A CONCEPT OF LUNAR BENEFICIATION TEST BED.

M. C. Tolton[1,2], K. Liang[1,2], C. B. Dreyer[2], X. Wang[3,4], M. Horanyi[3,4]
[1]Orbital Mining Corporation, 1600 Jackson Street, Golden CO, 80401, chris@orbitalminecorp.com, ken@orbitalminecorp.com,
[2]Colorado School of Mines, Center for Space Resources, 1310 Maple Street, Golden, CO 80401
[3]Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado, Boulder, CO 80303, xu.wang@colorado.edu, horanyi@colorado.edu
[4]Space Dust Research & Technologies LLC, Superior, CO 80027

Introduction: Valuable resources on the Lunar surface exist in concentrations that require significant energy expenditure to extract from the regolith. As one of the fundamental processes in Lunar mining, beneficiation prepares the regolith into a suitable feedstock through size separation and concentration, which is essential to increasing ISRU efficiency and capability. This often-overlooked Lunar mining process [1] will be critical for the development of additive manufacturing, sintering, and element extraction, with minimal energy consumption. However, lunar beneficiation techniques are in the nascent development stages.

As presented at the Lunar Surface Science Workshop, we propose a Lunar Beneficiation Test Bed (LBTB) to be established on the Moon. By positioning the LBTB on the lunar surface, it can be used to address the technical challenges confronting beneficiation in the harsh Lunar environment (vacuum, reduced gravity, abrasive dust, cold temperature, and radiation), made harsher by the presence of Lunar surface activity. This presentation will provide details on the LBTB's scientific value, proposed instruments, and a rough order of magnitude for cost. This concept also supports NASA's Lunar Infrastructure Objective LI-7 [2] which is "to develop industrial scale ISRU capabilities in support of continuous human presence and a robust lunar economy."

Scientific Activities: The LBTB will answer the following interrelated science questions (SQs):

SQ1: What is the effect of Lunar gravity on regolith flowability?

SQ2: What are the charge properties of regolith dust and how can charge be manipulated in a controlled manner for optimized electrostatic separator operations?

SQ3: What are the effects of dust-dust and dust-surface adhesion on size separation?

SQ4: What are the effects of regolith size distribution, composition (e.g., anorthosite, ilmenite), and petrography (e.g., Lunar glasses, agglutinates) on beneficiation methods, including electrostatic, magnetic, and enhanced gravity?

Secondarily, extensive Lunar surface activity, especially industrial-scale beneficiation, may have negative externalities on the Lunar environment, namely dust lofting and contamination. To fully evaluate beneficiation technologies, the LBTB will also enable characterization of the dust problem by answering these additional science questions:

SQ5: What is the expected range of lofted dust transport from different methods of beneficiation?

SQ6: How does dust affect and degrade materials over time and repeated exposure (i.e., Astronaut suit fabric, solar panels, etc.)?

SQ7: How well do dust mitigation techniques work on various surfaces?

With repeated return to a single location, the LBTB enables iterative in-situ development of beneficiation technologies, as well as long-term repeated exposure to Lunar regolith and dust for durability testing.

Recommended Payloads: Recommended payloads for LBTB include:

1) A centrifugal device to investigate enhanced gravity and dust-dust and dust-surface adhesion to address SQ1 and SQ3;
2) An electrostatic separator with a dust charge detector to address SQ2 and SQ3;
3) A particle size and shape analyzer to address SQ4;
4) A particle composition analyzer to address SQ4;
5) A dust detector to address SQ5;
6) A general-purpose microscope to visually inspect dusty surfaces to address SQ6; and
7) Dust mitigation techniques for efficacy tests.

These payloads can be standalone devices to address specific SQs, or configured as a system to address interrelated SQs and ultimately test optimized Lunar beneficiation efficacy.

References:

[1] J.N. Rasera, J.J. Cilliers, J.A. Lamamy, K. Hadler (2020). *Planetary and Space Science*, 186, 104879

[2] Moon to Mars Objectives, NASA, Sept 2022.

250 char summary:

We propose a Lunar Beneficiation Test Bed (LBTB). Leveraging repeated Astronaut return, LBTB allows for testing and iteration of regolith beneficiation technologies in the real Lunar environment, evaluating flowability, charge, adhesion, composition, and negative dust effects.