PHOTOMETRIC INVESTIGATIONS OF LUNAR ANORTHOSIC HIGHLANDS USING LROC NAC IMAGES AND DERIVED DATA. B. L. Jolliff1, 2, R. N. Watkins1, 2, E. M. Culley1, T. M. Hahn1; 1Washington University in St. Louis and the McDonnell Center for the Space Sciences; 2Planetary Science Institute, Tucson, AZ; 3Arizona State University, Tempe, AZ (bjolliff@wustl.edu).

Introduction: The Lunar Reconnaissance Orbiter (LRO) mission has opened up new avenues of investigation into the Moon’s primary crustal rocks. The Lunar Reconnaissance Orbiter Camera (LROC) investigations have benefited from over ten years of observation and repeat imaging of key sites on the Moon. Having multiple illumination geometries enables photometric studies using both the Wide Angle Camera (WAC) [1,2] and the Narrow Angle Cameras (NAC) [3-5]. Using NAC-derived digital terrain models (DTM), we can account for local topography and compute illumination geometry (incidence and emission angles) for every pixel. We then compute normalized reflectance or solve the Hapke equation for single-scattering albedo (ω) [3-6]. This process removes most of the effects of topography, whereby Sun-facing slopes appear more reflective and slopes facing away from the Sun, less reflective.

In studies of reflectance at lunar landing sites [3,4], we found that the composition of mature surfaces correlates well with the normalized reflectance and ω. For example, ω correlates positively with Al2O3 (i.e., plagioclase content) and correlates inversely with FeO+MgO+TiO2, which is a measure of the mafic mineral content (Fig. 1). Albedo and FeO are anti-correlated, which is useful because we have estimates of FeO from remote sensing. In addition to composition, maturity affects reflectance, with immature surfaces appearing more reflective. Because information about surface physical properties to account for immature surfaces is typically lacking, we restrict comparisons between ω and compositional parameters to mature surfaces where the compositional correlation is most robust.

Methods: We use NAC images coupled with DTMs derived from NAC geometric stereo images [7] to determine local incidence and emission angles for every pixel at 5 mpp spatial resolution. We then use the Hapke photometric model and nonlinear optimization techniques in MATLAB to solve for the ω and β parameters [6]. Slope maps are derived from DTMs and we use available FeO and optical maturity maps (Clémentine and Kaguya) for comparison, and M1 spectra where available. Although our method does not outright solve for all the variable parameters in the Hapke equation, in areas of mature regolith, the correlation between ω and compositional parameters is strong (Fig. 1). Because we do not adequately account for the different physical properties associated with immature surfaces, our method produces high values of ω for immature surfaces (e.g., steep slopes, fresh rock exposed in outcrops, ejecta from young craters). We therefore use slope and optical maturity to constrain the data to mature surfaces.

Results and Discussion: We mainly seek to examine compositional variations globally with respect to the primary rock composition of the Moon’s crust. From the Apollo samples, this includes anorthosite (i.e., ferroan anorthosite, FAN) and Mg-suite rocks. We seek to better understand their distribution in uplift structures (central peaks, basin ring massifs) as a reflection of rock types that exist in the crust beneath the megaregolith. Results from hyperspectral imaging suggest anorthosite with very high percentages (>95%) of plagioclase in numerous locations. In some areas, we find ω values approaching 0.55-0.6 where FeO is very low (<1%). However, by our correlation of ω with FeO, we estimate that plagioclase proportions in mature regolith in many areas does not exceed 95%, suggesting the presence of other mafic components in and among the primary anorthositic rocks. Although concentrations may locally exceed 98% plagioclase (cf. 4.6 kg FAN sample 60015 [9,10]), we infer from the photometric data that more mafic variants also occur. These findings have implications for the efficiency of plagioclase separation from the lunar magma ocean as well as for the mineral and chemical bulk composition of the primary lunar crust.

Acknowledgement: ASU contract NNG07EK00C.