Identifying Regions of Interest Needed to Characterize the Diverse Physical Properties of the Lunar regolith.

T. Trabucchi [1], S. Crites[2], A. Przepiórka[3], S. Quintana [4], C. Santiago[5], D. A. Kring[6], [1] University of New Brunswick, Brunswick, Canada, c8yq2@unb.ca; [2]University of Hawai'i, Honolulu, HI; [3] Space Research Centre of the Polish Academy of Sciences, Warsaw, Poland; [4] Brown University, Providence, RI; [5]University of Texas at El Paso, El Paso, TX, [6]Lunar and Planetary Institute, Houston, TX.

Introduction: The National Research Council (NRC) in its report about *The Scientific Context for Exploration of the Moon* [1] defined eight scientific priorities for future missions, one of which is to better characterize the lunar regolith. The report suggested an important goal (#7b) is to determine the geotechnical, mineralogical and chemical properties of the lunar regolith and the volatile components within it. To facilitate that goal, we examined a list of characteristics that might affect those properties and how they might vary across the lunar surface. We then conducted a global survey of the Moon to determine where those issues can best be examined.

Methodology: In order to locate sites suitable for regolith' studies we (I) constructed an ArcGIS map with the limits of the three main geochemical terranes of the Moon [2]; (II) constructed an ArcGIS map delimiting the boundaries of the maria and the highlands; (III) integrated those maps with a map of permanently shadowed regions at the lunar poles derived from [3]; (IV) categorized regions on the lunar surface where regolith properties had already been evaluated by previous missions or post-mission sample analyses [4] (similar types of regions are lower priority sites for future studies); and (V) used a decision matrix in conjunction with this integrated ArcGIS system above to develop a prioritized list of landing locations. Our procedure identified regions of interest that are indicated in Figure 1. We discuss the rationale for those regions next.

Discussion: For the purpose of NRC science goal 7b, the most relevant regolith properties are density, thermal conductivity and particle size/shape. These properties are the most likely ones to affect human explorers' endeavors to traverse and inhabit the lunar surface. According to Carrier [5] "geotechnical properties are expected to be the same everywhere, with the possible exception of the poles". The geotechnical properties of the regolith may be different at the poles primarily due to the possible presence of ice and the form it takes [5].

These geotechnical differences are most likely to occur in permanently shadowed regions (PSRs) that may be cold traps or sinks for volatiles[6,7], which are attractive for both scientific and exploration reasons. Volatiles are an important scientific target, because they may provide new insights about the evolution of the Moon, the bombardment of its surface and variation in solar activity [4]. Those volatiles may also be an important in situ resource utilization (ISRU) deposit for future explorers. For both those reasons the poles are the highest priority location to study the geotechnical properties of the regolith.

Although the geotechnical properties may be similar beyond the polar regions, the mineralogical and geochemical properties vary dramatically. That variation needs to be captured in additional landing sites.

Targets include the Feldspathic Highland Terrane (FHT) on the lunar farside [7] and rare mare deposits on the lunar farside. Both regions are chemically different from highland and mare sites on the lunar near side that were analyzed by the Surveyor, Apollo and Luna missions.

The most distinct region, however, is the South Pole-Aitken Terrane (SPAT), which has anomalously mafic interior [8] and some areas that may be ultramafic [9]. Interestingly some of the geotechnical regions of interest described above occur within SPAT, so a mission to that region has the potential of expanding our understanding of the geotechnical, mineralogical and chemical properties of the regolith more than any other region. Thus, our survey suggests sampling, in order, areas within the SPAT, the FHT, and if possible, more extensive sampling of the Procellarum KREEP Terrane (PKT), which is an area for which some data exists from the Apollo missions. Within the three geochemical terranes are regions of mare, highlands, and boundaries between the two. The boundary regions will provide access to both

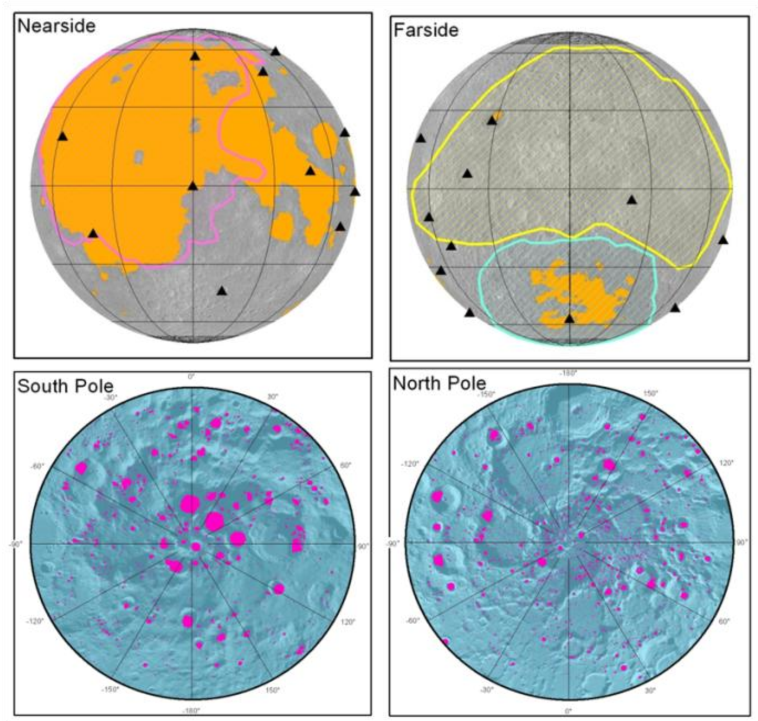

Figure 1 Goal 7b regions Map showing Science of interest

types of material during a single mission and are, therefore, better sites to land. Wherever possible in each of these regions, cryptomare, or ancient buried mare, and any paleoregolith that are preserved in them, should be accessed to determine if regolith has changed with time. Furthermore, it will be prudent to measure heat flow through the regolith in each of the regions. Heat flow is of particular concern, because it may influence habitat deployment. For example, the depth to where thermal variations between day/night or diurnal cycles cease may be lower at the poles than at the equator because the Sun is low on the horizon. If this is true, a structure or habitat may not need to be buried as deeply at the poles to avoid the extreme lunar temperature fluxes. Previously, heat flow measurements into the lunar regolith have only been performed at the Apollo 15 and 17 sites.

Summary: In conclusion regolith properties should be studied in: (1) the three main geochemical terranes (SPAT, FHT, PKT); (2) mare and highland sites (and boundaries between them) within the three terranes; (3) permanently shadowed and illuminated locations at the poles; (4) at sites of differing surface temperature; and (5) in varied locations within each site (e.g. crater rims, bases of slopes, intercrater areas).

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