Phase I Project Summary

Research Objective

Prior to future manned and/or unmanned Lunar exploration activities, it is imperative that high fidelity lunar soil simulants be developed in order to accurately evaluate the life span and efficiency of any equipment exposed to the lunar surface. Current regolith simulants lack certain constituents, such as agglutinate particles. Lunar agglutinates, which can account for up to 60% by volume of a mature lunar soil, significantly influence the hardness, flowability, friction, magnetic susceptibility, and electrostatic properties of the lunar regolith. The primary objective of this research was to investigate a viable method to produce lunar agglutinate simulants from JSC-1A feedstock. A secondary objective was to assess the manufactured material and determine if it met the requirements of a high fidelity lunar agglutinate simulant.

Research Performed

Using a manufacturing approach based on thermal (plasma) spray technology, PPI demonstrated a viable technique to manufacture a Mare lunar agglutinate simulant. The following characterization methods were employed to evaluate the agglutinate simulant material: scanning electron microscopy (SEM); SEM-based Energy Dispersive X-ray Spectroscopy (EDS); X-ray diffraction (XRD); differential thermal analysis (DTA); and inductive coupled plasma (ICP).

Research Results

The manufacturing approach developed during this effort ultimately produced material that reasonably satisfied the lunar agglutinate simulant requirements defined below. The combination of the developed agglutinate simulant and a root lunar simulant in the correct proportions can yield a high fidelity derivative simulant, deemed extremely important for validating equipment and operations exposed to the lunar surface.

i. A 1:1 mixture of a glassy phase and the original simulant crystalline phases.
ii. Particles should be $\geq$ 1 mm.
iii. Composition should mimic the source material or simulant from which they are formed.
iv. Highly irregular in shape with sharp edges.
v. Vesicles with nominal diameters between a few tens of nm to a few hundred µm.
vi. Glassy phase should contain nano-phase elemental iron (np Fe^0).

Phase II Justification

Follow-on efforts are essential to advance the current technology and capabilities. Specifically, additional efforts should consider the following:

1. Additional analysis to quantify volume fraction of np Fe^0, as well as quantify volume percentage and size distribution of vesicles observed in the agglutinate simulant material.
2. Determine correlation of process parameters and characteristics of agglutinate simulant material (e.g. crystalline/amorphous phase content; vesicle size and distribution; chemistry and np Fe^0 content). Once this correlation is determined, process can be optimized to produce tailored agglutinate simulant.
3. Identify means to increase production rate from grams/day to kilograms/hr.
4. Investigate production of Highland agglutinate simulants.