Development of lunar regolith simulants based on previous lunar explorations

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Several countries and agencies plan lunar missions to lunar polar regions in the 2020s (e.g., NASA’s Lunar Flashlight, Chinese Chang’E 6, NASA’s VIPER, Japanese SELENE-R) to investigate the existence (abundance) of water ice, with the aim to establish lunar bases as gateways to deep space explorations including a manned mission. For the assessment of lunar surface environment (e.g., surface temperatures, regolith properties) and its interaction to lunar lander/rover, as well as the planning of observations and in-situ analyses on surface compositions, subsurface structures, and water ice, a vast amount of lunar regolith simulants, which should be as realistic as possible, are necessary to produce. Previous lunar regolith simulants were developed based on Apollo samples, so that they approximate compositions of materials on the lunar nearside only, which is insufficient for the modeling of the surface of lunar farside and polar regions. Therefore, the objective of this study is to compile remote-sensing data (several chemical composition maps) (Elphic et al., 1998; Lawrence et al., 1998; Lawrence et al., 2007; Lucey et al., 2000; Lucey et al., 1995; Ohtake et al., 2009) and Apollo sample data, and to establish a procedure of the development of simulants of the far-side and polar region as well as the nearside.

In this study, we collected several types of igneous rock and test the accuracy of rock type and texture to use for simulants. Then we revisited Apollo sample data and decided the most favorable ranges of particle size distribution, chemical composition, mineral assemblage, particle shape and texture of our simulant, and established manufacturing procedure.

We finally developed four different types of lunar simulants: mare simulant of the lunar near side, highland simulant of the lunar near side, the South Pole Aitken (SPA) basin simulant, and highland simulants of lunar far-side were prepared by the above procedure using an analysis technique such as XRF. Unlike the existing simulants (e.g., JSC-1), the simulant produced in this study are within the constraints of elemental/chemical compositions of Apollo samples and remote-sensing data, and they show a wide range of validity for modeling the surface of each site, in terms of particle size-frequency distribution, mineral abundance and the chemical composition, which would lead to precise estimates of the surface conditions of future landing sites.

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