/or landed assets. However, a mining company might calculate that the ~20 wt.% average modeled ice over 7.8 ha (Table 1) is profitable with no further exploration needed; initial ice extraction from the upper meter in Lunar PSRs could play out like California in 1849 (just show up and dig) rather than present-day mining (decades of reserves mapped out in detail).

Reference Block Models: We are developing a series of procedurally generated 3D block models based on our suggested SMU sizes, with realistic ice contents and distributions for areas within and adjacent to PSRs (Fig. 1). These models will be openly distributed and can be used as standards to benchmark ISRU yields and to model strategies for extraction (for example with pit optimization software).

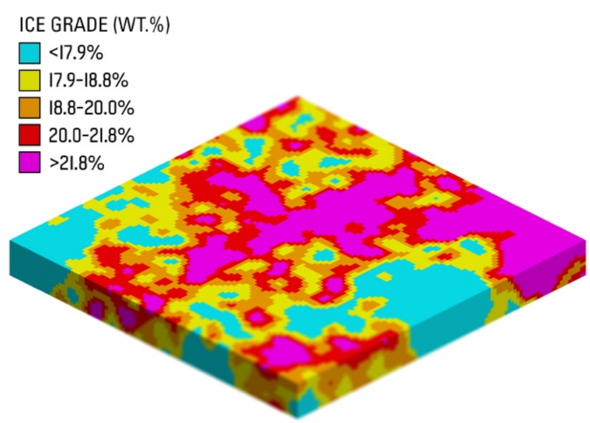

Fig. 1. Example of a reference block model with a mean ice content of 20 wt.%.

References: [1] Colaprete A. et al. (2019) *LPSC* Abstract #1120. [2] Sanin A.B. et al. (2017) *Icarus*, *283*, 20. [3] Teodoro L.F.A et al. (2010) *GRL*, *37*, L12201. [4] Li S. et al. (2018) *PNAS*, *115*, 8907. [5] Colaprete A. et al. (2010) *Science*, *330*, 463. [6] Lapotre M.G.A. et al. (2017) *JGR*, *122*, 2489. [7] Mueller R.P. et al. (2013) *IEEE*. [8] Stoica A. et al. (2017) *NTRS*, 20180007435. [9] Dreyer C.B. et al. (2018), *SRR*.