Lunar highland regolith simulant and agglutinate production at the University of New Brunswick. L. M. Thompson[1], J. G. Spray[1], and M. M. Battler[2] [1]Planetary and Space Science Centre, University of New Brunswick, Fredericton, NB E3B 5A3 Canada; [2]Department of Earth Sciences, University of Western Ontario, London, ON N6A 5B7 Canada

Introduction: Anorthosite constitutes a major component of the lunar highland crust and an important and perhaps dominant ingredient of the lunar regolith. If we are to return to the Moon, anorthositic regolith is likely to be a point of contact for landers, rovers, and astronauts and related infrastructure, including in situ resource utilization (ISRU) technologies. As such, highland regolith simulants are required to assist in preparation for lunar surface engineering activities. This work outlines the selection and development of a highlands root simulant and a derivative, OB-1, formed by the addition of olivine glass [1], [2]. We also discuss the generation of agglutinate from the highlands root simulant using friction welding apparatus [3].

Sample Selection: Four criteria were considered in selecting anorthositic root simulant candidates: (1) alteration and hydrous phase presence, (2) plagioclase composition, (3) uniformity of properties and texture (source reproducibility), and (4) access and production capacity. A number of anorthosites were evaluated both in Canada and abroad.

The best candidate found was a facies of the Shawmere anorthosite of northern Ontario, Canada. It comprises an annealed anorthosite core exhibiting few fractures and limited hydration. The 97 vol% plagioclase is fresh and has a relatively high anorthite content (average An_{78} – bytownite) for terrestrial plagioclase.

In addition to plagioclase, the Shawmere anorthosite consists of ~1% olivine, ~1% orthoclase, and 0.2-0.5% each of orthopyroxene and clinopyroxene, with accessory opaques, apatite and zircon. Alteration is largely localized in linear fault/fracture zones and the rock is homogeneous away from these zones, rendering it a good candidate for reproducibility. The rock is granoblastic, with 1- 3 mm grainsize; a hydrous phase content of <5 vol% (average loss on ignition = 0.39 wt%); a solid rock density of 2760 kgm^3, and a calculated liquidus temperature of 1243°C. The Shawmere anorthosite has previously been commercially exploited and, as a result, a number of exisisting quarries make access and extraction viable.

Standards and Crushing Protocols: The Apollo 16 anorthositic regolith sample 64500 was selected as the standard. Various crushing machines were tested separately and in combination in order to reproduce a comparable grainsize distribution to the standard sample. Crushed samples were assessed by sieving and microscopy. It transpired that the jaw-, roll- and ring-crushers in sequence led to minimal rounding and the most satisfactory grain size distributions. Crushing times and sequences were then adjusted over 33 trial runs to attain the best grain size distributions while retaining subangular to angular grain shapes [1].

An olivine (98 wt% Fe_2SiO_4) slag was added to represent a physical-mechanical equivalent of the glass and agglutinate components of the Apollo sample. The resulting simulant is referred to as OB-1 (Olivine + bytownite 1), which is a blend of 42% olivine glass and 58% anorthosite by mass. Friction welding apparatus was also used to generate an agglutinate component from the Shawmere root simulant [3].

Results: The grainsize distribution for OB-1 is typically within 15% of the Apollo 16 sample 64500 standard except for the 75-150μm fraction, which shows ~50% difference. Average Apollo values show greater differences both with OB-1 and 64500, except for the 150-250 μm range, where there is excellent agreement between all three. However, differences between 64500 and bulk Apollo values raise the issue of how viable it is to establish a representative average regolith particle size distribution.

Appraisal of OB-1 by Orbital Technologies Corporation (Orbitec) reveals an average cohesion of 1.4kPa and angle of friction of 41.2°. Evaluations by [4 indicate that OB1 is a viable geotechnical stimulant. It is recommended for "extraction and pourability", and is the most recommended for "drilling", and "abrasion and wear" out of eight simulants evaluated by NASA [5]. Agglutinate produced from the Shawmere root simulant via the friction welder reveals similar textures to Apollo 16 64500 agglutinate.

Considerations: We have reported production methods for a high-fidelity geotechnical simulant for lunar engineering applications. Creation of an authentic chemical simulant for ISRU extraction technologies is more difficult. Future work should aim to replicate the nanophase iron and solar-wind implanted components.

References: [1] Battler, M.M. (2008). *MSc thesis*, UNB 137pp. [2] Battler, M.M. and Spray, J.G. (2009). *Planet. Space Sci.*, 57, 2128-2131 [3] Spray, J.G. (2010). *Planet. Space Sci.* (in press). [4] Schrader, C.M. et al. (2008) *Geol. Soc. Am. Ann. Meet*. Abstract# 345-13. [5] Schrader C.M. (2009) Lunar Rego-

lith Simulant Workshop – March 17-20. Marshall Space Flight Center, Huntsville, Alabama. Abstract.