Data Fidelity Requirements for Defining Reserve Potential during a Coordinated Lunar Resource Evaluation Campaign. C. R. Neal[1] and A. Abbud-Madrid[2], [1]Dept of Civil & Env. Eng. & Earth Sciences, University of Notre Dame, IN USA (cneal@nd.edu); [2] Colorado School of Mines, Golden, CO USA (aabbudma@mines.edu).

Introduction: The terrestrial definition of an ore *reserve* is defined on one metric – money that can be made because of the demand for the commodity refined from the extracted resource (e.g., [1,2]). Reserve potential of lunar resources is based on mission success factors because the geologic context is currently not fully understood and sites are difficult to access [2]. However, continued activity on the Moon will cause the extraterrestrial and terrestrial reserve definitions to merge [2]. Indeed, a finding of the 2019 Lunar ISRU Workshop report stated "*Terrestrial mining companies will engage in lunar ISRU if they can see the profit potential and a net benefit to their terrestrial operations*" [3]. As lunar resource evaluation is still in its infancy, the understanding of any profit potential is rudimentary, because current datasets have insufficient fidelity [2,3], and only one lunar water price point (potential revenue) has been articulated ($500/kg [4]).

This presentation examines the reserve (economic) potential of lunar PSR water ice from a data fidelity standpoint. Our one point of ground truth is the LCROSS mission that recorded water ice in Cabeus crater at 5.6 ± 2.9 wt.% [5]. The graph below shows the revenue that would be generated from mining water ice from Cabeus crater from 1 to 5 m depth at the average, and various maximum/minimum values, assuming the price point of $500/kg. The premise followed is that more precise data will reduce the risk to commercial companies, so the exercise is repeated at 5.6 ± 1 wt.% and 0.5 wt.%. A crater floor diameter of 60 km is used [6], a density of 1600 kg/m^3 for highlands regolith and 917 kg/m^3 for water ice to calculate the densities of ice-laden regolith. The revenue differences between the average and the ± values are plotted in Fig. 1.

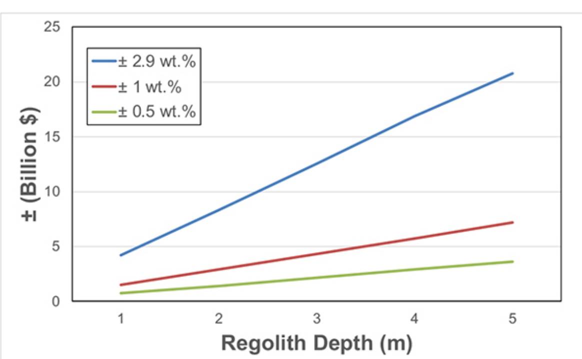

Fig. 1: Revenues calculated using LCROSS data of 5.6 ± 2.9 wt.% (actual data), 5.6 ± 1 wt.%, & 5.6 ± 0.5 wt.%.

Discussion: Actual LCROSS data show large variations in potential revenues from water ice extraction and refinement. The actual amounts are maximum values (100% recovery), but the point of this exercise is to evaluate if ±1 wt.% or ±0.5 wt.% is sufficient, or if more precise data need to be obtained. This has implications for the cost of analytical instruments on surface assets. For the ±1 wt.% H_2O case, the revenue deltas range from $1.5B at 1 m of regolith mined to $7.5B at 5 m. At a fidelity of ±0.5 wt.% H_2O, revenue deltas vary from $0.75B to $3.6B at 1 m and 5 m regolith mined, respectively. Assuming 5.6 wt.% H_2O, a total revenue of $8.2B is possible mining 1 m of regolith in Cabeus crater, and $41.2B at 5 m.

Apart from the question *What data fidelity is good enough for commercial companies to be interested?*, other questions arise: Can water ice in Cabeus crater be mined and refined at the price point of $500/kg? What value does NASA place on this commodity considering it has been touted as facilitating a sustained human presence on the Moon and developing a vibrant cislunar economy? [7-9]. These questions need to be addressed in order to define a coordinated lunar resource evaluation campaign that obtain datasets that are useful to the commercial sector in extraction of commodities. The most critical question from agency & commercial perspectives is the price point of lunar water, as this will define the economic viability of resource extraction. Calculating the cost of extraction will require data addressing accessibility and extractability (data addressing navigation, geotechnical, distribution, and form of the deposit), as well as understanding the refining process (composition and form). This will likely be an iterative process, and this process begins with the pathfinder mission, VIPER. Some of the questions posed here will be at least partially addressed by VIPER. However, a campaign of missions is required in order to better understand the reserve potential of polar volatiles and define the fidelity of data in all categories highlighted by [10].

References: [1] USGS (1980) Geol. Survey Circ. 831, 12 p. [2] Kleinhenz J. et al. (2020) LWIMS, NASA/TM-20205008626. [3] Lunar ISRU 2019, Final Report. [4] Sowers G.F. (2016) *Space Policy 37*, 103-109. [5] Colaprete A. et al. (2010) Science 330, 463-468. [6] Kozlova E.A. & Lazarev E.N. (2010) *LPSC 41*, #1779. [7] NASA (2020) NASA's Plan for Sustained Lunar Exploration and Development. [8] The National Space Policy (2020) *Fed. Reg. 85*(#242). [9] NASA (2021) Human Exploration & Operations Utilization Plan. [10] Neal C.R. et al. (2022), LSSW-17 (this workshop).